Digital Signal Processing & Its Application
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Lecture 18b
Specifications for Filter Design

We synthesize with some objective in mind, with some aim in mind. And therefore, we are first going to try and put down the aims, the kind of aims that we would like to satisfy to meet. And you know, we are talking about filters, filter are systems where our LSI systems, where the impulse response has a DTFT. So, naturally when we say we want to design filters, we are essentially asking what frequency response do you want out of the filter.

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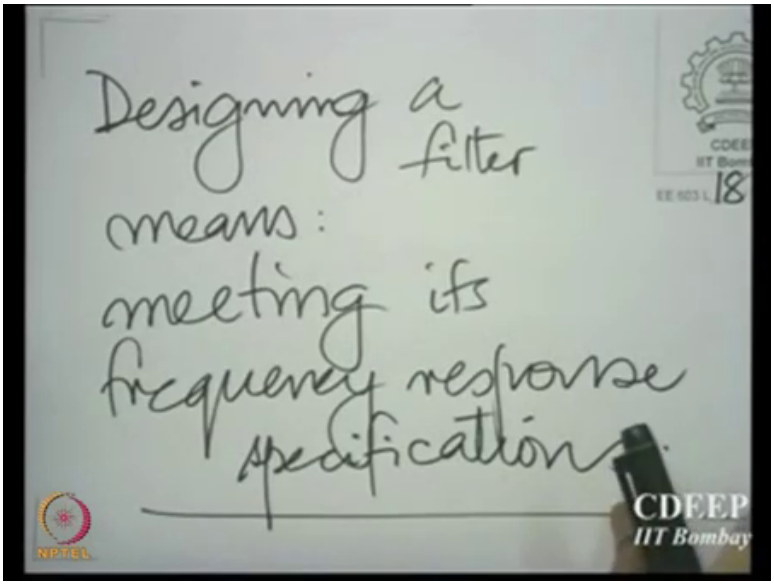

So, what do you mean by designing a filter? Designing a filter means meeting the frequency response specifications and when you say frequency response specifications, what are you talking about, there are two parts of a frequency response, a frequency response has a magnitude and a frequency response has a phase.

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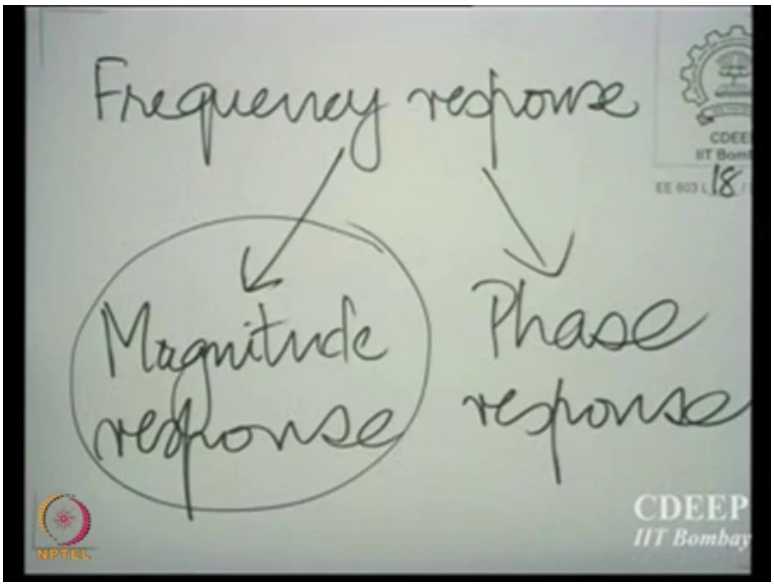

And therefore, we talk about a magnitude response and a phase response. Normally it is the magnitude response with respect to which we wish to design, it is rare that we wish to design for a given phase response. At least in this course, our objective will be essentially to design with the magnitude in mind and the phase is an accompanying necessary evil.

I have already remarked earlier on that the phase is a necessary evil. I have also put it as a problem or a challenge before you answer why, why is the phase a necessary evil. Anyway, the initial objective is to meet magnitude specifications and phase is what we can get given that we are trying to design for a set of magnitude specifications. And even among magnitude specifications, typically, what we have are piecewise constant specifications.

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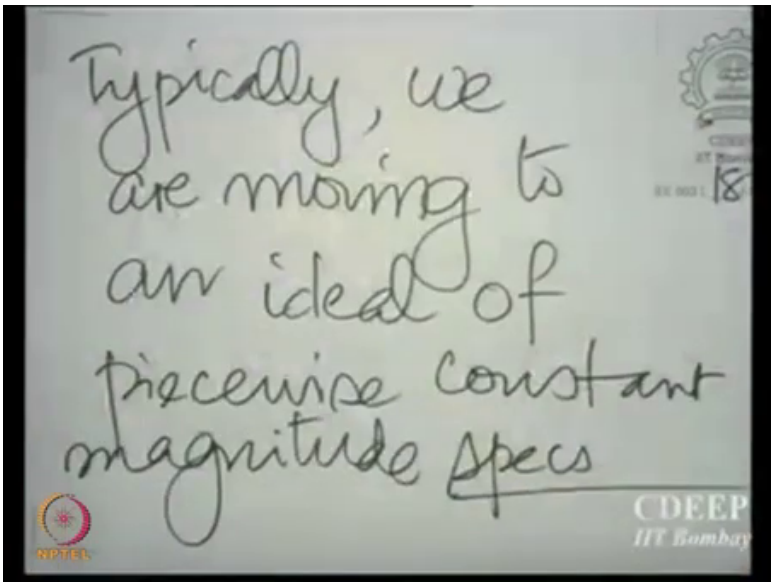

So typically, we are moving to an ideal of piecewise constant magnitude specifications. In fact, even among these there are four particular sets of piecewise constant magnitude specifications that we will often aim to move towards. Let us enumerate them one by one.

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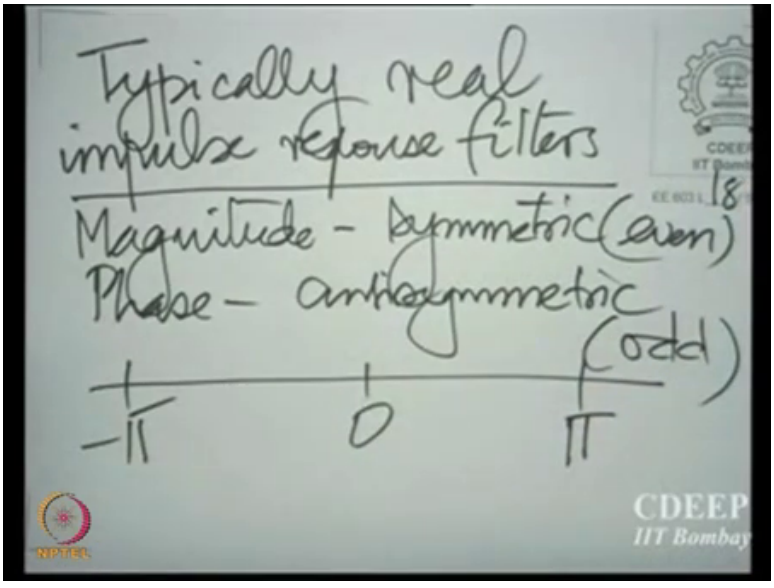

Of course, you will agree with me that we need to specify only between minus pi and pi. And we will of course want to deal with real filters, real filters means filters with a real impulse response. So, let me write real impulse response filters. If the impulse response is not real, we are incurring

the additional demand of complex number arithmetic, which we do not want to do, at least initially. So, it is easier to deal with real arithmetic and we will do that. We want real impulse responses.

Now, the moment the impulse response is real, what can you say about its frequency response, the frequency response is conjugate symmetric. So, the negative and positive frequencies have frequency responses that are complex conjugates that means, they have the same magnitude and they have opposite phase. Another way of saying it is, the frequency response is magnitude symmetric and phase anti symmetric.

So, we want magnitudes symmetric or the magnitude is an even function and phase anti symmetric or the phase is an odd function, even, magnitude is even, the phase is odd. And therefore, when we put down the specifications, we must of course, put down the specifications with these constraints.

The magnitude specifications must be symmetric and the phase specifications if any must be anti symmetric, or we leave the phase to be what it is, and we do not specify it. Or sometimes, if we are talking about the ideal, ideally, we do not want a phase at all. Phase, as I said a necessary evil. So, we accept what face we get, but we are not trying to put a phase there, intentionally.