

MULTIMEDIA COMMUNICATION SYSTEMS

ECE 434

Computer Project 1

Compare a digital video stream in both spatial and frequency domain using the following formats:

- (a) Original component signal (RGB).
- (b) Original component signal (YIQ).
- (c) Composite signal (YIQ).
- (d) Recovered component signal (YIQ).
- (e) Recovered component signal (RGB).

ECE 434 Multimedia Systems

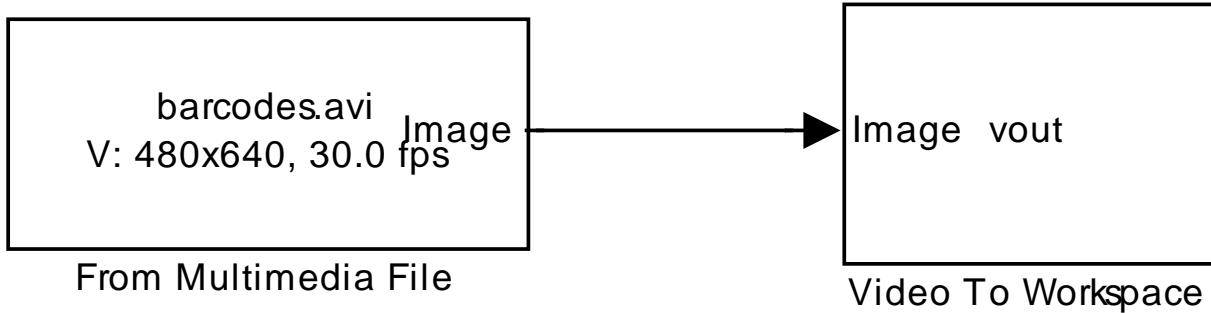
Project 01 Digital Video Stream

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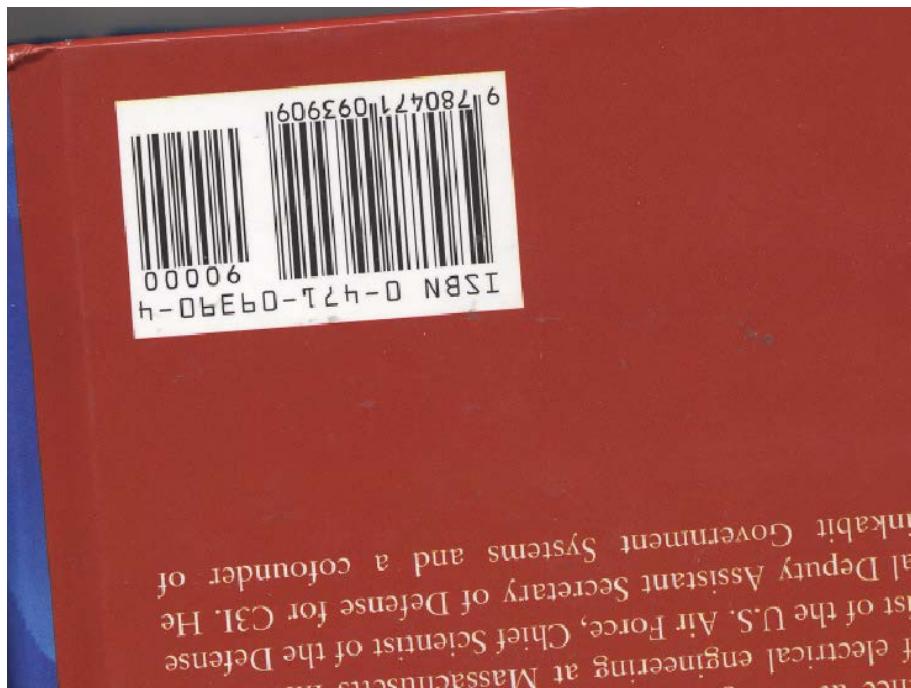
2013 October 03

```
% Simulink Model used to import the video as a 4D array (Height, Width,  
Bands, and Frames)
```



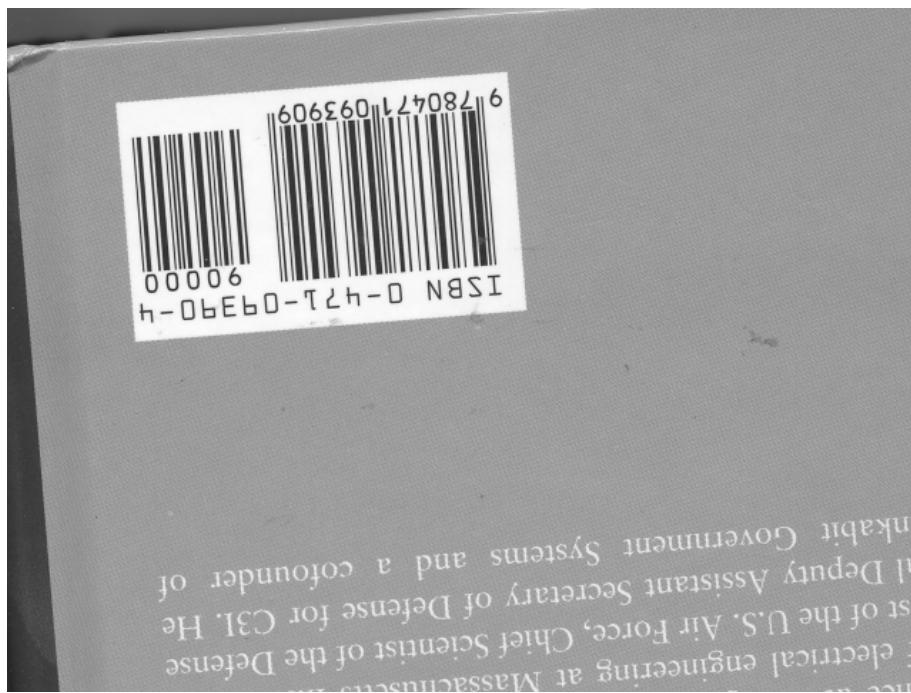
```
% Composite Video Spectrum Frequencies %%%%%%  
maxFrequency = 5450000;  
YbeginningFrequency = 1;  
YcarrierFrequency = 1250000;  
IbeginningFrequency = 3398001;  
IcarrierFrequency = 3875000;  
QbeginningFrequency = 4352001;  
QcarrierFrequency = 4830000;  
  
% Video Parameters %%%%%%  
numrows = 480;  
numcols = 640;  
numFrames = 11;  
% for frameNumber = 1:numFrames % uncomment this line and add  
% 'end' to the end of this .m file for multiple frames of a video  
frameNumber = 11; % for every frame in the video  
  
% 1. Original component signal (RGB) %%%%%%  
  
% Original RGB image  
RGBimage = vout(:, :, :, frameNumber);  
figure(1);  
imshow(RGBimage);  
title('RGB original image');
```

RGB original image

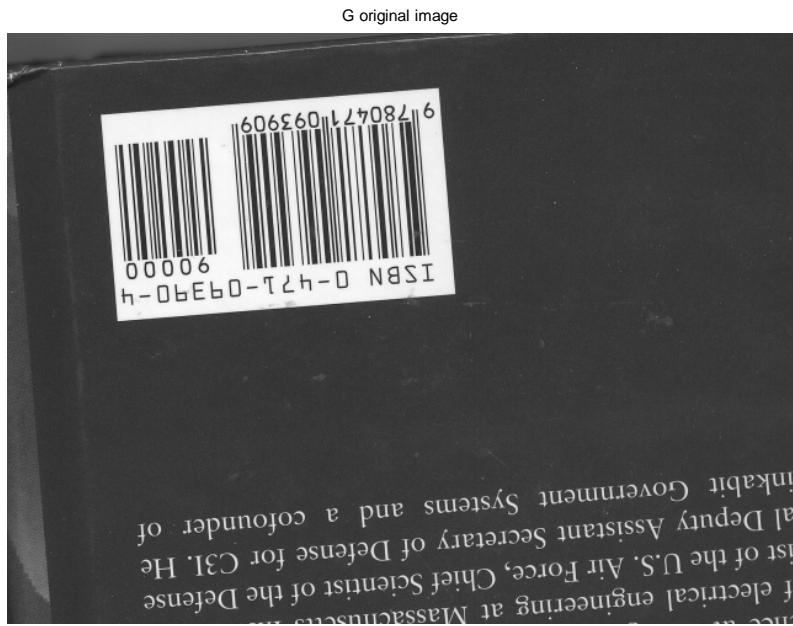


```
% Original R image
Roriginal = RGBimage(:, :, 1); % extract only R in 2D
figure(2);
imshow(Roriginal);
title('R original image');
```

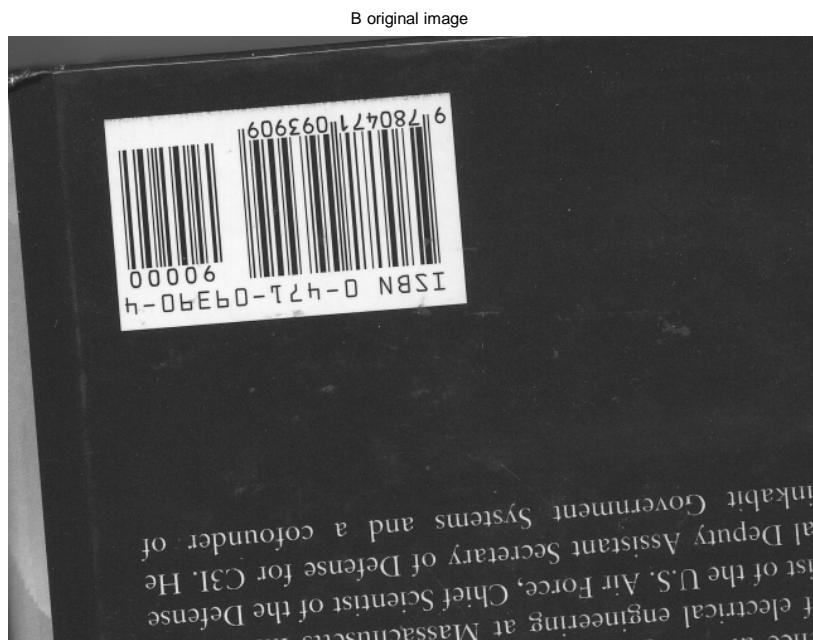
R original image



```
% Original G image
Goriginal = RGBImage(:, :, 2); % extract only G in 2D
figure(3);
imshow(Goriginal);
title('G original image');
```

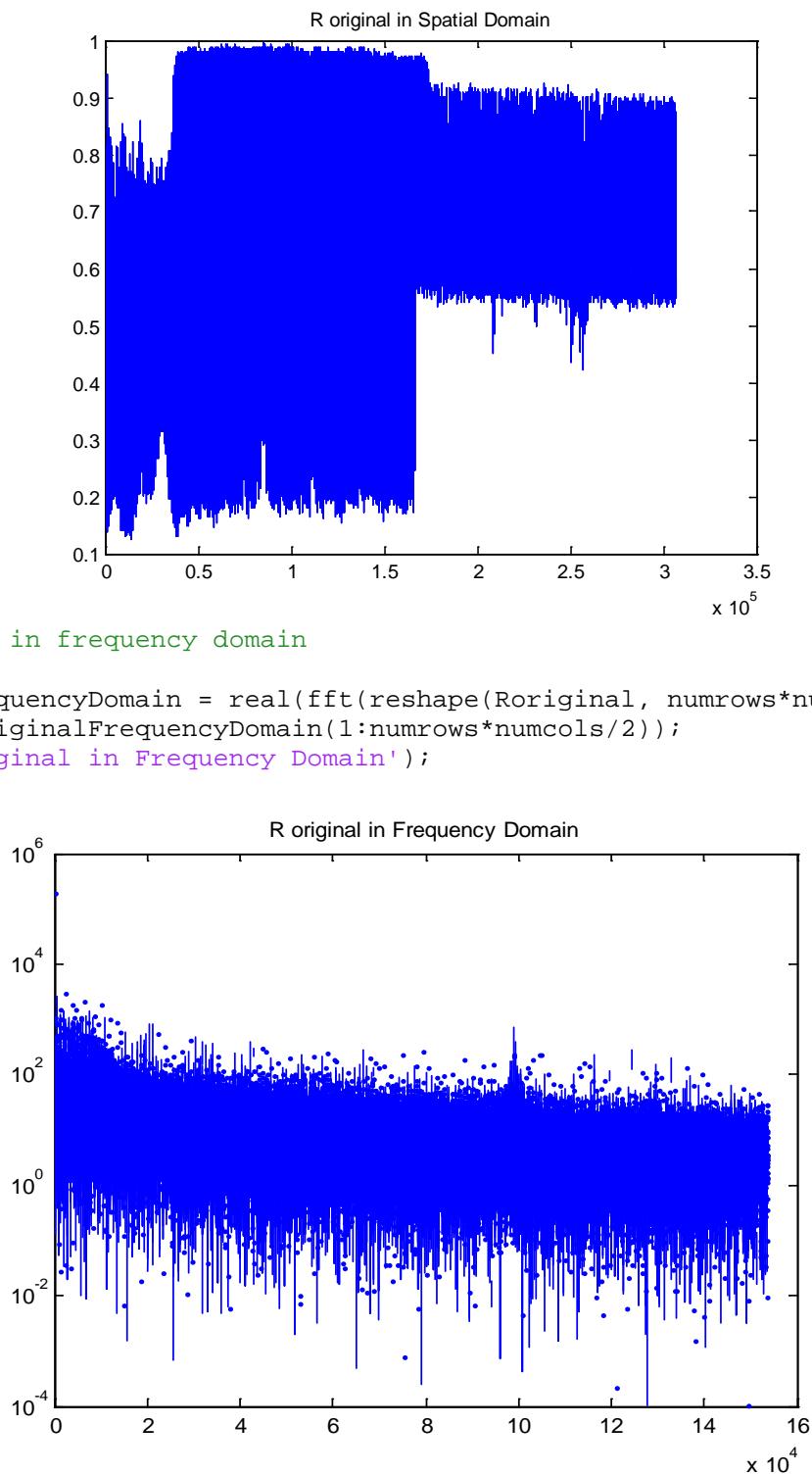


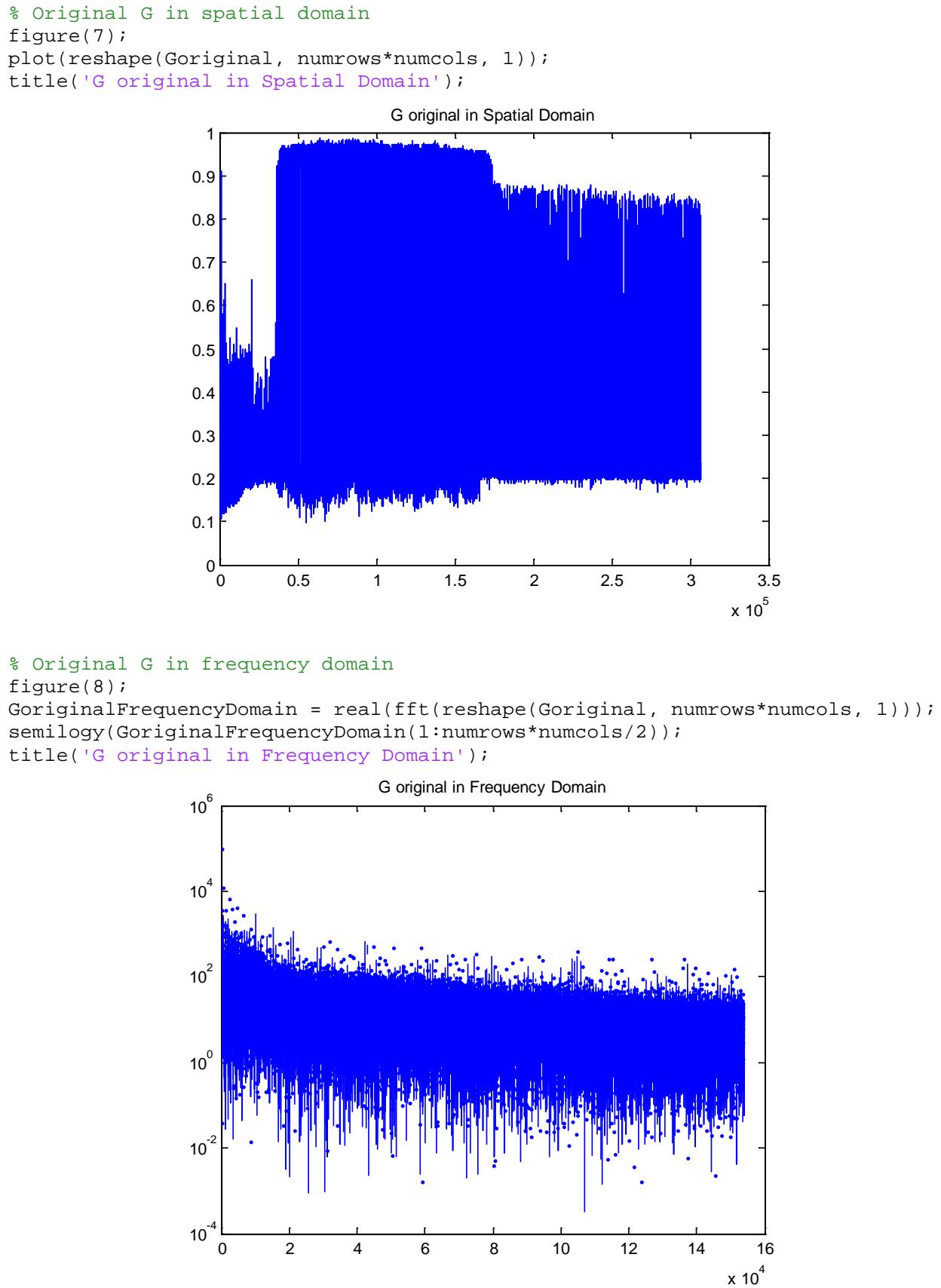
```
% Original B image
Boriginal = RGBImage(:, :, 3); % extract only B in 2D
figure(4);
imshow(Boriginal);
title('B original image');
```



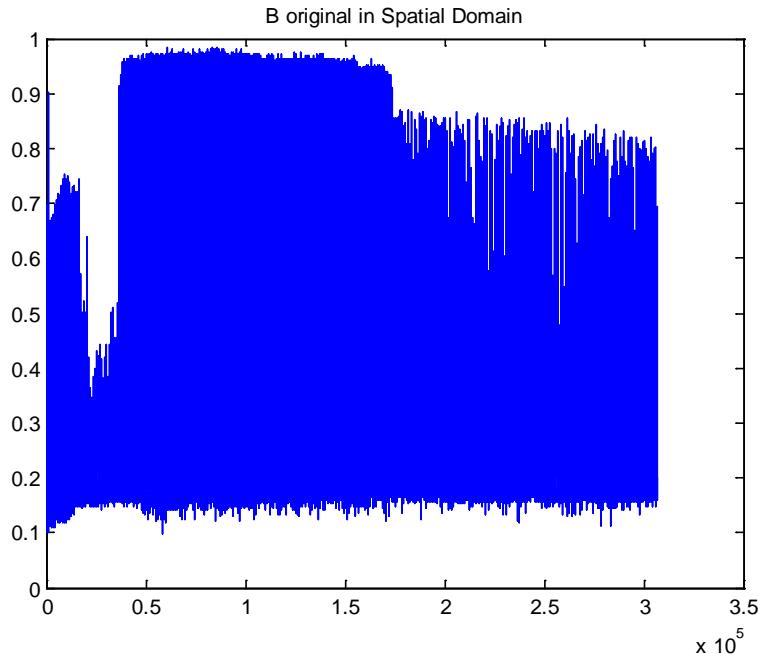
```
% Original R in spatial domain
figure(5);
plot(reshape(Roriginal, numrows*numcols, 1));
title('R original in Spatial Domain');

% Original R in frequency domain
figure(6);
RoriginalFrequencyDomain = real(fft(reshape(Roriginal, numrows*numcols, 1)));
semilogy(RoriginalFrequencyDomain(1:numrows*numcols/2));
title('R original in Frequency Domain');
```

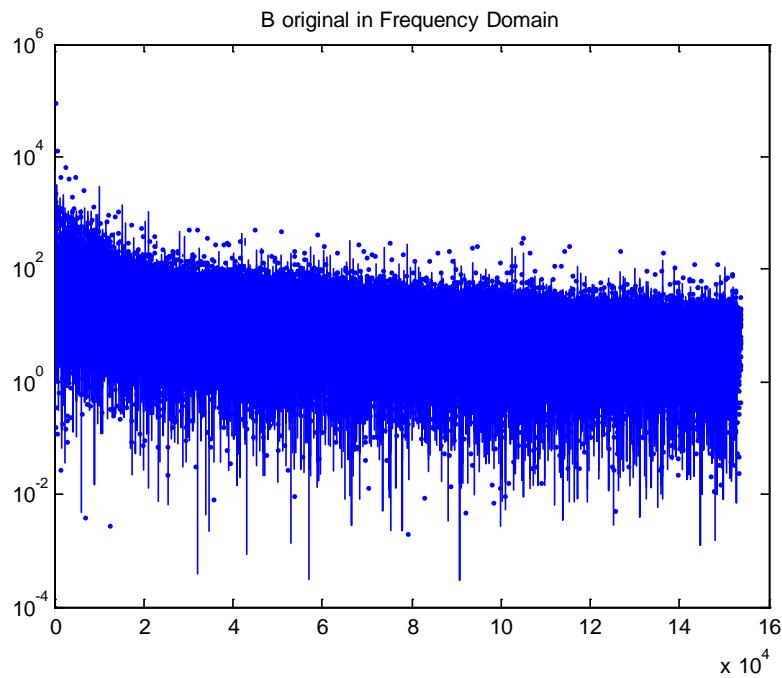




```
% Original B in spatial domain
figure(9);
plot(reshape(Boriginal, numrows*numcols, 1));
title('B original in Spatial Domain');
```



```
% Original B in frequency domain
figure(10);
BoriginalFrequencyDomain = real(fft(reshape(Boriginal, numrows*numcols, 1)));
semilogy(BoriginalFrequencyDomain(1:numrows*numcols/2));
title('B original in Frequency Domain');
```

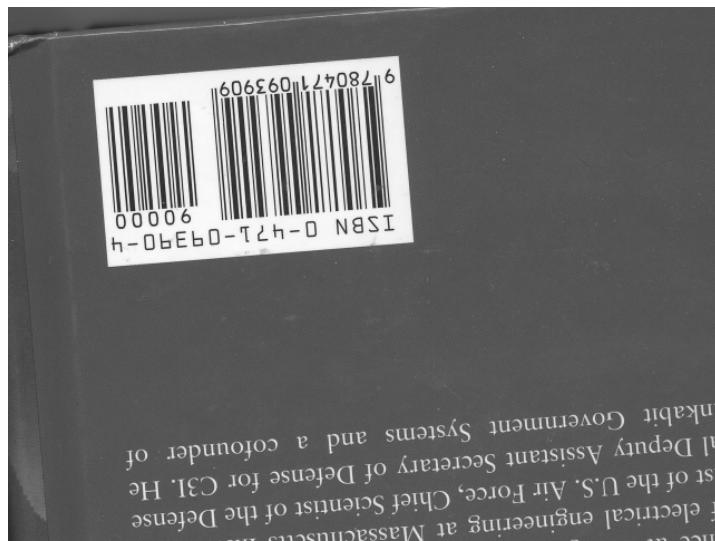


```
% 2. Original component signal (YIQ) %%%%%%%%
% Original YIQ image
Yoriginal = 0.299*Roriginal + 0.587*Goriginal + 0.114*Boriginal;
Ioriginal = 0.596*Roriginal - 0.275*Goriginal - 0.321*Boriginal;
Qoriginal = 0.212*Roriginal - 0.523*Goriginal + 0.311*Boriginal;

% Original Y image
```

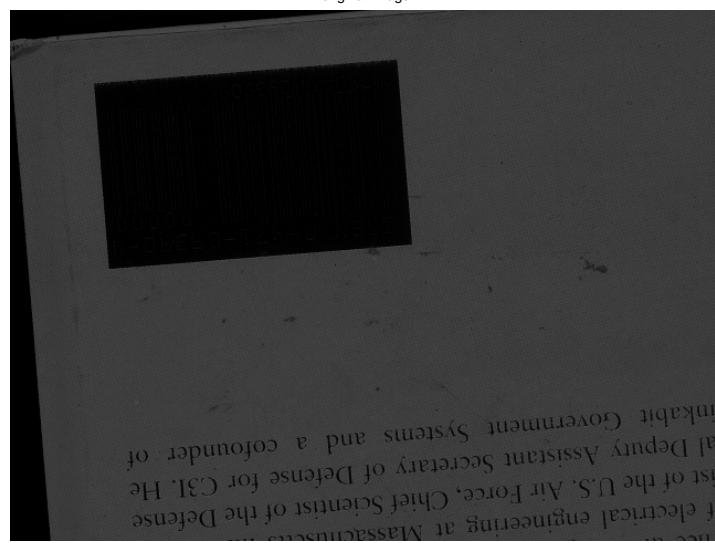
```
figure(11);
imshow(Yoriginal);
title('Y original image');
```

Y original image

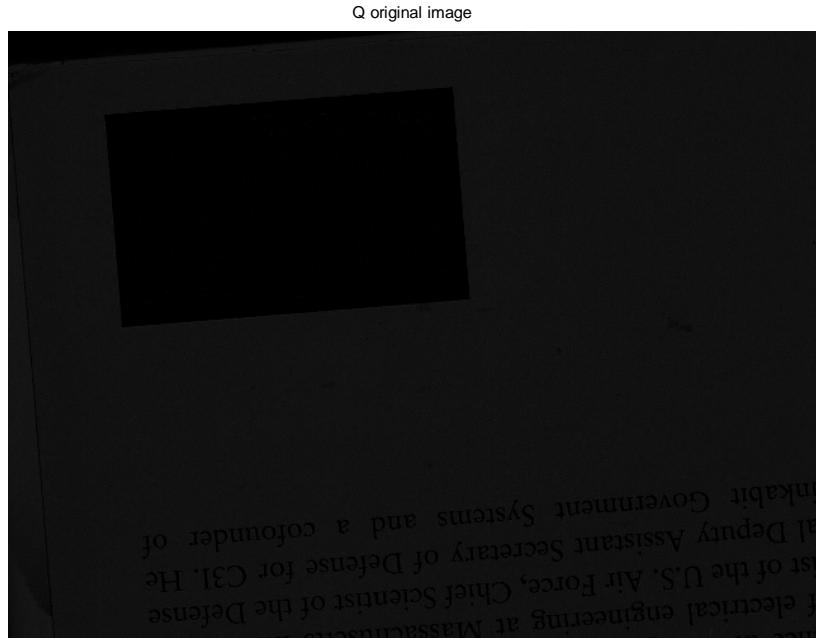


```
% Original I image
figure(12);
imshow(Ioriginal);
title('I original image');
```

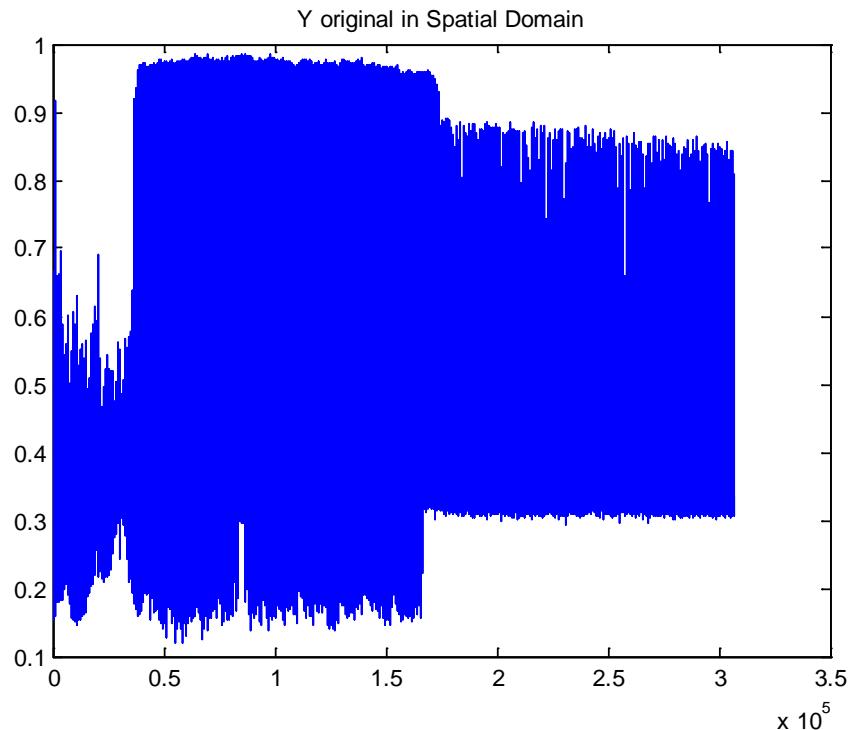
I original image



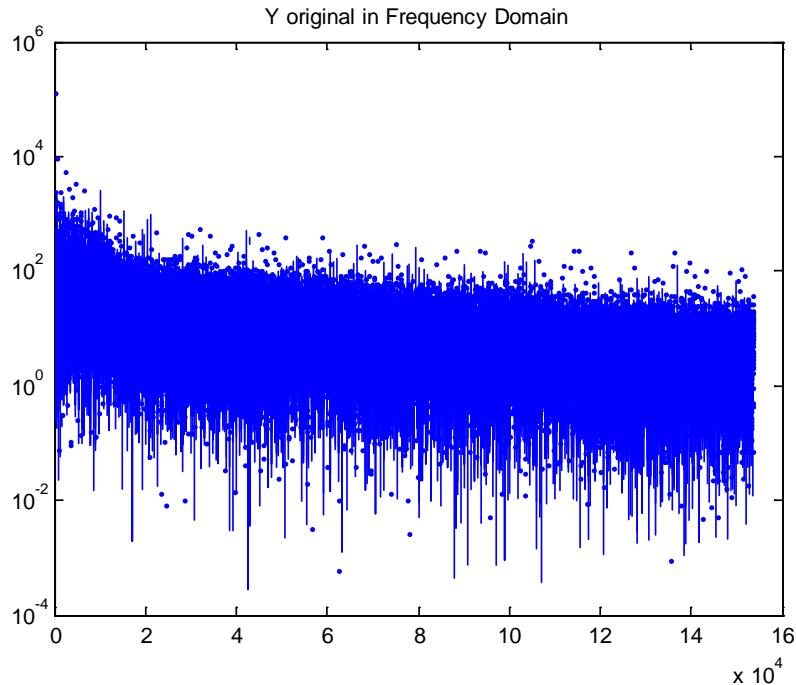
```
% Original Q image
figure(13);
imshow(Qoriginal);
title('Q original image');
```



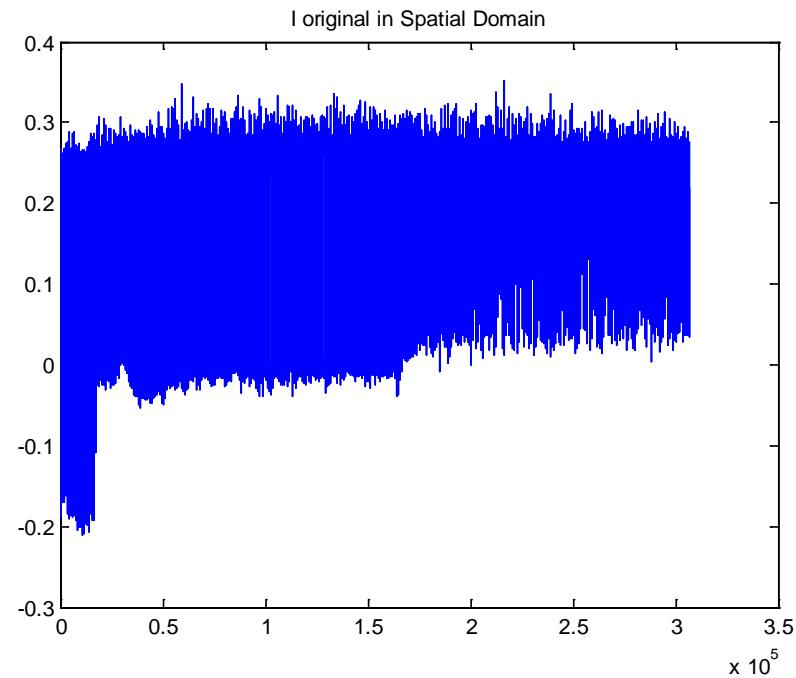
```
% Original Y in spatial domain
figure(14);
plot(reshape(Yoriginal, numrows*numcols, 1));
title('Y original in Spatial Domain');
```



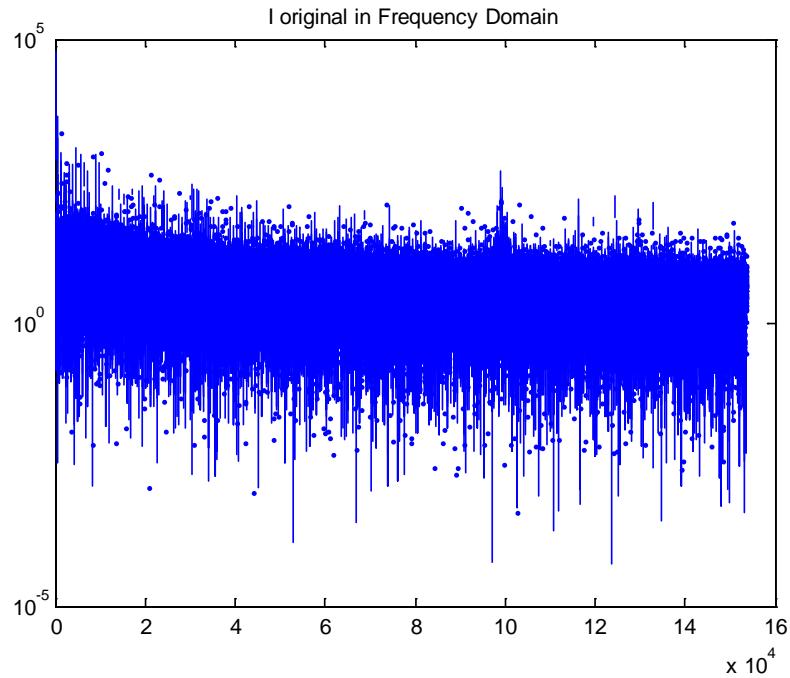
```
% Original Y in frequency domain
figure(15);
YoriginalFrequencyDomain = real(fft(reshape(Yoriginal, numrows*numcols, 1)));
semilogy(YoriginalFrequencyDomain(1:numrows*numcols/2));
title('Y original in Frequency Domain');
```



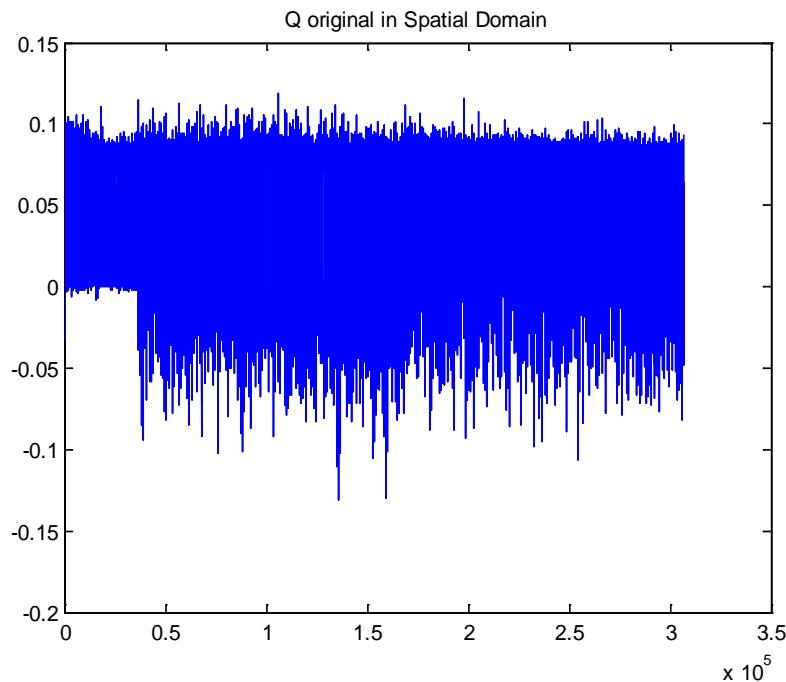
```
% Original I in spatial domain
figure(16);
plot(reshape(Ioriginal, numrows*numcols, 1));
title('I original in Spatial Domain');
```



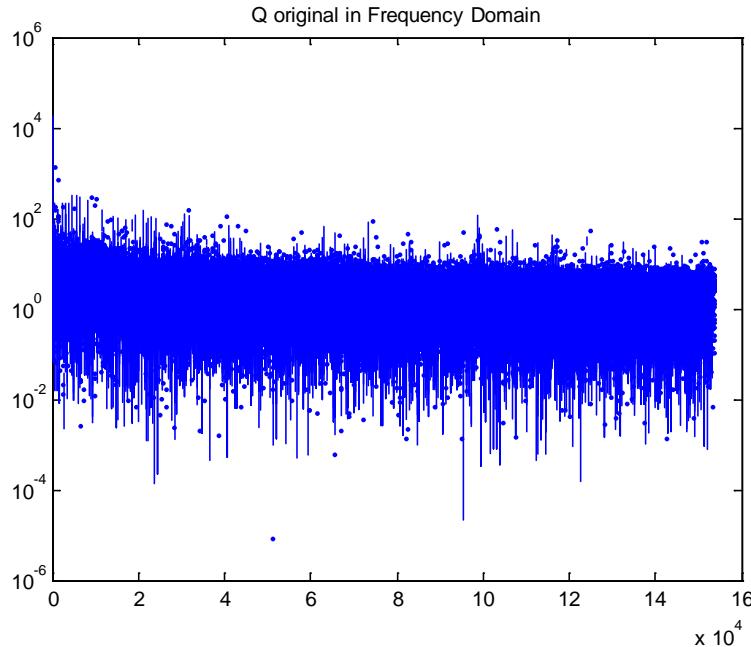
```
% Original I in frequency domain
figure(17);
IoriginalFrequencyDomain = real(fft(reshape(Ioriginal, numrows*numcols, 1)));
semilogy(IoriginalFrequencyDomain(1:numrows*numcols/2));
title('I original in Frequency Domain');
```



```
% Original Q in spatial domain
figure(18);
plot(reshape(Qoriginal, numrows*numcols, 1));
title('Q original in Spatial Domain');
```



```
% Original Q in frequency domain
figure(19);
QoriginalFrequencyDomain = real(fft(reshape(Qoriginal, numrows*numcols, 1)));
semilogy(QoriginalFrequencyDomain(1:numrows*numcols/2));
title('Q original in Frequency Domain');
```

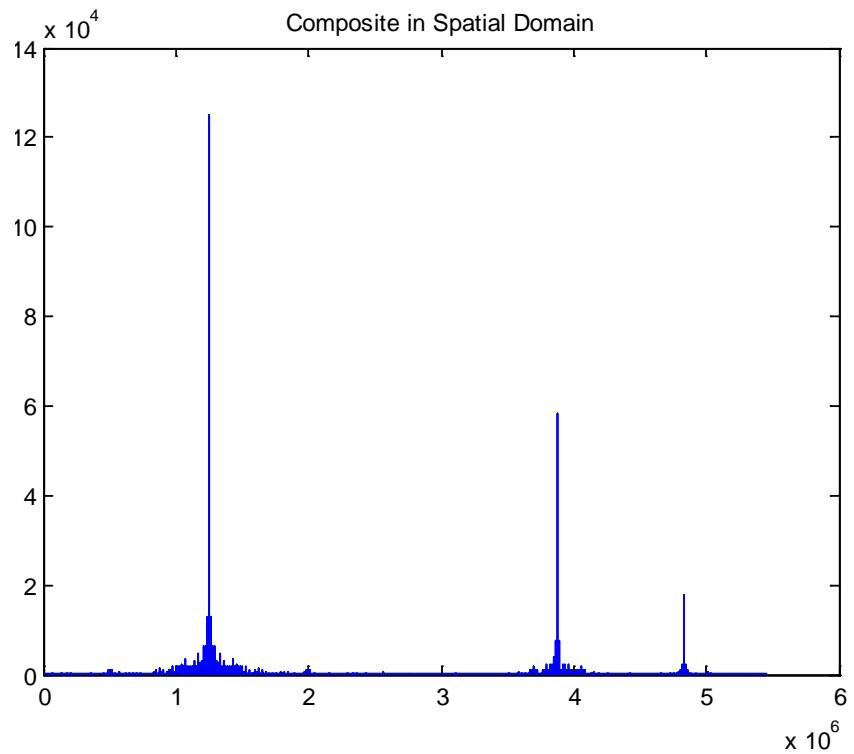


```
% 3. Composite signal (YIQ) %%%%%%%%
```

```
Y1D = reshape(Yoriginal, numrows*numcols, 1); % 1
dimensional Y array
Yfft = fft(Y1D, maxFrequency); % Y fft
Ysignal = circshift(Yfft, YcarrierFrequency); % Y phase
shift to picture carrier
Ysignal(IbeginningFrequency:maxFrequency) = zeros; % Y LPF
I1D = reshape(Ioriginal, numrows*numcols, 1); % 1
dimensional I array
Isignal = circshift(fft(I1D, maxFrequency), IcarrierFrequency); % I fft and
shifted
Isignal(1:IbeginningFrequency-1) = zeros; % I LPF
Q1D = reshape(Qoriginal, numrows*numcols, 1); % 1
dimensional Q array
Qsignal = circshift(fft(Q1D, maxFrequency), QcarrierFrequency); % Q fft and
shifted
Qsignal(1:QbeginningFrequency-1) = zeros; % Q LPF
Y = Ysignal;
IandQ = Isignal+Qsignal;
Chrominance, Multiplex of I and Q
compositeSignal = Y+IandQ; % Composite
Video Signal

% Composite signal in spatial domain
figure(20);
plot(abs(compositeSignal));
```

```
title('Composite in Spatial Domain');
```

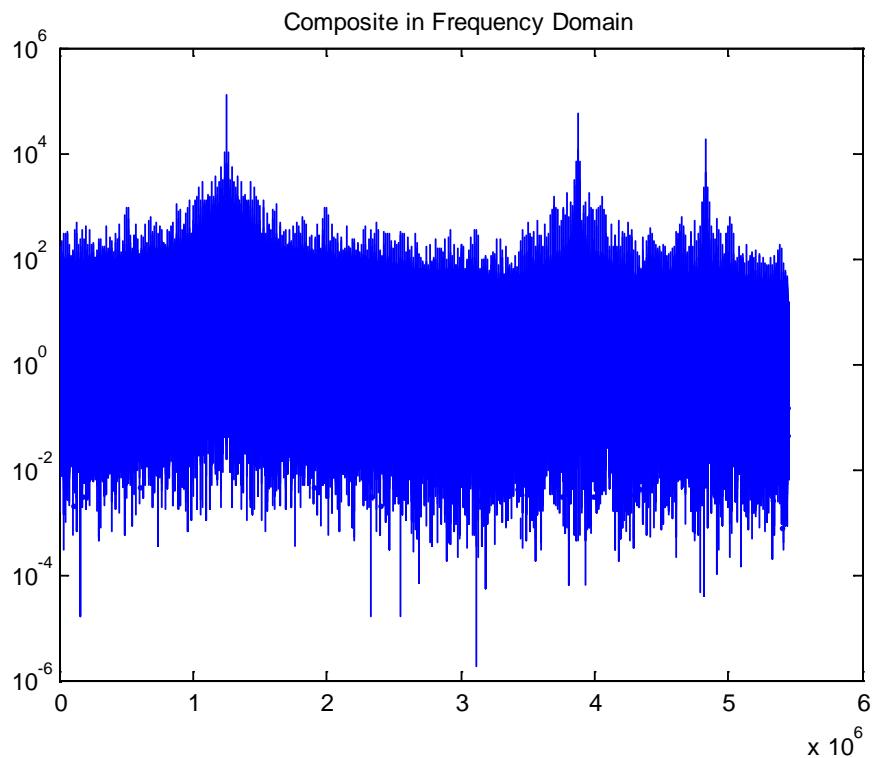


```
% Composite signal in frequency domain
```

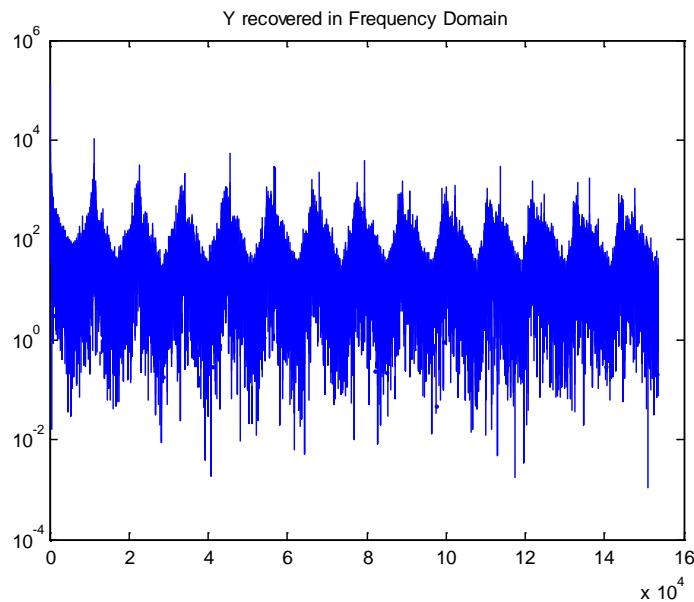
```
figure(21);
```

```
semilogy(real(compositeSignal));
```

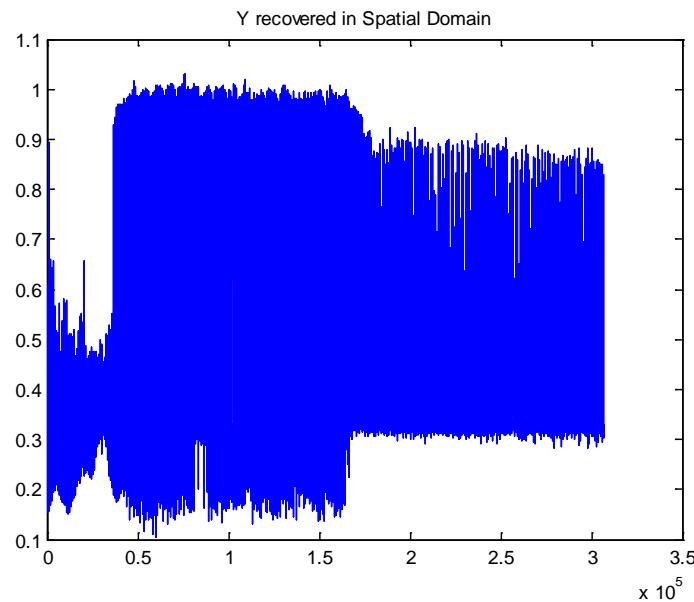
```
title('Composite in Frequency Domain');
```



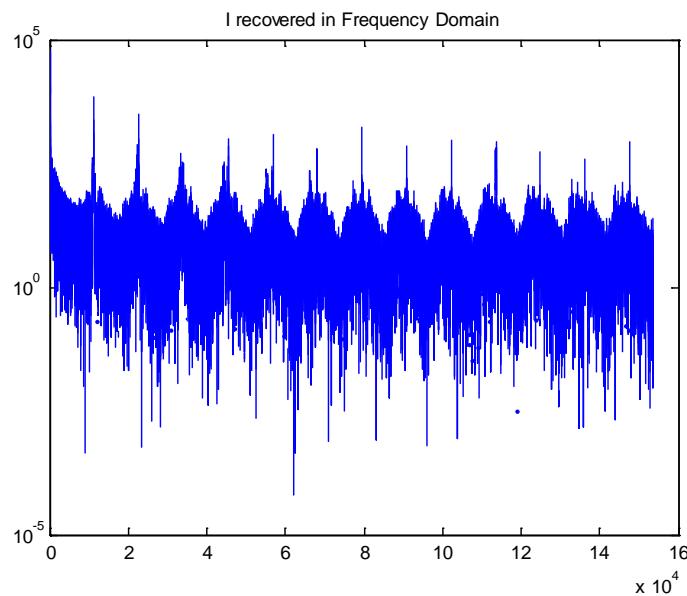
```
% 4. Recovered component signal (YIQ) %%%%%%%%
% Recovered Y in frequency domain
YsignalRecovered =
circshift(padarray(compositeSignal(YbeginningFrequency:IbeginningFrequency-1),
maxFrequency-IbeginningFrequency, 'post'), -YcarrierFrequency);
% extract Y part of the composite and shift it back
figure(22);
semilogy(real(YsignalRecovered(1:numrows*numcols/2)));
title('Y recovered in Frequency Domain');
```



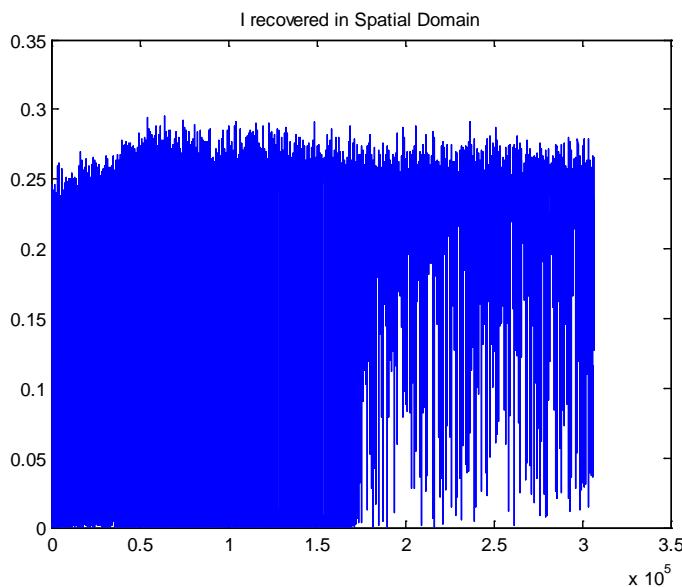
```
% Recovered Y in spatial domain
Y1Drecovered = ifft(YsignalRecovered); % recover Y signal by ifft
Y1Drecovered = Y1Drecovered(1:numrows*numcols);
figure(abs(23));
plot(abs(Y1Drecovered));
title('Y recovered in Spatial Domain');
```



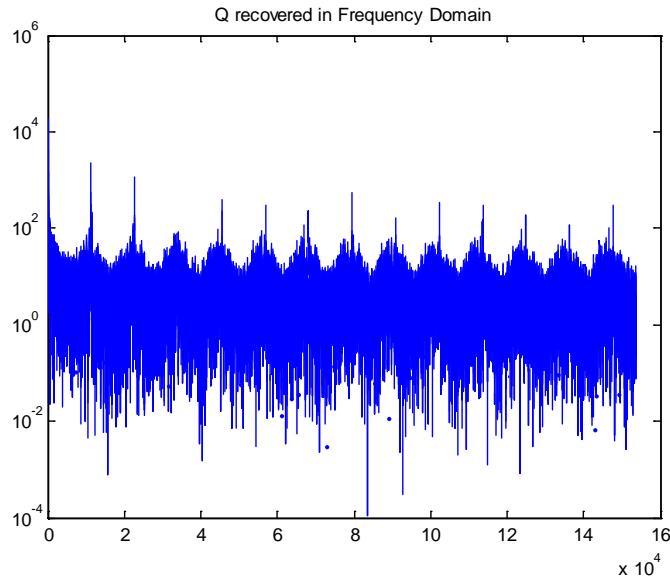
```
% Recovered I in frequency domain
IsignalRecovered =
circshift(padarray(padarray(compositeSignal(IbeginningFrequency:QbeginningFrequency-1), IbeginningFrequency, 'pre'), maxFrequency-QbeginningFrequency, 'post'), -IcarrierFrequency);
% extract I part of the composite, phase shift it back, and shift it back
figure(24);
semilogy(real(IsignalRecovered(1:numrows*numcols/2)));
title('I recovered in Frequency Domain');
```



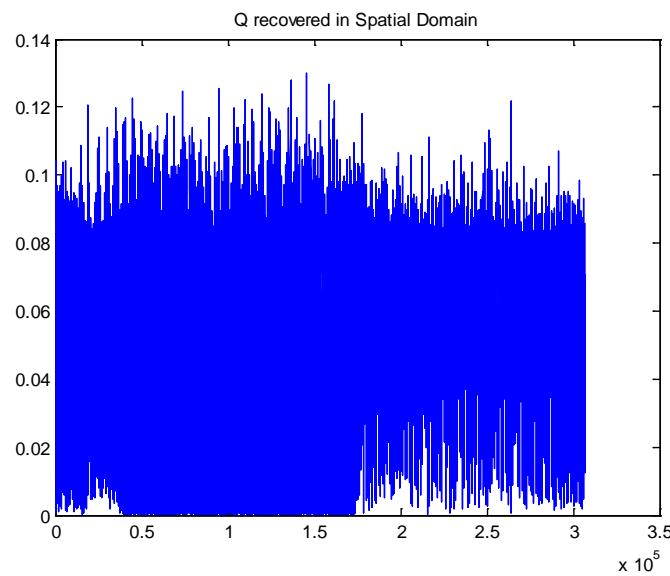
```
% Recovered I in spatial domain
I1DRecovered = ifft(IsignalRecovered); % recover I signal by ifft
I1DRecovered = I1DRecovered(1:numrows*numcols);
figure(25);
plot(abs(I1DRecovered));
title('I recovered in Spatial Domain');
```



```
% Recovered Q in frequency domain
QsignalRecovered =
circshift(padarray(compositeSignal(QbeginningFrequency:maxFrequency),
QbeginningFrequency-1, 'pre'), -QcarrierFrequency);
% extract Q part of the composite, phase shift it back, and shift it back
figure(abs(26));
semilogy(real(QsignalRecovered(1:numrows*numcols/2)));
title('Q recovered in Frequency Domain');
```

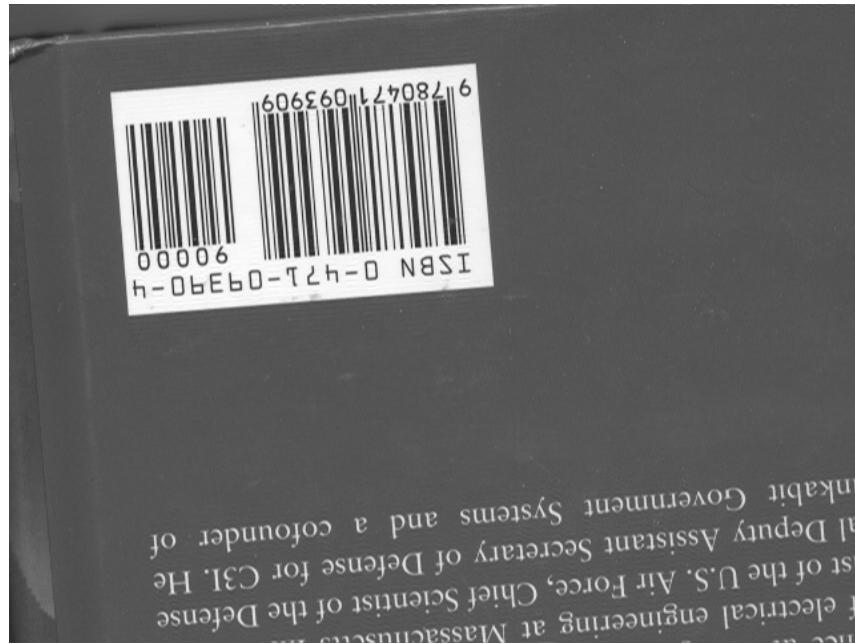


```
% Recovered Q in spatial domain
Q1Drecovered = ifft(QsignalRecovered); % recover Q signal by ifft
Q1Drecovered = Q1Drecovered(1:numrows*numcols);
figure(27);
plot(abs(Q1Drecovered));
title('Q recovered in Spatial Domain');
```



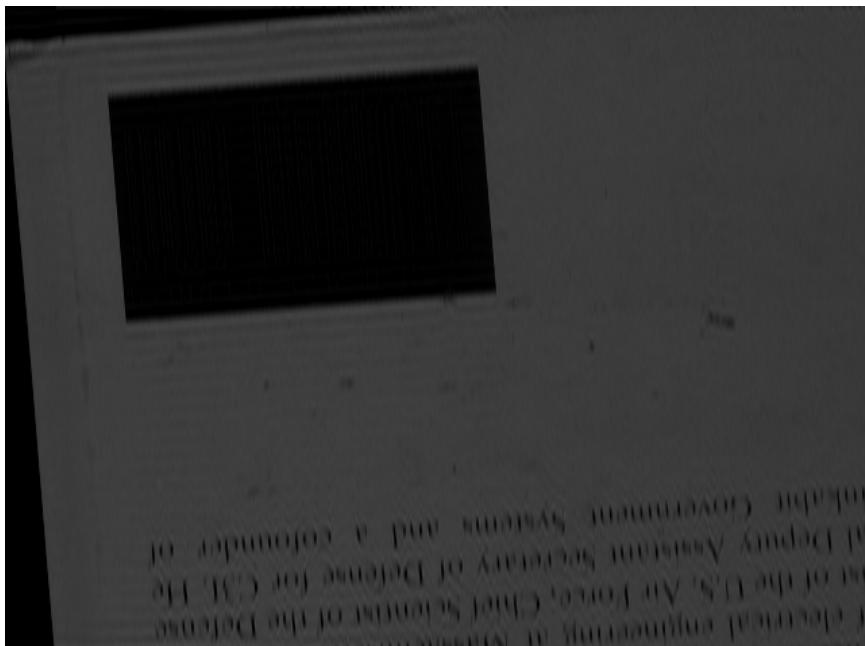
```
% Recovered Y image
Yrecovered = reshape(Y1DRecovered(1:numrows*numcols), numrows, numcols);
figure(28); % reshape Y signal back to 2D
imshow(Yrecovered);
title('Y recovered image');
```

Y recovered image

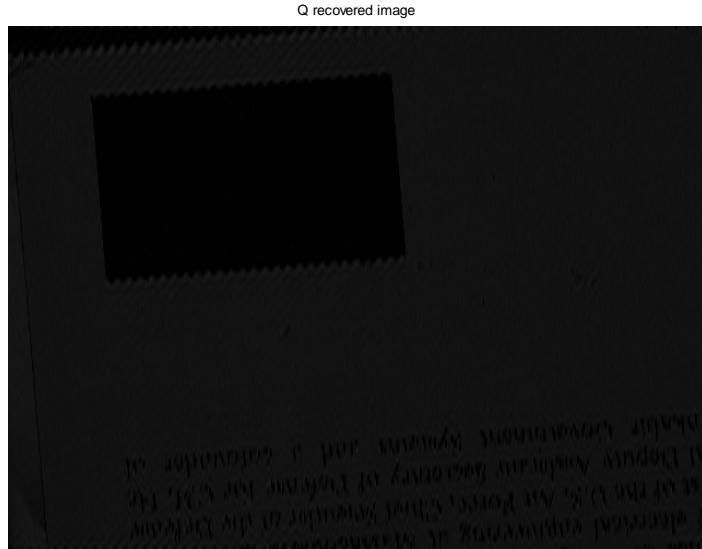


```
% Recovered I image
Irecovered = reshape(I1DRecovered(1:numrows*numcols), numrows, numcols);
figure(29); % reshape I signal back to 2D
imshow(Irecovered);
title('I recovered image');
```

I recovered image

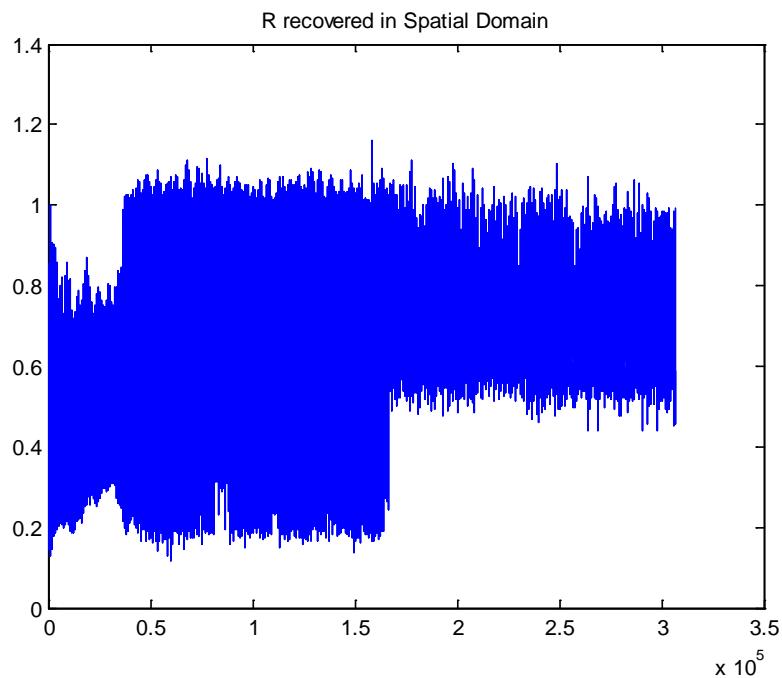


```
% Recovered Q image
QRecovered = reshape(Q1DRecovered(1:numrows*numcols), numrows, numcols);
figure(30);
imshow(QRecovered);
title('Q recovered image');
```

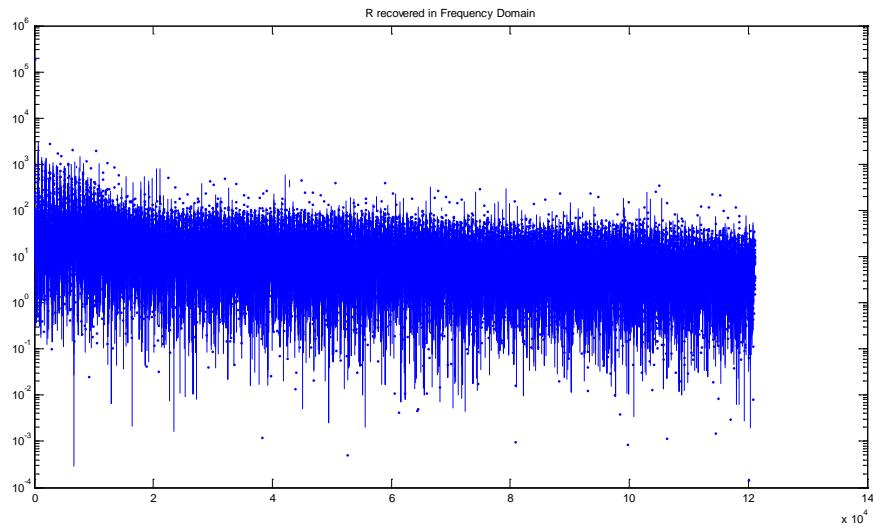


```
% 5. Recovered component signal (RGB) %%%%%%
RRecovered = 1.0*YRecovered + 0.956*IRecovered + 0.620*QRecovered;
GRecovered = 1.0*YRecovered - 0.272*IRecovered - 0.647*QRecovered;
BRecovered = 1.0*YRecovered - 1.108*IRecovered + 1.700*QRecovered;

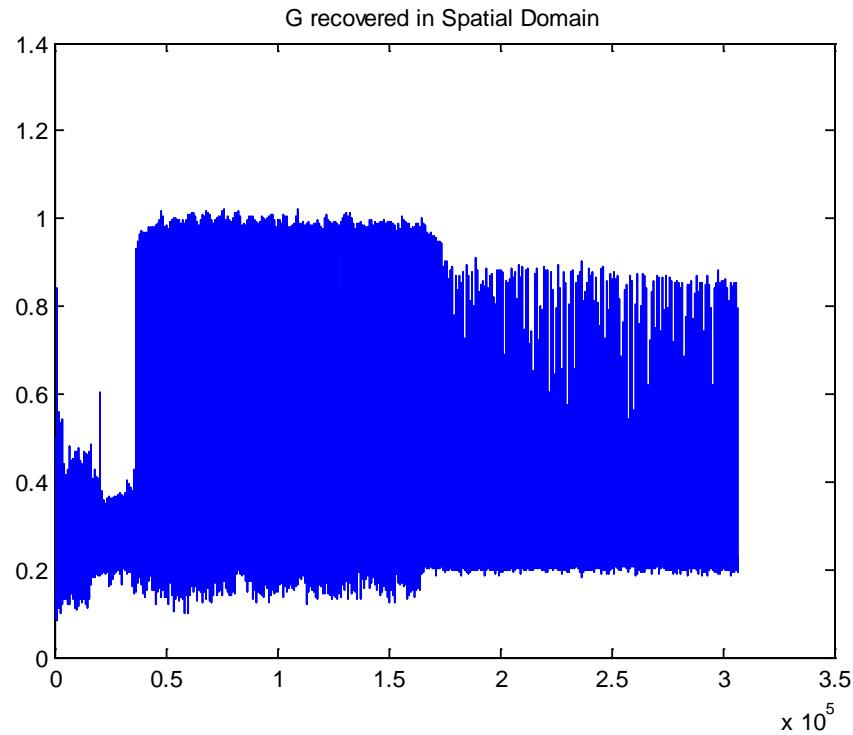
% Recovered R in spatial domain
figure(31);
plot(abs(reshape(RRecovered, numrows*numcols, 1)));
title('R recovered in Spatial Domain');
```



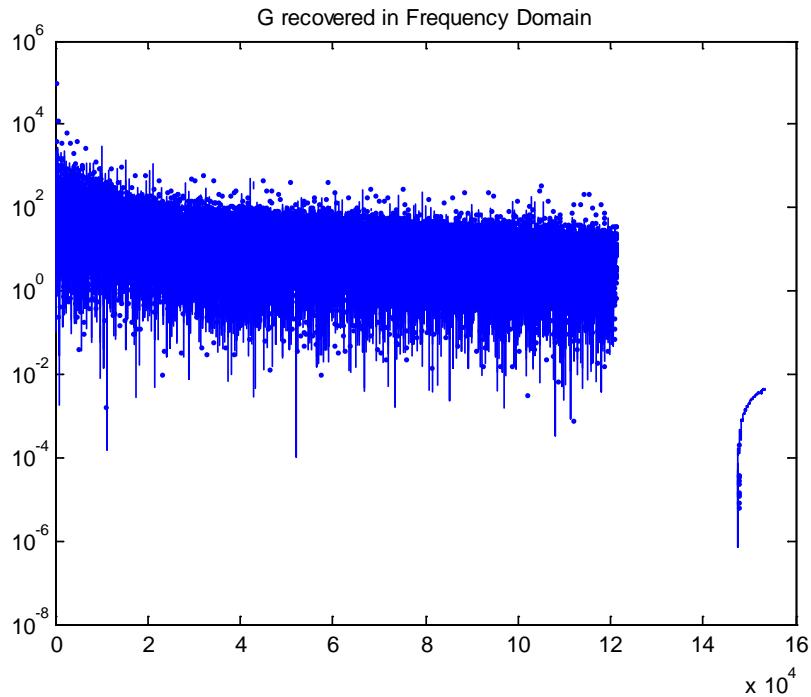
```
% Recovered R in frequency domain
figure(32);
RrecoveredFrequencyDomain = real(fft(reshape(Rrecovered, numrows*numcols, 1)));
semilogy(RrecoveredFrequencyDomain(1:numrows*numcols/2));
title('R recovered in Frequency Domain');
```



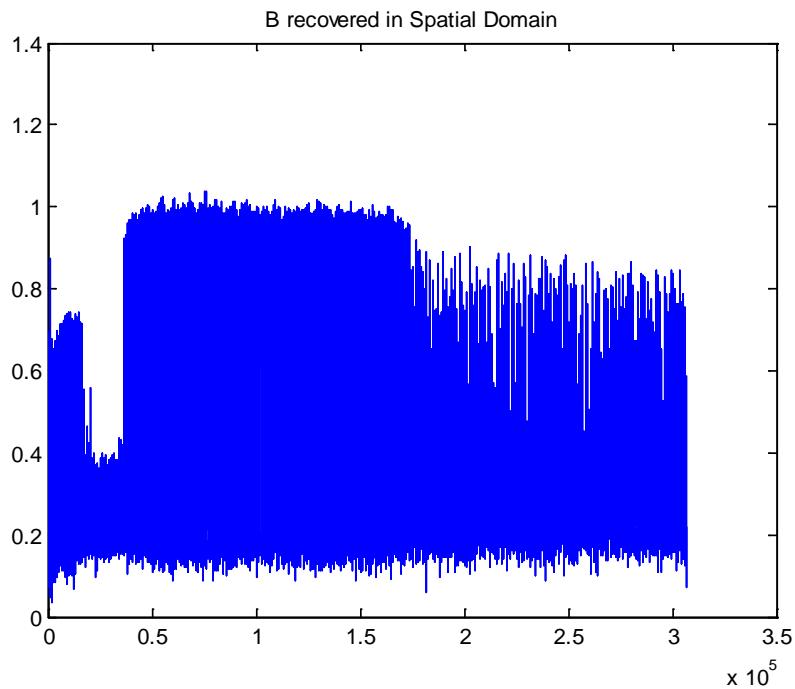
```
% Recovered G in spatial domain
figure(33);
plot(abs(reshape(Grecovered, numrows*numcols, 1)));
title('G recovered in Spatial Domain');
```



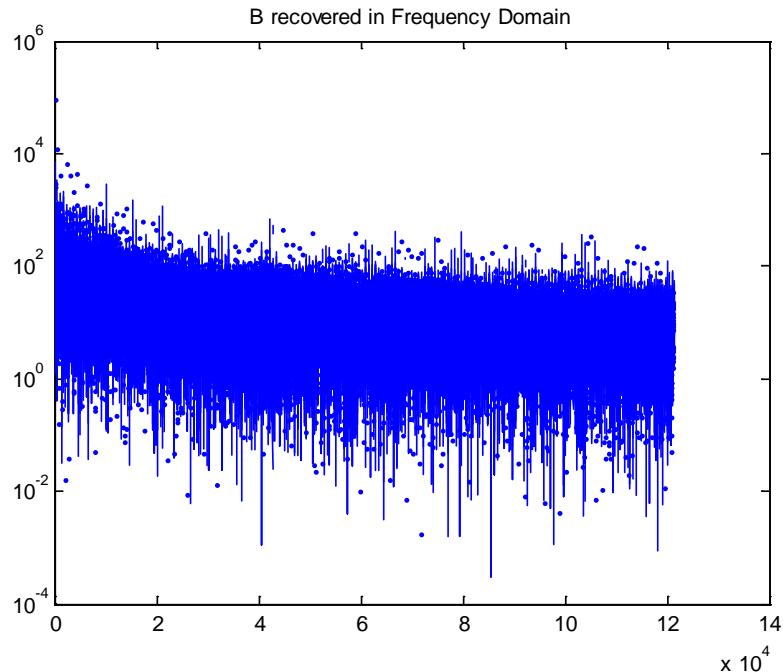
```
% Recovered G in frequency domain
figure(34);
GrecoveredFrequencyDomain = real(fft(reshape(Grecovered, numrows*numcols,
1)));
semilogy(GrecoveredFrequencyDomain(1:numrows*numcols/2));
title('G recovered in Frequency Domain');
```



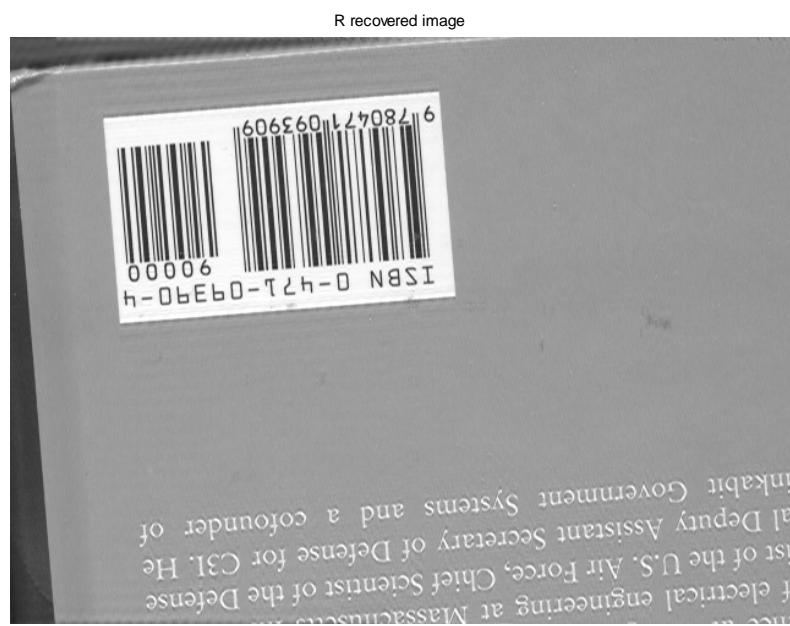
```
% Recovered B in spatial domain
figure(35);
plot(abs(reshape(Brecovered, numrows*numcols, 1)));
title('B recovered in Spatial Domain');
```



```
% Recovered B in frequency domain
figure(36);
BRecoveredFrequencyDomain = real(fft(reshape(Brecovered, numrows*numcols,
1)));
semilogy(BRecoveredFrequencyDomain(1:numrows*numcols/2));
title('B recovered in Frequency Domain');
```

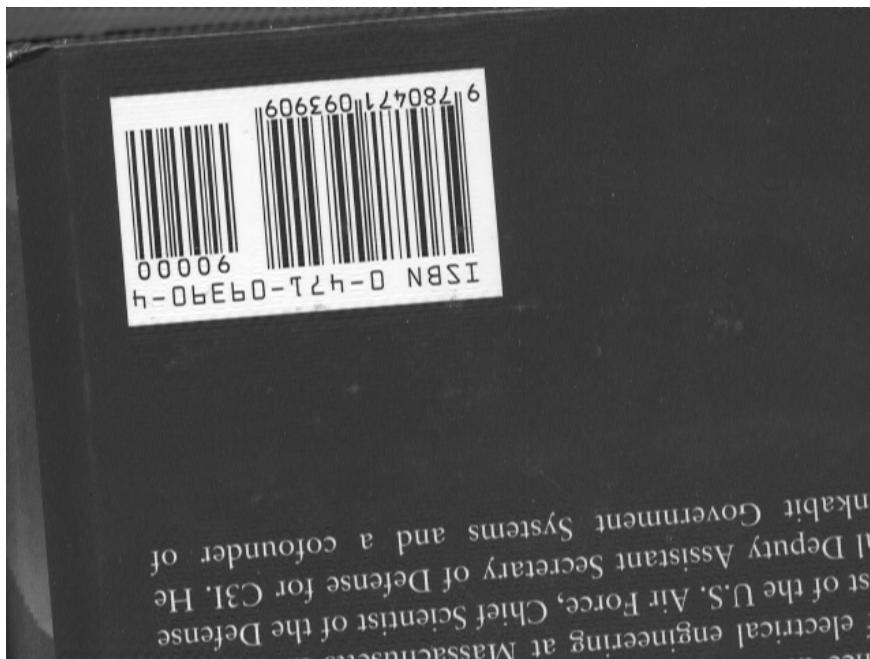


```
% Recovered R image
figure(37);
imshow(Rrecovered);
title('R recovered image');
```



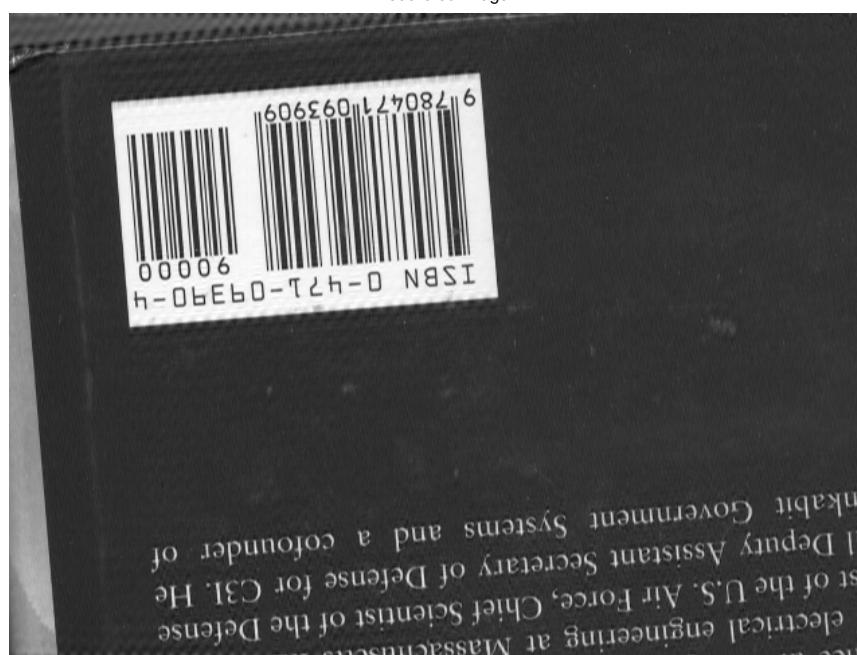
```
% Recovered G image
figure(38);
imshow(Grecovered);
title('G recovered image');
```

G recovered image

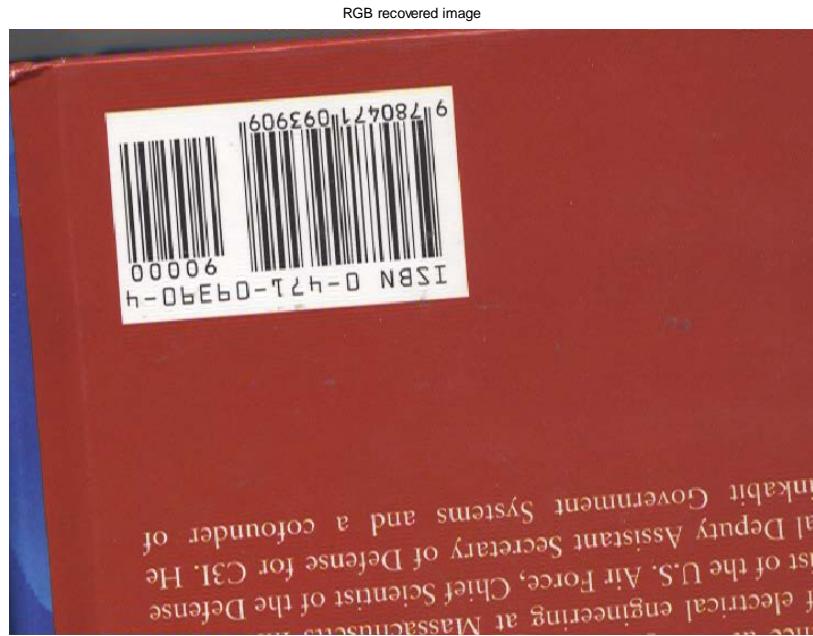


```
% Recovered B image
figure(39);
imshow(Brecovered);
title('B recovered image');
```

B recovered image

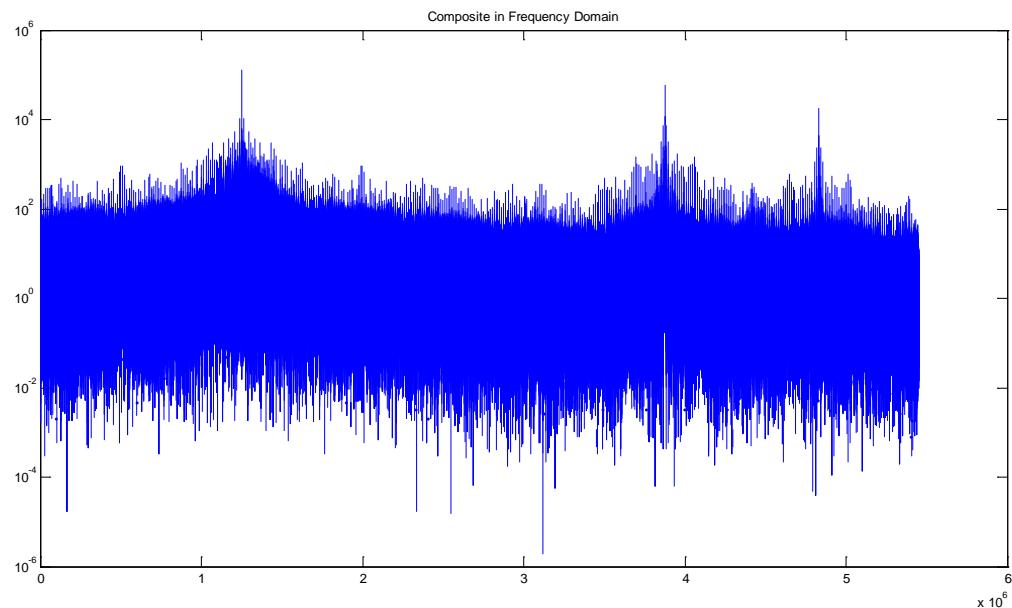


```
% Recovered RGB image
RGBImageRecovered = zeros(numrows, numcols, 3);
RGBImageRecovered(:, :, 1) = Rrecovered;
RGBImageRecovered(:, :, 2) = Grecovered;
RGBImageRecovered(:, :, 3) = Brecovered;
figure(40)
imshow(RGBImageRecovered);
title('RGB recovered image');
```

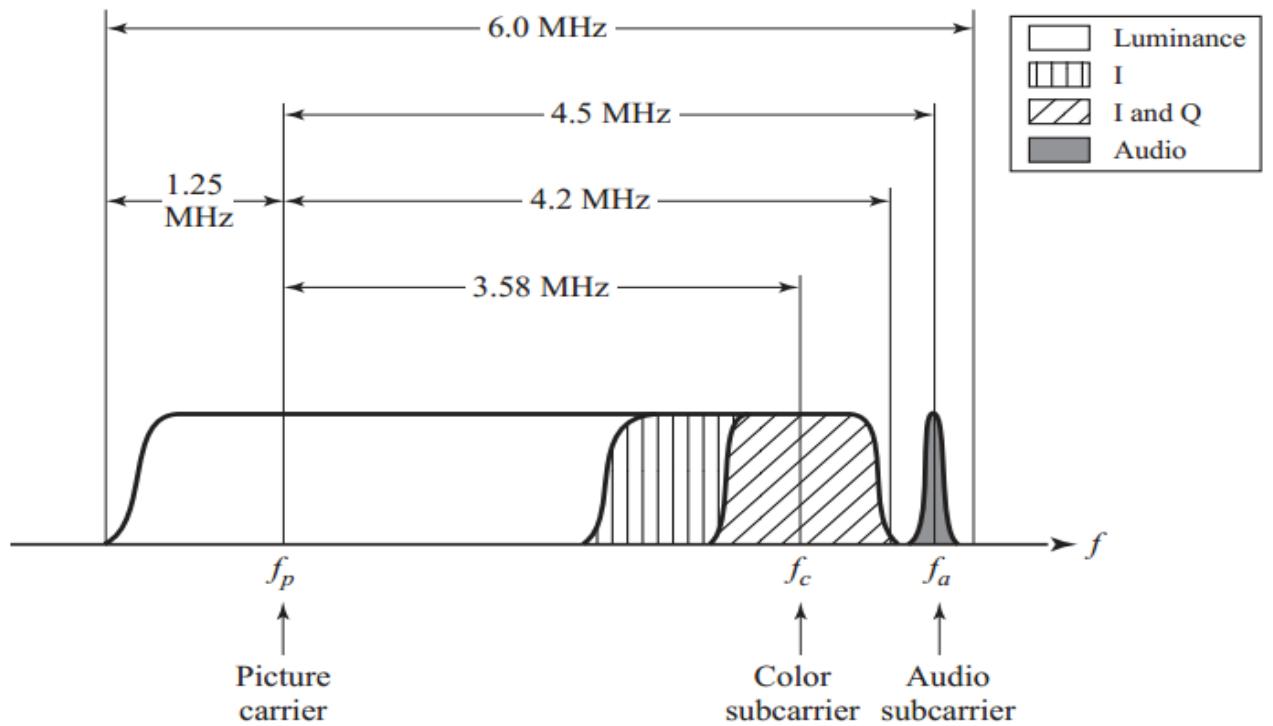


Results (Side-by-Side Comparisons)

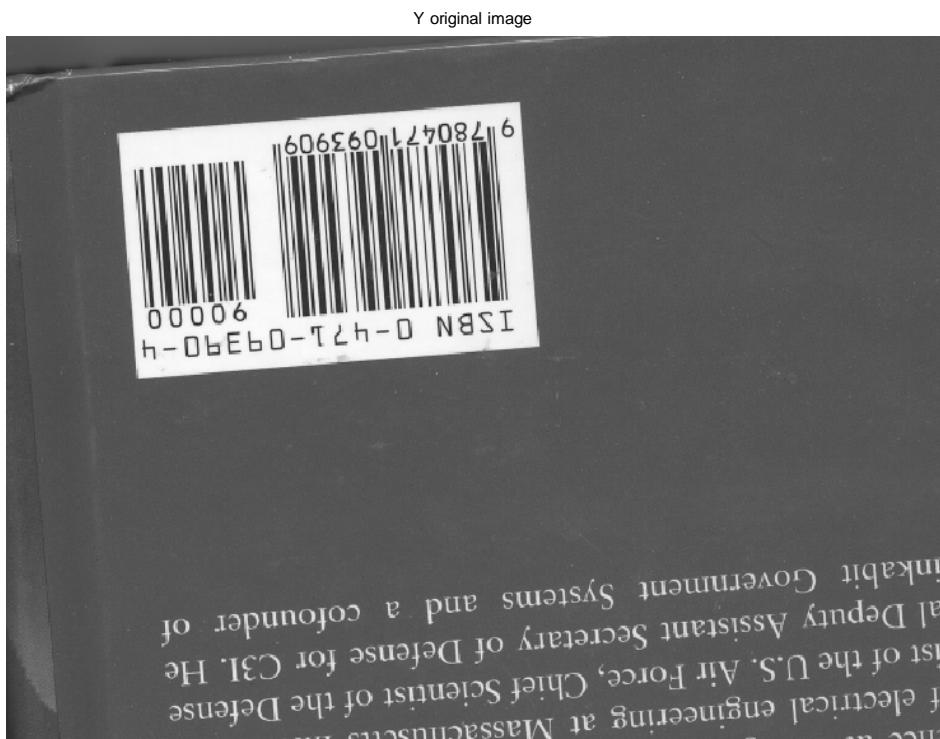
Comparison 1a: Actual Composite (Figure 21)



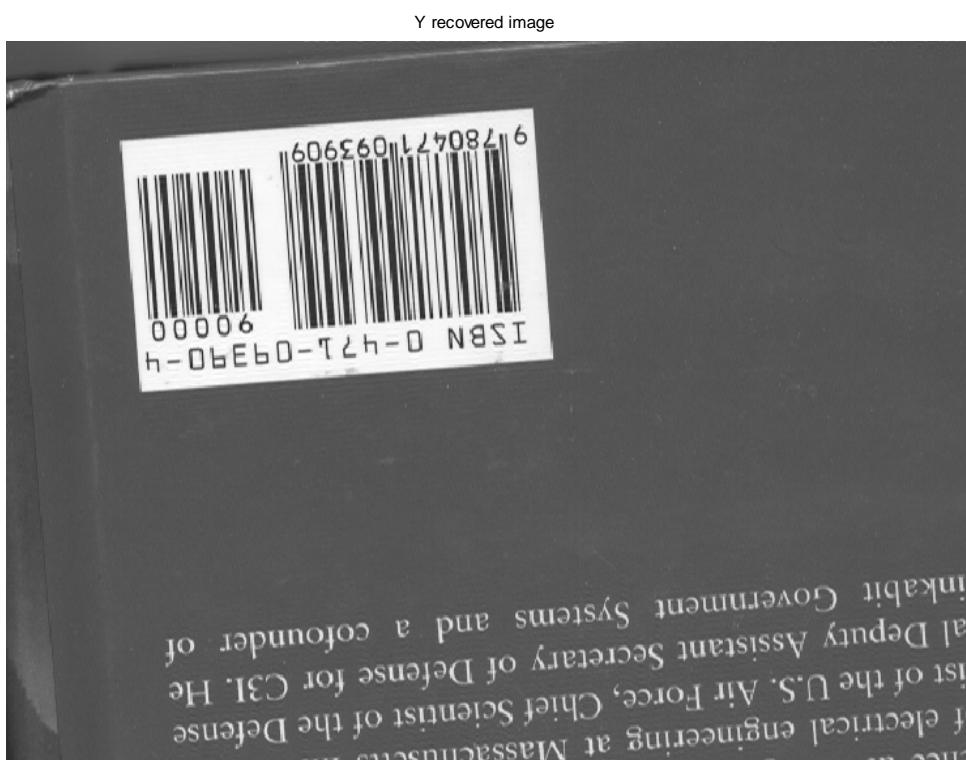
Comparison 1b: Theoretical Composite



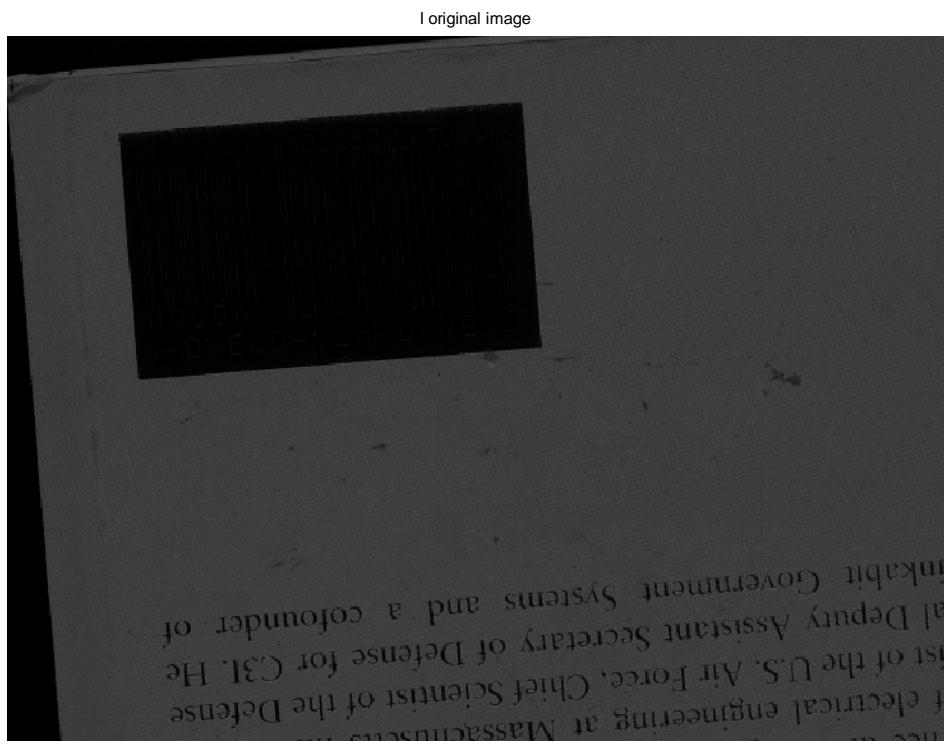
Comparison 2a: Original Y (Figure 11)



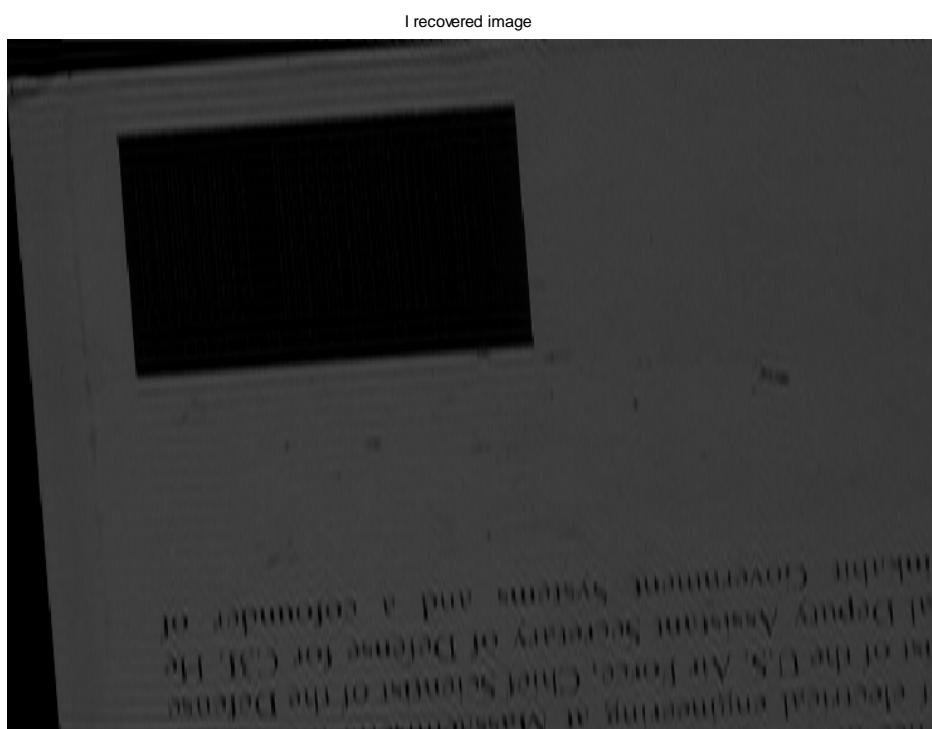
Comparison 2b: Recovered Y (Figure 28)



Comparison 3a: Original I (Figure 12)

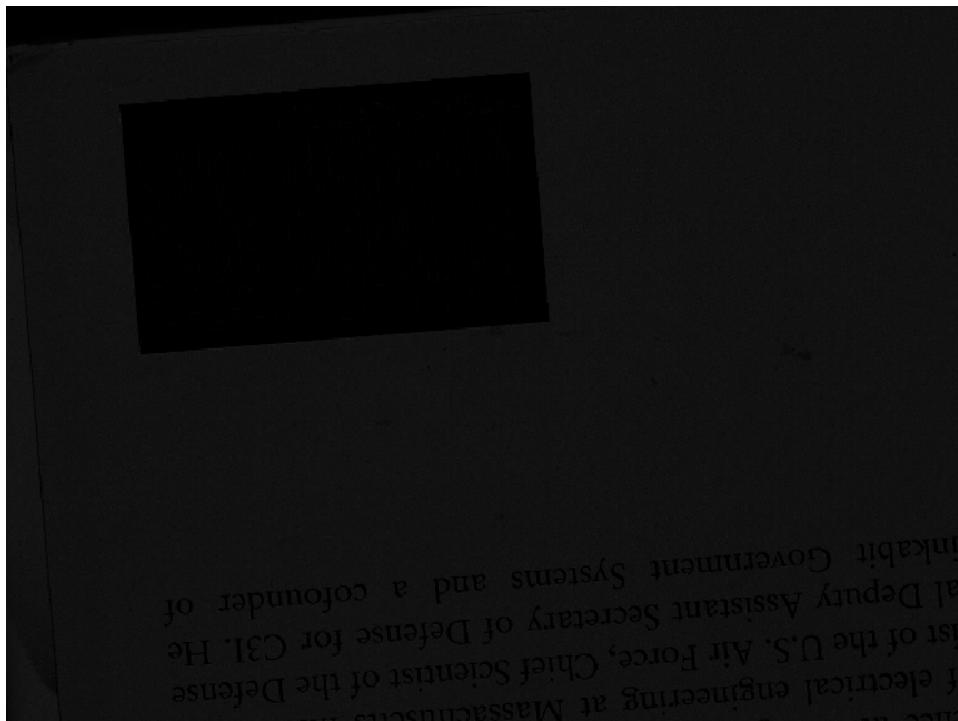


Comparison 3b: Recovered I (Figure 29)



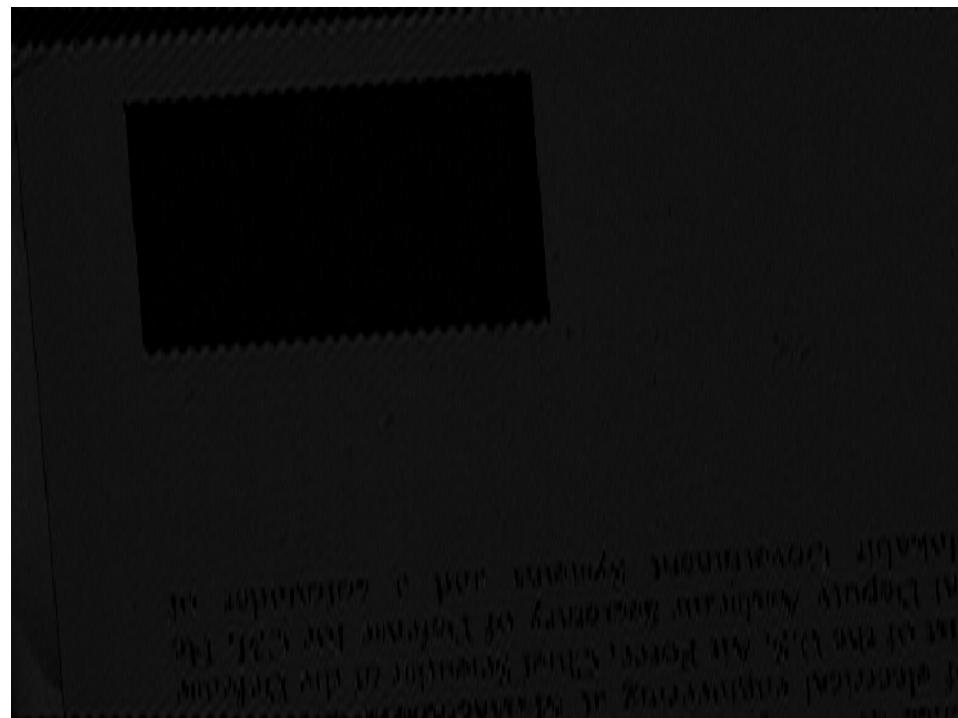
Comparison 4a: Original Q (Figure 13)

Q original image

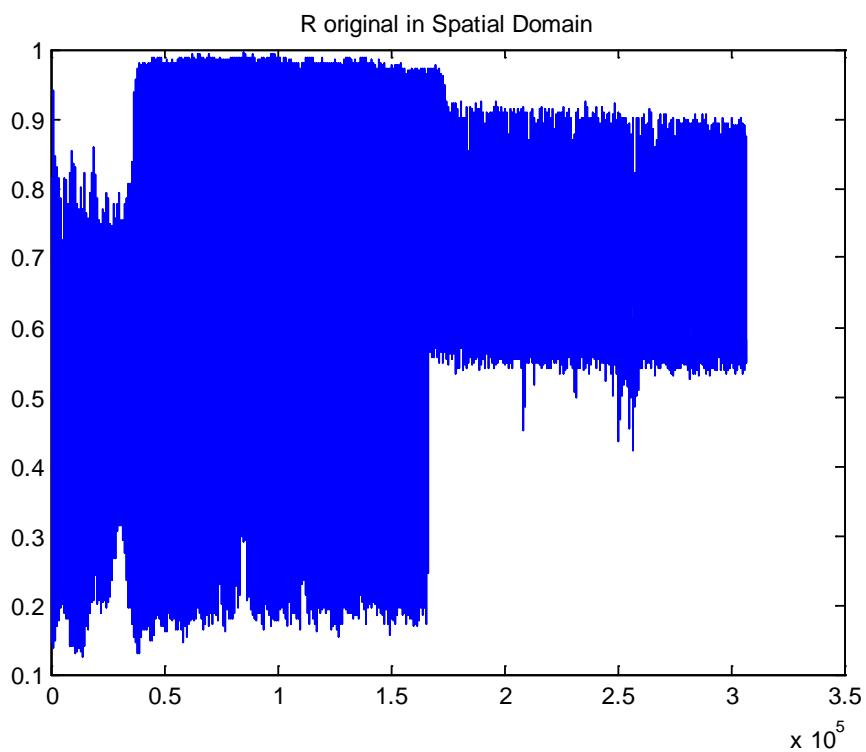


Comparison 4b: Recovered Q (Figure 30)

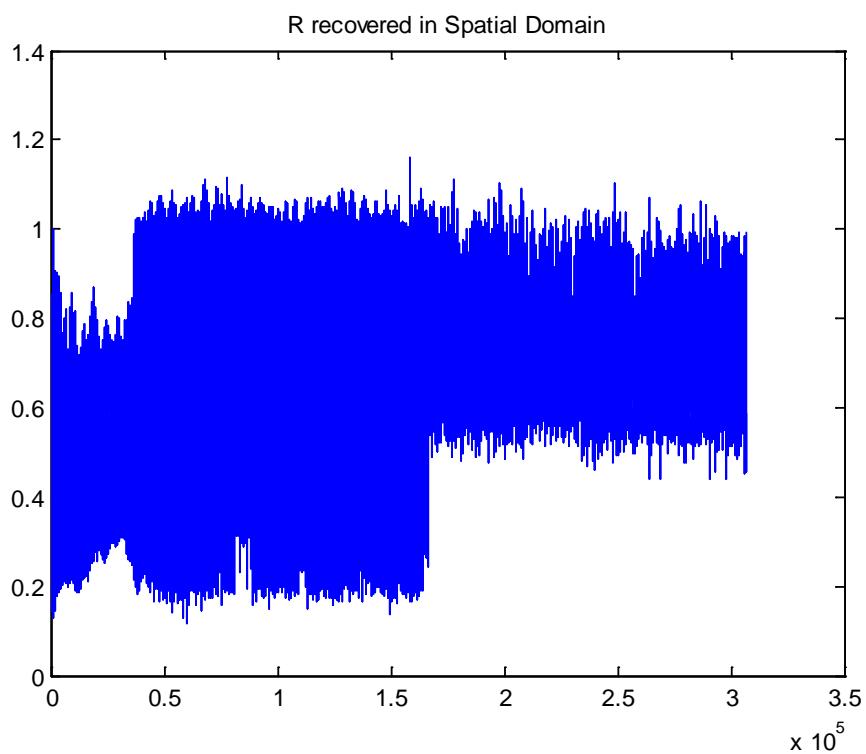
Q recovered image



Comparison 5a: Original R in Spatial Domain (Figure 5)

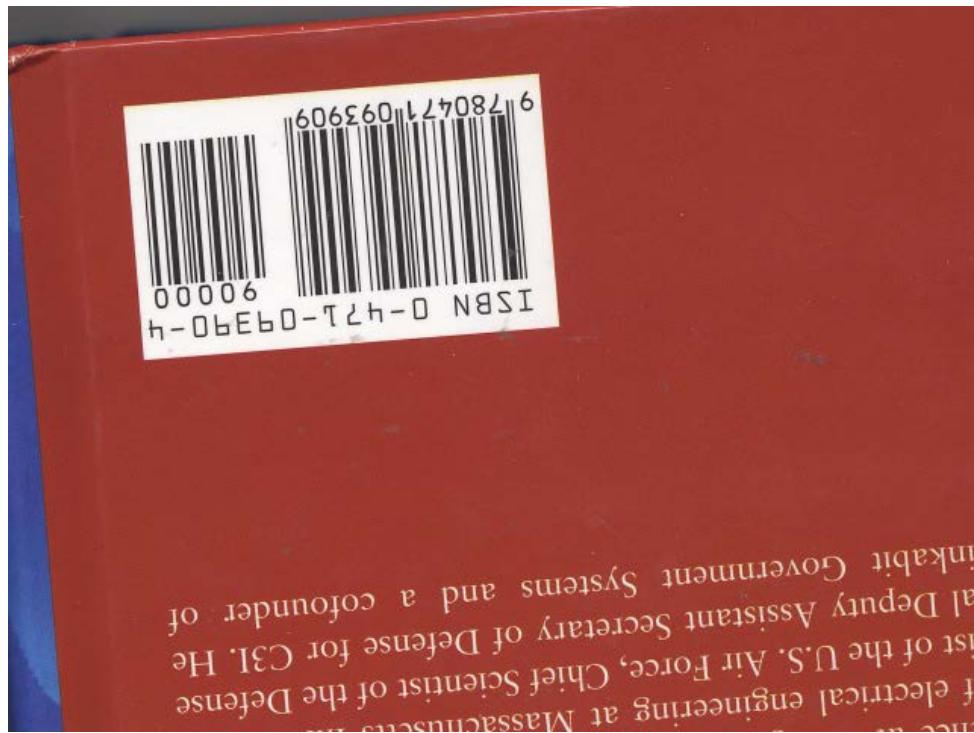


Comparison 5b: Recovered R in Spatial Domain (Figure 31)



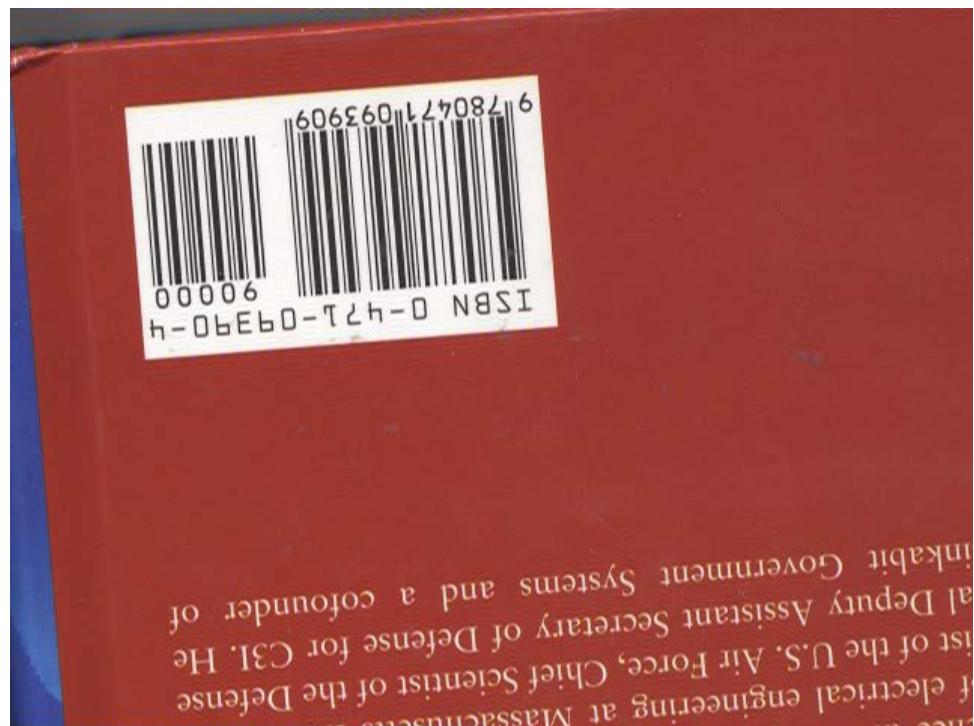
Comparison 6a: Original Image (Figure 1)

RGB original image

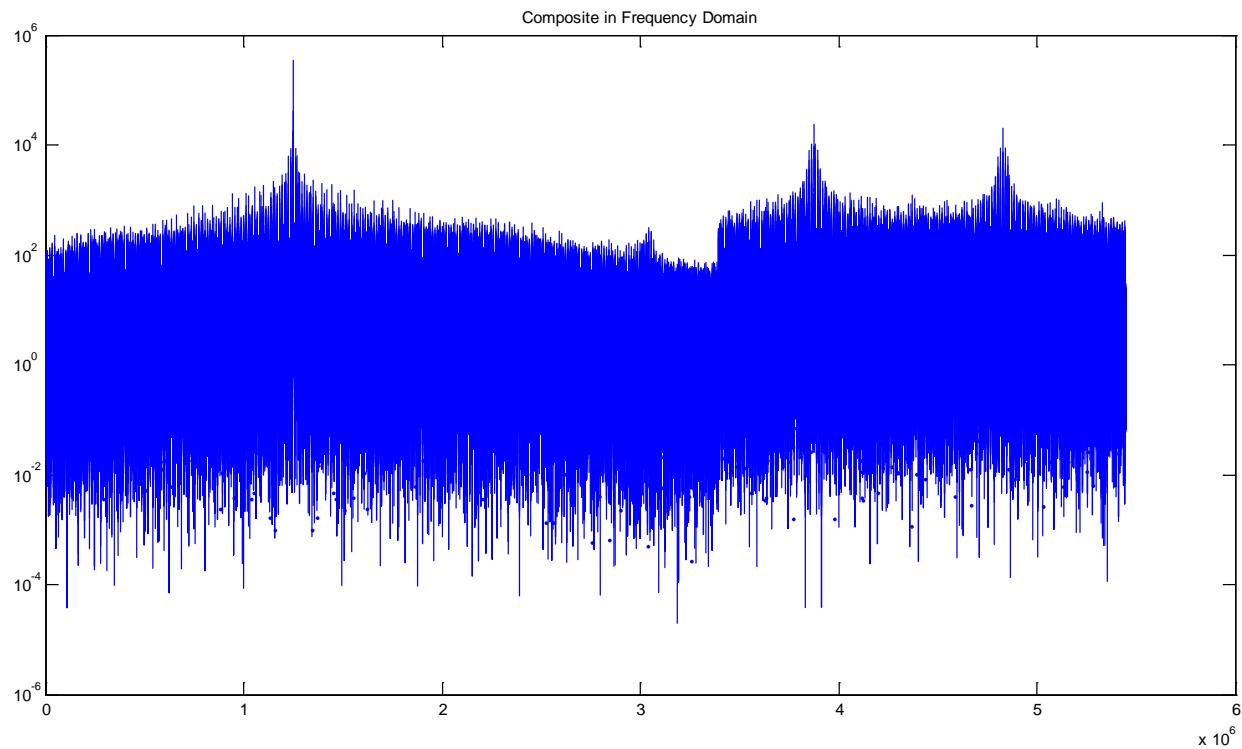


Comparison 6b: Recovered Image (Figure 40)

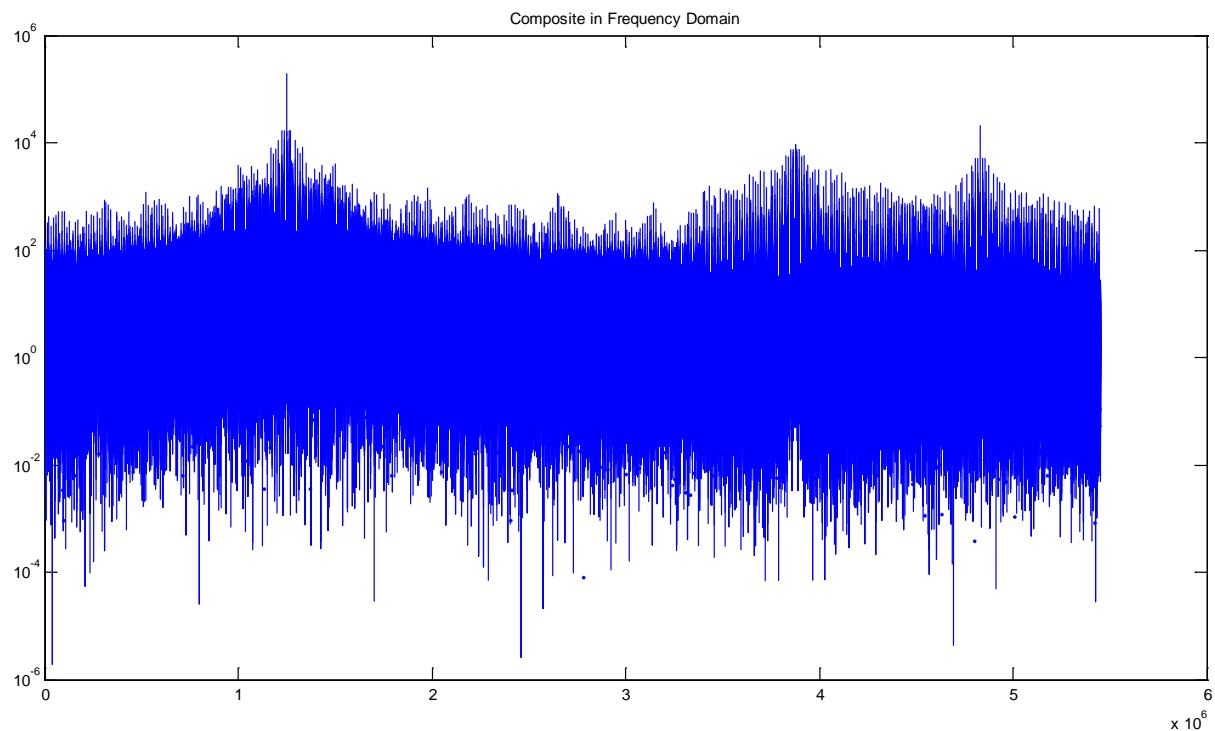
RGB recovered image



Comparison 7a: Composite of Previous Frame



Comparison 7b: Composite of Next Frame



Summary and Conclusion

Video signals were broken into multiple frames and multiple bands (RGB). Using a single frame, the RGB bands can be converted to YIQ bands with a rotation on the color circle. YIQ is preferred over RGB for transmission because the image will still look fine if I and Q is band limited. Then different low pass filters were applied to the individual Fourier transforms of the YIQ signals. Y forms the luminance signal while the multiplex of I and a phase shift of Q forms the chrominance signal. The chrominance can be band limited because it is only color. Luminance and chrominance can be added together to form the composite signal. The composite signal can be transmitted as a single signal for video. The composite signal can also extract the YIQ signal, which can be inverse Fourier transforms to get back the YIQ signal. Then the YIQ signal can be converted back to RGB as a source of a video signal for televisions.

The composite signal frequencies can match the expected frequencies (comparison 1). The Y component is transmitted without much change (comparison 2). There is some deterioration from transmitting the I component (comparison 3) and even more deterioration from transmitting the Q component (comparison 4). However, since I and Q only serve as chrominance, their deterioration does not really affect the recovered RGB spatial domain (comparison 5) nor image (comparison 6). An entire video can be transferred by transmitting a frame at a time through the frequency channels (comparison 7).