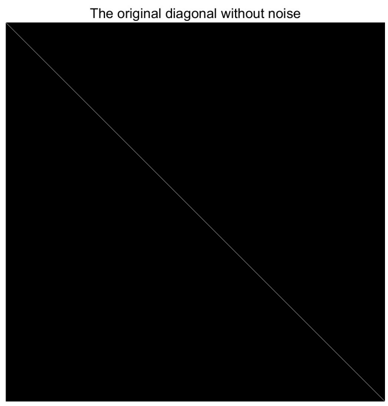
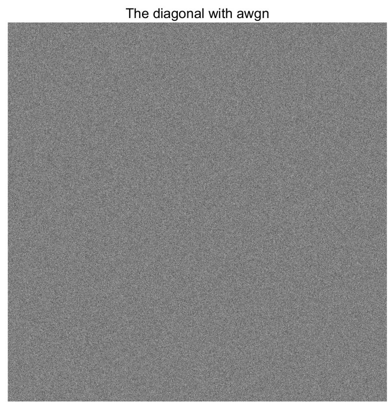
Problem analysis:

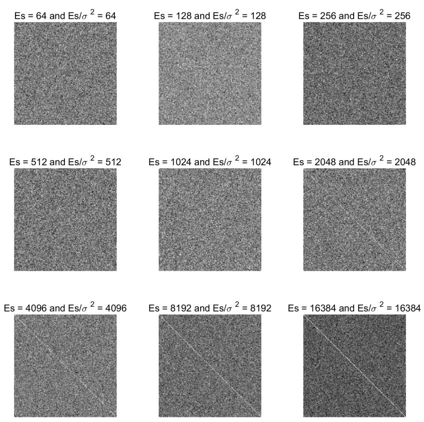
For this problem, several points require scrutiny.

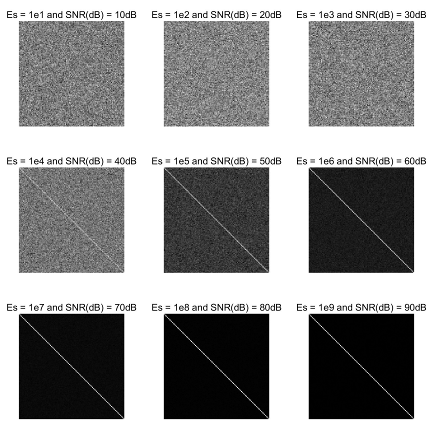
- Total signal energy should be distributed to equal packs on each pixel.
- Gaussian white noise can be generated simply with the function “normrnd”.
- In order to find the adequate Es for the line, we need to change Es with reasonable ratio. We can simply make a wild guess that only when the signal power on each pixel is of the same order comparing to the noise power that the line is visible. According to this prediction, we can make adequate change to Es in problem d.
- Grayscale unifying. To draw the picture, we need to figure out some ways to unify the value of both Es and power of noise into grayscale. Fortunately, MATLAB have in-built functions and parameters which can solve this problem properly.
- Plotting and add notes to the figures.

Graphs 1-4:









From my own perspective, when SNR reach 30dB, I can “just see” the signal diagonal. As the SNR goes bigger, the line become clearer and I can see it with confidence.

MATLAB source code (which can also be found in .m file):

```
clear;clc;close all;
%% a image generation
image1 = diag(ones(1,1024));
Es = 4;
scale1 = sqrt(Es/1024);
image1 = image1.*scale1;
figure(1);
imshow(image1,[]); %colormap(gray);
disp(['The total signal energy of the image1 is ' num2str(sum(image1(:).^2))]) %expected to
be 4
title('The original diagonal without noise')
% imagesave1 = getframe(gcf);
% imwrite(imagesave1,'imagesave1.bmp')

%% b noise add
sigma = 1; % so sigma^2 also = 1;
noise_gaussian1 = normrnd(0,sigma^2,1024,1024); % miu = 0; sigma^2 = 1;
image2 = image1 + noise_gaussian1;
figure(2);
imshow(image2,[]); % [] means auto scale to [low high];colormap(gray);
title('The diagonal with awgn')

% obviously cannot see anything but noise on the figure. i bet the Es is
% too small therefore the line is too dim.

%% c adjust the Es

% I've no idea about what is a subroutine, and I cannot get the point with
% "runs"... I'll just do it like what I think about the description

image1 = diag(ones(1,1024)); % re-definition of image1

% I plotted the figure by 1/64 of it original size to see the diagonal more
% clearly.

for i = 1:1:9
    Es = 2^(i+5); %add 5 just to make 1024 as the central subfigure.
    noise_gaussian2 = normrnd(0,1,1024,1024);
    scale2 = sqrt(Es/1024);
```

```matlab
    image(:,:,i) = image1.*scale2 + noise_gaussian2;
end

figure(3);
for j = 1:9
    subplot(3,3,j)
    imshow(image(1:128,1:128,j),[]);axis square off; box off;
    title(['Es = ' num2str(2^(j+5)) ' and Es/\sigma ^2 = ' num2str(2^(j+5)/sigma^2)])
end

% at least for me, the SNR need to reach the level of 30dB so that I can
% distinguish the white line. I'm not so sure about the result since it is
% a little bit different from what I have learnt.

% I would like to use the dB representation of SNR to take a try.

for i = 1:1:9 %sqrt will be rational
    Es = 10^i;
    noise_gaussian3 = normrnd(0,1,1024,1024);
    scale3 = sqrt(Es/1024);
    image(:,:,i) = image1.*scale3 + noise_gaussian3;
end
figure(4)
for j = 1:9
    subplot(3,3,j)
    imshow(image(1:128,1:128,j),[]);axis square off; box off;
    title(['Es = 1e' num2str((j)) ' and SNR(dB) = ' num2str(10*log10(10^(j)/sigma^2)) 'dB'])
end
```