Biomedical Signal Processing
Prof. Sudipta Mukhopadhyay
Department of Electrical and Electronics Communication Engineering
Indian Institute of Technology, Kharagpur

Lecture - 64
Tutorial - V (Contd.)

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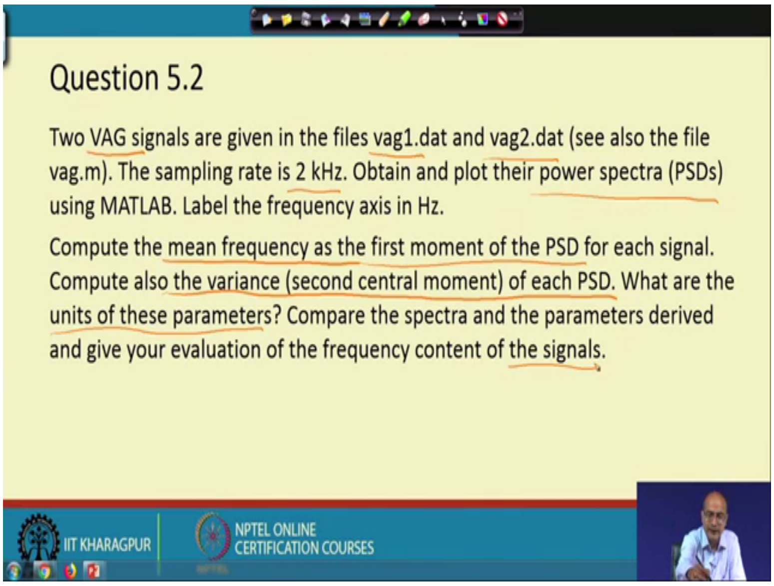

The second problem we take two VAG signal that is vibrio auto gram. The two signals vag1 dot.dat and vag2 dotdat and they are sampled at the frequency 2 kilo hertz. Now we have to get the plot of the power spectrum ok. And next we need to compute the mean frequency ok. That is the first moment of the PSD and we have to compute that is a second moment of the PSD. Now we are also asked that what would be the unit of these parameter; the mean and the variance ok. And we have to compare the spectra and the parameter derived and based on that we need to evaluate the two signals or compare the two signals ok so, that is the task given to us.

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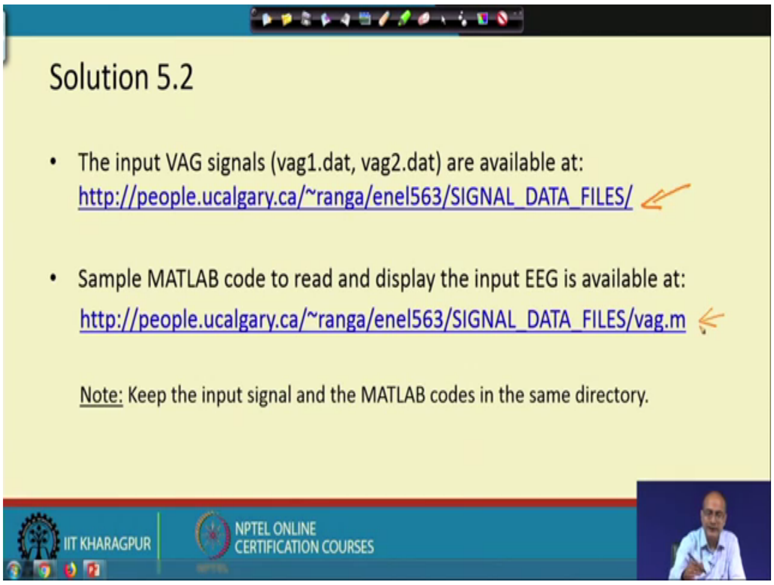

So, first thing is to look for the signal. So, we get the signal in this link and the corresponding that MATLAB code to read that signal vag dot m we will get it there. And first thing is to download them and keep it into the working directory of the MATLAB.

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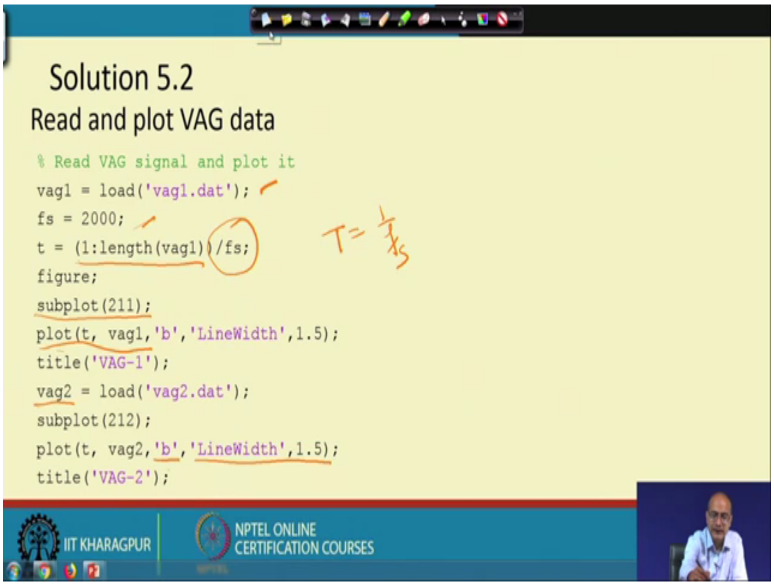

Next first we load the signal, the first signal vag1 dot dat and we note that sampling frequency that is 2000 hertz. So, that if you look at the time axis to plot that, we find out the number of samples that is there and we multiply it with capital T that is the time period. And capital T is nothing but 1 by f s where, f s is the sampling frequency. So, to do that we have divided the, this vector by the sampling frequency ok now we create the plot. So, we issue the figure command to create the pin, then we divided into two parts that top half part of it sub plot 211. There we plot the that vag1 signal with respect to time and next is that we have read the vag2 signal and we have taken the plot of it below. In both the case we have mentioned the color would be of the plot would be blue and line width would be 1.5 ok. So, that is the extra information that is given here.

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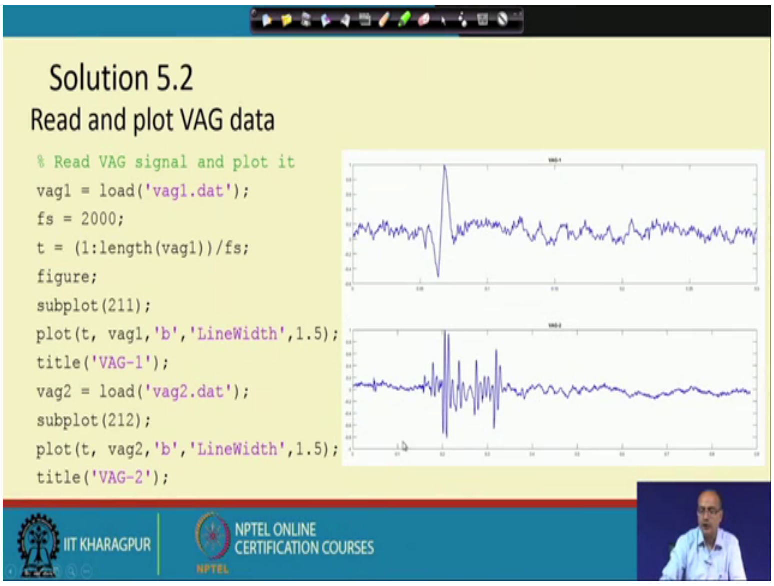

So, here we see the plot in the right hand side. Now what we notice the two signals they there of the same duration. No not exactly they are not of the same duration. Duration is different. And also they look actually much different. The first one duration is small, second one the duration is big and looks more kings are there in the second one ok.

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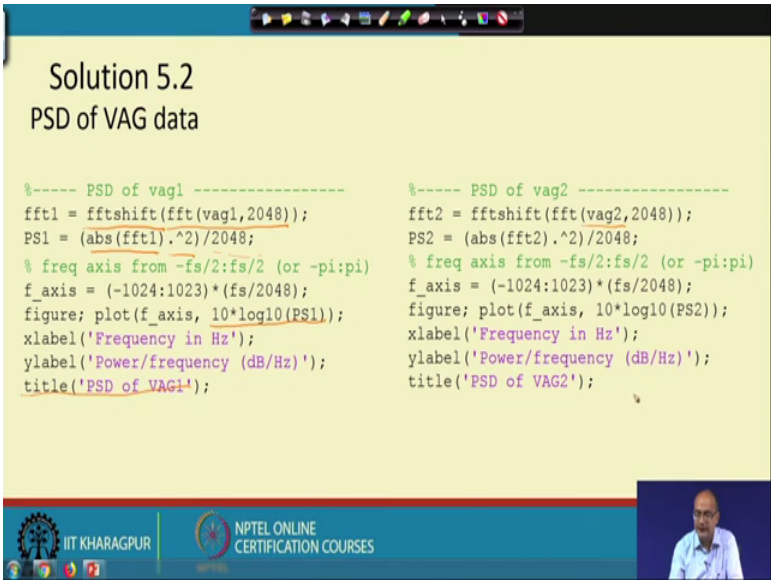

So, now let us see that how actually we would compute the PSD. We have already seen that in the previous example we are repeating the same thing. So, you move it fast in this case. So, what we do first we take the fft of the signal 2048 point fft. We have use the command fftshift to get the signal from minus pi to plus pi and we are taking the absolute value and compute the square of each of these value divided by the number of samples ok. And then we get the frequency axis that starting from minus fs to plus fs ok. We have how many samples 2048 samples.

So, we have the samples starting from minus 1024 to 1023 into fs by total number of samples That is the way we create the frequency axis and we plot that in the whether we plot the PSD in the log scale or to be more precise in the dB scale. So, we take logarithm to the base 10 and multiply with 10 and then we label the x axis and y axis ok. And also we write the title. So this is the way we could get it for signal one that vag2.

Now we repeat the same procedure for vag2 that is our second signal and we can get the spectra in the same way. So, let us see what is the result that what is the PSD we get.

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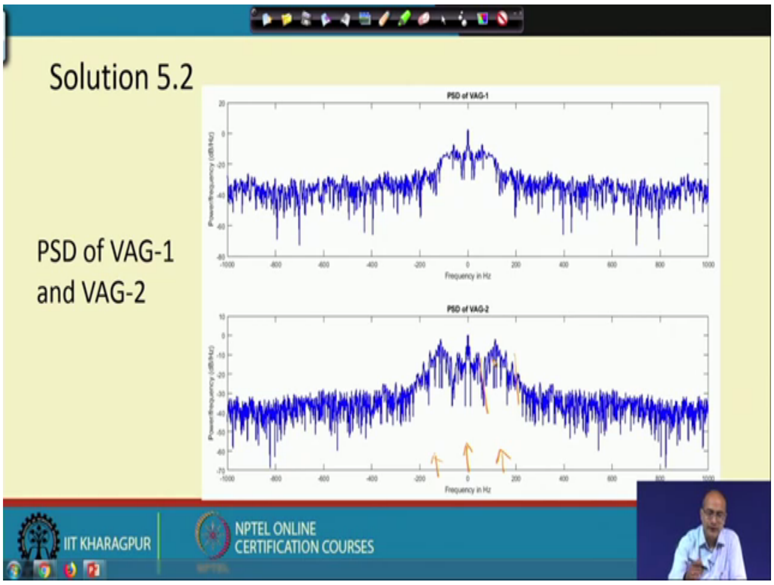

So, first we see the PSD of the signal 1 that VAG-1 followed by the that the second signal that is VAG-2. So, here is the VAG-2. What we get if we flip through go back again VAG-1 and come back. We see two peaks are here near by the that zero frequency they are more prominent ok. That is the essential difference between the two cases of spectra. Now to get it more clearly we show them in the same pen and we can see that basic nature of these two are same. We have a has value is in the DC value ok.

Apart from that that we have here and here that two that band is there this band. We have good amount of energy in both the case; however, for VAG-2 that strength of the signal here in this band is more so that is what we notice. And now we go for the next task that is, we have to computer the mean frequency and then we have to compute the variance.

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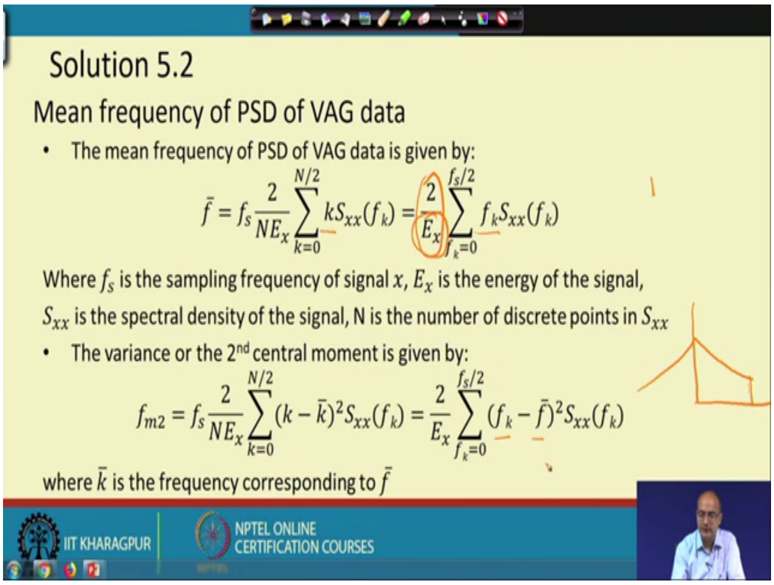

So, how do you compute the mean frequency? The mean frequency here is the equation given that we are taking our spectrum is S xx f k in the discrete domain; k is varying from 0 to N by 2. So, for that to compute a first movement we are multiplying it with k and we are taking the summation. And as we have to take the mean we have a term that we have a term here that, f s by 2 this is the number of samples or frequencies.

We are taking actually we are dividing it by the energy, total energy or if we compute the take these that is half of the energy. As the spectrum is symmetric half of the energy is in the one half ok. So, if you look at the plot if we just try to draw a sketch if the spectrum is like this we are taking only one half. So, the energy is half. So, E x by 2 we are normalizing it with E x by 2 and for that we are computing the energy starting from 0 to that that a f s by 2 up to which we can get the values and we are computing the first movement. So, that is the way we get the mean.

Next is for the second central moment or variance what we can do? We are multiplying instead of f k we are multiplying it with f k minus f bar square where, f bar is the mean frequency ok. So, we this is the way we get the mean frequency of the PSD and the variance of the PSD. So let us see how the results we get.

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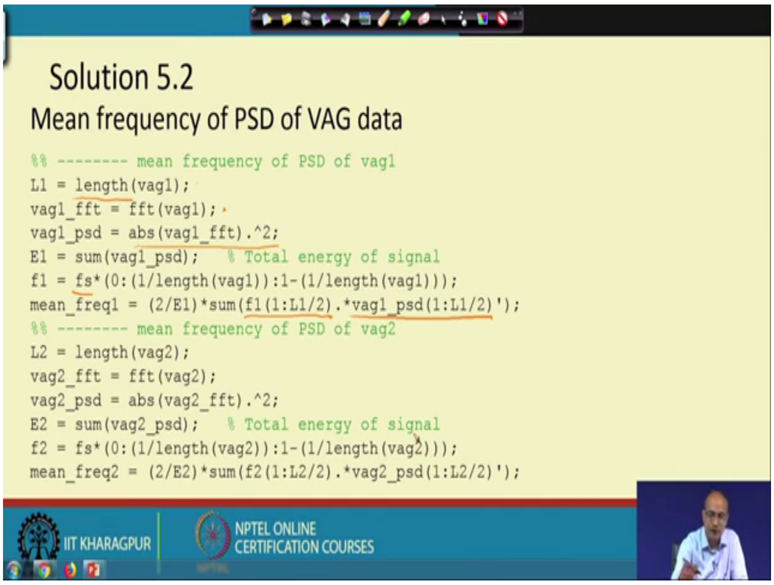

So, here we start writing the code that first we have to take care of the length of the signal. That is for vag1 the length is l one we are computed with this command length. And then we compute the Fourier transform and we take the absolute value and square of each of these actually values and to get that what is the energy. We take the sum of the spectral energy and to get that mean we are looking at that part. First we concentrate on the part that multiplying with the frequency f s. And here we are taking from 0 to that the length of the VAG that is 1 minus the total length would be 1.

So, 1 minus 1 by that count it will give us the same number of samples that frequency axis ok. We are going in a increment of the that one by the length. So, here this is the full length of the frequency axis and we are taking this sum for half of it ok. We are not going the full length. We are going half of it 1 to L1 by 2 for the frequency axis and for the spectrum. We are taking the dot product and we are taking the sum over this and divided by that half of the energy to get the mean frequency. And we are repeating the same exercise for vag2 to calculate the mean frequency ok. So, that is a way we can get the mean frequency and we plot them for better visualization.

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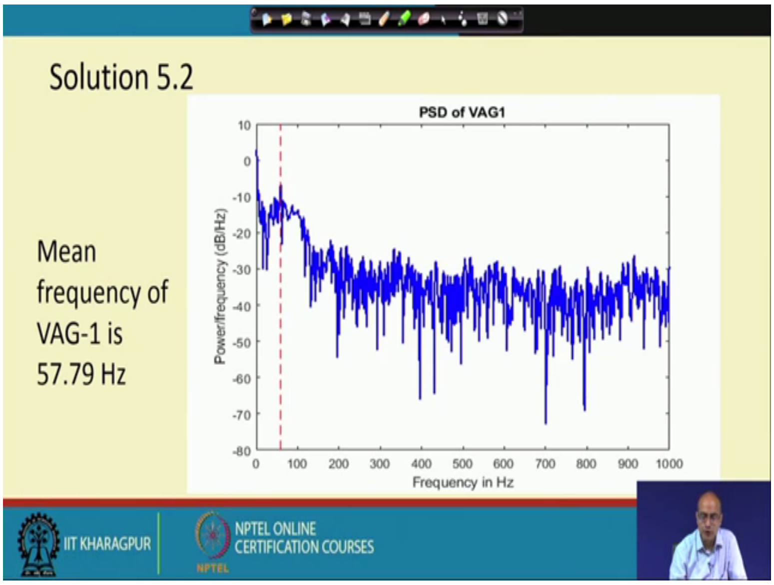

So, here we show that how it looks like; for the VAG-1 it is coming here the mean frequency 57.79 Hertz ok.

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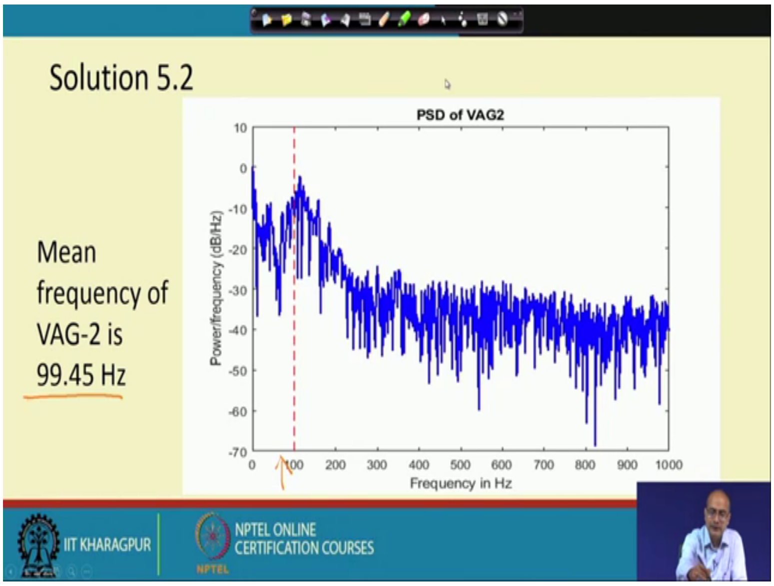

And for the next one that is VAG-2 we get it at 99.45, we get that mean frequency. So, the mean frequency for the second VAG signal VAG-2 is higher ok. That is what we have noticed.

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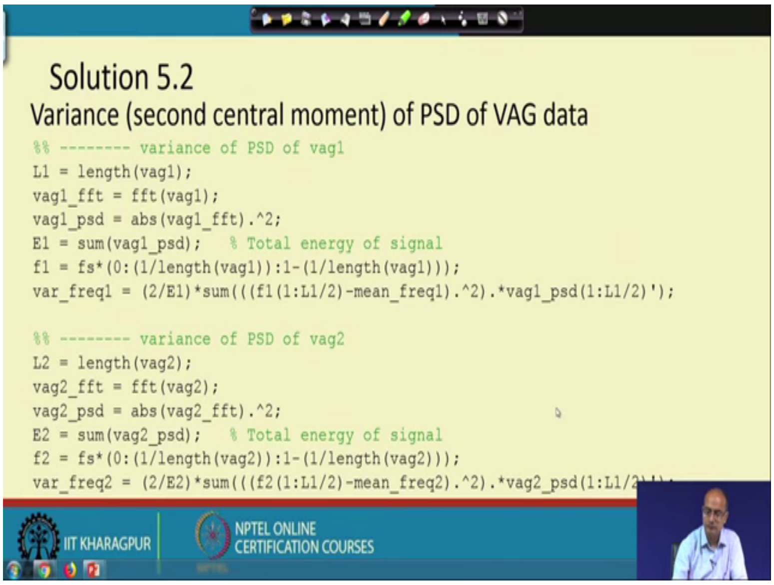

Now let us proceed to get the variance of the signal or we can say, what is the second central moment. Here is the equation we get that we have that VAG-2 and VAG for VAG-1 that first we start with that. So, same way we compute the length we compute the fft, and we compute the psd and we compute the frequency axis values. Now for the variance, we make use of the mean frequency, we take the difference from that frequency at that point and with respect to the mean and take the square of it and point by point multiply with the psd. And again we are looking into half of the psd that is the positive part of it ok. So we repeat the same thing for vag2 and we get the variance.

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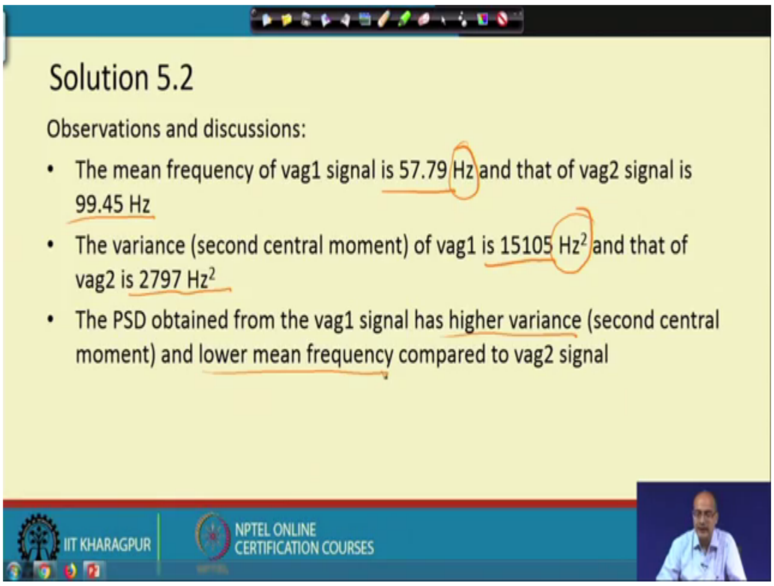

Now, what is the, what are the values we get? We get that the mean frequency for vag1 is 57.79, and for vag2 it is 99.45 Hertz. And corresponding variances are 1510 or rather 15105 Hertz and sorry Hertz square and for vag2 it is 2797 Hertz square. So, the that units that is asked for the mean it is Hertz and for variance it is Hertz square ok. And if we compare the two signals with respect to the PSD and the means and variance that derived from the PSD, then what we get that, vag1 has high variance compared to the second one. But it has lower mean compared to the first signal ok so that is the tradeoff we get. The first signal vag1 the mean is small, but the variance is much higher compared to the second signal ok.

Thank you.