Principles of Communication- Part I
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Module No 5
Lecture 25
Complex Pre-Evelope and Complex Envelope of QCM (Quadrature Carrier Modulated) Signals

hello welcome to another module in this massive open online course, so we are looking at the complex pre-envelope and complex envelope of the complex ways that equivalent of a passband signal that is continued that discussion today, that is looked the complex pre-envelope and the complex baseband equivalent of a quadrature carrier modulated that is the QCM signal.

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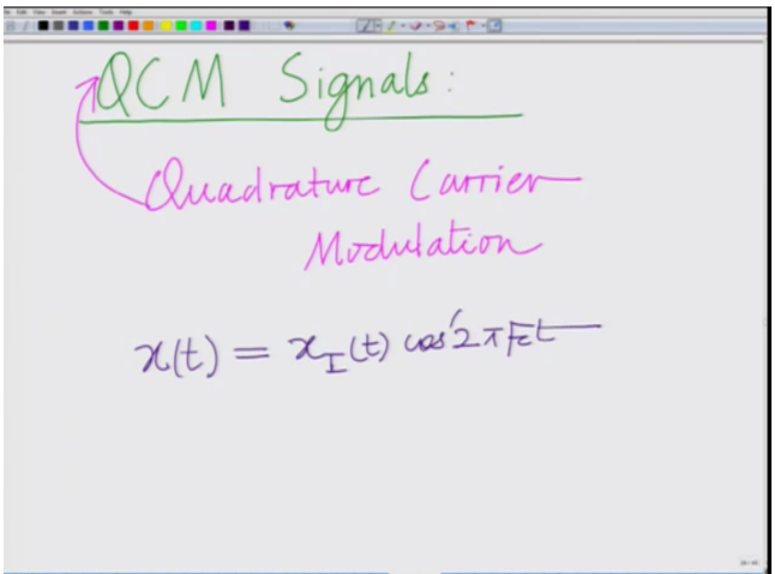

So let us start by considering a QC M signal we already seen QCM. QC M stands for quadrature carrier modulation QC M denotes quadrature carrier modulation and the QC M modulated there is quadrature carrier (module) quadrature remember QCM we say quadrature carrier modulation is there is a carrier cosine two pi Fct, alright. And another carrier sine two pi Fct the phase difference between these two carriers is uhh Pi by two or ninety degrees therefore this two carriers are in quadrature hence they are orthogonal and independent message signals can be modulated on this quadrature carrier, alright. So that is the basic uhh that is a basic description of quadrature carrier modulation, okay.

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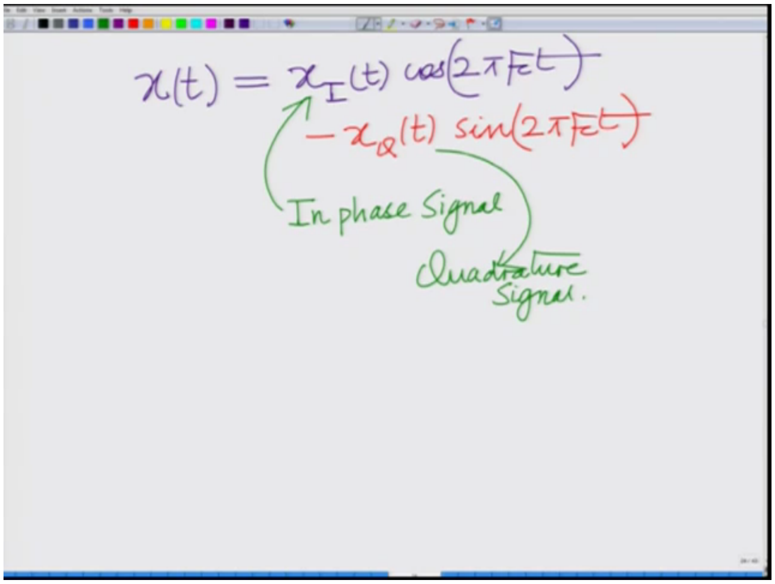

So let us recall that a quadrature carrier modulated signal x(t) is given as x(t) equals, well xi(t) cosine two pi Fct minus xq(t) sin two pi Fct this is a cosine carrier sin carrier xI(t) is the remember this is your xI(t)is the in phase signal and xQ(t) is a quadrature signal is the signal in quadrature, okay. And these are the two independent message signals which hve been modulated on the cosine carrier and sine carrier which are orthogonal, okay.

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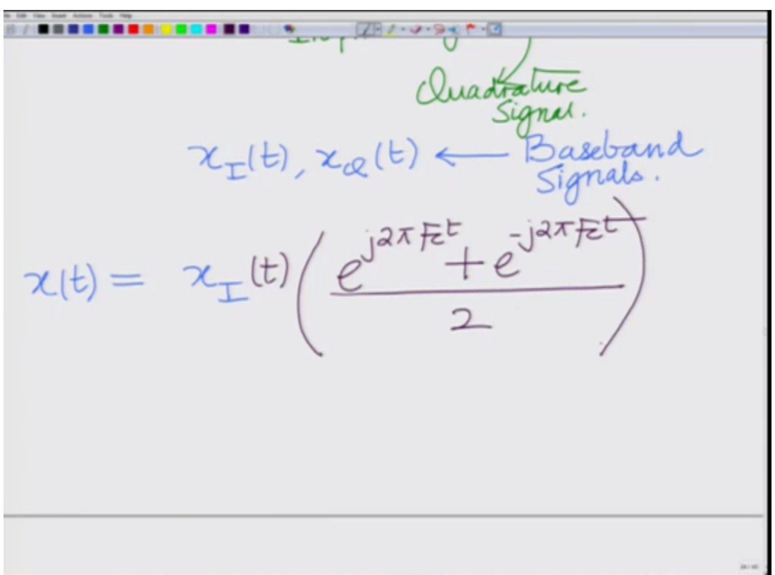

So now let us try to express let us try to find the complex pre-envelope and the complex envelope of this passband signal, okay. And of course notice that these two signals xi and xq, alright. These two that is your xi, xI(t), xQ(t) these are naturally your these are naturally your baseband signals that is there are central (())(3:33) zero frequency and therefore they are modulated on the carriers, alright. So these are uhh basically have centered at zero frequency and have maximum frequency Fm that is from minus Fm to Fm both the in phase and quadrature Uhh message signals, okay. Now let us look at, now I can write this as remember this is xI(t) cosine two pi Fct I can write therefore x(t).

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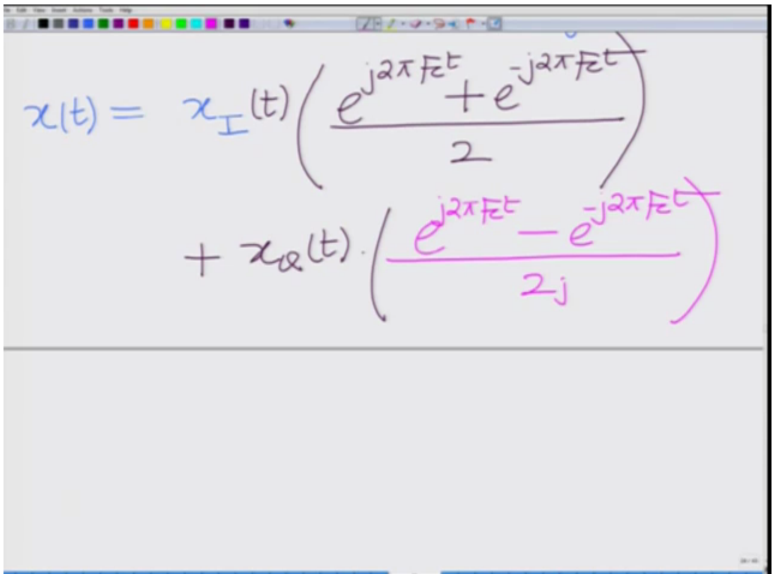

I can express it as cosine t as xI(t) and cosine t can be expressed as e to the power of j two pi Fct plus e to the power of minus j two pi Fct divided by two that is your alternative uhh equivalent way of writing cosine two pi Fct plus, now I am going to express sine two pi Fct as xQ(t) times e to the power of j two pi Fct minus e to the power of minus j two pi Fct divided by two j, so this is basically your cosine two pi Fct is e to the power of j two pi Fct plus e to the power of minus j two pi Fct divided by two sine two pi Fct e to the power of j two pi Fct minus e to the power of minus j two pi Fct divided by two j. Now let us collect the terms belonging to e to the power of two j two pi Fct and the terms belonging to e to the power of minus j two pi Fct separately, alright.

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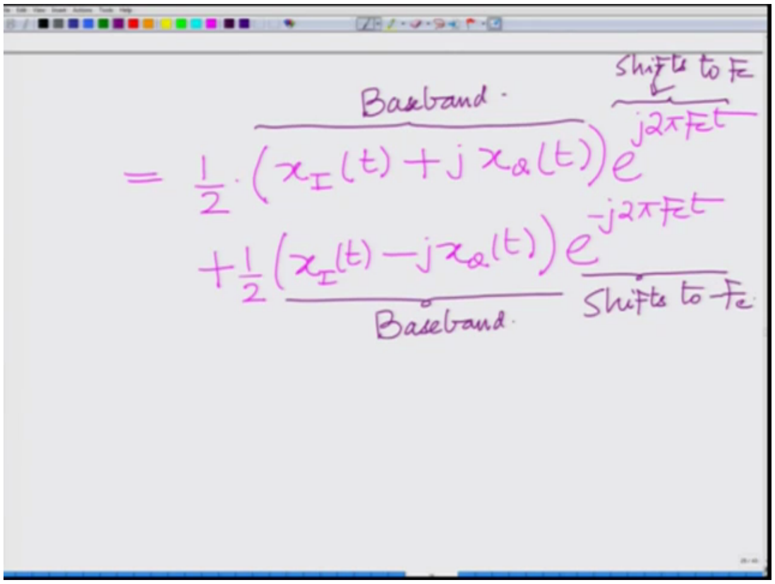

So I can write this as well, xI(t) that is I can write it extracting the terms corresponding to e to the power of j two pi Fct half there is a factor of half times xI(t) xI(t) minus j uhh this is a minus sign, sorry this is a minus sign over here. And there is a factor of half xI(t) plus j xQ(t) into e to the power of j two pi Fct plus half xI(t) minus j into e to the power of minus j two pi Fct, alright. So I have written I have collected the terms belonging to the e to the power of j two pi Fct and the terms belonging to e to the power of minus j two pi Fct. Now you can see this is of course xI(t) plus j xQ(t) this is in the baseband, correct? Because xI(t) and, so these two terms are in the baseband.

Now e to the power of j two pi Fct this shifts baseband to shifts to Fc, alright. So this is the modulation property shifts to Fc and this shifts to minus Fc therefore if you look at the (pos), so we have a baseband component there is a xI(t) plus j xQ(t) and xI(t) minus j xQ(t) these are the two baseband components multiplying by e to the power of j two pi Fct shifts it to the positive frequency that is uhh positive frequency band centered around Fc multiplying by e to the power of minus j uhh multiplying by e to the power of minus j two pi Fct ships it to Uhh minus, correct?

Minus Fc that is the negative frequency band therefore the positive frequency band of this passband signal corresponds to the first component, right? X i that is half xI(t) plus j xQ(t) e to the power of j two pi Fct that is if you look the signal corresponding to the positive frequency band centered around Fc that is basically this half xI(t) plus j xQ(t) e to the power of j two pi Fct and if you look at the negative frequency band that is the frequency band centered around minus Fc that is a component half xI(t) minus j xQ(t) into e to the power of minus j two pi Fct, alright.

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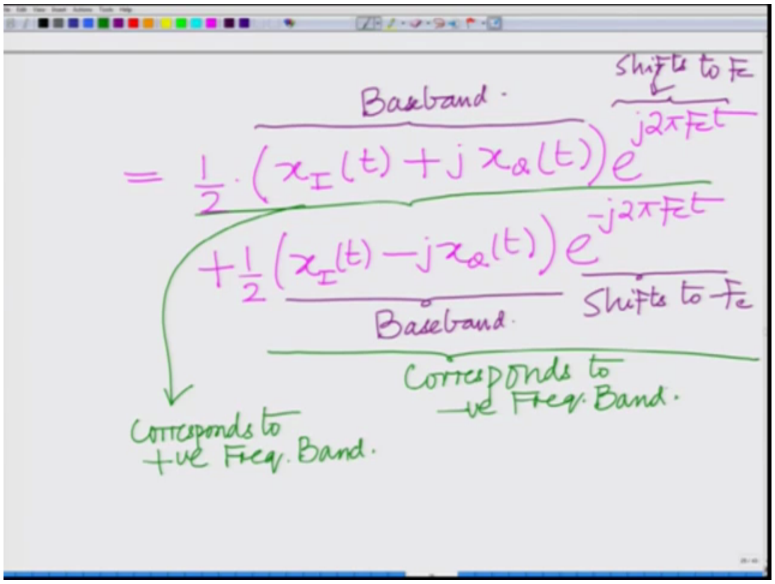

So basically if you what we have reasoned is this corresponds to the this component corresponds to the corresponds to the positive frequency band that is X(F) for x f greater than zero this corresponds to the corresponds to the negative frequency band that is Uhh this term which is xI(t) plus j x xI(t) minus j xQ(t) e to the power of minus j two pi Fct this corresponds this corresponds to the negative frequency band. Therefore now realize that the complex pre-envelope basically is twice the spectrum of the complex pre-envelope is twice the spectrum corresponding to the positive frequency band of the signal, correct?

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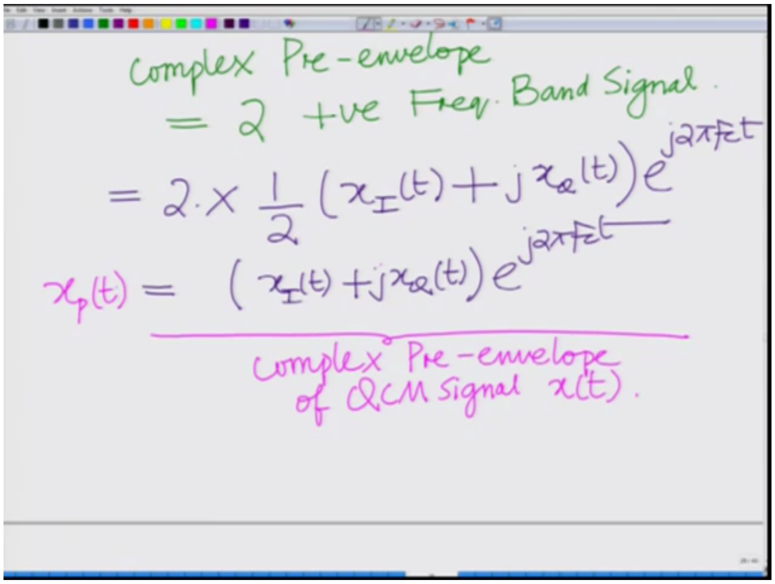

And therefore the complex pre-envelope of this signal remember complex pre-envelope equals twice the positive frequency band signal which is basically equal to twice we have already isolated the signal corresponding to the positive frequency band, so this is twice into half xI(t) plus j xQ(t) e to the power of j two pi Fct which is basically xI(t) plus j xQ(t) e to the power of j two pi Fct this is a complex pre-envelope. Therefore this is the complex pre-envelope of the QCM signal x(t).

That is xI(t) plus j xQ(t) e to the power of k two pi Fct, let us also denote this by x p of t, that is if I can call this as x p of t or x p of t is a complex pre-envelope, alright. So the complex pre-envelope of the QCM signal which is xI(t) cosine two pi Fct minus xQ(t) sine two pi Fct is xI(t) plus j xQ(t) into e to the power of uhh j two pi Fct that is the twice the signal corresponding the positive frequency band of this passband signal, okay.

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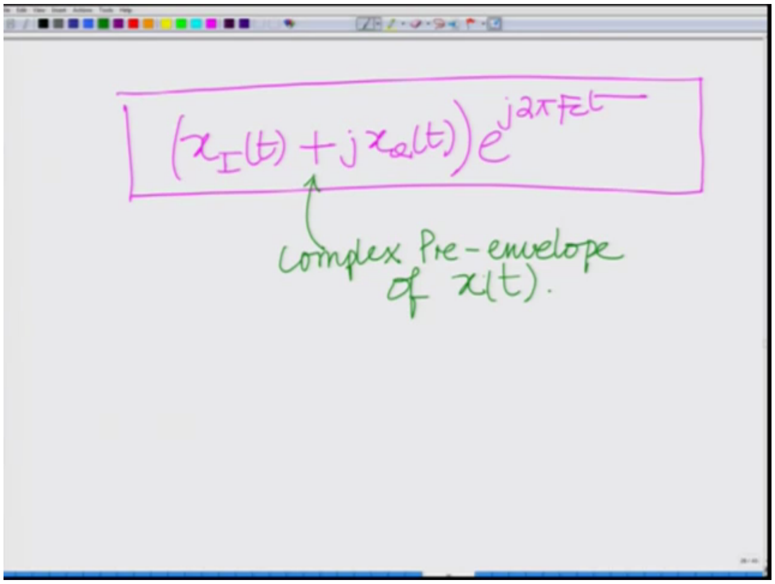

So let me write this again xI(t) plus j xQ(t) into e to the power of j two pi Fct this is the complex pre-envelope, okay. This is the this is a complex pre-envelope of x(t), now the complex baseband equivalent is given by the complex pre-envelope and shifting it by minus Fc there is shifting it by minus Fc or shifting it by Fc to the left that is multiplying by e to the power of minus j two pi Fct.

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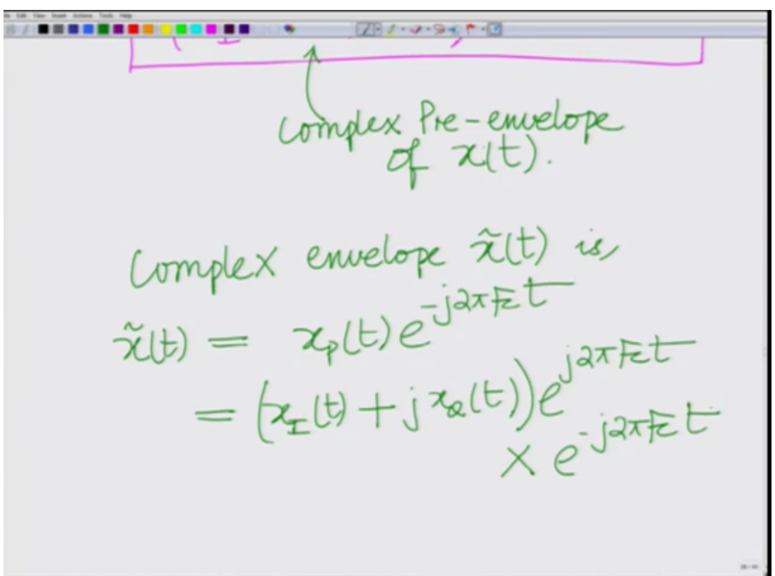

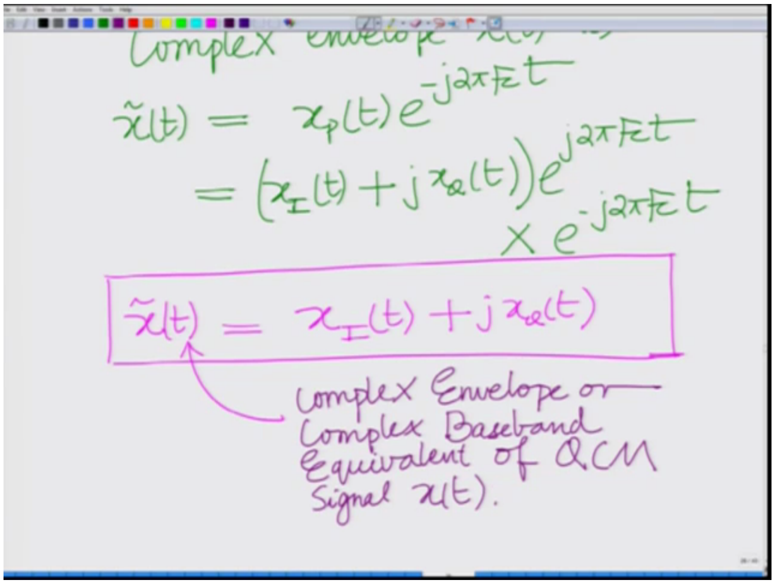

So therefore complex baseband or the complex envelope x tilde t is x tilde t is the complex pre-envelope into e to the power of minus j two pi Fct which is x(t) xI(t) plus j xQ(t) into e to the power of j two pi Fct this is the complex envelope into e to the power of minus j two pi Fct and this is equal to basically simply your, now you can see this is simply xI(t) plus j xQ(t) this is your x tilde t which is the complex envelope you can see this is basically the complex envelope or the complex baseband equivalent of the QCM signal x(t).

This is a complex envelope complex baseband of the QCM signal that quadrature carrier modulated signal x(t). So of the complex baseband equivalent of the quadrature carrier modulated signal interestingly is xI(t) plus j times xQ(t) that is the in phase component xI(t) plus j times the quadrature message signal xqt, okay.

So what we have done here is basically we have taken the standard quadrature carrier modulated signal which arises very frequently in a typical communication system it is a pass band signal derived the complex pre-envelope of that signal that is xI(t) plus j xQ(t) into e to the power of j two pi Fct and also derived the complex baseband equivalent or the complex envelope of this signal which is simply xI(t) plus j times xQ(t) where xI(t) is the in phase signal and xQ(t) is the quadrature signal, alright. So we will stop here and continue with other aspects in the subsequent modules, thank you.