Power System Generation, Transmission and Distribution

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Lecture No. # 27

Load Flow Problem

Now**,** welcome to this lecture twenty seventh lecture on load flow problem. I think if you all recall we last lecture, we introduced load flow studies. Now, continuing from there.

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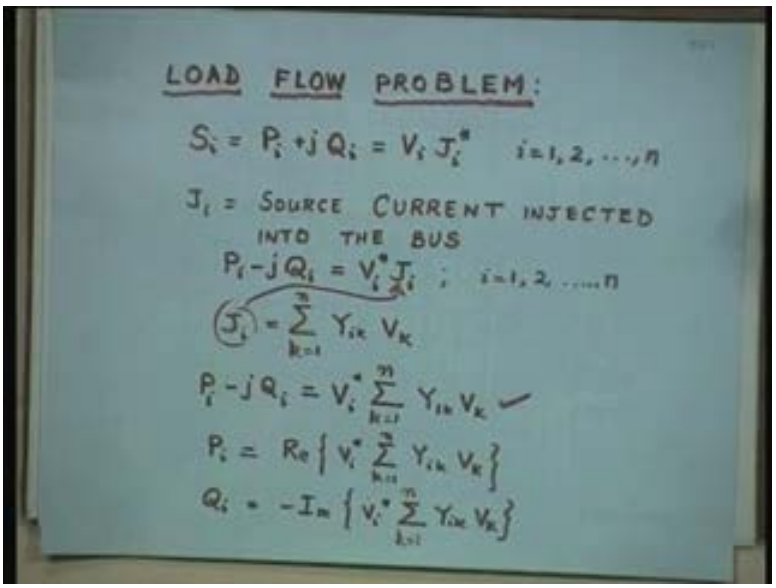

Today let us define, what is load flow problem? All of you are aware that complex power is equal to real power injected plus reactive power injected, which is nothing but V i- J i conjugate. J is the current; V is the voltage for all the n buses. J i- is defined as the source current injected into the bus.

So, I can always, always take the conjugate of both the sides, this equation you may write if you want equation number 1. So, taking the complex conjugate of equation number 1, I get this equation number 2. P i- minus j Q i- V i- conjugates J i. Now this J i- from Ohms law, as we saw it last time is nothing but sigma Y i k- V k-. Current is equal to, Y is equal to V or V is equal to z into J, J is the current. So, I can rewrite this equation

as, P i- minus j Q i- V i- conjugate, substituting this value of J i from equation 3 into equation 2 we get, what we get? We get P i- minus J Q i- is equal to V i- star sigma Q is equal to one two and V i k- V k-.

Now, separating real and imaginary parts, as we must we must have done thousand times in our carrier, since the time you have read your complex variables in algebra or in mathematics now. P i- will be the real of this and Q i- will be this is minus sign is here, we transfer this minus here. So, minus imaginary of this, I think you do not need any great intelligence to understand this. These are the two equations of real power injected into the i eth bus and this is the equation for reactive power injected into the i eth bus.

Now, we can express any phaser in several ways, this you must have done throughout your B Tech, B E or B s c engineering carrier million times. So, here I have expressed the phaser V i- that is voltage at the i eth bus in three different ways.

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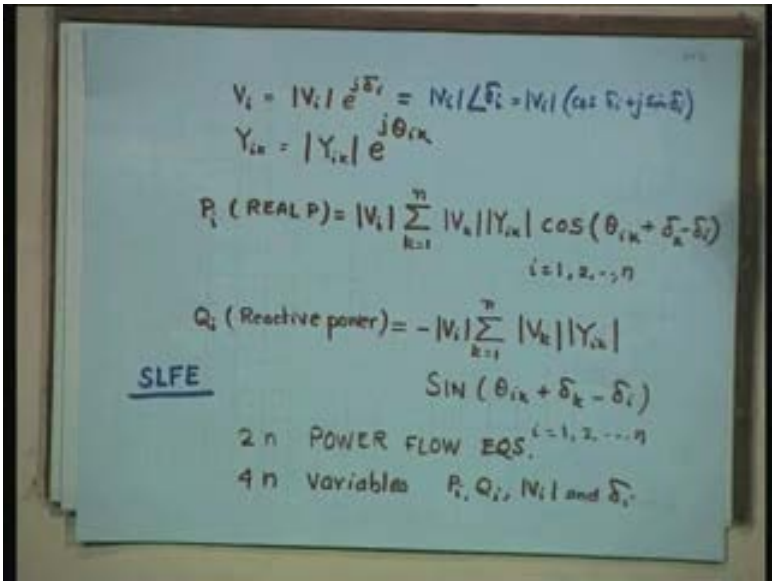

This is an exponential form, this is a polar form and this is a rectangular form, all are same. This absolute value of V i- or V i- magnitude to make it ample clear, I am writing these vertical lines to differentiate it from phaser V i-. So, that there is no confusion, the clearity should be there whatever you present, because as someone has said it is not that mater that matters, but the way of presentation. Your presentation should be crystal clear, should not leave any doubt or ambiguity. That is a good presentation.

So, we have put it as an amplitude or magnitude, same delta i becomes angle here in polar form and same thing if you expand it, cosine delta i- plus J sign delta I- V i-. It becomes a rectangular form. a i- plus J b i- form ,and this is the angular form ,and this is your exponential form. Similarly Y i k-, which is the admittance between the nodes i and k, can be expressed as magnitude and then angle. Angle is theta i k- please remember these thetas will be close to 90 degrees, because resistances or conductances as the case may be are always negligible in power systems. If they are not, then such a power system is called ill condition power system, which I already told you last time. And we do have ill condition power systems at times and at that time, you cannot ignore resistance or conductance. Expanding this earlier two equations P i- and Q i-, which we just now seen. Substituting this voltage and admittance, we get V i- sigma k- is equal to n V k- Y i k- magnitudes, cosine of theta i k- plus delta k- minus delta i; i varying from 1 to n.

And similarly for reactive power, we get minus V i sigma k is 1 to n; V k- Y i k-, sin of theta i k- plus delta k- minus delta i-. Now these two equations are very important in power systems. Whatever you do in power systems, you cannot readout of these two equations they are called SLFE. What is SLFE, Static Load Flow Equations. These are as evident, 2n power flow equations and this and this P i- is n equations, Q i- are further n equations. So in all we have 2n power flow equations or load flow equations. It is used interchangeable, depending on your fancy or liking or whatever. But how many variables are there? Unfortunately mark my word, unfortunately variables are 4 n. What are they P i- Q i- V i- magnitudes and delta i? At each bus we have these four variables and hence on n bus system, we have four n variables.

So, what is the problem? You may ask me this question. The problem is we have been told right from our middle school stage, our teacher must have told us, as many equations, as many variables. No problem X plus Y is equal to four; X minus Y is equal to six, you can solve this and you get explicit values of X and Y. Provided, if you studied linear algebra, they are linearly independent equations. If X plus Y is equal to four and two X plus two Y is equal to eight, these are not two equations. These are same equations. You multiply the first equation by two you get the next equation then they are not linearly independent, but we are talking about linearly independent set of n equations, n variables. No problem you can use Crammer’s rule, you can use matrix ,

you can use any tool and you can get the values of all variables, because you have as many variables, as many equations.

Unfortunately here, the number of variables are double than the number of equations. So, to solve such a system what we have to do? We have to assume 2n variables or to specify 2n variables, knowing our system. Since we are engineer, since we are analyst since we are the master of our system. We know our system too well. So, I can specify problem is familiar to me, like when I make thermo meter? I do not make from zero Fahrenheit, two hundred Fahrenheit. I know the human temperature varies between ninety six degree Fahrenheit, two hundred and eight or you will go straight upstairs.

So, hundred and six, like that. That would not make it the full scale, because there is the knowledge and this is a knowledge society, knowledge based algorithms, and knowledge based methods, expert system, ANN - Artificial Neuron Network fuzzy, neuro fuzzy and so on. you are reading it in your control process or your other process. So, we should know the knowledge of the system and then assume, we should be able to assume 2n variables. So, that remaining 2n variables, then can be easily solved because we have 2n equations anywhere with us and that is why, there is a need to assume 2n variables.

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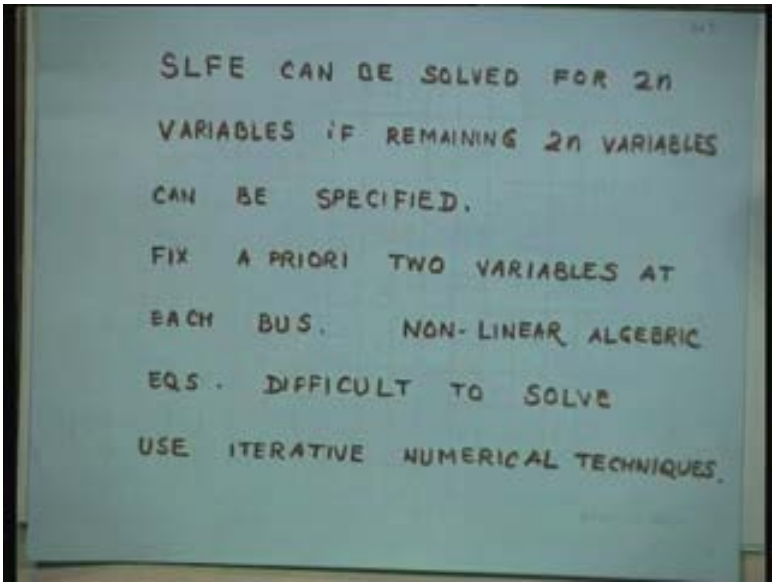

SLFE can be solved for 2n variables, if remaining 2n variables can be specified. This is what I was talking so for and this can be done, because we know our system so well. Fix a priori two variables at each bus then, this please remember these equations are what

sort of equations are these? They are non-linear, but they are algebraic, there is no time here like swing equation. All of you must have studied, stability in your under graduate. So, you know, what is swing equation? t square theta one d t square R delta double dot is equal to, I mean P a- is equal to m delta double dot. Let us put it very simple.

So, that swing equation you have to solve means, you have to go for numerical techniques and input method or modified Euler method or whatever. That you will learn again, reads stability somewhere, here luckily this is no time.

So, what it is? It is a non-linear, a set of non-linear algebraic equation. Why non-linear? There is a V V square, this cosine and sine themselves are non-linear. If you expand, cosine theta minus theta square Y factorial two etcetera etcetera infinite series. Similarly sine theta is also, you know theta minus theta Q by factorial three and so on. Since they are non-linear algebraic equation, you cannot get a close form solution, you understand what is close form solution? x square is equal to four. So, x is equal to plus minus two. This is called close form solution. You did not could computer, you did not write any mat lab program or program or any FORTRAN program or c plus or c plus plus or whatever. You simply use your knowledge and got the value x is equal to plus minus.

So, this is called close solutions. But if you are a fuzzy person, you can always say let x be equal to two point one, the initial value of x. Substitute oh it is going more than four. What is the difference? There is the difference, there is an error. So, you correct that x, two points naught five. Now error is reduced. That is converging and depending on your convergence criterion, you make it again two or two point naught naught naught naught naught four or whatever. So, that is a numerical solution for x square equal to four. You can also solve, x square equal to four numerically. You may get exact answer is equal to two, depending on your convergence criterion, or you make it two point 0001 or something like that.

So what you do, fix a priori two variables at each bus, non-linear algebraic equations difficult to solve. We have to go for iterative numerical techniques, there is no other way. Because we cannot solve them straight, there is no direct solution possible; there is no closed form solution possible. Hence you have to resort to numerical, depending upon which two variables; you specify the buses or the nodes in power system are categorized

into three categories. What are those three categories? PQ bus, PV bus or slack bus or swing bus or reference bus.

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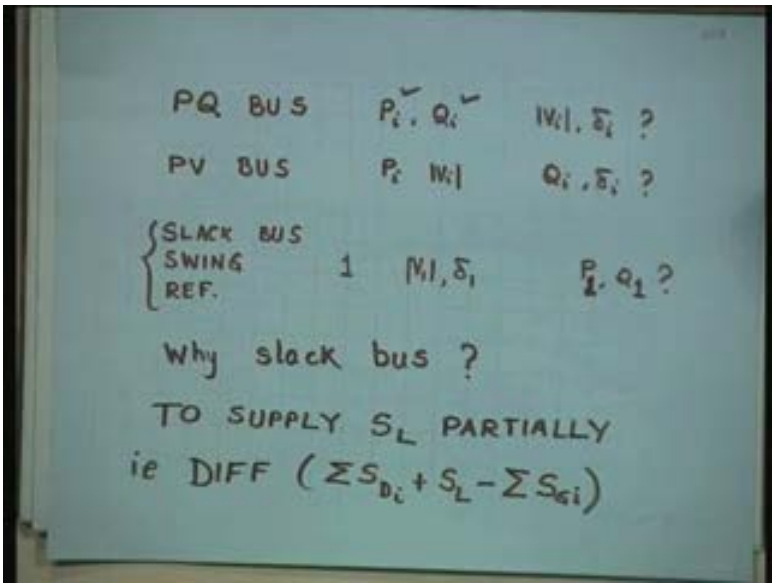

So, there are three names given to this special category of bus. Even, some experts or some books called PQ bus as a load bus. But according to me, load bus is a special case of PQ bus, when no generator is attached to bus and yet if it is a PQ bus, it is called load bus. Some people call PV bus as a generator bus, but according to me a PV bus need not have a generator attached to it. You may have a capacitor bank attached to it, whole idea is to keep V constant and V can be made constant by. So, many ways the voltage control, you must have studied in your under graduate. So, you know what is static control, you know what is , you know what is dynamic compensator, you know what is a synchronized motor running at low load. That is dynamic compensator or synchronized converter. There several ways by which, you can call this controllers are static controllers, dynamic controller and so on.

Though these are the different names though given, if it is asked in interview, you should not worry. What is generator bus? Generator bus normally means PV bus. A load bus normally means PQ bus and similarly, I have written three names here slack, swing reference. There is a meaning to each name, let us start with reference bus, why it? And mind it this only one such bus, that is what I have written this one here. This one

indicates that such a bus is only one in the whole system. Whereas, PQ bus is eighty five percent of the buses are PQ buses and roughly fifteen percent of buses are PV buses.

Why normally, generator is attached to PV? That is what, it is called generator bus. So, what do we specify PQ bus? P i- and Q i, what is not specified? V i- and delta i, the question mark means not specified, because here. In a slide, you have to write minimum and you have to explain maximum. This is no point in writing each and every thing, because you have about planning and you are all intelligent people.

Similarly PV bus, what is specified? P i and V i. What is not specified? That is the known Q i-, reactive, injected power and angle at the i eth bus, delta i-. So, these two are two special categories PQ bus and PV bus. Eighty five percent of the buses are PQ bus, fifteen percent of the buses are PV bus. Now come to this one single bus, first of all this question is always asked in a interview in UPSC Indian administrative service exam, U P engineering service exam, Anti P c exam, even gate exam.

Which now you do not have to give, you already gone through that. Why slack bus is a very important question? First thing are you had to refer, all angles at remaining buses with reference to some bus. And hence delta one is normally assumed to be zero and rest of the buses is referred to this bus angles. This is without loss of any generality; you can always say five digits. No harm that, but why not take zero?

Now this V 1is also specified, normally one point zero four per unit or one per unit or whatever, you can specify. Why we do not know P 1 and Q 1 till the end? Because if you know P 1 and Q 1 at all the buses, then we do not have to solve out ; that means, you know the solution, and why is it necessary to leave one bus? Where P 1 and Q 1 are not known because there has to be a generator bus.

Please understand slack bus always have a generator attached to it. Always no exception here, like PV bus exception and mind it this generator is normally the biggest in the system. And if it is still, if it is centrally located, it is not a must it is not a must condition. But it is as I said, if it is centrally located. If it is UP state electricity board Singrolli, super thermal power station can be considered as slack bus. Why? It is two thousand Mega Watt station; it is a super thermal.

So, super thermal is anything called; super thermal is more than two thousand Mega Watt anything, which is called Mega power station? It is more than thousand Mega Watt. These are the two special categories of power stations. That is of course thermal, because hydro we are not yet crossed Bakra, which itself is less than thousand. The two wings of Bakra east west swing generators each, as I told you slack bus is there to supply S L; S L is complex losses, P L plus j Q L. Partially, that is a difference between total load plus loses minus total generation.

So, whatever is extra left that will come from this slack bus. That is why anything, that is slack. Anything which is remaining? Anything which we could not fulfill from rest of the buses? Will come from… suppose you need to spend twelve rupees and you have only ten rupees? Who gives you minimum two rupees? When you are a child, a young child small child … Your parents, they are slack bus for you. So, this is the slack bus, swing means all buses swing with reference to this, bus that is called swing. So, each word has a meaning, I hope all of you have understood now, why we should have a slack bus? In case anybody asks you this question, at least eleven of you should be able to answer, any one of you. However, this is known in the end only, when you are solve the network that is alright loses are the last item in the menu. When you solve load flow problem, as I told you couple of minutes back.

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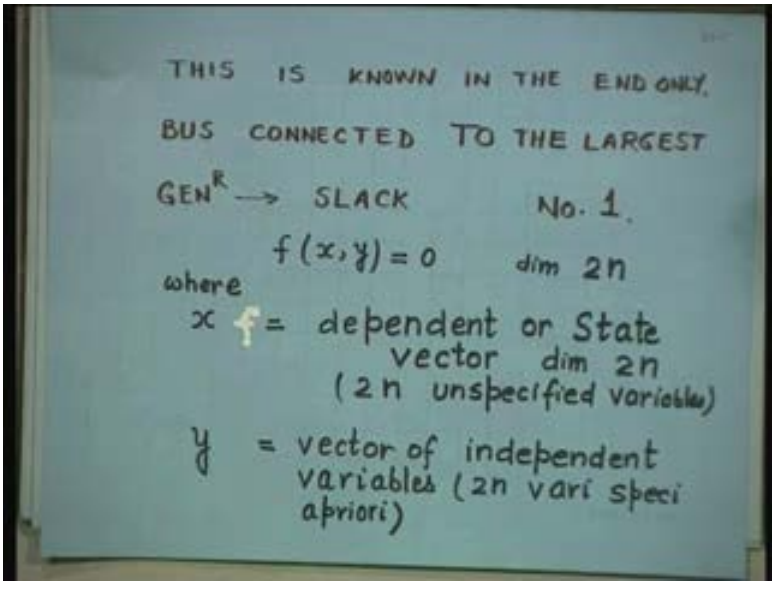

Bus connected to the largest generator is normally assumed to be or considered to be a slack bus and it is always called either one eth bus or n eth bus, just for convenience. If you are fuzzy, if you are you know different type of person, you can always call it twenty eth bus does not matter, comfortable take care of it. But for convenience, since you do not lose anything, why not call it number one? So, that you start your computations from two to n mathematical convenience.

Now let us consider a general equation f of function of x , y is equal to 0, the dimension is 2n. That you know already, because load flow equation dimensions are 2n. This consist those two equations, SLFE; two means 2n. Each equation is n, where x is always. Since you have started learning, your teacher have must told you anything unknown is x. Let x be whatever question was asked, height of Elephant, let x be the height of Elephant. You know that, since the time you you must have started learning, you must have been talking about this, x as a unknown.

So, f is a dependant or state vector of dimension 2n. These are in fact, 2n unspecified variables or unknown variables in all control system, you or any system, why control system? Let it to be Aerospace, let it be Medical system. x is always considered as a irrespective of car speed, color, country, etcetera everywhere it is x. Including your former USSR, there is no USSR left now. They use to consider voltage is u not v, but as far as this unknown is considered, they also used to consider at x, because they wanted to be different then America always. Since America considers v, they consider u. Anyway what is y? y is always a vector of independent variables. Please understand I am not using word control variables, because independent is bigger than control. Control is a subset of independent variables, why you need not control anybody and everybody? Suppose suppose there is a class and you know, who which two students are naughty. If you control them, you do not have to worry about rest of the class.

Similarly here, and then mind it control is effort, money which is to spend money. Any control is not free, whether it is a P control, or PI control, or PID control, or fuzzy control or whatever control, you have to pay money for it. If you use that stabilizer, you have to pay money for it. It is not free and incidentally and interestingly, not interestingly, unfortunately in India whatever you could be purchase, let it be TV, let it be PC, let it be AC, let it be fridge, that investments have to be accompanied by

another's investment called . Because you are not sure, what quality of power you are getting.

So, that is again a control, you control try to trying to control the voltage. So, y is a vector of independent variables and they are 2n variables. And these variables are indeed specified a priori. So that we can solve this x, which is 2n dimension using this, which is also 2n dimension right, any problem.

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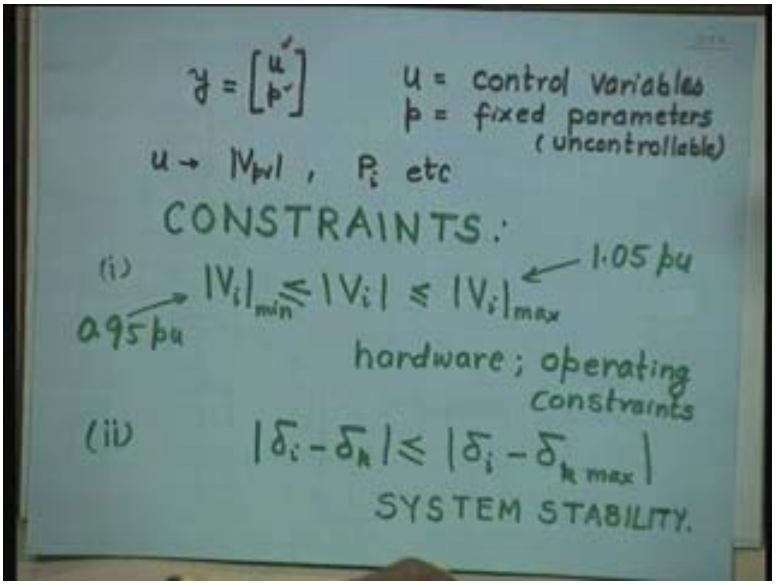

So far as I was talking this, y can be further divided into two's of vectors u and p. u are control variables and P is a fixed parameters, and indeed some of them are uncontrollable like in a class, when it happens then you to ask him politely, would you please leave? Because he is uncontrollable and you cannot afford to have, resist of the class suffer. Because of that one element in IIT of course, no such things happens. As I told you, what can be u, the example of control variables? Voltage at PV bus, you want to keep it fixed. How do you keep it fixed by controlling it? If you leave it, it will vary depending on your supply, depending on load the moment you start. It is a one lamp on in your room and if I start another lamp, you will find it go slightly dim, you can notice this phenomena the moment.

You start your AC or your fridge in your house or in hostel, you do not have individually AC and fridge. You may have a cooler I do not know, you may have a PC, but that load is not significant. But if you start an AC or fridge, you will find that voltage gets dim

slightly right, so you have to bring it back. How do you bring it back by controlling real power? I control it the generation power, can be controlled by, controlling the steam input I do not know. Whether you have studied automatic generation control, which you must have studied in your under graduate. And you must have seen that steam, if you increase the steam, power output increases; if you decrease the steam, power output decreases. And if it is a hydro power plant, what you do? Gate opening, if you put more water on the hydro to hydraulic turbine, more power generated. If you reduce, less power generated.

So, you can control active power or real power generation by whatever means; let it be thermal, let it be hydro, let it be nuclear of course. Nuclear power control is very minimal, you cannot do much and that is why it is used as a base power? This question is always asked in interviews, why nuclear power station is used as a base power station? Because you cannot do much, you cannot play with its generation. The rods are fixed, everything is fixed. And hence that is used as a base power and there is always a base load to be catered to. Like your fellowship, you have a certain basic expenses, base expenses, you have to pay fees, you have to pay your hostel bill, mess bill, minimum other compulsory expenses, the word constraints is very important in life. Forget about electric engineering or energy engineering or any engineering constraint.

In life we have to face this word, to face this reality every moment that you live. I have a constraint of one hour; you have a constraint of two years, to complete your M Tech. you have a fellowship, limited to six thousand or whatever possibilities. You cannot just go, said and make it 7000 this month onwards. Similarly, there are constraints in electrical engineering and there are three types of constraints. If you have studied optimization techniques or as indeed mechanical engineering students studied, even electrical engineering students studied, a management person MBA people studied or means operational research optimization techniques. There are two types of constraints one is equality, another is inequality.

What is equality constraint? The total power generation must be equal to the total load. There is no point in generating, more than required; it is an equality constraint. You get to three hours appear for an exam or two hours like in IIT, we have 2 hour major. So, it is it is eq[uality] equality constraints. You cannot say, sir half and hour more, teacher may give of his own, if he thinks the paper is tough are lengthy five minutes more. But then

he is giving you, cannot say I want to stay for one more hour. Get out, give me your copy whatever you have done in olden days, they used to write extra time taken or that they used to cut that question, not to be checked very strict.

If you come five minutes late in the class, our teacher use to tell us, you are fifty five minutes early for the next class, Please wait outside. Even if you are 5 minutes late, now voltage is one of the important constraints, I just explain you, why you have to have a fixed voltage. Because your entire PC is, AC is, fridge, everything all equipment are suppose to work at a given voltage. It may be 220 volts, it may be eleven KV, it may be four hundred volts depending on that particular equipment, particular device, and particular instrument and hence voltage must be equality constraint, I already explained.

Now I come to inequality constraint must be within V i minimum and V i maximum, and please understand it is a very narrow range. If I want to plot it, this is V min and this is V max and this is, what normally we should be. And this range is, point nine five per unit to one point naught five per unit; that means, plus minus five percent. But in India, what is a voltage variation? Plus minus infinity. What is the meaning of that a two twenty volt? Can be supplied as low as one seventy volt, can be as high as two seventy volts. If you go and see sixty Watts bulb, it is giving you luminous of 40 watts, because a voltage is low, low voltage problem is very familiar in this country.

High voltage, if you want to see, you have to get up in mid night; it is how bright because most of the load is not there. People are sleeping, the industries are not there, the roads are closed, and people are not working. So, the voltage is very bright.

Both are bad like a blood pressure, neither high blood pressure is good, nor low blood pressure is good. Neither low fever is good, nor is high fever well. if you get ninety five degree Fahrenheit or ninety four degree Fahrenheit, equally worry some as your hundred and four degree Fahrenheit. Similarly, blood pressure range is 120 – 80, so if you go below eighty also a problem, if you go above 120 there is a problem. Similarly voltage should go neither below V i min, nor go above V i max, you should strictly remain within this range. For that, we have hardware, we have operating constraints and so many things.

Voltage control itself is a separate topic. In fact, voltage stability has become a very popular topic in power systems; people are doing Phd’s in voltage security and voltage

stability, books have been written on just voltage stability. Second, delta i minus delta k- should be less than equal to delta i- minus delta k max-, this constraint is due to system stability requirements. All of you know, a power angle curve and this is the linear portion, this P versus delta and normally, it operates up to thirty degrees, though maximum it can go up to ninety.

In fact the maximum power occurs when the delta is equal to ninety. E V by x, that is a P max, but in practices it never goes beyond thirty degrees. Because of stability requirements and hence, delta i minus delta k- should be less than max.

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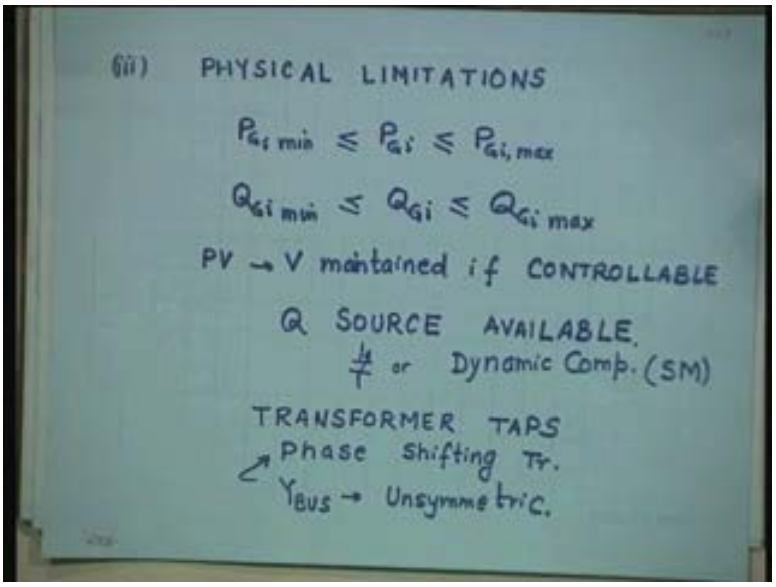

What are the physical limitations? If you go to Batharpur, I do not know whether you have gone, you must go whichever department you are electrical or energy, tell your coordinator or faculty in charge to make a trip to Batharpur or Indraprasth power station or power centre in . And lot of very good controllers has been installed, which you must see how they are operating? How real time operations going on? How he can find out the frequency at Morad Nagar frequency, at Mathura frequency at Kanpur and the power exchanges taking place? All these things are automatic; all these things are now computer control.

So you must go and see it, why P is control? Why P is constraint? Because once you have decided a hundred Mega watt generator, you cannot generate one twenty five Mega Watt out of it, at least permanently for all the time, temporarily you can overload it. See

in car, you can go for hundred miles per hour for few minutes, moment the traffic comes, moment you know, you are not on highway or freeway. You have to control the speed; you cannot go on hundred miles per hour ever that all the time you have to vary.

So, largely the power generation will remain around hundred Mega Watt or slightly lower than hundred mega watt and hence, there is a P g min and P g max. Why there is a minimum? If you at all using a generator, at least the rates at minimum Mega Watt. Otherwise why you are started? If you are using a car, we cannot go zero kilometers per hour or five kilometer per hour, unless until it is a marriage procession or it is going to be Delhi of two thousand twenty, wherein all cars are going to run on roads with five kilometers per hour. Because there will be thousands of car and may be, the people are walking may have to walk on the top of the car like this. That is what the cartoon of lax man came sometime back Delhi of two thousand twenty. This may not happens once the metro comes, but that is a sort of a cartoonist way of warning people that the way, you are purchasing car every house, three cars, four cars ,and every son has a different car, every daughter has a different car and no .

So, this is what found to be happen and no good public transport system like, you have in Madras, Calcutta and Bombay, there is no public good public transportation system. Naturally we able take out their own vehicles, which of course I have been this at. So, similarly there has to be maximum as well as minimum, you cannot go beyond hundred Mega Watt and same thing, volts good for reactive power generation is this a bank of capacitors.

What even generator? It generates a given a synchronous machine, all of you must have drawn PV curves, O curves, performance chart, capability curves. All of you know that, there is a limitation on reactive power generation, there is a minimum limit, and there is a maximum limit at PV bus voltage has to be maintained, if you want to make the controller. So, Q source is available, then only you maintain as I told you, Q source may be a capacitor bank or inductor bank. I hope you all of you know, what is effect? The voltage goes beyond the normal value, to bring it back you have to use bank of inductance. In our country Kanpur near Kanpur, there is a station. There is an only station where there is static war controller stability, no other place because; it is very costly and dynamic compensator. All of you know, that is synchronized motor running at no load, a synchronous motor is the only motor which can give you, which can operate

lagging power factor, as well as the leading power factor. Whereas, induction motor means always lagging power factor.

Then there are transformer taps, they are also controllers, they can also control the voltage, online transformer taps, offline transformer taps and transformer taps are always put on the high voltage side. This question must have been asked you, in your machine laboratory for viva or interviews. Why you keep taps on high voltage? Because high voltage winding is outside, low voltage winding is inside and then control is smoother. There is a phase shifting transformer also, which controls real power angle. So, Y bus becomes unsymmetrical, if you have a phase shifting transformer in your system. Y bus does not become a unsymmetrical, if you have a only magnitude controlling transformer taps.

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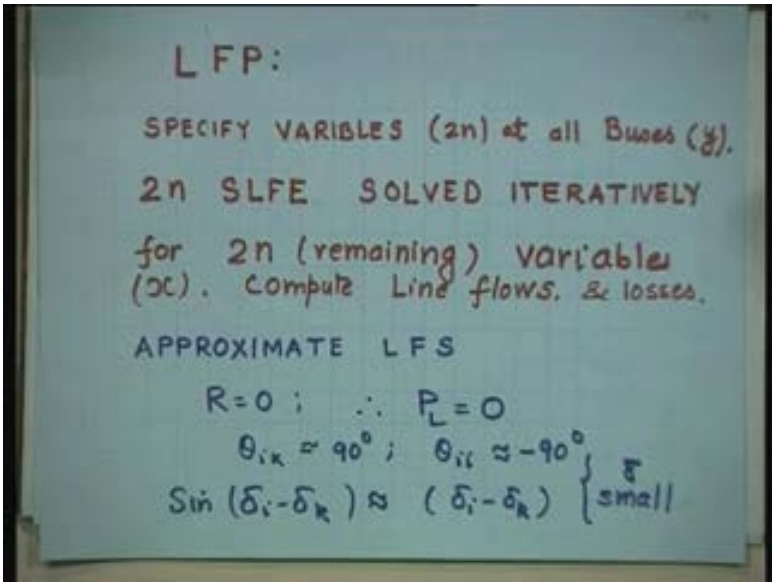

Let us define now load flow problem, specify variables 2n at all the buses that will give you a vector Y. 2n SLFE solved iteratively for 2n remaining variables, x compute line flows and losses that is all we do in load flows. Why do we compute line flows? These are important to find out, whether we are fulfilling the obligations; we have a contract with Panipat. Look we will supply you this. In fact, it is a reverse in Delhi, everybody supplies power to Delhi, and everybody supplies water to Delhi. Delhi cannot supply anything to anybody, because there are shortages everywhere. Power, we get thousand Mega Watt from NREB, water we get from Haryana.

So, there is an obligation from Haryana electricity board or NREB, they supplies power. So, that will be by knowing the line flows. Secondly, you need to know line flows for protection region, you cannot have a… You know overloading of transmission lines. Otherwise security problems will be there. In power systems security, what are the two problems? The frequency variation also creates security problem, frequency should not vary plus minus point five hertz beyond this limit. In India, of course varies from it varies from forty seven hertz to fifty three hertz. But in rest of the world, it is forty nine point five to fifty point five hertz and in USA of course, fifty nine point five to sixty point five hertz, where it is sixty hertz. Sometimes we need to conduct approximate load flow, how do you get transmission line losses computed? Add all the line flows having computer line flows, just add them one more command computer command .Add all line flows, if it is zero ideal situation. If it is not zero which is a practical situation, it gives you losses.

Approximate load flow solutions we need, sometimes when we do planning steps, we do not have to do exact change. What will happen in two thousand twenty? God only knows, god only knows. So, there is no point in doing accurate steps for two thousand twenty. So, we can always for expansion sake, to decide where we should establish next power plant. So, we can do these our planning studies, offline studies and approximate load flows. And how do you solve approximate load flow, by considering resistance zero. Once you say resistance zero, losses are also zero. The losses are there because of R, if resistance is not there any losses i square R.

And these thetas also become ninety degree or minus ninety degree, once resistance goes … R X Z; there is no R, it is only X so, and it is only ninety degrees. And sine of delta i- minus delta k- becomes delta i minus delta k, because delta is small. What is sin thirty? Zero point eight six six; root three by two. Sin zero is zero, so it varies from zero to point 866. So, you can always say the angle and sine are same, when delta is small and delta is indeed small, you always operate on a linear zone.

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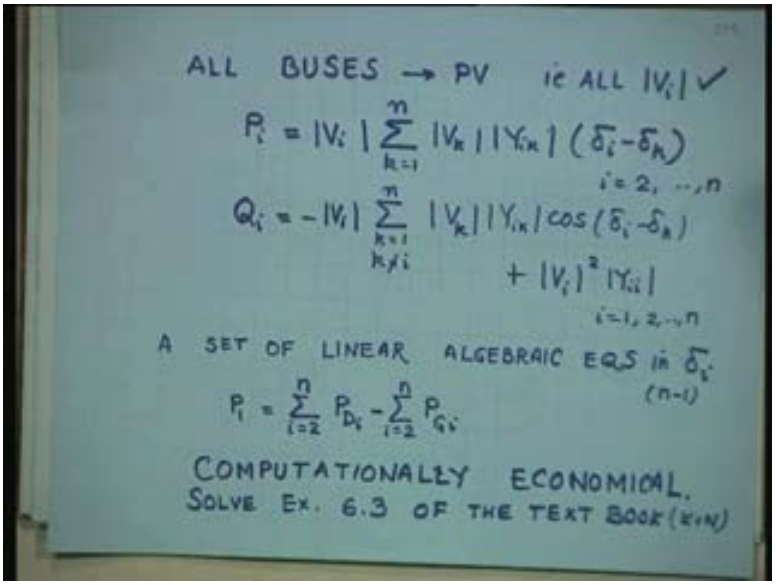

Let us also assume all buses are PV buses; there is no PQ bus. If you assume that, what is advantage? All voltages are node. Once you say PV means, what V is specified; that means, your non-linear equations SLFE get reduced to linear equations. All voltages are known sine, cosine gone. So, what is left? Only deltas, and this equation will give you the values of delta which then you some substitute here, you get value Q.

So, a set of linear algebraic equation in delta i- only; voltages are not unknowns. And hence, we can solve them by ordinary close form solution. Crammer's rule to determine all those things and once we know that, and then P 1- is known to us. Anyway because all P D s known, all P G s known, so P one is also known because losses are not there. Earlier why they are not known? Losses were not known and losses we know use to know in the end. And hence, P 1 we use to know in the end, now there is no such problem. Computationally it is very economical. Please solve, this is a take home exercise, not take home test. In US, they give take home test, they believe the students and whatever the student submits, they get marks on that basis. Here somehow, we have no faith on each other and hence, take home test are not given in India, because it is assume that one third of can solve it; rest can done it Xerox, that is what happens in assignments. But I do not mind even, if you understands and copies unfortunately what happens? He gets Xerox, he does not want to understand even, and that is what creates problem in India.

So, please solve six point three examples, which is already solved example. You have to only read, how do you solve solve example? It is also an art; do not read it like India today or film fare or whatever. Read the language of the problem, close the book, and solve it yourself. The advantage is in solved problem, you will exactly pin point where you are gone wrong. Assuming that the author is correct, that is a big assumption. There are books in India where nobody knows, who is correct? , Mehta. There are so any books, because god only knows, what is correct? And what is not correct? But if the book is standard, and if you know that the book is not wrong, then you can find out where you have gone wrong, which is not a facility in unsolved problem. Because there only answer; if you get answer, then you can only feel satisfied. Sometimes, even if you get answer, the method can be wrong.

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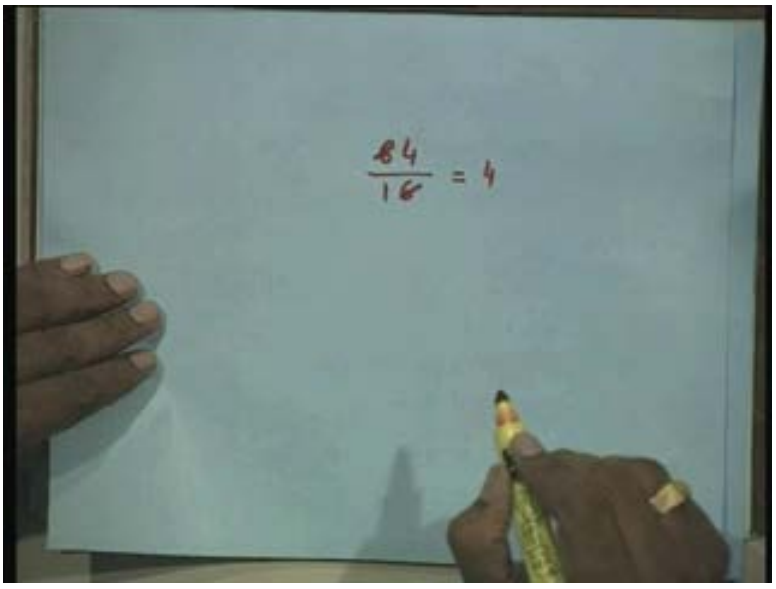

I will give an example; sixty four by sixteen, answer is four. If you just get six and six and get four this is wrong. So, even if you get a correct answer, is no guarantee that you have done correct. You might have made two mistakes, which will cancel each other and still you may get a correct answer. And that is why, and this is true for any course till you are appearing in exam. In your life, which will not be long now, because you will have to stop PhD, you do not have to appear in course courses. So, this may be your last year of appearing in exam and so on, university exams. So, that is where the the solved example helps you in building confidence. So, do not just read it, but close the books try to solve it and see, whether you can get the final answer. So, example six point three, please try at

home. I assume that, all of you have books. Now, we come to one of the methods that, we adopt for solving load flow problem; approximate solution, you will do it at home that problem.

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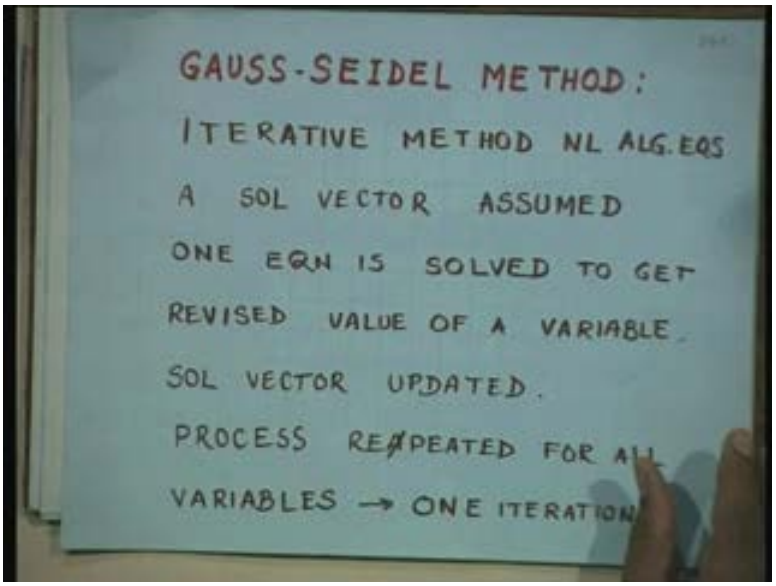

There is a Gauss method. What does the gauss method and Gauss - Seidel method? What is the similarity? The Seidel is another person, who modified gauss method, what they used to do in gauss method? They never used to update till the end, which will use to take more time in convergence. What does is Gauss Seidel method does? Suppose you calculate x 1, so while calculating x 2, it uses this letters value of x 1 rather than earlier assume values of x 1, x 2, x 3, x n.

So, this will definitely has in the convergence process and that is an only difference Gauss and Gauss - Seidel method. I do not think, I want to start this method. Today I will start it on next Tuesday which will be, what today-sixteenth, so twenty fourth of august. So, gentlemen will meet hopefully on twenty fourth of august, same studio, time is not same; that is twelve to one. Any questions you have in this lecture, whatever you have done today. I assume that, when you go back home, you do read what is given in book? Even if you are done this topic earlier, it is nice to revise it.

So, that it gets perfected and in case some of you become teachers, because teachers now lot of vacancies. So, you may have to also teach similar topic or any topic, any questions, any doubts in todays lecture in that case, if not then. Thank you very much.