Dynamics of Physical Systems
Prof. S. Banerjee
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 16
The Bond Graph Approach – IV

Well, in the last class, we were beginning to learn how to obtain the differential equations from the bond graph. And we learnt that we essentially asked two questions. One we asked about all the elements what do they give to the system, and we asked to this integrally causaled storage elements what do, they received from the system. So, just by answering these two questions and trying to express the answers in terms of, the identified state variables, we get the equations. And we had done it with respect to one system, in the last class let us recapitulate by working out another example.

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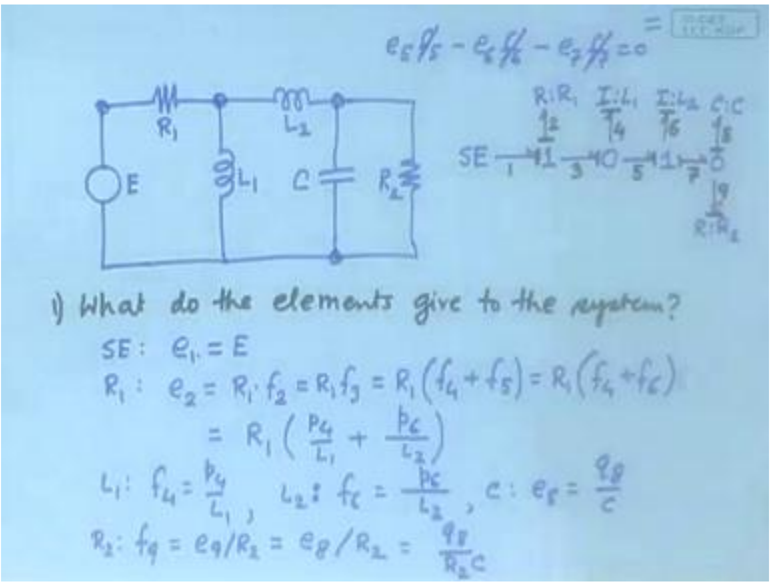

Let us take a circuit example today, so in this example we have a source of effort E then connected to a resistance, connect to an inductance here, is another inductance, here is a capacitance and finally, another resistance. Suppose, this is my circuit there will be R 1 R 2 here L 1 L 2 here and C, so when we begin to do the bond of this we start from one of the ends say the S E element. So, we start from the S E element here it shares the same flow with R 1, so it will be a 1 junction connected to an R which is R 1.

Then this combine shares, the same effort with the L 1, so it will be connected to a 0 junction, with L with I which is L 1, you see inertial element which is designated as I. Notice that I am not directly writing L 1 here, there is a generic representation of a resistive element as R inertial element as I, so we are writing that way. Now, after this stage it is in series whatever this combination is that shares the same flow with L 2, so it will be a 1 junction connected to I L 2.

And finally, here these two share the same effort, they have the same voltage, so it will be a 0, there will be two things connected 1 I will connect this side it is R, which is R 2 and here it is C, which is just only one C. It is visible, so that completes the story. Now, let us put the power directions and the numbers. Now, when we want to put power directions, we start from the S E element power directed outwards, these ones will have the power directions into the elements and here.

Since, the power is flowing in this direction there is only one power source therefore, it is logical to put the power direction here like this, so you may choose to do it otherwise because these are bond to junction to junction bonds. So, let us do it this way now let us give the causalities, how do you assign the causalities where would you start.

Student: ((Refer Time: 05:04))

Let us start from the source of effort, the effort is causal in what way this way, because it receives the flow information and gives out the effort information. Then this element I normally what does it do.

Student: ((Refer Time: 05:25))

In this one is it completely causal, no because, it has not yet is a 1 junction it has not yet received the flow information, so only when it is does. So, we will say that it is completely causal, so here we will first put this which means that the I element is receiving the effort information and giving out the flow information and it has come to the 0 it is not yet causaled, because 0 will be completely causal, if a strong bond brings in what information, effort information.

So, let us move to the next one, here let us put the, the moment you do that the flow information has come into the 1 junction. And therefore, the flow information must go out of the 1 junction, so these two are immediately causaled fine. Come to the this point, now see it has taken out the effort information, it has taken out the effort information and therefore, this bond must be on the effort information, so it must be like this. So, here is a 1 junction, which has received the flow information and therefore, the flow information must go out.

Now, you come to the last one 0, which has received the flow information, but you need a effort information normally, the C element would create the effort information and bring it here. And therefore, the moment you do that, the other ones are immediately causaled, because this has brought in the a effort information and effort information will go out through these two which is going out.

So, all these bonds are now causaled is that clear, now we let us give numbers, simply 1, 2, 3, 4, 5, 6, 7, 8 and 9 done, so we are through as far as the as far as, drawing the bond of the concern we are through now the next step is to obtain the equations. Now, let us ask the first question, so that is the first question let us ask this question to all the elements let us start.

First S E what does it given to the system.

Student: Effort information.

S E gives the effort information, which is e 1, so e 1 which is we know E, next come to the R 1, so R 1 what does it give to the system R 1 notice here, you have to refer not to this, but to this in order to find out what it gives, it gives effort.

Student: Effort.

It is not by elements, see apiary unless you draw the bond graph, because a R element could give both the information's. Now, here in this specific case it is giving out the effort information, so you start with e 2, e two will be related to its own character which is,

Student: R 1 times.

Yes R 1 times f 2, then we have to find out where did this f 2 information come from, f 2 information has come from this as the strong bond. So, this is equal to R 1 f 3, now f 3 information where did is come from 0. Therefore, f 3 is a combination of this and that and notice the power directions the f 3, because the voltages are equal efforts are equal, so f 3 is equal to f 4 plus f 5 is that right, because of the power directions remember that.

Had the power directions been opposite, then it would have be it would be some minuses, so here it is R 1 f 4 plus f 5 done. Now, f 4 is known why because, it is a state variable, so we are through. F 5 what is it, f 5 should be coming from somewhere and f 5 is coming from this bond f 6. So, is R 1 f 4 plus f 6 actually, now we can write the things properly, R 1 into f 4 is, f 4 is what?

Student: ((Refer Time: 11:18))

Actually, while writing this we should have done it for the storage elements first, because then it would be directly available, but we can see the f 4 is P 4 by L 1. So, it is P 4 by L 1 plus f 6 is P 6 by L 2 done, have you notice how we went about, we basically try to figure out where does the information get created and we reached that particular thing, this will always be some storage element. And therefore, ultimately we get the right hand side in terms of the state variables fine.

Next we move on to these three, these three would be trivial, for L 1 what does it give to the system.

Student: f 4.

Yeah, f 4 which is P 4 by L 1, then L 2 what does it give to the system f 6 f 6 P 6 by L 2, C what does it give to the system, e 8 can you all see that it gives to the system e 8, e 8 which is…

Student: ((Refer Time: 12:50))

Yes, q 8 by C, so this is done one thing left here let us let us do that, see here is a space I will push it a little up, so that you can see we can write here, R 2 what does it give to the system f 9, so R 2 f 9 f 9 is…

Student: E 9.

Yeah, e 9 by R 2 fine, so we have related to the character of that particular system element. And then e 9, we have to scout the rest of the ((Refer Time: 13:54)) to find out, where this fellow has got created. E 9 was created at,

Student: E 8.

E 8 right, so e 8 by R 2 and e 8 we know, q 8 by 6 is equal to q 8 by R 2 C fine. So, we have obtained everything, we have obtained the answers of this question related to all the elements, so the first part is done, second part.

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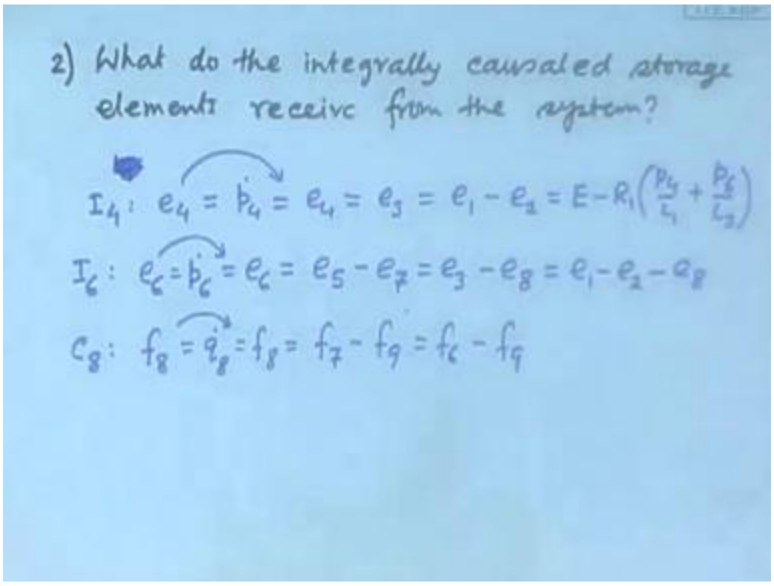

The second part, the second question is what do the integrally causaled storage elements receive from the system, yes this is important though in this particular problem all the storage elements are integrally causaled can you see that. ((Refer Time: 15:21)) for the I element an integral causality is, where the causal stroke is here, because then it is receiving the effort information giving out the flow information and they are integrally related, for this it is correct, for this it is correct and therefore, all these storage elements are integrally causaled.

So, our state variables are f 4 f 6 e 8, so we ask this question with respect to these elements let us start. First we ask this question with respect to L 1 or basically it is better to write that, I am asking the question with respect to I element connected to bond 4 I element connected to bond 4. What does it receive from the system e 4, e 4, so we will say it is e 4 and e 4 is equal to P 4 dot.

Student: ((Refer Time: 16:33))

No P 4 dot.

Student: ((Refer Time: 16:36))

That is the character of any integral, or any inertial element that the effort is the P 4 dot that is it, so we bring this thing to this side is equal to e 4. So, the dotted term is in the left hand side and the un dotted term in the right hand side, and then we try to figure out where this information comes from. E 4 ((Refer Time: 17:03)) e 4 where did it come from, it is connected to a 0 junction and therefore, there should be a strong bond bringing that information which is e 3, so that is e 3, now e 3 yes, this is a 1 junction.

And therefore, that is a combination of no, not e 1 plus e 2 notice, here the power direction has to be considered, e 1 is equal to note the power direction is equal to e 2 plus e 3 and therefore, e 3 is e 1 minus e 2 minus e 2 this is e 1 minus e 2. Now, both these we already know, e 1 will know e 2 we know from the answers to the last question, just substitute.

So, we get this as E minus R 1 P 4 by L 1 plus P 6 by L 2 fine, so one differential equation obtained. Second we ask the question related to the ((Refer Time: 18:26)) I element connected to bond 6 , so I 6 what does it receive from the system, ((Refer Time: 18:37)) it is e 6 . So, e 6 is equal to P 6 dot and then we bring it to this side e 6, now e 6 is,

Student: ((Refer Time: 18:48))

Yeah, this is a 1 junction therefore, notice e 5 the power direction is that way is equal to e 6 plus e 7, so e 6 is nothing but e 5 minus e 7, e 5 minus e 7 good. ((Refer Time: 19:11)) Where does the information e 5 come from.

Student: E 3.

E three yes, so e 3 here and where does the information e 7 come from,

Student: E 8.

E 8, so minus e 8 fine, now e 3 ((Refer Time: 19:35)) where does e 3 come from,

Student: E 1 minus e 2.

E 1 minus e 2 yes, so e 1 minus e 2 minus e 8, ((Refer Time: 20:03)) you see e 8 e 3 minus e 8, e 3 has come from e 1 minus e 2 and e 8 is fine, e 7 is equal to e 8. Now, all these are known in the right hand side just substitute, because e 1 is known from here, e 2 is known from here and e 8 is known from here, just substitute you will get it happy, let us go to the C element, that is connected to C connected to 8 bond number 8.

Student: ((Refer Time: 21:08))

How will you write it.

Student: ((Refer Time: 21:10))

F 8, f 8 ((Refer Time: 21:16)) is what it receives from the system and that is equal to q 8 dot is equal to q 8 dot and then bring it to this side is equal to f 8 and then find where the f 8 comes from, ((Refer Time: 21:32)) f 8 this is a 0 junction and therefore, it has to be relate to f 7 and f 9.

Student: F 7 minus f 9.

Yeah, f 7 minus f 9 is equal to f 8, because of the power directions fine f 7 minus f 9, f 7 comes from f 6, that is the strong bond bringing in the information to the 1 junction when it becomes distributed to the two sides. So, f 6, f 6 which is known, ((Refer Time: 22:09)) so we will not bother about that f 9, f 9 is also known minus f 9 which is also known.

Just substitute f 6 is known ((Refer Time: 22:19)), because of this f 9 is known because of this substitute you will get it, yeah.

Student: ((Refer Time: 22:28))

Where…

Student: ((Refer Time: 22:34))

Wait, wait, let us, let us see, let us see, let us check e this is e 6, e 6 is…

Student: ((Refer Time: 22:46))

E 6 is e 5 minus e 7 e 5 minus e 7 and e 5 is e 5 is ((Refer Time: 22:56)) coming from here.

Student: ((Refer Time: 23:02))

Power directions, your question is why is this true this part e 6 is equal to e 5 minus e 7, let us, ((Refer Time: 23:16)) let us illustrate that, in this particular 1 junction you have the power direction like this power direction like that power direction like this, which means that e 5 f 5 is going in minus, this going out e 6 f 6 this also going out, minus e 7 f 7 should be equal to zero because there is no power here.

Now, it is a 1 junction which means the effort flow equalizing junction, which means the flows are all equal they cancel off, which means we were interested in f 6 e 6, so e 6 goes this side which is e 5 minus e 7 is that right, yes.

So, e 5 minus e 7 was correct fine have you understood the procedure, then all these are known from the from this, so you just substitute you get the equations fine. Let us do another problem related to we have already done the motor problem.

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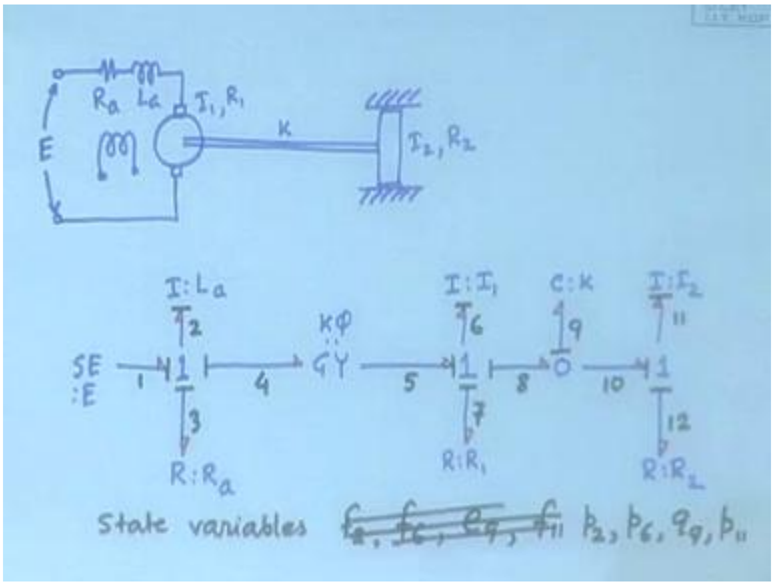

In the motor problem your system description was, you had a DC motor and it was connected to a source, and there would be the internal resistance inductance and this was constant field was constant. This was connected by means of a shaft to some rotational mass, which is allowed to move against a frictional element that was the system description. Now, when we obtained the bond graph how did you go about it, we started from the applied voltage here.

So, it would be S E which is E that is connected in series with the inductance and the resistance, so connected with 1 junction to the I element, which is armature inductance L a to a R element, which is R a armature resistance armature inductance. And that shares yes that shares the same effort with whatever, is here now what is here, it sees the electrical circuit sees it as a something that gives a back EMF. And that we have already seen that that would be ((Refer Time: 26:27)) by gyrator, so it is a gyrator here with ratio k phi and the gyrator will be connected to this side.

So, this is the electrical side, this is the mechanical side, the electrical sides effort is a back EMF and that is related to the speed of rotation, in this side that is a flow. The electrical sides flow is the current that is related to the torque in the mechanical side that is why it is a gyrator fine. So, we have come to this point at this point here is a rotational element, which will have its own mass as well as it is bearing friction.

So, they whatever the mass is whatever the bearing friction is shares the same flow share the same flow with this. So, it will be a 1 junction it will be a I, which was I one and here, it was a R, R 1, so here it is I 1 R 1 here it is I 2. Now, here there was a springiness there was some bit of freedom some degree of freedom, so that they can move somewhat independent of the, that this point and that point share the same effort.

Student: Effort.

Yes, they share the same effort, as a result of which this C element will be connected by means of a 0 junction to the C which is K. Then in this side, you have these two element sharing the same flow, so it is 1 I, I 2, R, R 2, so that is the bond graph, let us give numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. Now, let us give the power directions, here these are very standard, so let us not spend time on explaining this.

Now, since there is only one source, it is logical to have the positive power flow assumed to be in this direction though as I told you, you can as well put then on the opposite direction, but let us do it this way. Now, let us assign the causalities causalities, first S E element will be receiving the flow information and giving out the effort information. At this point this 1 junction is not causal, so let us put the causality of the I element integral causality, which is like this.

The moment it brings in the flow information, it has to take out the flow information and therefore, this junction becomes completely causaled, well the flow information coming this way into the gyrator. And therefore, the effort information must go out, which means the stroke must be here, so here the flow information is coming in gyrator therefore, it is multiplied the flow is multiplied with the K phi to give the effort information. So, the information flow would be effort in this direction, so effort goes out.

Now, this one is not yet completely causaled, because this is not a strong bond, so we have to put the causality integral causality in this storage element, which is like this. The moment, you do this it has already obtained the flow information and must take out the flow information in the other bonds which is right. Next you come here this is not yet causaled, so let us put it here, this is the integral causality for the C element and the moment this receive the effort information, it must give out the effort information in the other two bonds like this.

1 junction, if you put the integral causality like this it has received the flow information and therefore, it must take out the flow information, it is already taking at the flow information here and it must take out the flow information like this. So, this is how you causal it, so it has been power directed numbered causaled done, now let us start the business of obtaining the bond graphs, what are the state variables here.

Student: ((Refer Time: 31:38))

Yes, yeah f 2, f 6, e 9, f 11 right here, sorry, sorry, no, no, no, f’s are not the…

Student: ((Refer Time: 32:04))

Wrong.

Student: ((Refer Time: 32:06))

Wrong, P 2, P 6, q 9 and P 11 these are the state variables fine, So, let us start ask the question what was the first question. What do the elements give to the system let us ask this question to the first.

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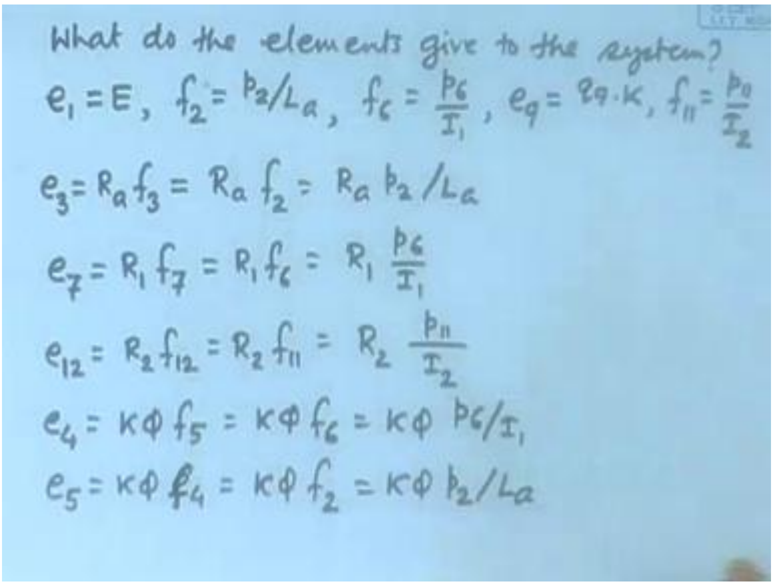

So, let us start with first one, e 1, so what does it give, ((Refer Time: 33:05)) it gives e 1, e 1 is E, so the first question answered. Next come to come here it gives f 2, f2 is P 2 by L a, I am just writing with commerce, so that we conserve space. ((Refer Time: 33:33))

This one let us finish the storage element it will be easier, this is f 6, f 6 is equal to P 6 by I 1,((Refer Time: 33:52)) this gives e 9, e 9 is q 9 times K. And your f 11 is, P 11 by I 2, so we have done it for all the storage elements and the source these were simple, but now let us do it for the three resistances.

First one, ((Refer Time: 34:37)) this fellow what does it give to the system e 3 yes, so e 3 is equal to R a f 3 is equal to now, we start to find out where is f 3 information comes from, f 3 information obviously, comes from f 2, so R a f 2, which is known R a P 2 by L a, so completed. ((Refer Time: 35:16)) Second one, what does it give to the system, e 7, e 7 that is, R 1 f 7 and f 7 information comes from clearly from here, ((Refer Time: 35:29)) that is the strong bond bringing in that information, so R 1 f 6 which is again simple R 1 P 6 by I 1.

Similarly, the last one, ((Refer Time: 35:51)) this one it gives e 12, e 12 is equal to R 2 f 12 and f 12 information comes from simply here. So, R 2 f 11 which is also known R 2 P 11 by I 2, so all these answers are obtained we are happy have, we have we obtained everything. ((Refer Time: 36:23)) No not really, because the gyrator element also receives gives something to the two sides let us text of that, what does the gyrator element give to this side and what does the gyrator element give to this side, well to this side it gives.

Student: ((Refer Time: 36:41))

Yes, effort f sorry, e 4, so to this side it is e 4, e 4, so when we start with e 4 that is K phi times f 5, K phi, f 5 yes f 5, f 5 comes from f 6.

Student: F 6.

F 6 is P 6 by I 1 [FL], ((Refer Time: 37:24)) next what does it give to this side it is what does it give to this side

Student: ((Refer Time: 37:31))

No, no what does, what does it give to this side.

Student: ((Refer Time: 37:38))

No, see yes, yes yeah e 5, because it gives e to this side, it give e to this side can you see that, because the causalities were the causal structure is there, it gives e to this side e to this side. Therefore, e 5, e 5 is K phi e 4, f 4 sorry f 4, now f 4 information where does it come from f 2 simple, so K phi f 2 is equal to K phi f 2 is P 2 by L a. Had it been a transformer ((Refer Time: 38:35)), yes then it would be different, but since it is a gyrator it gives if either it gives flow to both sides or it gives effort to both sides, so we have done it, now let us answer the second question.

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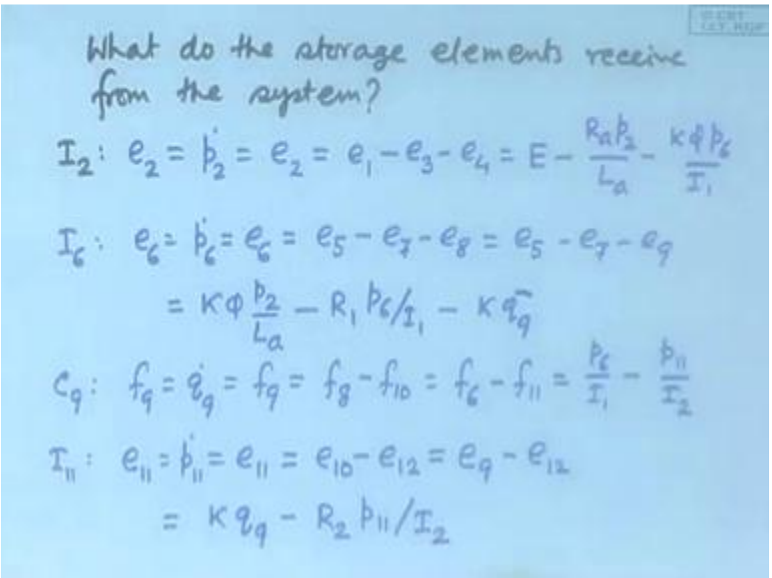

First, let us ask this question to, ((Refer Time: 39:18)) I in bond 2, I 2 what does it receive from the system, I 2 it receives effort 2, so e 2 is equal to P 2 dot. So, bring it to this side is equal to e 2 and then e 2, where do you obtain e 2 from.

Student: ((Refer Time: 39:44))

Yes, it is a 1 junction therefore, e 1 minus e 3 minus e 4 is equal to e 2, because of the power directions are you now comfortable with how to set the pluses and minuses. From the power directions, e 1 minus e 3 minus e 4 is equal to e 2, e 1 minus e 3 minus e 4, e 1 is known is equal to E minus e 3, e 3 is known ((Refer Time: 40:23)) e 4, e 4 is known right all these are known substitute. Can you see that e 1 is known e 3 is known e 4 is known put it, so you get Ra P 2 by L a minus K phi P 6 by I 1, so that is one differential equation with a dotted term in the left hand side and un dotted terms in the right hand side. Now, let us ask this question two this one, I 6 here it receives e 6 is equal to P 6 dot is equal to e 6 we will start from here. P 6, e 6, e 6 where did it come from ((Refer Time: 41:33)).

Student: ((Refer Time: 41:35))

Yes, because it is a 1 junction it will be effort summing junction therefore, e 5 minus e 7 minus e 8, e 5 minus e 7 minus e 8, ((Refer Time: 41:55)) e 8 is equal to where did this information come from,

Student: E 9.

E 9, because that is the strong bond, so we can write e 5 minus e 7 minus e 9. Now, you notice that all these are available e 5 here ((Refer Time: 42:12)) e 7 here, e 9 here, just substitute. So, if you substitute you obtain K phi P 2 by L a minus R 1 P 6 by I 1 minus K q 9 dot sorry not dot, e q 9 K q 9 sorry, so this is the second.

Now, we ask this question in relationship to this one, which is C in the bond 9, ((Refer Time: 43:16)) C in the bond 9, it receives flow f 9, f 9 is equal to q 9 dot is equal to f 9. And then we scout the bond graph to find out where does f 9 come from f 9, is e 8 sorry f 8 minus f 10 in this bond f 8 minus f 10. F 10 is actually comes from f 11 and f 8 is actually come from f 6, so f 6 minus f 11 ((Refer Time: 44:04)) and both these are available f 6 is here f 11 is here put it in, is equal to P 6 by I 1 minus P 11 by I 2 done.

Finally, let us ask this question in relationship to this one ((Refer Time: 44:27)) I connected to bond 11, I 11 it receives effort. So, e 11 is equal to P 11 dot is equal to e 11 we bring it to this side and then find out, ((Refer Time: 44:45)) where does e 11 come from it is e 9, no e 10 minus e 12 e 11 is e 10 minus e 12, because of the power directions e 10 minus e 12. ((Refer Time: 45:07)) E 10 is coming from e 9, so e 9 minus e 12 should be directly available, so because, is related to this e 12 is available and e 9 ((Refer Time: 45:23)) is here put it in, so you have e 9 is K q 9 minus e 12 is R 2 P 11 by I 2, so these are the 4 equations done.

Whenever we ask such questions in exams and when the result whatever you have, obtained are linear you should always give the final result in terms of a matrix equation. So, can we express this as a matrix equation, do that fast do not give the final answer in exams like this, if there if the resulting equations are linear equations always express that as a matrix equation.

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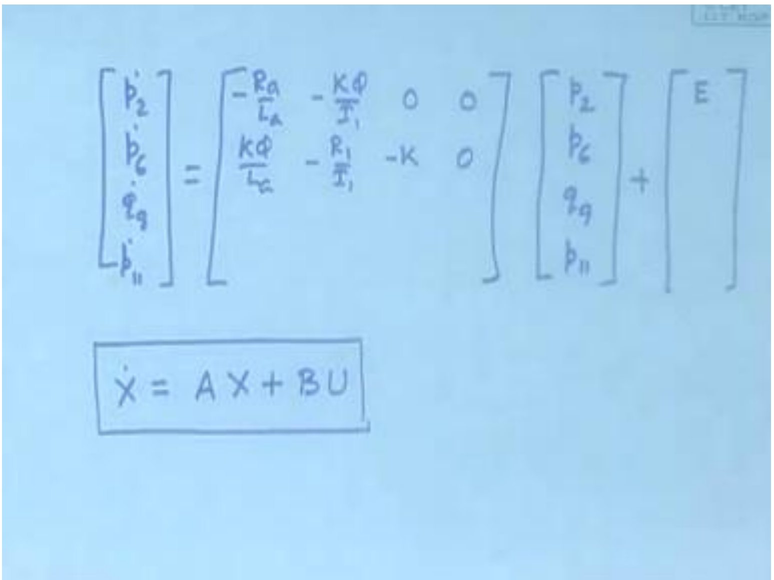

So, it will be in this case a, this is P 2 dot P 6 dot q 9 dot and P 11 dot is equal to something times, P 2 P 6 q 9 and P 11. And whatever this matrix is, for example ((Refer Time: 46:56)) in the first equation it is plus this seems, that are the external inputs, so this will be E, this is related to minus R a by L a minus, R a by L a the first one, next one is minus K phi by I 1 times, P 6 and this is these two are 0 0, fine. Notice it is in the right hand side, you only have P 2 and P 6 and not the other two variables, so these two terms would be 0.

Next one P 6 dot contains this terms it contains P 2 P 6 and q 9, so P 2 P 6 and q 9, but not P 11, so these three will be there. And then you can write, K phi by L a, K phi by La for P 2 term, P 6 term the second one minus R 1 by I 1 minus, R 1 by I 1, third one minus K 0 and so on, and so forth clear. Make it a habit whenever, the equations are obtained in linear form always give the final thing in matrix, this will be the vector of state variables, which is say X dot is equal to this will be called the A matrix A, this is the X vector X plus B U, U is the externally applied force, so you will always express these equations in this form fine.

Now, please complete the rest that will be trivial and I am not showing each and every term for it. So, far whenever we were trying to obtain the bond graph, we were we are following some kind of a logical procedure, in case of electrical circuits what did we do we, started from say the left side and went on into the circuit trying to argue, which one share the same flow and which one share the same effort.

For simple circuits, these are these are fine I mean you can argue things, but for more complicated circuits you know something that looks like a jumble of things, it will be rather difficult to do it that way. So, there you need some kind of a blind procedure which will work, the blind procedure is something like this say, ((Refer Time: 50:16)) if we if we take this circuit we had obtained this bond graph by simply working by logic. Now, in this case what we will do the procedure, which is somewhat algorithmic will be that identify the points, that can be at different voltages what are the called the nodes.

So, what are the nodes here, fine these are the nodes, so in this case all these nodes if they are in different voltages, so things that are connected between them should share the same voltage. And it, so point is that in between these two nodes, whatever are connected they should share the same voltage. And in between two nodes, if there is a element that shares the two sides of it share the same flow, so in between you can connect by a 1 junction lets illustrate.

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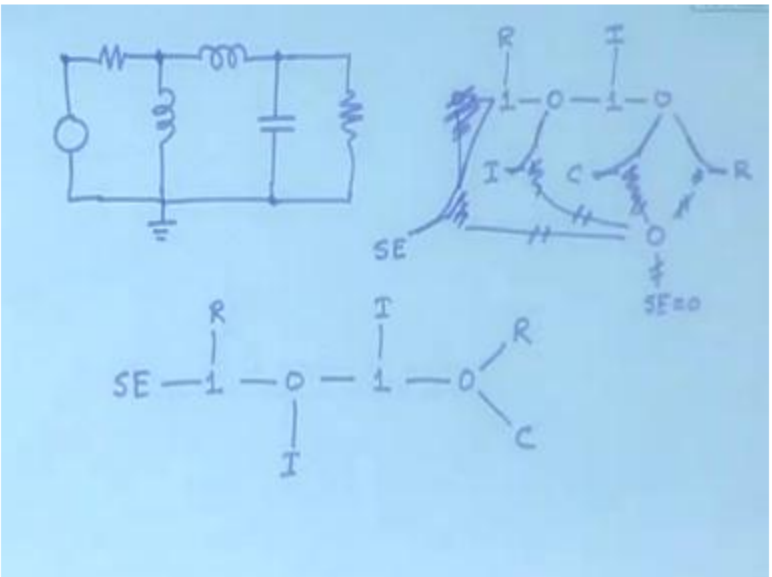

Let me rewrite, it and then do it, otherwise it will be difficult for you to see, you need to see both the things together in order to appreciate. Here, you have this point, this point, this point and this point at different voltages fine. So, you will say that these are simply blindly put at as the 0 junction, so a 0 here, a 0 here, a 0 here and a zero here, here is a 0 junction, here is a 0 junction, here is a 0 junction and here is a zero junction, so there are 4 0’s.

Between these two there must be a 1 junction and a resistance connected to it, between these two, there must be a 1 junction with an inductance connected to it. Between these two there should be a 1 junction connecting a C and there will be another 1 junction connecting a R fine clear. Between these and that you have 1 junction connecting a S E have you connected everything, yes.

Student: ((Refer Time: 53:22))

One more inductance, yes, yes, yes, between these two, between this point and this point fine, so 1 junction connected with a inductance. We have blindly done it, we have just said it that these 4 points represent different voltages in between whatever, are connected or connected by one junctions done. But now we have landed up with a bond graph that will turn out to be containing more number of bonds, that you then you really require.

For example this is a 0 junction, which is connected to only two things therefore, the effort whatever comes here, must go here whatever flow here must go here, the powers are equal, and the effort and flow are also equal. Therefore, this 0 junctions have no purpose you can short it, that is one way of shortening the bond graph. The other way of shortening the bond graph is to say, that we something that we always do we say that let this be at the ground potential, so if that is at the ground potential how is it reflected here, this is this bond we will say that here, you have connected a S E element which is equal to 0.

The moment you say that, this is equal to zero this bond carries no power, therefore it can be ignored not only that it is a 0 junction, where the effort is 0 therefore, all these bonds carry no power therefore, they can be ignored. Have you understood the line of logic, that this we always say that one of the voltage points or nodes would be at 0 potential, there is no harm in doing that that is a datum.

And then the moment you do that in the bond graph, that is reflected as S E becoming 0 and S E becoming 0 connected to a 0 junction means, all these bonds will carry 0 effort. Therefore, 0 power, because the power is effort multiplied by the flow, so all these are unnecessary, now we can we see that these again becomes a through junction is unnecessary, this also unnecessary fine, this is also unnecessary, we can connect it this is also unnecessary, we can connect it is there anything else this is 0.

Therefore, this will become unnecessary this can be get connected, now at this stage it looks ugly, so let us just redraw it in a more handsome way. What will you say S E connected to 1, S E connected to one, connected to R, connected to zero, zero is connected to I, I is connected to one, the zero is connected to one to I to a 0 to R and C that is it.

And notice that this exactly the same as what you had earlier, just check once ((Refer Time: 56:53)), by argument we had obtained this, by blind procedure we have obtained this they are exactly the same. So, the act of drawing bond graph can also be somewhat algorithmically done. I will illustrate that further in the next class.

Thank you.