Power System Dynamics, Control and Monitoring
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Lecture – 14
Power System stability (Contd.)

Ok, so next so previous example a little bit of you know nothing to be confuse actually just see very carefully it is a if this example is a very unique example actually. And just you try yourself to derive that thing and most of the things I have derived and I have told you how to do it.

But if you give elaborate your derivation then it will not be it will be very your lengthy procedure and it will consume more time in a video course and video lecture class right.

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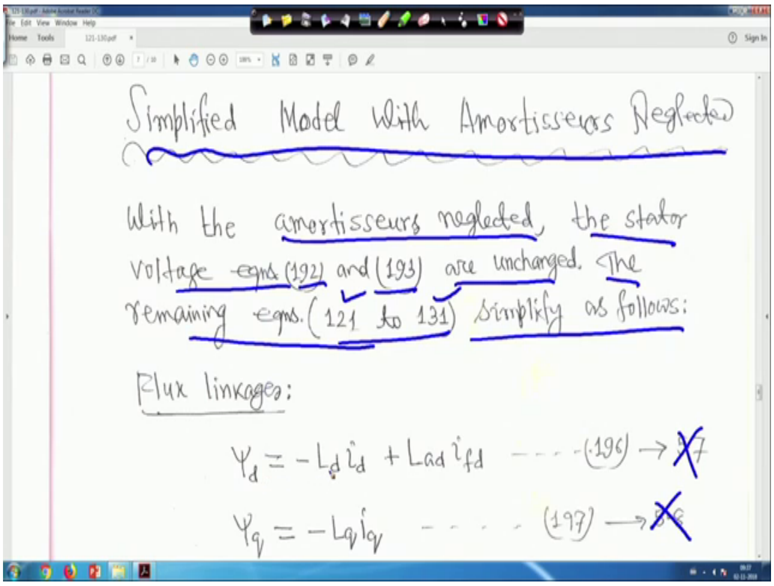

So, next is that your simplified model with amortisseurs neglected right. So, first we will we will take a simplified model. So, with the amortisseurs neglected the stator voltage equation that is equation 192 and 193 are unchanged. But the remaining equation 121 to 131 simplify as follows right.

So, your what you call that your from equation 121 to 131. So, total 11 equations right so because we are neglecting the amortisseur terms. If you do so this is not required for you this is for my reference right. So, psi d is equal to ok, let me move let me move little bit up.

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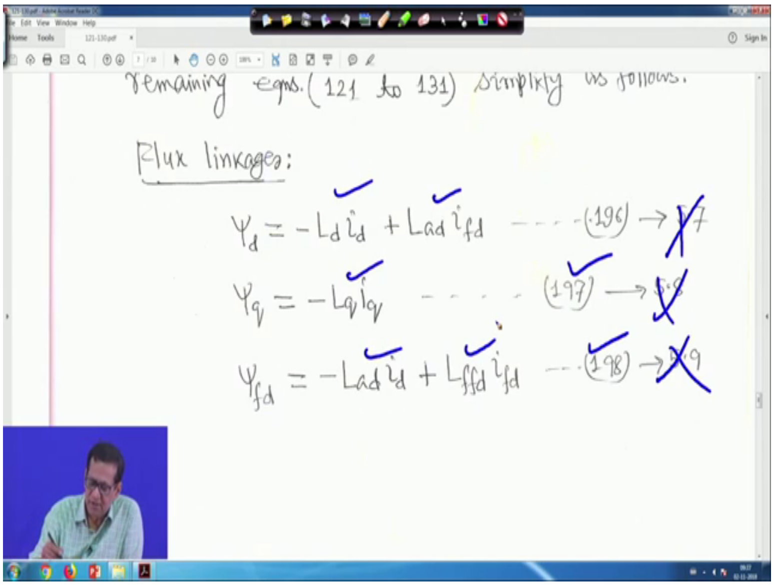

So flux linkage first, so psi d is equal to minus Ld id plus L ad i fd with amortisseurs neglected. This is not for you this is for my reference right. So, psi q is equal to minus Lq iq this is equation 197 and psi f d is equal to minus L ad id plus L f f d i f d this is equation 198. All these nomenclatures all this nomenclatures have been given before so right.

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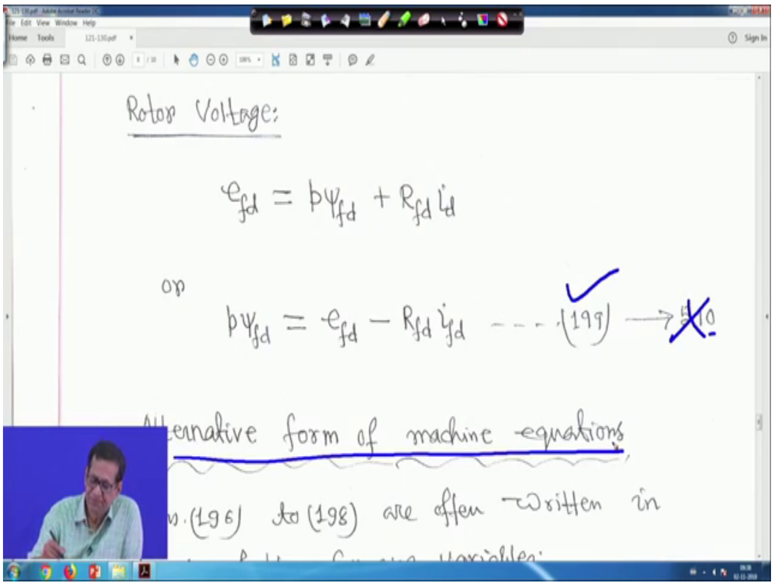

So, next is the rotor voltage equation with amortisseurs neglected. So, in this in here e f d will be p psi f d plus R fd id right or this p psi f d or p psi f d is equal to just rewrite this equation is equal to e f d minus R fd i fd this is equation 199. This is not required this is for my reference right. So, next we will make that alternative form of machine equations. Because we have to make it in till that block diagram whatever you have started it will slowly and slowly it will block diagram will grow later you will see.

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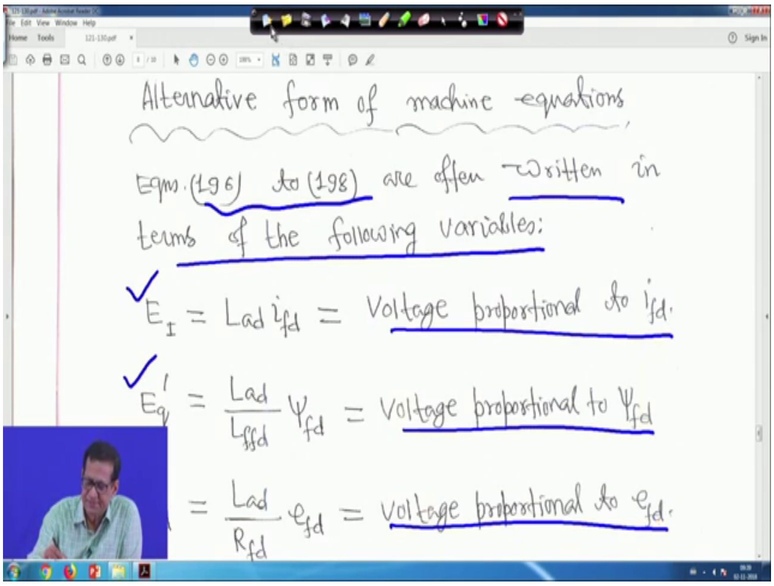

Now, alternative form of machine equations now equations 196 to 198 this we will write little bit different way are often written in terms of the following variables right. That is EI we define a variable EI; E suffix capital I is equal to L ad i fd; that is voltage proportional to i f d right. Another term we write capital Eq dash is equal to L ad upon L fd psi f d that is voltage proportional to psi f d. Another term we write capital E f d L ad upon R fd into your e f d that is voltage proportional to e f d. Because we have to simplify we have to simplify the whole mathematical derivations right. So, we represent like this.

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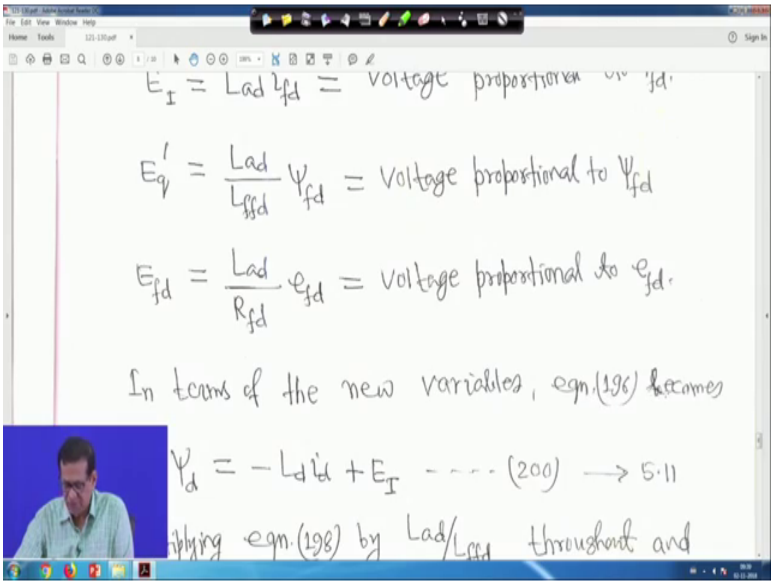

So in terms of the new variables equation 196 will become; that means, whatever we have seen here equation 196, 197 and 198 right. All these things in terms of new variables, it will become that your psi d will be minus Ld id plus EI this is equation your this is equation 200 right. So, this is not required this is for my reference.

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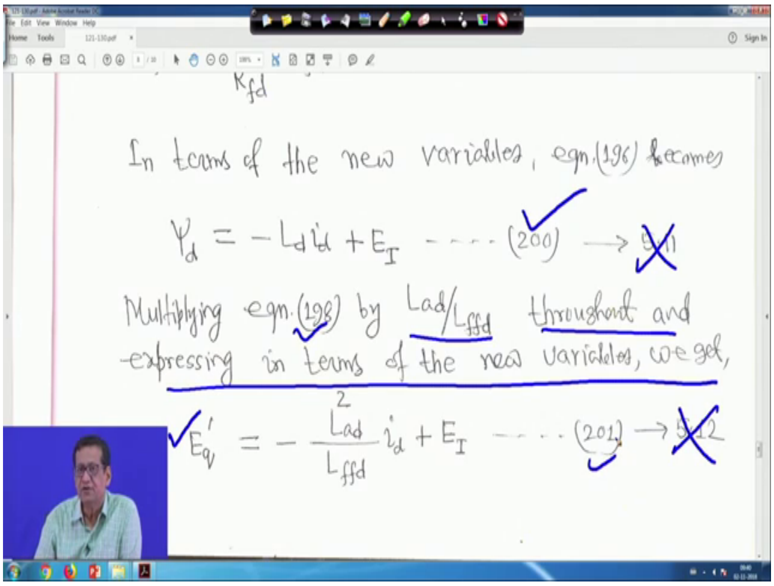

So and multiplying equation 198, you multiply equation 198 by L ad upon L ffd right. And throughout and expressing in terms of the new variables, then you will get Eq dash will be minus L ad square upon L fd L f f d id plus EI. You just equation 198 multiplied both side by L ad upon L a L a f f d and then you simplify and whatever assumptions we have made right and then you can get Eq dash will be minus L ad square upon L f f d id plus EI. This is equation 201 right.

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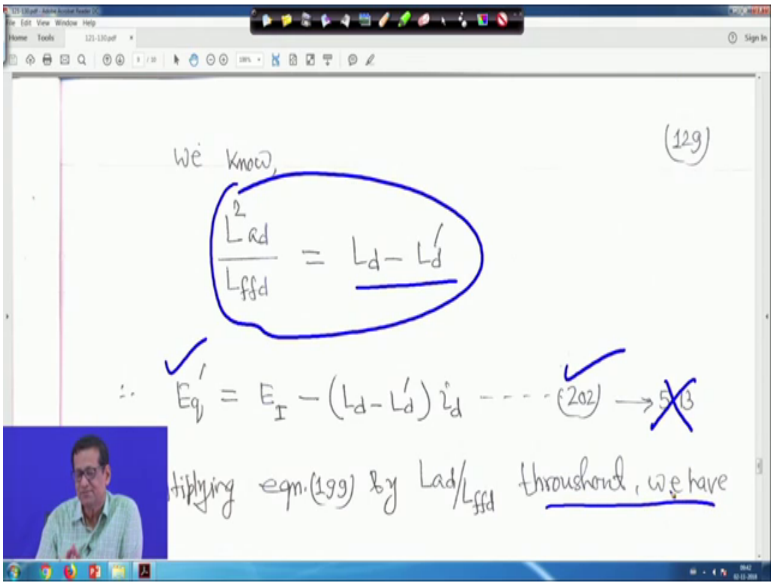

So, now this one we cannot we here what you call we cannot we are not interested to prove this one right. So, we assume L square a d upon L fd L d minus L d dash. This is actually it can be derivation is there, but I will keep that one we will assume that L square a d upon L f f d L d minus L d dash right. And when you will listen to the lecture if you need the your what you call that expression of this one, then we will put it in to the forum right.

But otherwise what will happen the continuity of this your topic will be lost right. That is why L square a d upon L fd it is L d minus L d dash like your X d double dash X d dash half transient, transient steady state reactance's right. So, it can be proved L d minus L d dash. So, L square a d upon L f f d so, but if you have anything you put in the forum we will explain, but here w will we will not then continuity will be lost right. So, that is why I have written we know L square a d upon L f f d is equal to L d minus L d dash.

This also you should keep it in your memory right. So, if it is so then E q dash it can be written as E I that is capital E suffix capital I minus in bracket L d minus L d dash id this is equation 202 right. This is other things for my reference right. Now, what you do now multiply equation 199 by L ad upon L ffd throughout right. I mean left and left I mean left and right side both right.

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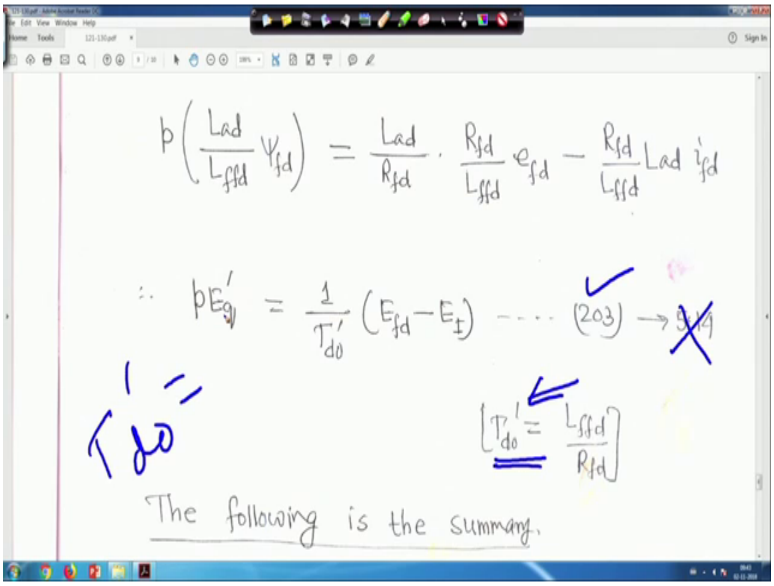

If you do so then we have that is p into L ad upon L ffd psi f d is equal to L ad upon R fd into R fd upon L ffd e fd minus R fd upon L ffd L ad into i fd right. Or this term this term we have as you know if this thing is it will be p Eq dash will be is equal to 1 upon actually T do0 dash into E fd minus E I. And this is T do dash is equal to L ffd upon R fd. I am not telling you know this term so this is question to you what is what is your T do dash?

It is time constant of course but what is the full form right it is time constant. So, this is a small question to you that T do dash is equal to L ffd upon R fd right. And if you multiply and simplify this we will if this equation will simplify become that 1 upon T do dash E fd minus E I this is equation 203 right. So, this is your what you call that your basically it is nothing, but E q dash dot right. So, now the following is the summary.

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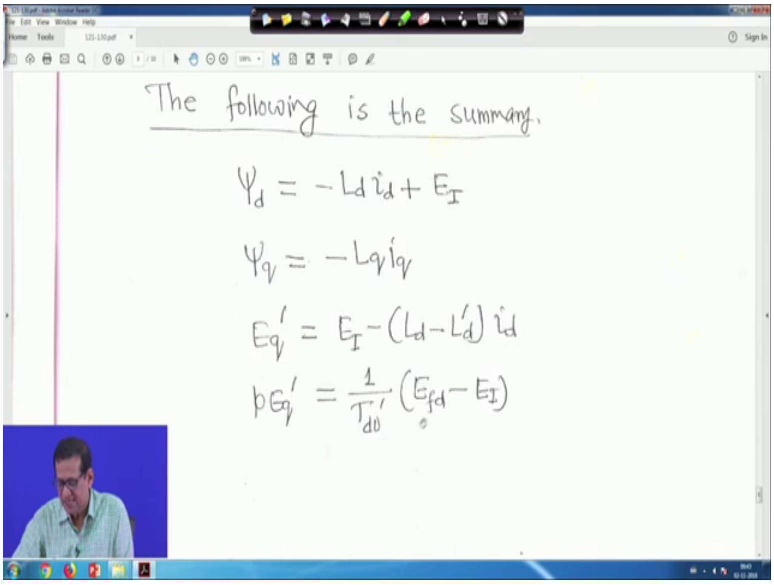

So, summary is that psi d is equal to minus L d id plus E I; psi q is equal to minus L q iq E q dash will be E I minus in bracket L d minus L d dash id right. And p E q dash will be 1 upon T do dash in bracket E fd minus E I this is the summary right. Now, phasor diagram for transient condition right.

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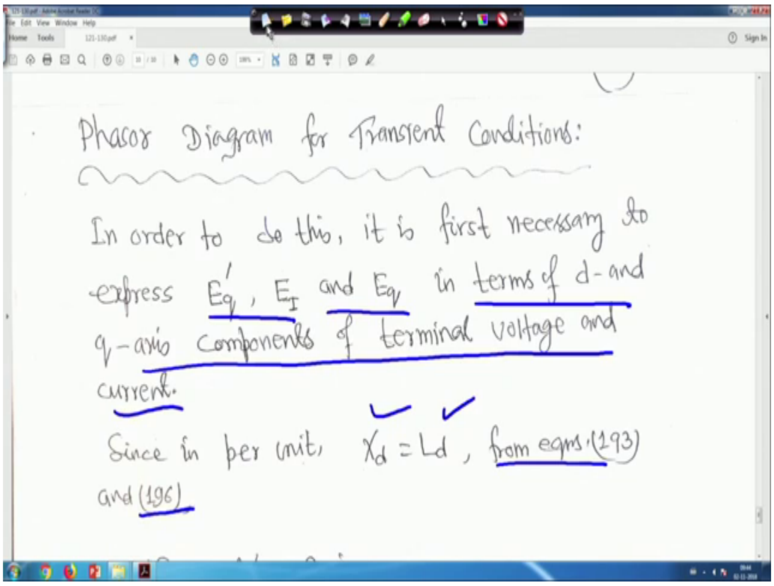

So, in order to do this; this is first necessary to express E q dash E I and E q in terms of d and q axis is component of terminal voltage and current. Because we have to this representation that your phasor diagram for transient condition we want. So, if you do so that that your express E q dash E I and E q in terms of d and q axis component of terminal voltage and the current right.

So, in per unit X d is equal to L d I told you in per unit reactants and inductance are same. So, from equation 193 and equation 196 right we will write like this. So, we will replace L d L d dash by X d, X d dash right. So, it will be something like this.

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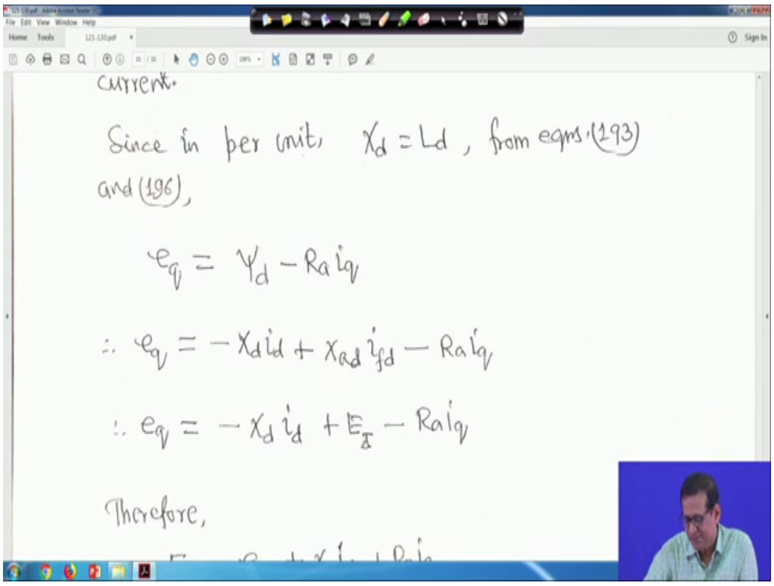

That e q that in equation 193 to 196 e q will be psi d minus R a iq this is same as before right, e q will be instead of L d we will write X d minus X d id plus instead of L ad we will write X a d i f d minus R a i q right because in per unit inductance and reactants are same right.

So, e q will be minus Xd id plus capital E suffix capital I minus R a i q this first you will rewrite right. Therefore, we can write therefore, E I is equal to e q plus j X d id plus R a iq right.

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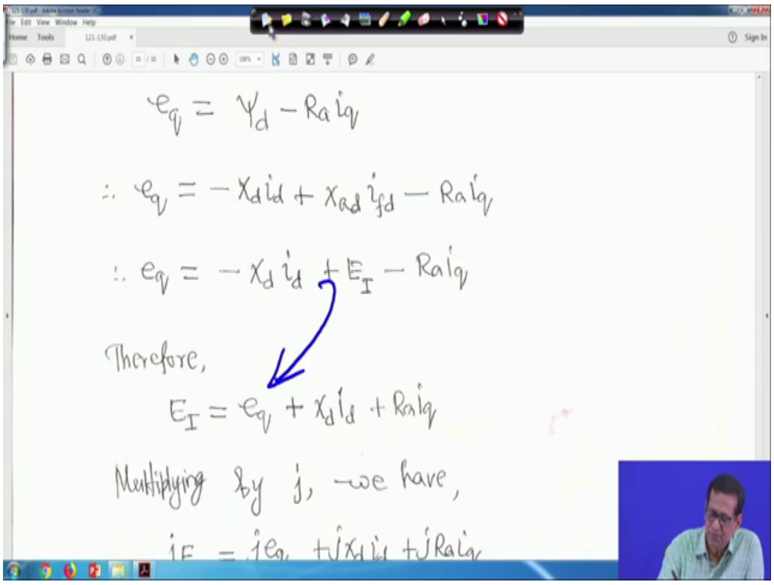

Therefore E I will be e q plus your; I mean from this equation E I will be e q plus I mean from this equation it is coming from this equation only here it is writing E I is equal to e q plus X d id plus R a iq right. Now, multiply both side by j right that is the complex operator.

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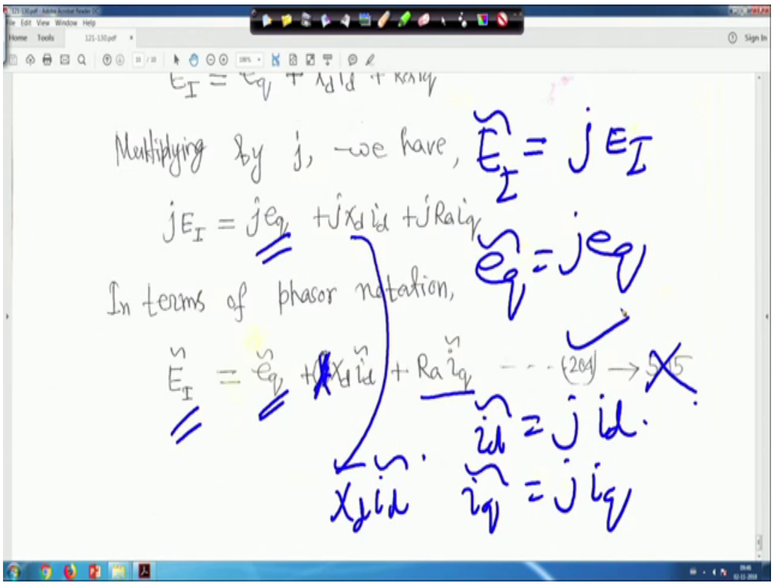

If you do so it will be written as j E I is equal to j e q plus j X d id plus j R a iq right. So, in terms of phasor notation then, this one can be written as E I tilde is equal to j e q can be written e q tilde right and j X d id can be written X d id tilde it is not there this term this term will be actually X d id tilde right.

So, it will be X d id tilde this j is not there, it is when I writing by mistake I made it. So, it will X d id tilde and j iq can be made R a iq tilde. That means, your for your understanding that E I tilde this is actually j E I right because we have to represent by phasor quantity. Similarly, your small e q tilde is equal to j eq right.

Similarly your id tilde is equal to j id right. And similarly your iq tilde is equal to j iq right. So, just to represent that the all our tilde is given these are phasor quantities. So, this way we can write and this is nothing this is for my reference. And this is actually equation 204 right. So, we will go to the just hold on we will go to the next page.

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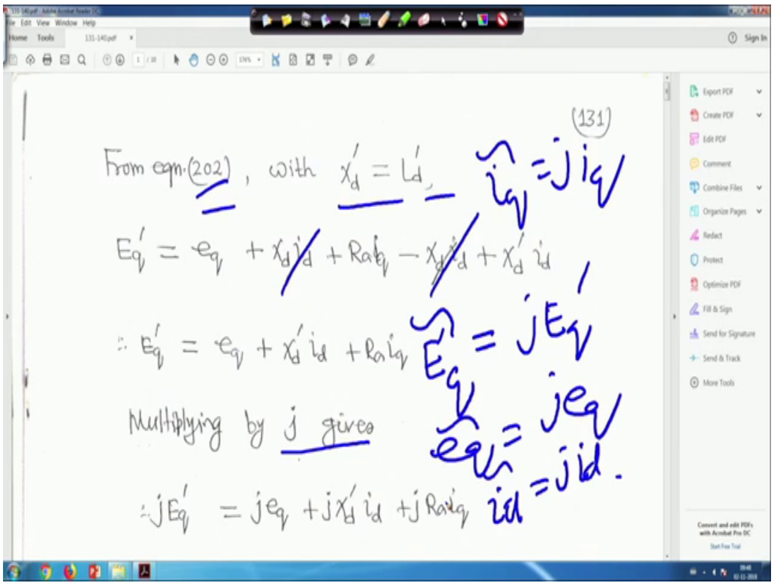

So, similarly you're for equation 202 right; with X d dash is equal to L d dash because I told you in per unit reactance and inductance are same right. Therefore, you can write if it is so that E q dash will be e q plus X d id plus R a iq minus X d id plus X d dash id. So, this X d id and X d id will be cancelled; that means, E q dash will be e q plus X d dash id plus R a i q.

Now, if you multiply both side by j that complex operator. So, it will be j E q dash it will be j e q plus j X d dash id plus j R a iq. Now before going to the next page so, we will define that your same as before the phasor quantity say E q dash your E q dash tilde it is

E q dash tilde will be j E q dash right. Similarly your e q will be e q tilde will be j eq right. Similarly your id tilde will be is equal to j id right.

And similarly here I am writing that i q tilde will be j iq right. So, because we are because we have to represent now your, we have to draw the phasor diagram and for transient condition. So, we have to put them in the phasor form. So that way you can write if you do so then next equation will be in phasor notation.

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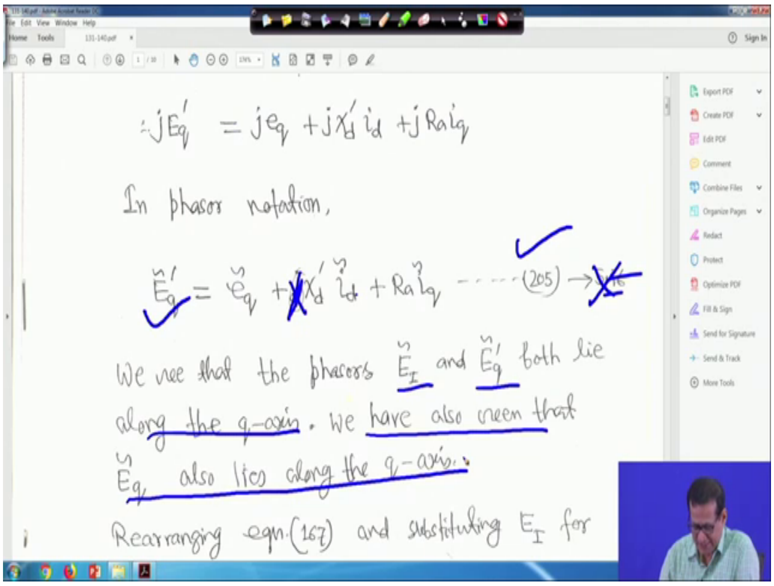

It will be your E q dash tilde E q dash tilde is equal to e q tilde I told you this j should not be there. It will be X d dash i d the, your tilde this should not be there right. Then plus R a i q tilde this is equation 205, this is nothing this is for my reference right.

So, that way first we make this one after this we see that the phasors E I tilde and E q dash tilde both lie along the q axis because multiplied by j only right. So, we have also seen that the E q your tilde also lies along the q axis because all you multiplied by j and all are lying actually along the q axis right. So, what you can do is that if you rearrange equation 167.

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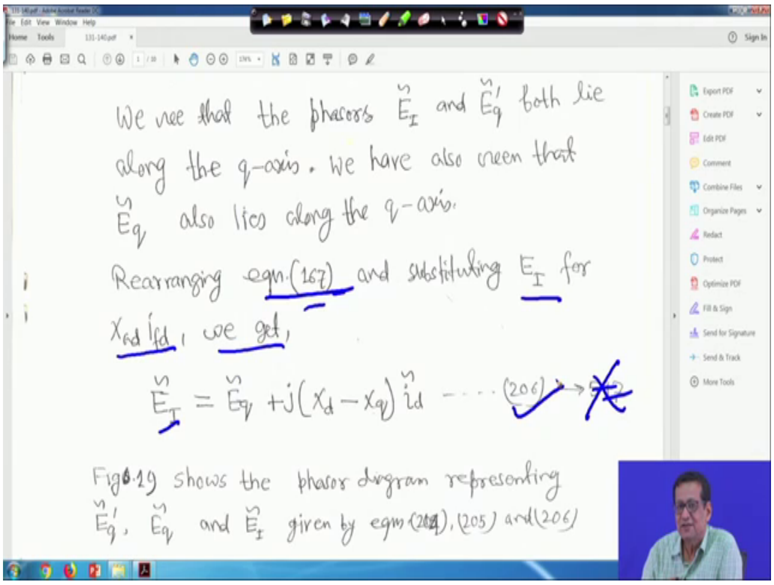

And substitute E I for X ad i f d that go to equation look this is this again and again it is difficult to go back to that equations. Then this is for my reference nothing required that it is difficult to go back again and again. But when we will when you are reading this, I mean listening this lecture at that time notes also will be available right. So, everything will be uploaded.

So, at that times see the equation 167 other and substituting E I for X ad i fd. Then you will get E I tilde is equal to E q tilde plus j Xd minus x q id tilde this is very simple thing actually I mean just you put it and you will get it. By chance if you stuck somewhere you just put a question to the forum a answers will be given there right and absolutely there will be no problem right. So, in that case you will get E I tilde is equal to E q tilde plus j into X d minus X q id this is equation 206 right.

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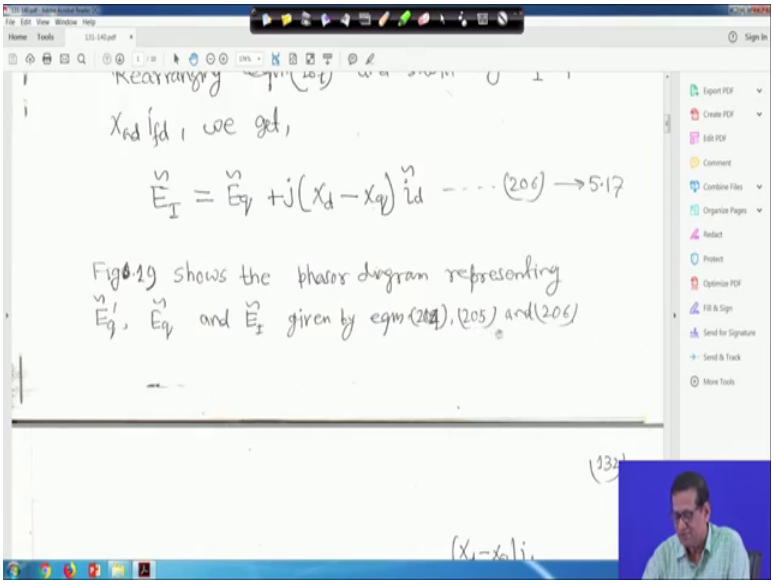

Now after doing all this figure 19 actually shows the phasor diagram representing E q dash tilde E q tilde and E I tilde given by equation 204, 205, and 206. So, this 204 this equation previous 204 has gone to the previous page 205 and 206 right.

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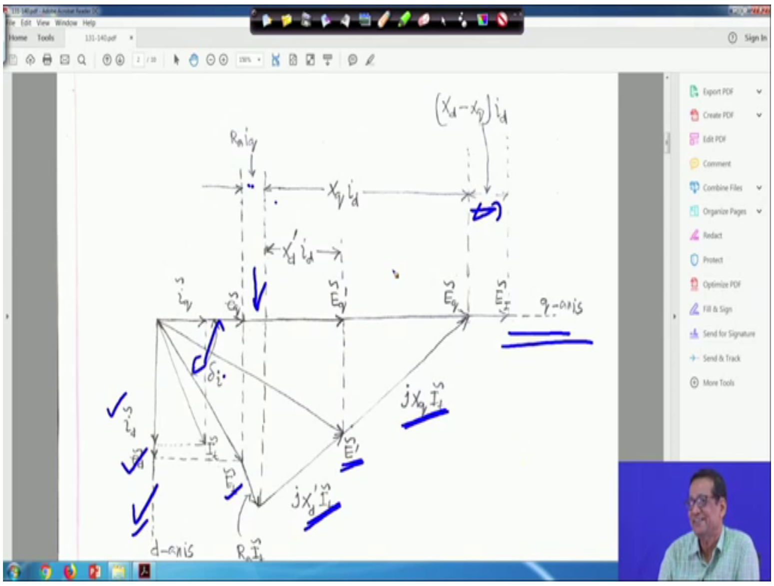

If you draw the phasor diagram the phasor diagram will look like this right. I mean just hold on if I can reduce the percentage little bit then all so here it is accommodated right. So, in this case if you see this that, this is my q axis for my own drawing this is has been taken q axis such that and this is your d axis this is your d axis right. Such that drawing will be phasor diagram drawing will be here you know like easier way.

So, this E I tilde E q tilde E q dash tilde and E q tilde and of course, i q tilde all are your, what you call lying on that your q axis right. And if you look into that that E I tilde is equal to E q plus X d minus X q id because just know we have seen that E I tilde is equal to E q plus X d minus X q id. So, this is your this portion is X d minus X q id. And from here to here this is the, and this voltage this voltage is E t tilde right.

And this voltage is E dash tilde right and this angle that is between your what you call this E E E your what you call that E t tilde and E q tilde E q tilde or E I tilde or E q dash tilde whatever it is. This is that your delta i this angle is delta i right this we have seen earlier also and this is the current I 2 tilde. So, current is lagging from E t right because this is E t tilde and this is I t tilde. So, this current is lagging and this is your i t tilde and e d this is d axis right. So, that when this and this current is i q tilde all are along the q axis.

So, if you now and this term this your from here to here from here to here this term is X q id this we have seen just look at those three equations you will get it this term is Eq. And this term is R a iq right. This term is R a I q I mean from here to here because this is my I t and this is my E t tilde. So, this term is actually this term is R a iq just see those equations its I mean you will simply get it like E q like E q dash tilde is equal to e q tilde plus R a iq plus X d dash id and all this things are there in the equations.

So, I could just see the equation and just make this make this phasor diagram. And this term your j X d id I t tilde right and from here to here this is j X q your, I t your tilde right. So, just see those E three equations and just make this phasor diagram this phasor diagram is under transient condition right. So, all these things are drawn just you have to open the notebook and you have to make it right from this three equations.

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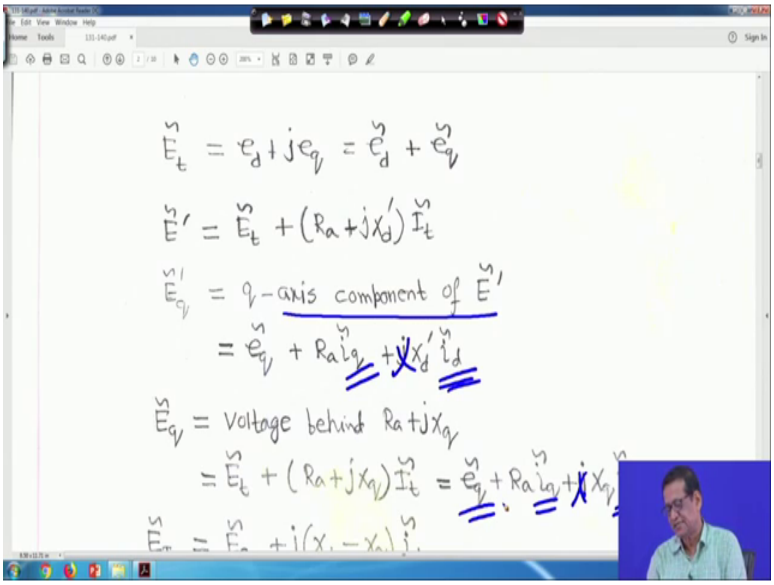

So, just for your reference I have written that E t, E t your what you call that your I am now little bit zooming it. So, E t just hold on so E t tilde is equal to e d plus j e q is equal to e d tilde plus e q tilde this way we write this way we write right so whatever has been drawn here. And similarly E tilde E E dash tilde is equal to E t tilde plus R a plus j X d dash I t because a you are we have we have replaced L d dash by X d dash right.

I t tilde and E q dash tilde that is q x is component of E tilde dash or E d dash your E E dash tilde right is equal to e q tilde plus R a i q tilde plus j X d dash id your what you call here one thing is there it should not be there it is X d dash id id tilde right this should not be there. Now, at E q tilde is equal to voltage behind R a plus j X q it is voltage behind R a plus j x q. So, here also one j should not be there it is E t tilde plus R a plus j X q oh no here I have multiplied by this thing sorry, sorry. Here also here also sorry. Just hold on just hold on here actually it is multiplied.

So, R a here what you call your q axis component that e q tilde R a i q plus j X d id here tilde right. And similarly your this thing your Eq tilde voltage behind R a plus it is E t tilde plus R a plus j X q I t. So, it is E q tilde plus R a i q no this should not there it is correct it is correct right it is correct. Because we are making already id tilde and this is i q tilde and this is id tilde and this is i q tilde e q tilde all are in phasor quantity right so, this j should not be there.

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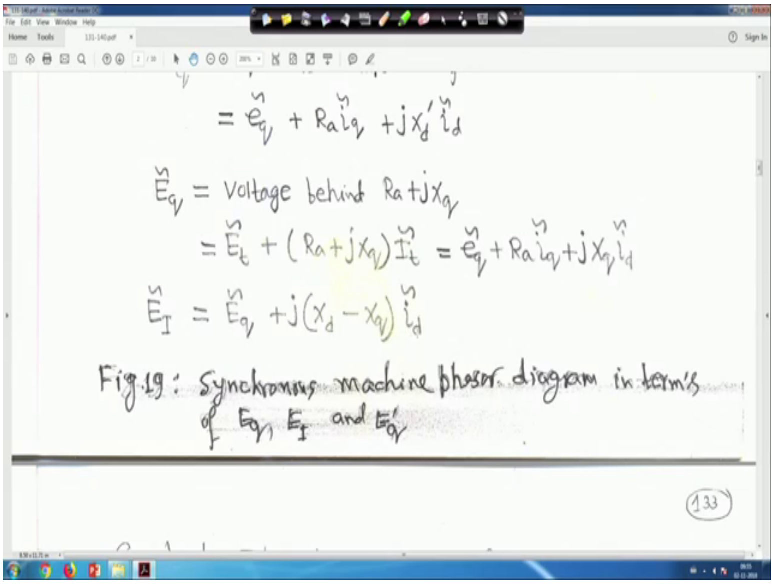

So, similarly your E I this thing your tilde is equal to E q tilde plus j X d minus X q id tilde right. So, this is your figure 19 that is this is the figure 19 right. And this is your synchronous machine phasor diagram in terms of E q E I and E q dash right. So, that is your what you call that is your phasor diagram and this is your X q and this is id let us me have a look Xd x q i t dash i t tilde so this is the phasor diagram.

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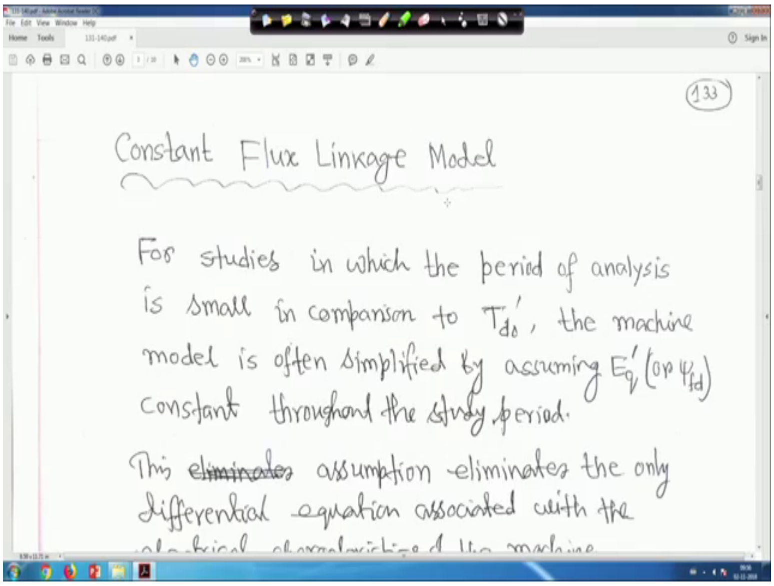

Now, next is that constant flux linkage model right. For studies in which the, it is constant flux linkage model. So, before going to your constant flux linkage model I will suggest that just have a look all these things once again right. And throughout all the derivations are there it is basically you know that power system dynamics control course is basically synchronous machine course and it may huge mathematics is involved later we will see much more mathematics right.

If you see by chance if have made any error even anything is there you please put the question in the forum such that I can rectify myself right. So, this is one thing so many things we have made j operator and other thing if you see anywhere I have made any error or anything you just please here what you call put that in the forum right. So, next is constant flux linkage model.

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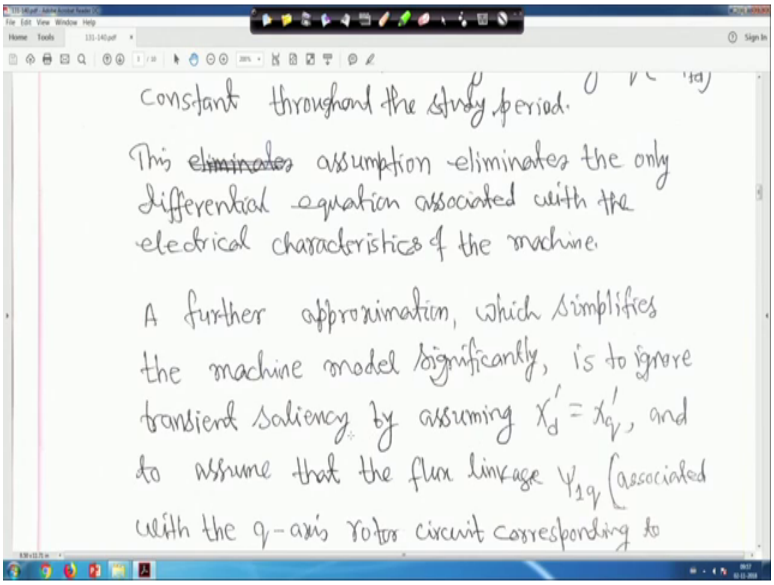

So, for studies in which the period of analysis is small in competition to T do dash the machine model is often simplified by assuming E q dash or psi fd constant throughout the study state period right. Now this assumption eliminates the only differential equation associate with associated with the electrical characteristics of the machine.

A further approximation which simplifies the machine model significantly is to ignore transient saliency by assuming X d dash is equal to X q dash and to assume that the flux linkage psi 1q associated with the q axis rotor circuit corresponding to X q dash also remain constant right because we are going for your constant flux linkage model right.

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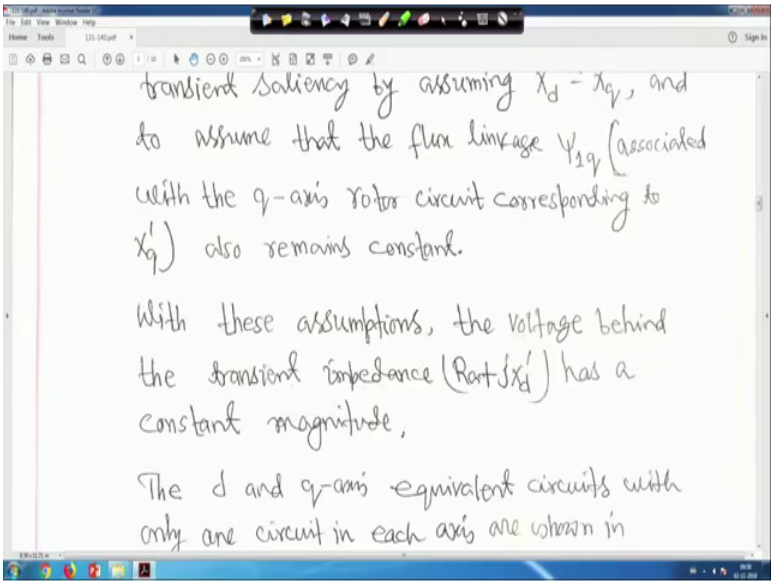

Now, with these assumptions the voltage behind that transient impedance that is R a plus j X d dash has a constant magnitude right.

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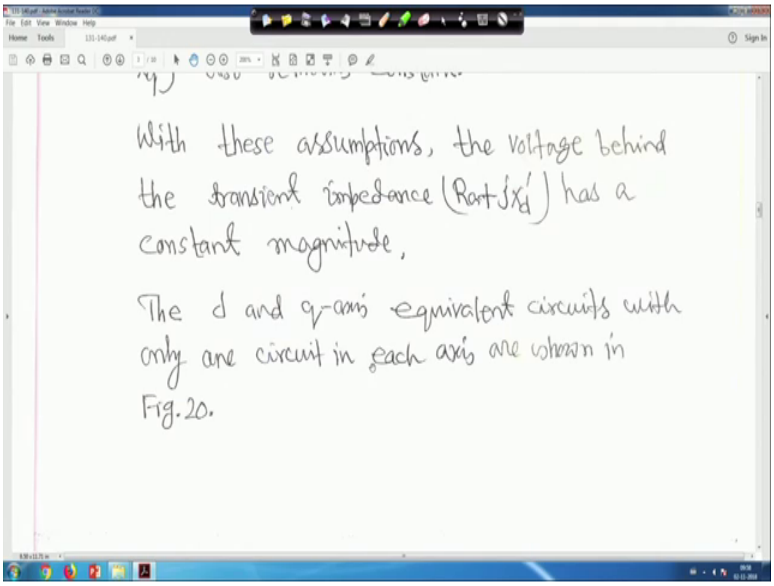

That d and q x is equivalent circuit with only one circuit in each axis are shown in figure 20 right. So, if you if you that d axis d and q axis equivalent circuit with only one circuit in each axis are shown in figure 20.

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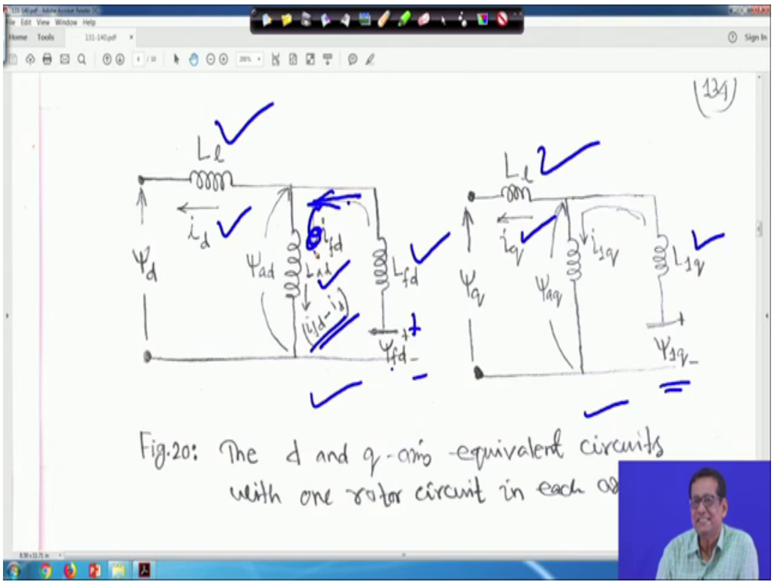

That means this actually it is a analogous to your what you call the dc circuit. Where this is psi d whenever you are showing a arrow means it is positive and no arrow means it is negative. And this is psi ad and this is actually this is this is actually psi fd and current. So, this is actually i fd minus id right. And this is actually plus minus this is psi fd and this is L fd.

So, it is it is something like your what you call that analogous to dc circuit. So, this is d axis and this is q axis this is psi 1q, this is L 1q and this is psi aq, this is psi q and this is i q and this is L l. And this is also capital L suffix L and this current is i d this current is i q and this is actually L ad right. So, the d and q axis equivalent circuit one with one rotor circuit is each axis. I mean whatever equations we have seen before this way you can represent I mean if we can put the circuit like this. So, it will be analogous to the dc circuit right.

So, from this also I mean from this also you can write all that equation. For example, sorry for example, psi ad will be L ad into I fd minus psi d right and you can apply k v L also if you apply k v L for example, if you apply k v L say here if you apply k v L.

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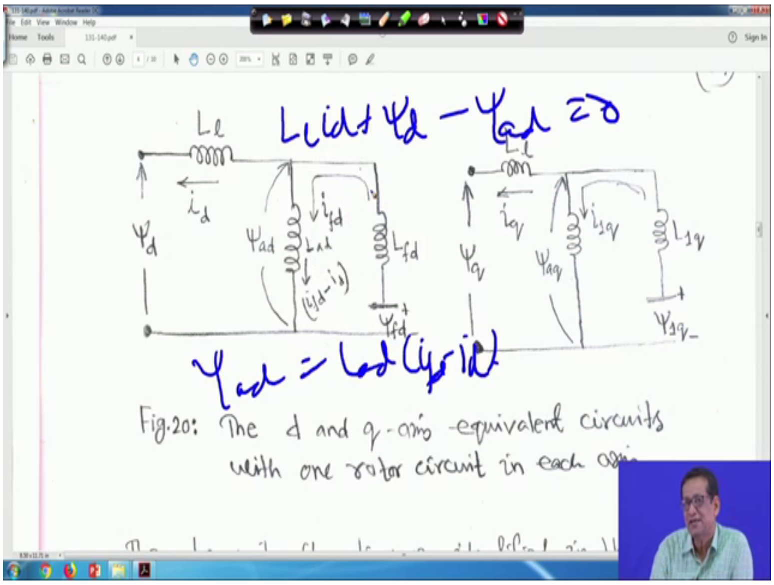

So, it will be L l id plus psi d minus psi a d is equal to 0. This equations you have seen. And similarly if you write psi ad from here it will be L ad into i f d minus id right and here also you can apply the in the in this in this mesh also you can apply k v L right. So, whatever equations you have written this way you can represent the circuit right.

So, now the per unit flux linkage identified in the d axis is given by your psi ad is equal to minus L ad id plus L ad i fd. That means, this one we are write directly you can write psi f d is equal to i fd into i f d minus id then you multiply. And you simplify it will be a psi ad is minus L ad id plus L ad i fd.

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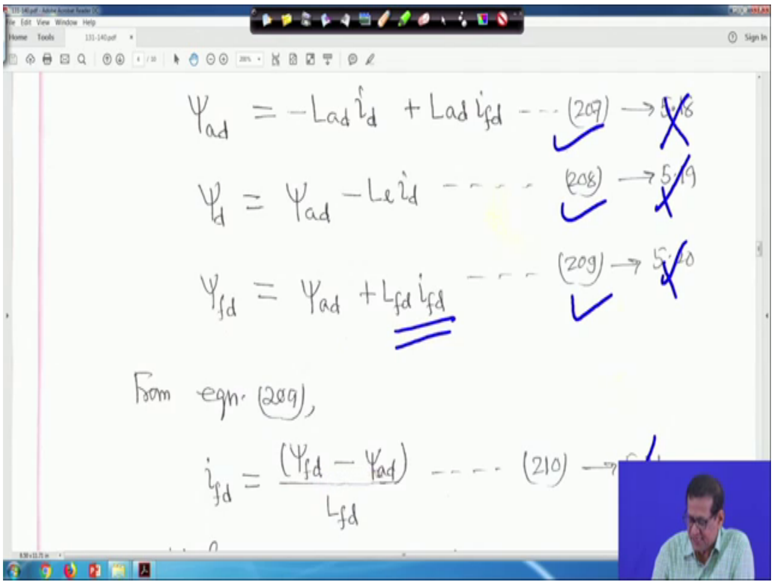

Similarly psi d will be I told you that k v L that psi a d minus L l id and similarly psi f d will be psi ad plus i fd i fd. I mean here I mean here there should not be any confusion here, this current is i fd actually this in this branch current is i fd minus id.

Now, if you apply your k v L right if you apply k v L say anticlockwise then your it is L fd then your i fd i fd i fd plus L ad then i fd minus id this term. Then minus psi f d is equal to 0 because this plus this is minus minus psi f d is equal to 0 and you simplify right.

So, if you do so if you do so you will get psi fd is equal to psi ad plus L fd i f d. This is equation your what you call 209. So, this is this is nothing this is for my own reference this is nothing this is 207 208 209 right.

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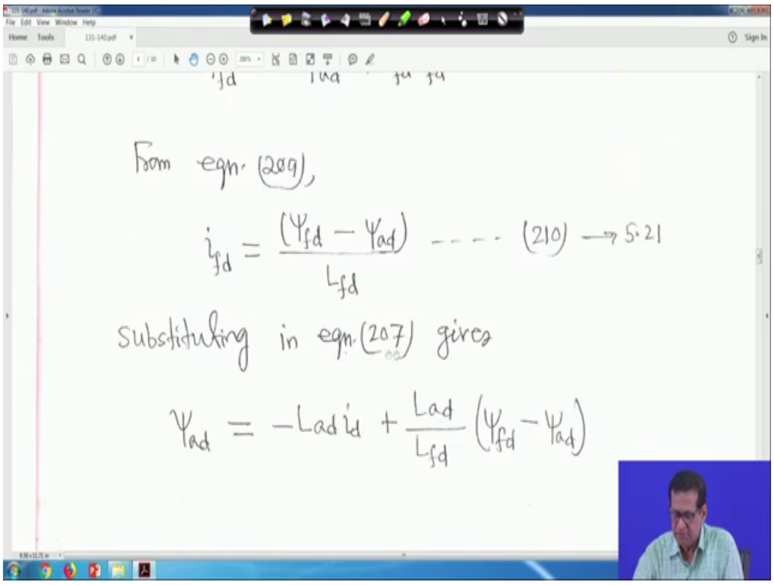

And from equation 209 from this equation you can write i fd is equal to psi fd minus psi ad upon L fd this is equation 210 right. So, if you substitute in equation this one in equation 207 that mean this equation you substitute for i fd. If you do so you will get psi ad is equal to minus L ad id plus L ad upon 004C fd in bracket psi fd minus psi ad right.

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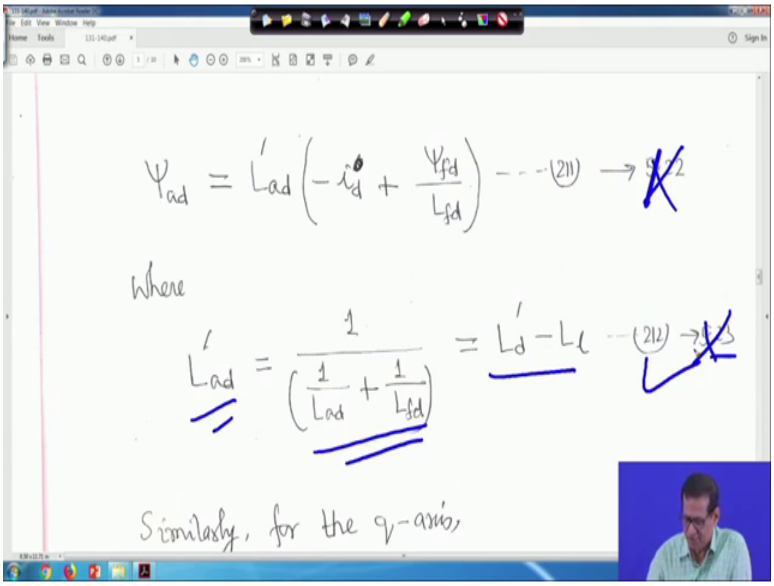

So, therefore, we simplify this one we can write this equation like this that psi ad is equal to L ad dash in bracket minus i d plus psi fd upon L fd, this is equation 211 right. I just hold on so this is for my own reference this is nothing for you. So, where L you put it and simplify you will get L ad dash you can write 1 upon in 1 upon 1 upon L ad plus 1 upon L fd. And this is nothing but your L d dash minus your L l this is equation 12 right.

Similarly for the q axis I mean for this circuit similarly for the q axis again you apply k v L you please do yourself right I mean. So, all these things are derived before, but just we have put it that your at the analogous this is analogous circuit right for that flux linkage equation. So, this is from this your, what you call from this figure only you can get like this right this one.

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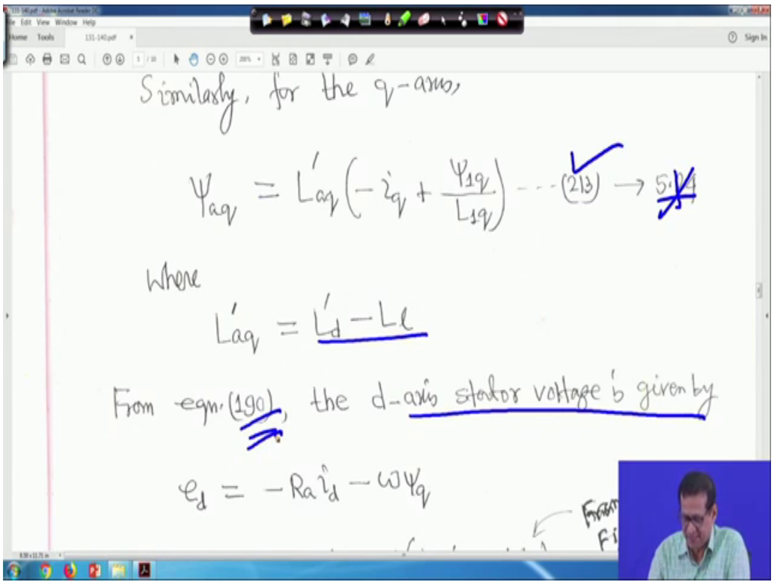

Similarly, for the q axis only that from the figure you write those equations and simplify you will get psi aq is equal to L aq dash in bracket minus i q plus psi 1q upon L 1q this is equation 200 your 13 213 right. This is, this is nothing this is for my reference where L aq dash is equal to L d dash minus L l right, same as before. So, from equation 119 that d axis stator voltage is given by e d is equal to minus R a id minus omega psi q. We go back to equation 190 right.

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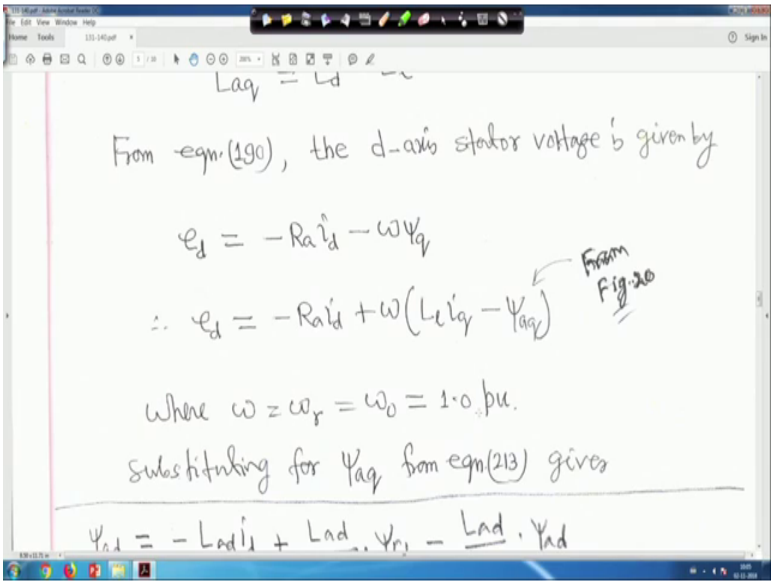

So, and therefore e d is equal to minus R a id plus omega and psi q is equal to L l i q minus psi here what you call psi aq from that q axis that your analogous circuit diagram is there from there just you apply k v L that psi q is equal to is equal to L l i q minus psi q this is from figure 20. I have written here; that means, from here ; that means, from this figure from here right from this figure.

You apply it will look it will if you apply k v L I am telling from my mouth it will be L l into i q plus psi q minus psi aq is equal to 0 from there you substitute right. From there you substitute that your this thing this is that is why it is written from figure 20 and where omega is equal to omega R is equal to omega 0 say 1 per unit all are same. So, if you and substituting for psi aq from equation 213 right you do this you will get psi.

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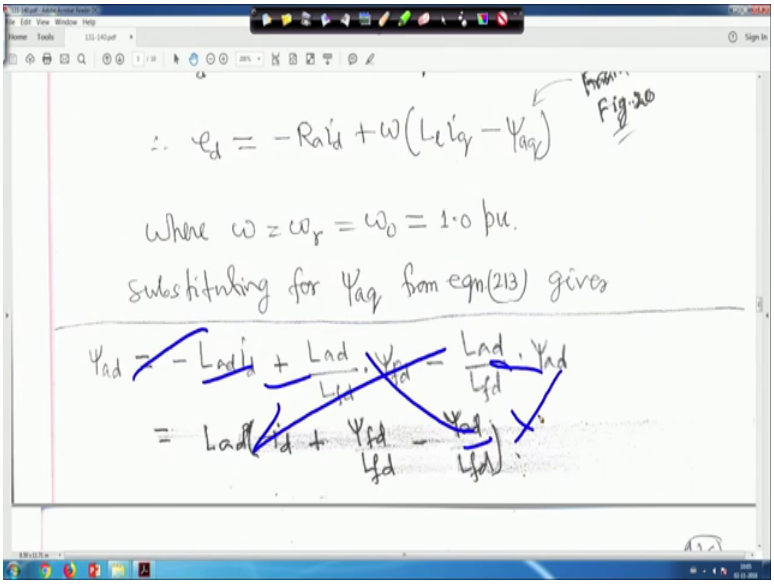

Here what you call that this is nothing this is no you need not you this is nothing for you this is no need right you better you skip this one go to the next page this is nothing for you right. So, go to next page.

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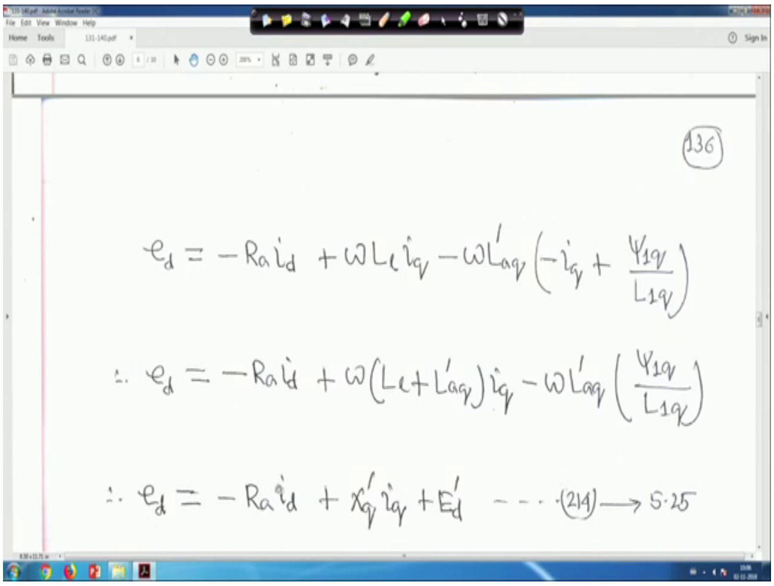

Then you will see that e d will be is equal to minus R a id plus omega L, L l i q minus omega L aq dash in bracket minus i q plus psi 1 q upon L 1 q right. Or you will see e d is equal to minus R a id plus omega in bracket L l plus L aq dash i q minus omega L aq dash in bracket psi 1q upon L 1q or or it can be written as minus R a i d plus X q dash i q plus E d dash.

So, next is phasor diagram for transient conditions right. So, in order to do this it is first necessary to express that E q dash, E I dash, and E q right. In terms of d and q axis components of terminal voltage and current right. So, we know that in per unit that reactance is equal to inductance. So, X d is equal to L d therefore, from equation 193 and 196 right. So, whenever you will go through it that all the previous lecture notes will be available to you. So, immediately you will open that equation 193 and 196 right.

So, e q will be small e q will be psi d minus R a i q right or e q is equal to substitute expression for psi d right previously we have derived that. So, minus X d id plus x a d I f d minus R a i q right. So, this terms small e q is equal to minus X d id plus capital E suffix I minus R a i q right. Therefore, we can write that E I this E I is equal to capital E I is equal to e q plus X d id plus R a i q right.

Now, question is that you multiply both side by j. If you do so it will be j E I is equal to j e q plus j X d i d plus j R a i q. Now in terms of phasor notation in terms of phasor notation your then basically it is E I. So, whenever we are doing this I mean before explaining this one right just hold on before explanation of this one we will go to the next page right. So, I am not multiply both side by j so it its matter that j means that is your q x is actually leading the d axis by 90 degree right.

So, whenever you make it so basically E I E I tilde is equal to your is equal to your E I right. This is angle 90 degree that is nothing, but your j E I right j E I right. So, similarly your e q tilde also is equal to your e q angle 90 degree. So, j e q, but this is this j will be there j X d id because your id actually if aq actually leading the here what you call the d axis by 90 degree.

So, that is why if this id tilde then your this i d tilde will be is equal to i d then angle is what? Because i d is q your q is leading that here what you call id if you take that your i d is a reference one then it will be angle 0 right. But this j should be there from the phasor notation and i q also because this i q also along the q axis. So, it is j i q we are taking that is your i q angle 90 degree so it will be actually j X d i d tilde right. And if you think that id is the, your d axis is the reference one the q is actually leading the d axis. So, this j should be there right in the phasor in the in terms of the phasor notation.

So, next we will go to the next one phasor diagram right. So, now from equation 202 with X d dash is equal to L d dash. Therefore, E q dash can be written as your e q then you then it will be plus X d i d plus R a i q minus X d i d plus X d dash i d dash. So, X d i d and X d i d will be cancelled Therefore, E q dash will be e q plus X d i d plus R a i q. Here also you multiply both side by j. So, in that case it will be j E q dash is equal to j e q plus j X d dash i d plus j R a i q right.

So, in phasor notation from the same philosophy right from the same philosophy this j should be there. So, it is E q dash tilde is equal to e q small e q tilde plus j X d dash i d plus R a i q tilde; that means, your here I making it; that means, your E q dash E q dash tilde is equal to basically your E q dash E q dash and angle 90 degree that is j E q dash this is j E q dash. Similarly for small e q tilde right similarly for i q tilde and I told you that q X is leading this one. So, it we will be j X dash i d tilde. So, this is your phasor this is for my reference nothing this is equation 205 right.

Now, we see that just hold on let me clear it. So, we see that the phasor just hold on. We see that the phasor E I tilde and E q dash tilde both lie along the q axis we have also seen that E q tilde also lies along the q axis just on the previous page. So, rearranging equation 167 right. So if you that is and substituting E I for X a X a d I f d right. We get that E I tilde you go back to equation now 167 and you your X ad i fd you replace by E I then you will be E I tilde will be E q tilde plus j X d minus X q i d tilde this is equation 206 right.

So, figure 19 shows the phasor representing E q dash tilde then capital E q tilde then E I tilde given by equation 204 205 and 206. Now if you draw the phasor node diagram this is your q axis this is your d axis. So, this is for easy understanding this thing q axis actually leading the d axis by 90 degree. So, this is your capital E I tilde look at that all these things right. So, E I just now we have seen know equation 216 E I tilde is equal to E q tilde plus X d minus X q into id right.

Similarly, your this is your E q tilde this is E q dash your tilde right. So, it is basically E q small e q tilde plus R a i q plus X d dash id dash right. And from here to here this distance is X q i d and this is that your current I t tilde right and. And this is your voltage E t tilde and this is this portion is R a I t tilde this portion is X d I t dash your tilde into j. And this is your E dash tilde and this is your j X q I t tilde right.

So, this is the, and this angle is delta i; earlier we have explained about delta i. A nd this is your q axis component I q tilde of I t dash this is q axis is component and d axis is component for this one it is i d tilde right. Similarly for your E t that d axis is component E d tilde direct axis component and for E t tilde it is Eq tilde right and this this one your x axis component is your R a i q right.

So, this is the compete phasor notation from this your three equation 204, 5 and 6 previous page 204 is there. This is 205 and here also j j is should be there this j should be there right this j should be there this is phasor notation. So, so that is why your this is your ah; that means, at the bottom the E t tilde is given E d plus j E q E q is equal to E d tilde plus E q tilde. So, I told you previously E q tilde is nothing, but j E q. Similarly E dash tilde is E t tilde plus R a plus j X d dash I t tilde.

So, most of the cases actually we will find R a is very small right and it is neglected. So, I will suggest one thing that neglect R a and redraw the phasor diagram just neglect R a. And E q dash tilde is q x is component of your E dash tilde right. So, it is e q tilde look at the phasor diagram everything is given there R a i q tilde plus j X d dash i d tilde right. Because, because this j should be there because if you take that i d is a reference though id tilde will be actually i d angle 0 degree right.

So, and Eq tilde will be voltage behind R a plus j X q that is also given. It is E t tilde plus R a plus j X q I t that is Eq tilde plus R a I q plus j X q i d all these things are given in the phasor diagram and this equations also shown. And E I tilde is equal to E q tilde plus j X d minus X q id tilde. This is the summary of this phasor diagram all the equation and this is synchronous machine phasor diagram in terms of E q E I and E q dash. I think this portion is now understandable for this phasor diagram right.

Just see this equation 204, 205 and 206 and just see how it has been drawn. The way you draw the single phase (Refer Time: 39:42) circuit or three phase (Refer Time: 39:43) circuit phasor diagram right the way you draw single phasor circuit phasor diagram only three equations you put in front of you and just see how it is drawn. So, automatically you can easily draw this phasor diagram ok. So, next will be this constant next it will be your constant flux linkage model.