Digital Signal processing & Its Applications
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Lecture – 05 a
What do we want from a discrete system?

So, good morning and welcome to the fifth lecture on the subject of digital signal processing and its applications. We will just spend a minute or two in recalling what we did the last time. We will take a couple of questions and then we will proceed to discuss what we intended to in the lecture today. In the previous lecture we were looking at the whole idea of discrete systems.

And before we started talking about the properties of systems we thought it more appropriate to find out what we wanted out of the systems at least at the first glance. You know in the first step of design, what is it that I would expect from a system if I wanted to be able to succeed in the process of design. And in fact, we put down certain requirements. Let us summarize those requirements.

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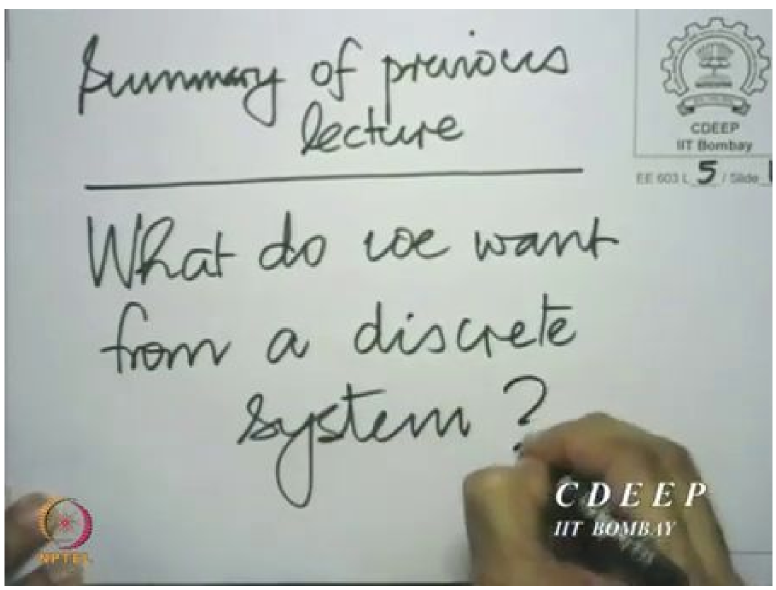

So, this is a summary of the previous lecture. The theme was what do we want from a system. And the answer was contained or in fact the answer was completely captured by the following three experiments.

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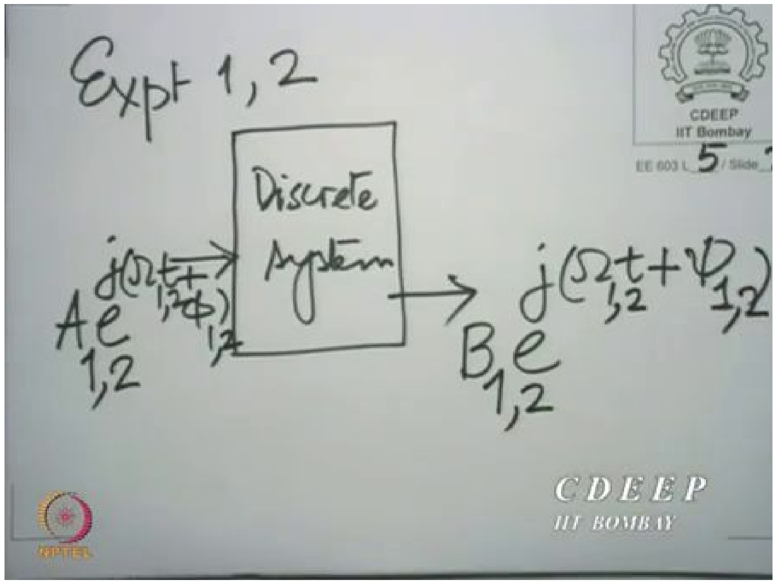

We said experiment one. We have a discrete system. We give it a complex exponential or a phasor which we can denote. We will use just for variety of notation. We will use the following notation today. We agreed that we insist that the output should also be a phasor of the same frequency.

Let us call it $B_1 e^{j(\Omega_1 t+\Psi_1)}$ here. And in fact now we use a shorthand notation we will say we will perform experiments 1 and 2. In which we respectively have $A_{1,2}$, $\Omega_{1,2}$, $\Psi_{1,2}$ you see so this is a shorthand notation for capturing two experiments of a very similar nature in one drawing.

You must interpret when you read something like this which I have intentionally brought in this notation here because it is useful to use this notation where you have very similar drawings to be repeated. Similar expressions or equations to be repeated, what I have drawn here is two systems or two experiments with the same system in one drawing and the way you read it is read it with the comma denoting respectively.

So, you say experiment 1 respectively 2 has $A_1 e^{j(\Omega_1 t+\Phi_1)}$ applied respectively. In the second experiment it would be $A_2 e^{j(\Omega_2 t+\Phi_2)}$. It is the same discrete system in both the experiments and the outputs are respectively $B_1 e^{j(\Omega_1 t+\Psi_1)}$ and $B_2 e^{j(\Omega_2 t+\Psi_2)}$. So , one must read it like that so two experiments written down.

And then the third experiment or the test experiment which determined whether we wanted whether we got what we wanted from the system is.

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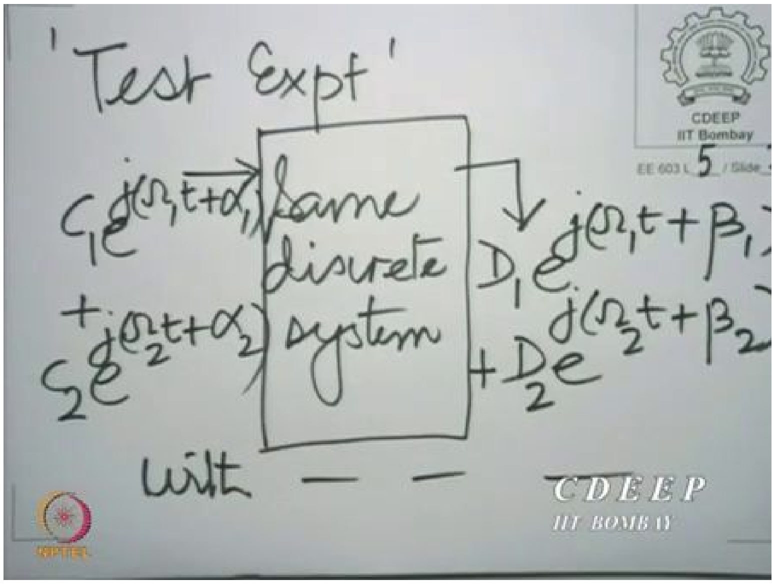

Same discrete system, I gave it the input $C_1 e^{j(\Omega_1 t+\alpha_1)}$. Let me call it that. Plus $C_2 e^{j(\Omega_2 t+\alpha_2)}$ C2 e raised to the power j omega 2 t plus alpha 2 and I ensure that what I get was $D_1 e^{j(\Omega_1 t+\square_1)}$ if you please. Plus $D_2 e^{j(\Omega_2 t+\square_2)}$ with the following relationships which we are now going to write.

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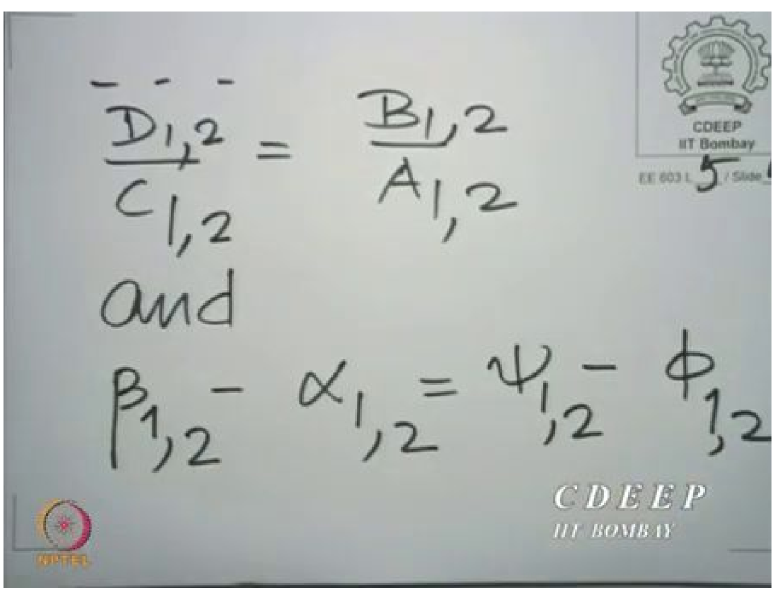

D_1/C_1 is the same as B_1/A_1. And of course we write two equations all at once here. And $\beta_1 - \alpha_1 = \Psi_1 - \Phi_1$ and similarly for 2. Do we all agree with this this is what we wanted. What are we saying in words or in you know in a verbal description what are we trying to say.

Here we are saying that, firstly when I have a combination of rotating complex numbers applied to the system I get a combination of the same rotating complex numbers. Appropriately, changed in amplitude and phase and the change in amplitude in phase is independent of the original amplitude and phase. The change in amplitude and phase is described by the system.

Not by the particular amplitude of phase that you have given it. You see at a an even higher level of thinking or at an even more abstract level what are we trying to say we are saying that we can deal with each rotating complex number rotating with different possibly different angular frequencies in its own right.

So, we do not need to you know we do not need to worry about what is happening to the complex number rotating with some other angular velocity, when I am dealing with a complex number rotating with a particular angular velocity. I can deal with them in a decoupled way. Now, going down even further why did I come first to the question of complex rotating numbers at all.

Because, I want to deal with sinusoids and why did I want to deal with sinusoids because there is a large class of wave forms which I can think of as a combination of sinusoids. And why is it that I am so fond of sinusoids or why is it so fond of thinking of waveforms as a combination of sinusoids because sinusoids are extremely smooth, sinusoids are convenient to deal with.

And if you can think of waveforms as a combination of sinusoids I can deal with the waveforms more appropriately from what I want to do with them. So, I gave you the example of separating out male and female voice components in an audio piece which can easily be described in terms of its sine wave composition.

So any physical circumstances many physical descriptions of systems require thinking of the underlying waveforms that we are dealing with in terms of the sine waves that comprise them. And therefore it is convenient if I can build a system design philosophy which rotates around what the system does to sine waves.

And what I want is further that I should be able to specify in a decoupled way what the system does to each sine wave separately without the other sine waves interfering in the process. So, this is the whole story this is where we are at the moment. As I said, these you see the next thing that we are going to say is often present in textbooks. But, it is often not clear why we look for those properties. The next thing that we are now going to say is if we want to get this from a system to get this.

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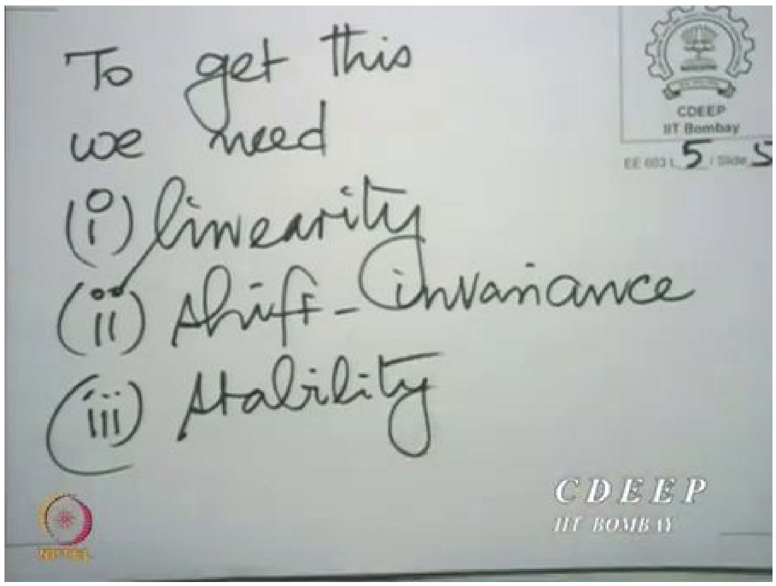

We need linearity and shift invariance. In fact we need three things we need linearity, we need shift invariance and we need stability. And today our objective is to deal with these properties what do these properties mean. So, these are the questions that we had posed in the last class and we are now going to answer them that is right.