MEDT4165: Exercise 8
09.03.20

note: When I say in K-space, I mean the PSF in the K-space.

Part 1

(i) By reducing the bandwidth we increase the pulse length. If we reduce the bandwidth, then we reduce the frequency components in the K-space. And when we have less frequency components and take the inverse Fourier and get to the spatial dimension, we get a larger point in the radial direction and the point is more smeared out. The point spread function gets worse or smeared out.

(ii) When we increase the bandwidth, we decrease the pulse length. In this case we get more frequency components in K-space, which in spatial dimension gives more compressed/smaller point spread function in radial direction (depth).

Part 2

(i) By reducing the center frequency, we reduce the frequency components in the K-space. We reduce the axial and radial components in the K-space. So when we take the inverse Fourier of the k-space we get more wider point spread function, this is because the we get wider lobe of the sinc function in the spatial dimension, due to smaller width in K-space of the beam.

(ii) (ii) By increasing the center frequency, we increase the frequency component. Since we have the same angle for the beam pattern, and move further down the radial direction, we get a larger width (more frequency components) in the radial direction. This give narrower point spread function in the spatial domain. This also increases the pulse frequency response

Part 3

(i) By reducing the F-number the frequency response increases, gets wider. Recalling that the F#=F/D. And since the focus point is constant, we only vary the aperture. By reducing the F-number, we increase the aperture. Meaning that we use more elements to image the object. We thus get a narrower beam, which yields a larger width in the K-space in the lateral direction. Which in spatial domain yields a smaller/compressed point in the lateral direction. We can also see this concept from another point of view: The point spread function is the aperture frequency response * pulse frequency response.

(ii) The opposite happens when we increase the F-number, the frequency response gets smaller, narrow in the lateral dir. But the pulse frequency response is constant. In this case we use less elements on the transducer, which gives a wider lobe at the focus, which smears out the object in the spatial domain.

Part 4

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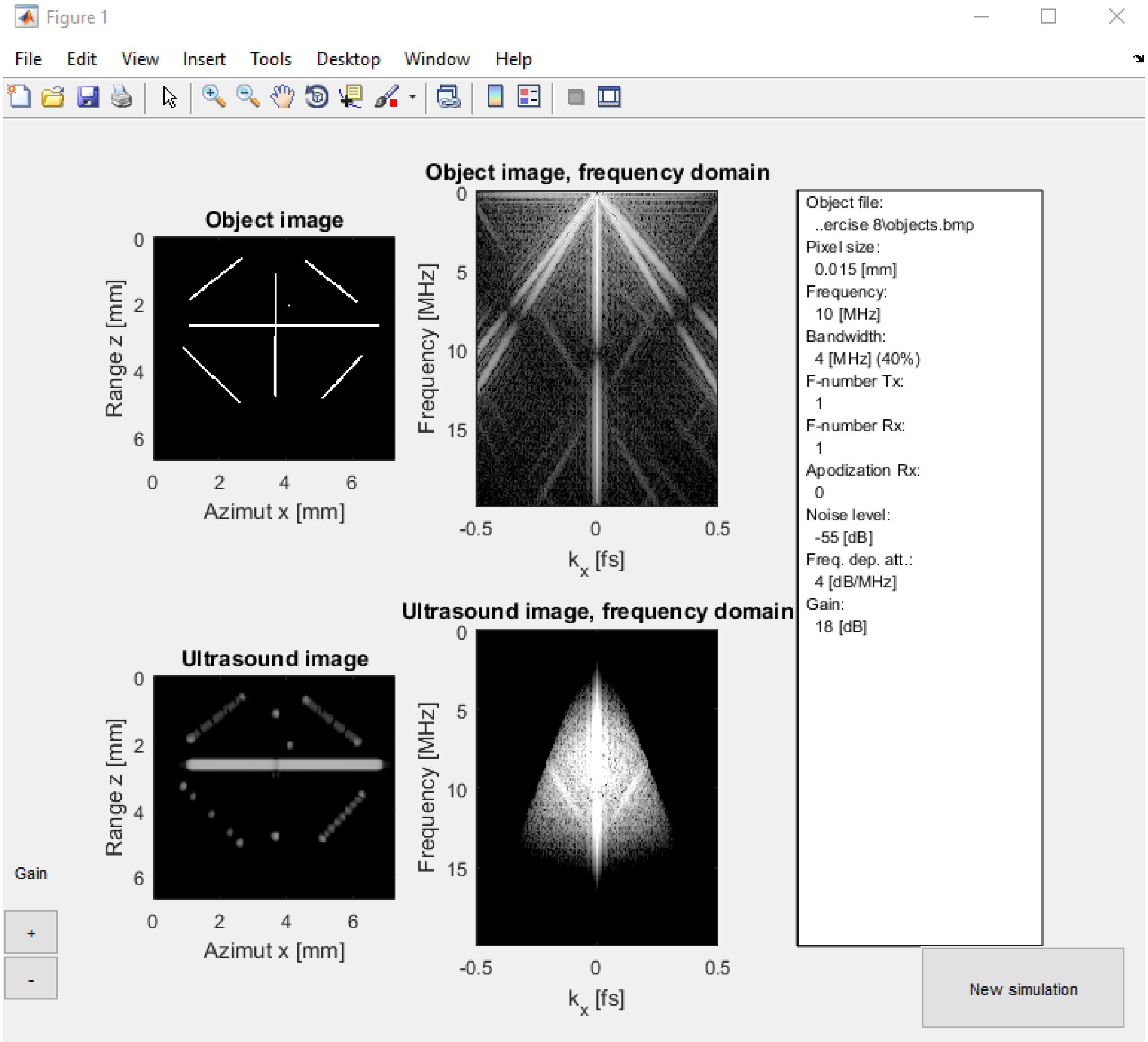

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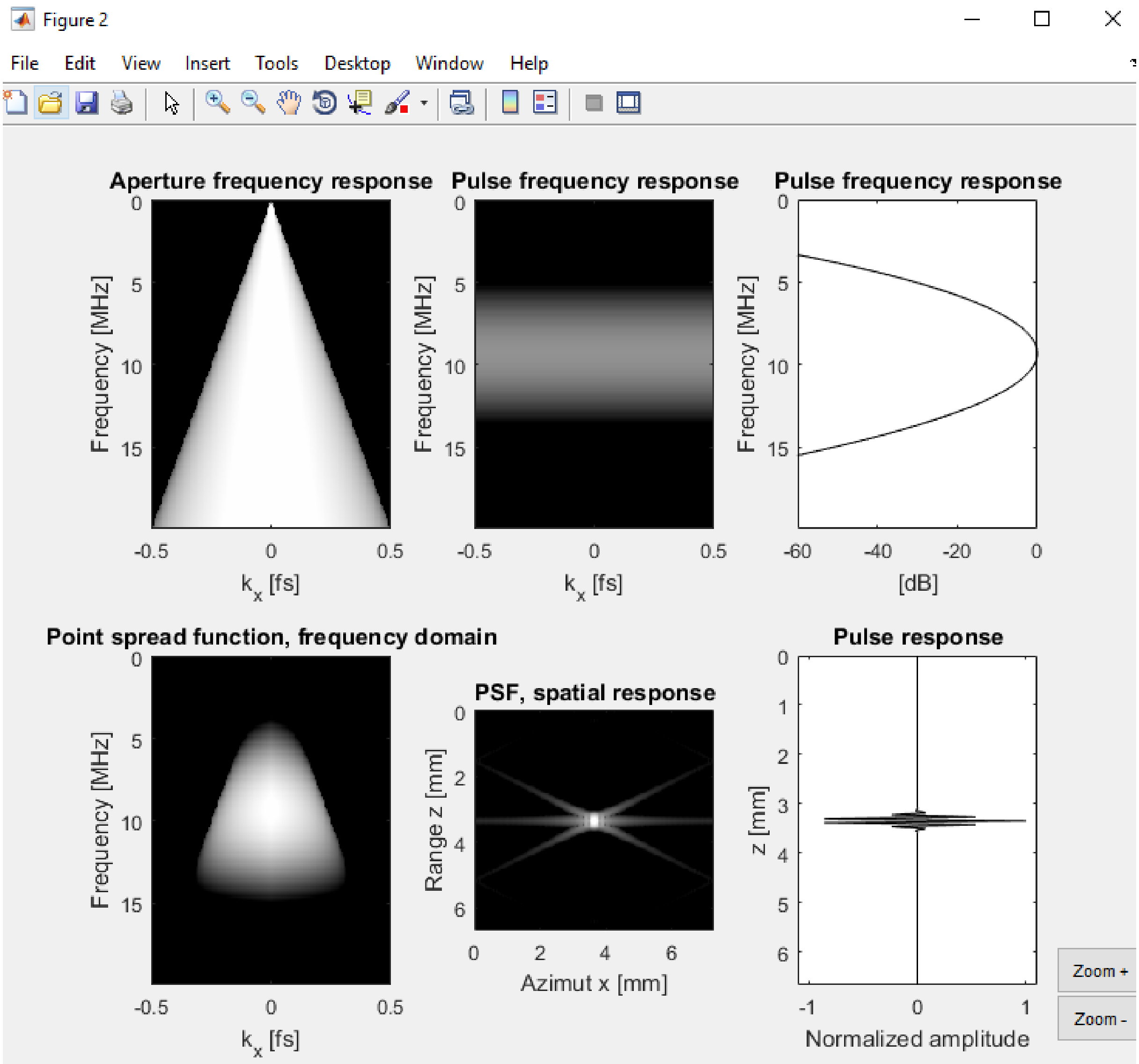
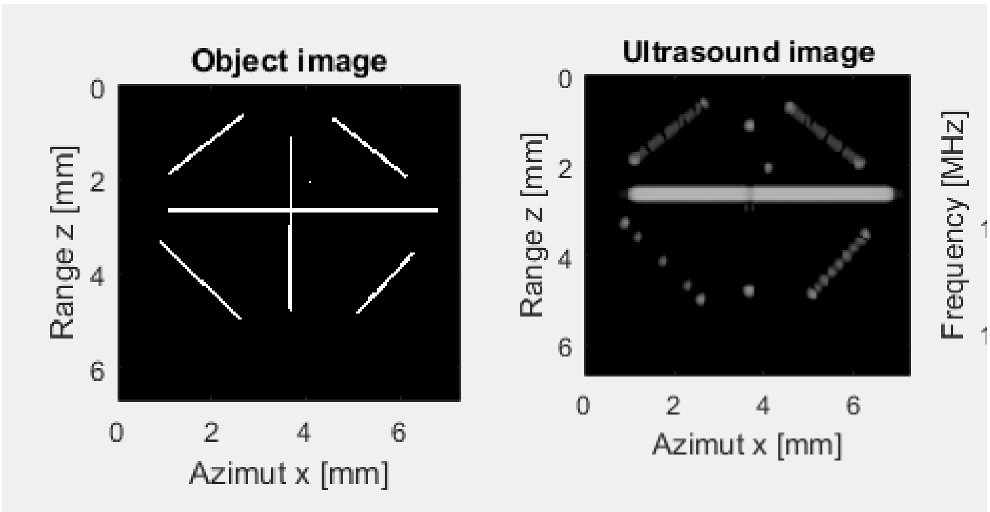
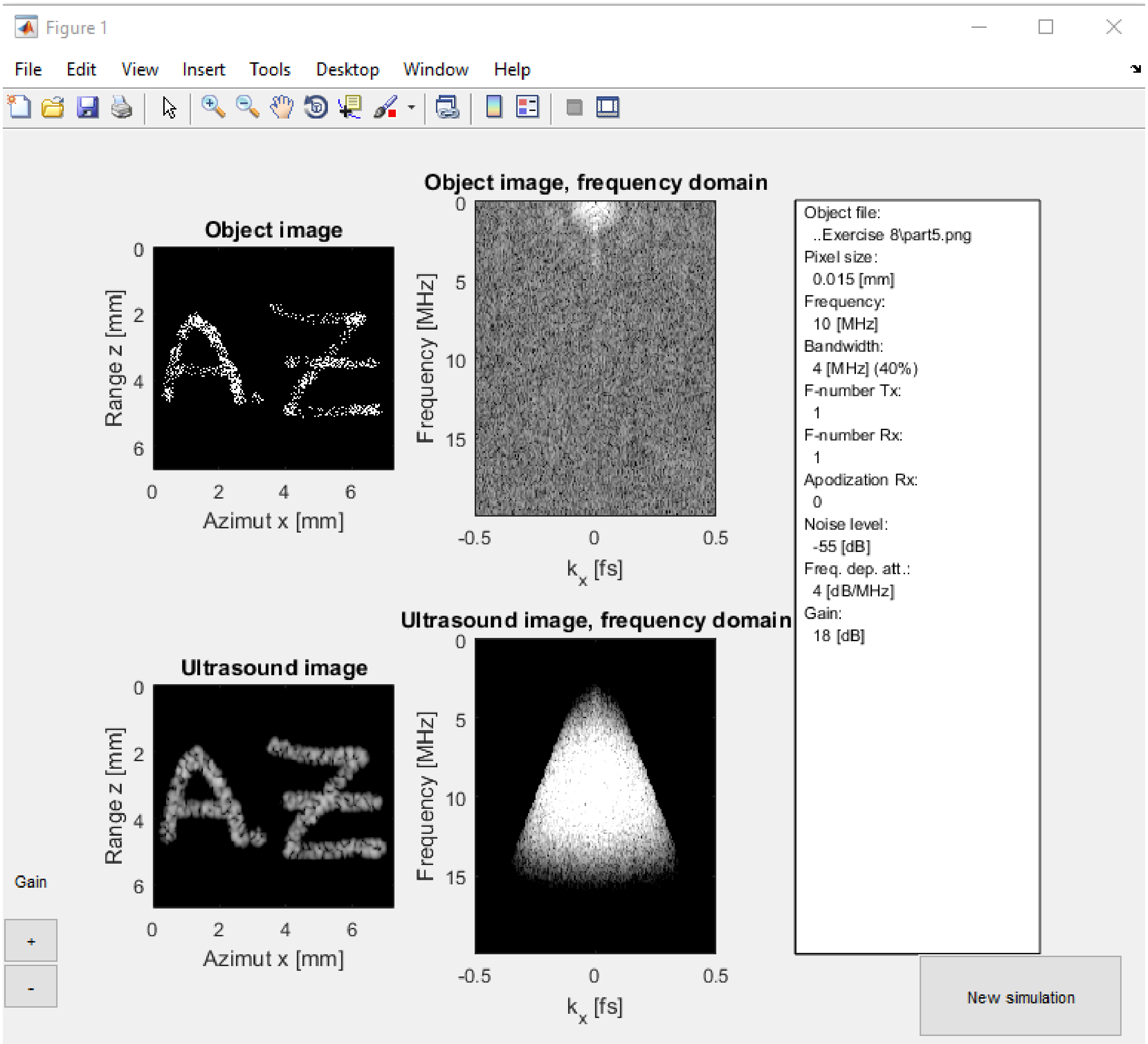




By reducing the gain to 18, and the transmitting and receiving aperture to 1. The Ultrasound image looks something like my object image. As one can see; the horizontal line is quite easy to see ad has a lot of energy in the ultrasound image. This is due to fact that nearly all the energy from the transducer is reflected to the transducer. While for the vertical line, we only obtain some dots, this has the same reason; the energy from the transducer is not reflected to the transducer, only some small parts which are the dots in the ultrasound image. One can improve the ultrasound image by reducing the F-number. This increases the element (when the length to focus is constant) used in the beam which improves the lateral resolution.

Part 5



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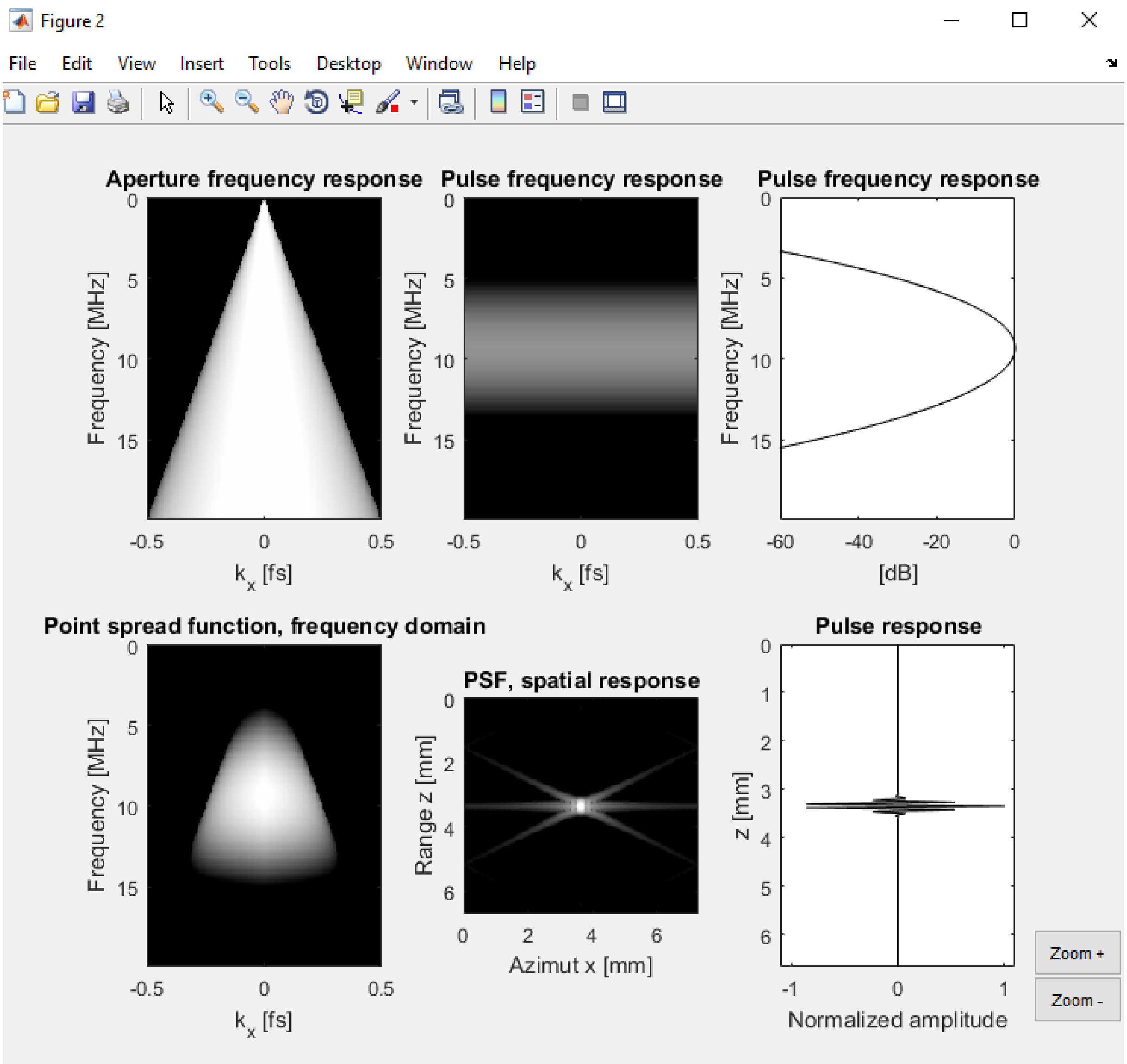


In this case, the object image is more like a scatter pattern. What we can see from the ultrasound image is that it is smeared out. This can be seen from the point spread function in the spatial response, where each scatter is a psf. In contrast with part 4, nearly all the point in the object is images, because the energy of the scatter is the more or less the same for each scatter-er.

Part 6

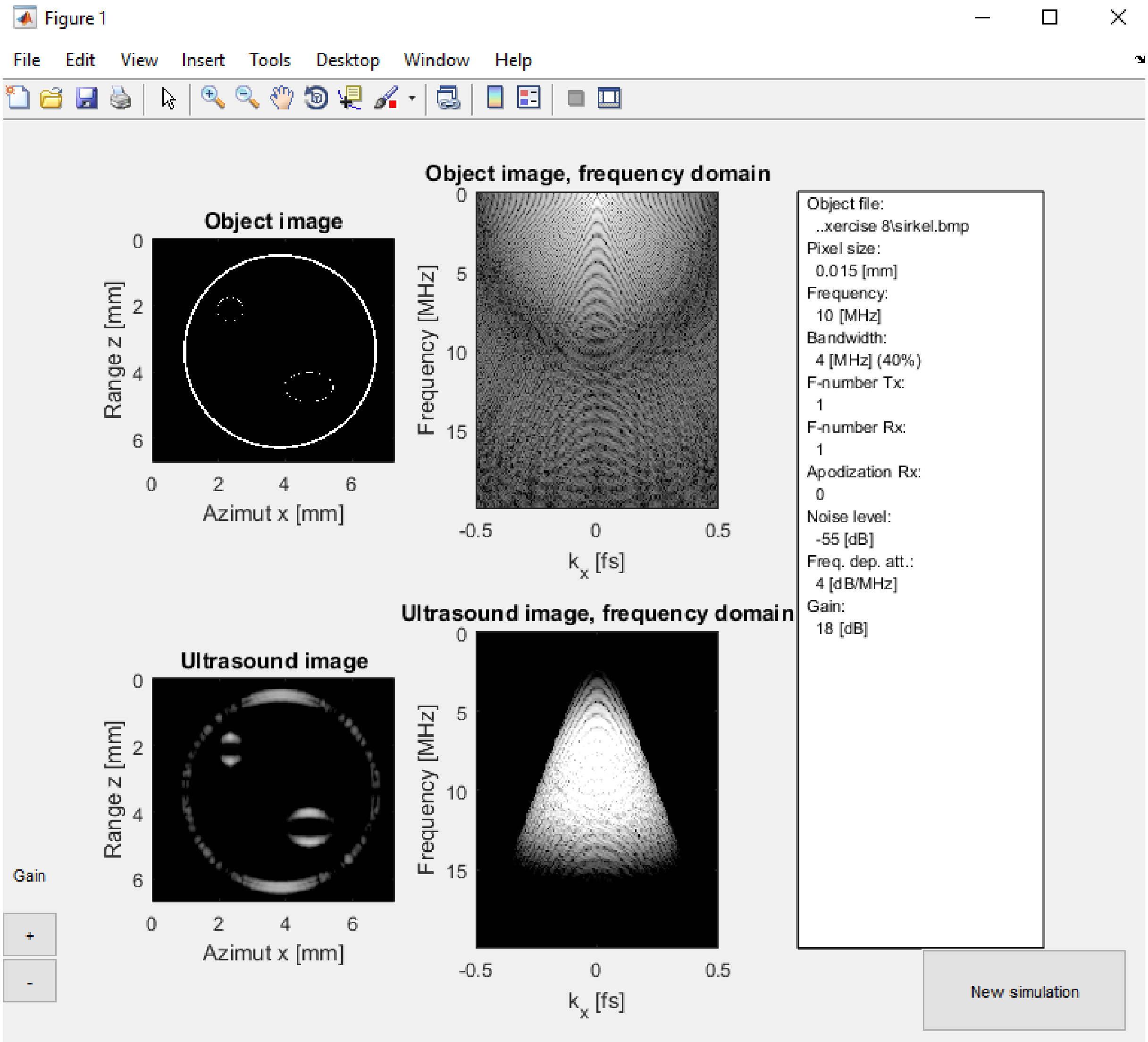
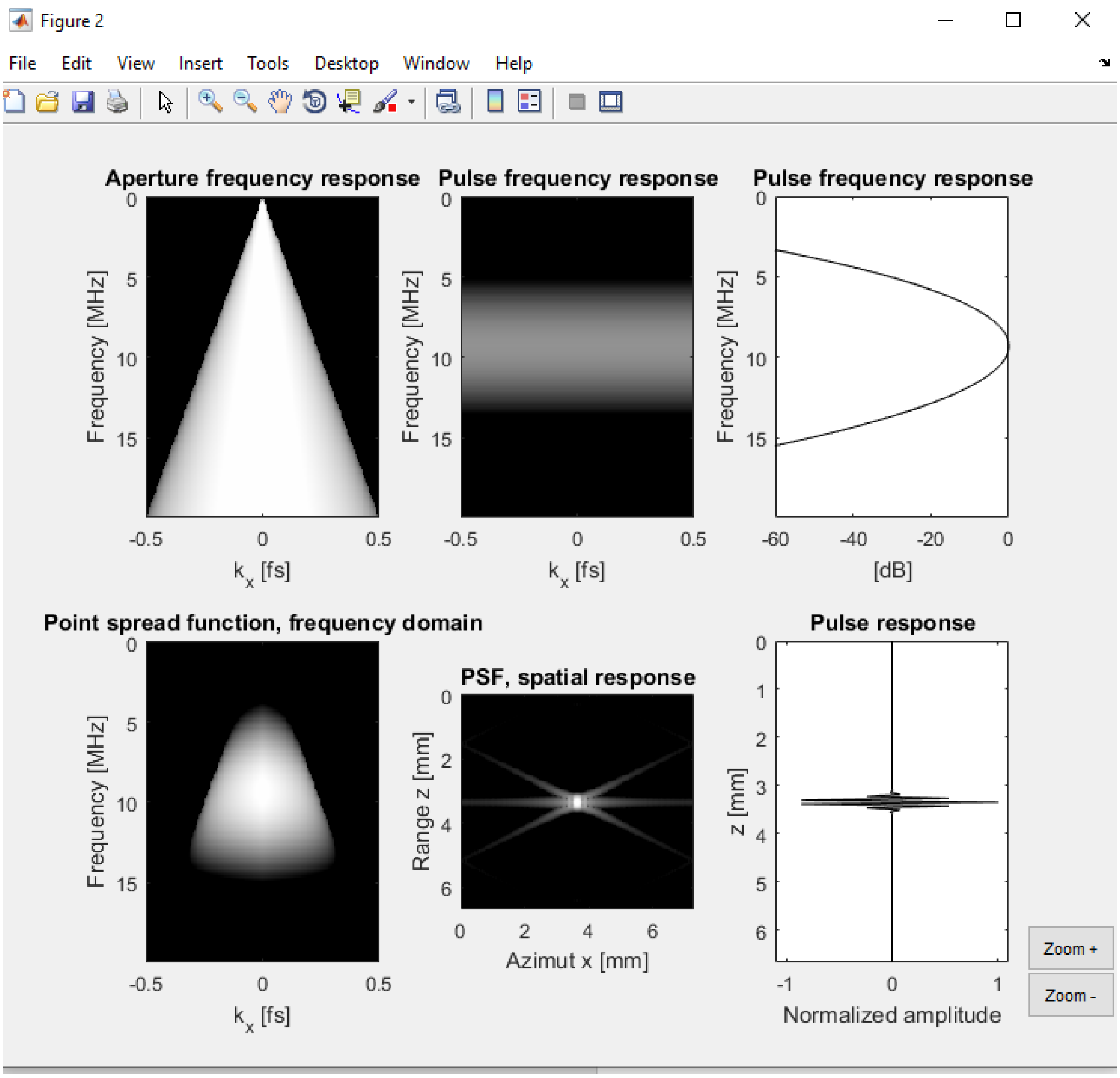


Figure 1
File Edit View Insert Tools Desktop Window Help
Object image
Range z [mm]
Azimut x [mm]
Object image, frequency domain
Frequency [MHz]
k_x [fs]
Ultrasound image
Ultrasound image, frequency domain
Gain
+
-
Object file:
..xercise 8\sirkel.bmp
Pixel size:
0.015 [mm]
Frequency:
10 [MHz]
Bandwidth:
4 [MHz] (40%)
F-number Tx:
1
F-number Rx:
1
Apodization Rx:
0
Noise level:
-55 [dB]
Freq. dep. att.:
4 [dB/MHz]
Gain:
18 [dB]
New simulation



The same thing is happening here as in part 4. Horizontal lines are easy to see, compared to the vertical lines in the ultrasound image.

Part 7