Power System Generation, Transmission and Distribution
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Lecture No. # 30
Fast Decoupled Load Flow

We start today 30th lecture and it is an Fast Decoupled Load Flow method, before we go for this lecture, we just had a minor one, the test one, I distributed the copies, some of the ideal answers I will try to give the slack bus, why do you select slack bus, what is an importance as you all know, there is only one slack bus, rest of the buses are either P q or P v.

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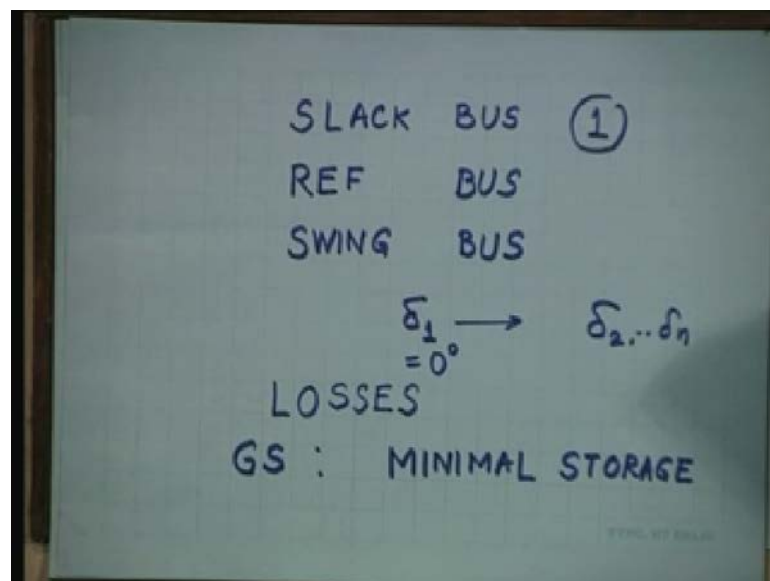
Now, when you say slack bus, it is only one in number. Now, it is also called reference bus, it is also called swing bus, if you remember all three names, you could answer this question, rest of the bus angles swing with respect to this bus or rest of the deltas right from delta 2 onwards delta n are referred to slack bus, which is normally numbered as 1, delta 1 and this is also called sometimes is 0 degree, not necessary no loss of generality by assuming it to be 0, otherwise let it will be 5 degree and some bus can be 45 degrees. So, angle between them is 40 degree.

So, this one reason, why you have to have a slack bus, secondary thing the losses, losses are not known till the end of the solution. So, you have to have a bus preferably the biggest, the largest unity in a system, preferably located centrally not necessary, if you have a state like UP and you have a singroli power plant, which is not located in the middle of the UP does not mean you will not have a slack bus as singroli super thermal power station, but it is always better through the located centrally.

So, that the distance travels to feed that power is minimum, less the distance, less will be the losses. So, this is the reason, why you have is slack bus that is to satisfy part portion the losses and to give either reference bus, because rest of the buses swing with reference to this particular bus, this is the importance of slack bus and the requirements are it can be the largest bus, it can be centrally located, largest generator attach to the bus, these are two requirements and this is the importance.

Now, what is the advantages of GS methods, when you say GS - Gauss Siedal, this is not just specified to gauss most of your given the advantages, difference to only gauss, no even if you do NR even is respect to FDLF, you remember we drew table comparing various methods with attributes and in that if you recall, GS needs minimal storage.

Minimal storage is not only gauss even respect to FDLF and respect to NR, why minimal storage, there is no complicated equation, there is no matrices, just play the equation V i k plus 1 is equal to V i k, one upon Y i i P i minus J q i upon Y i j minus sigma V i Y i upto upto K minus 1 with bus, the latest values after that the one iteration earlier values, because we have not computed them for this particular equation.

I hope you are understand, we are come up to fourth bus. So, first, second, third will be latest value; fifth, sixth, seventh will be the earlier iteration value, because that just cannot available, this is the most important advantage of GS is it leads minimal storage, this is highly anything to store.

The second biggest advantage of GS method is any fool will be able to program, it do not need any knowledge, because the hardly anything to program, it is not a complicated programming; no inversion required no traingularisation, no back substitution etcetera etcetera. So, this is a second biggest advantage of Gauss Siedal is, it is simplest, anybody can program, programming is very easy, it needs minimal storage and these are the advantages, you should have given and you did not talk about it is disadvantages,

because it is not whatever is not you should never give information more than require whether it is a coat room, whether it is a viva, whether it is a interview, because we should be crisp we should be to the point in all these in whole life, you should not speak more than what is necessary unless actually you are among your friends and all those things that is the separate issue.

And the last was write SLFE, I think most of you have written correctly in plural form barring few who are forgotten to write minus sign in Q I, you need to have a minus sign for second equation, some of you have not written and some of you have done other some spelling mistakes, but by enlarge SLFE have been properly written.
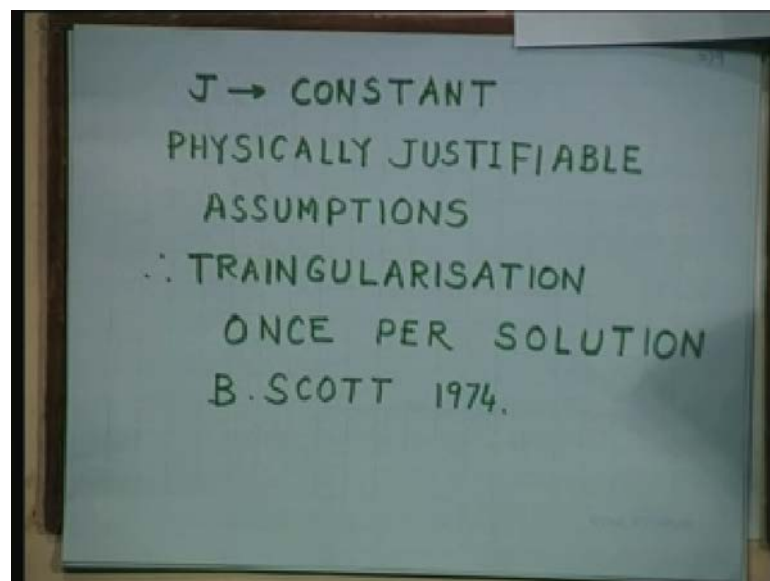
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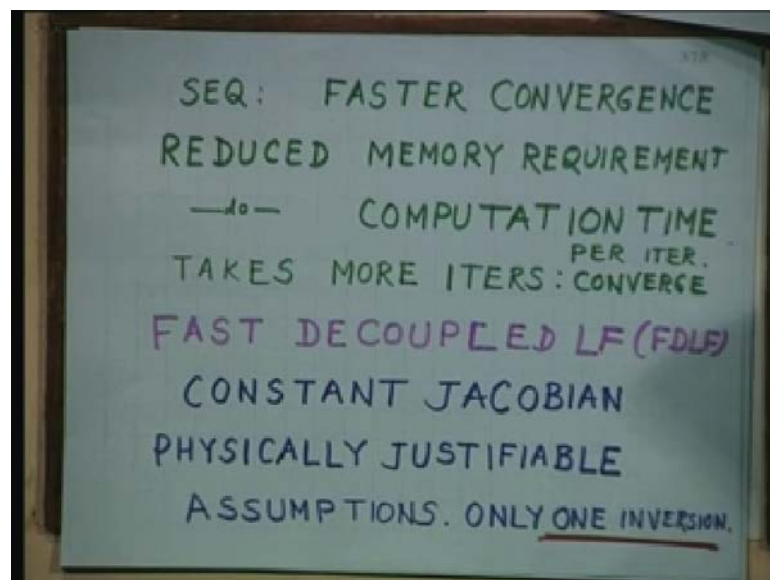
Now we come to today's thing, if you recall, we were talking about fast decouple load flow method. Now this method was first given by start brand start a Professor at UMIST, University of Manchester of Science and Technology, Institute of Science and Technology, Manchester is about 3 hours from a airport, this was given in 1974, why did it give this method at that time, the computer was in it is infancy.

In fact, the first computer was invented I told you 1948 by three British Scientist working in UMIST again Manchester, where you have that ground of old deferred, where you play test matches, where I think for would engineers used to play his county matches we are back, I do not know whether newer version born at that time and talking about 71 that was 70s was the .

So, why there was a need to evolve or work on such a matter, the jacobian has to be involved it every treasure. So, that from baby computer we came to calculating board, slide rule, analog computer, digital computer, the gauss siedal method came in 1956 by two gentle man called Ward and Hilly; that came Newton's method by Tiny and he is associates in BBA then only power administration, this is a power company in US and tiny in associates gave this Newton's method, then came decouple method again by start in 73 and 74, he gave a fast decouple he was not a quiet happy with only decouple.

What was a need, so that jacobian becomes constant and once your jacobian sorry once the jacobian becomes constant, you have to invert it only once, because in every patients no changes take place, once it will becomes a constant matrix, there is no point in inverting it again and again you are still going to at the same answer, but this has to be done by physically justifiable assumption. So, that only one inversion is required.

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So, once J becomes constant traingularisation also has to be done once per each solution, method given by B.SCOTT. What are these, physically justifiable assumption. Now, I am going to list them.

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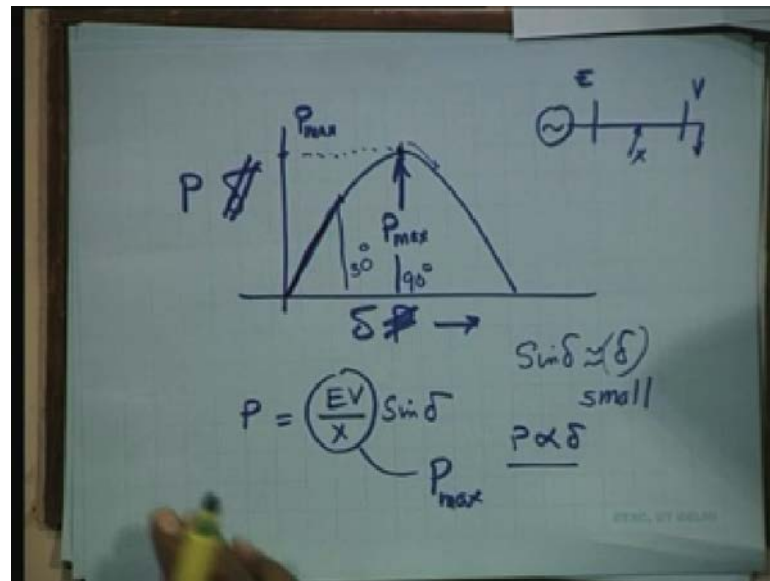
As all of you know, the angle delta at which we operate is small, why this small, I will tell you,

P is proportional to sin delta EV by X is constant, this is called P max, why it is constant, P versus delta, this is P max. EV, E is fixed; V is fixed, this is the transmission line, this is V, this is E and this is X. Once transmission line is fixed, X is fixed voltage at the receiving end is fixed, voltage at the sending end is fixed. So, P max is constant.

Now this p max occurs obviously, sign delta is 1 and sign delta is 1 and delta is equal to 90 degrees, but we do not operate at delta is equal to 90 degrees, because it is dangerous you are standing here Mount Everest, slight distortion, slight fluctuation, slight portables will through down. So, you are critically stable here, since some of your controls students you must have studied, stability in control systems, you have critically stable system, you are marginally stable system that is several adjectives used along with stability. So, it is better to be safe and the safe is linear portion of this curve and the linear portion goes up to 30 degrees, sin 30 is how much? 0.866 roots 3 by 2, root 3 is 1.73 by 2 divided by 2.

Sin 30 is?

0.5

0.5, sin 30 is 0.5. So, why we are saying now that is all the reason, which was giving sin 0 is 0. So, sin increases very slowly, so it remains a linear portion. So, sin delta can be put equal to delta for small values, this is ok for small values of delta. Is it ok? So, it becomes a linear that is P directly proportional to delta and that is why, this is linear. I am sorry that is not the answer, the answer is this. Why this is linear, I was trying to explain that. So, it is linear, because P varies as delta as long as delta is small. So, we operate somewhere here 30 degree. So, we are safe.

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So, we come back to our original slide and that is why when delta is small, cosine of delta is 1, it is exactly at 0 degree, but for small it goes up to 0.866, this is 0.866, 30 degree cosine is 0, this is very close to 1, 86.6 percent you get A grade, 99 percent also you get A grade. So, as for your guiding system is concerned 86 is same as 99 or 100 for that matter and that is why start was knowing about our guiding system, he says this is equal to 1, the reverse sin of that small angle is close to 0, this is very nearly equal to…

And hence, G i j, G is conductance, sin of delta i k is less less than much much less than B i k and similarly, Q i is less less than B i V i square, what is this, where do you use this, this is an expansion of H i k, L i k, N i k, J i k, you may ask me, what is this H, L, M, J you never talk about it, this is the some matrices, when you write this Newton Rapson method, delta P delta Q, H, N, J,L, delta delta, delta V, if we require, we did not use H, N, J,L. What did you use? You use delta P by delta delta, delta P by delta V delta

Q by delta delta and L was delta Q by delta V, but if you are fuzzy you do not want to do more work than you can replies those derivatives, first order derivatives, because JACOBIAN was defined as the matrix whose each element is first order derivative of something delta p by delta delta, delta p by delta V, delta Q by delta delta, delta Q by delta V and this some authors, some experts replies it by H,N,J,L.

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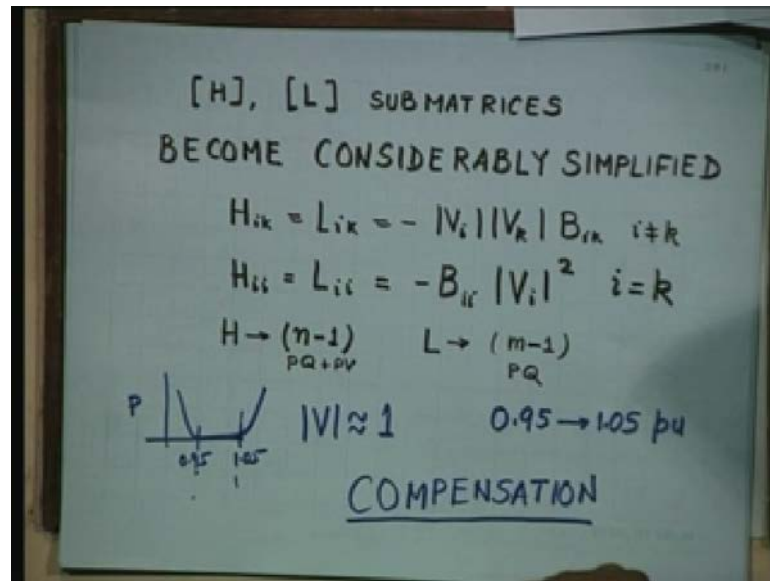
H and L are diagonal sub matrices and J and L are sub diagonal, sorry of diagonal sub matrices. Now, this is the full expansion of H and L, N and J for Newton Rapson method, but when you use these assumptions they get simplified, considerably simplified and you just get V i V k B i k, minus B i V i square. Now, we can make further assumptions that we also remains more or less near to 1, which is of fact V suppose to vary between 0.95 to 1.05 per unit, I think all of you know, this curve

V should vary in this range and once we crosses this, there is a penalty and penalty will be still, as you cross more and more this limits particular penalty, some electric companies now penalize you , because the movement V goes below 0.95 or above 1.05 you start using compensation and those of you are in control systems they understand, what is a meaning of compensation, you all the time talk of compensation lead lack, lead lack and so on.

Similarly, power system people also talk of compensation, but this is the different variety of compensation is not lead lack or lead lack, this compensation is capacitors the bang of

capacitors, the bang of inductors, where do you put this bang, I sure you where do you put this bang.

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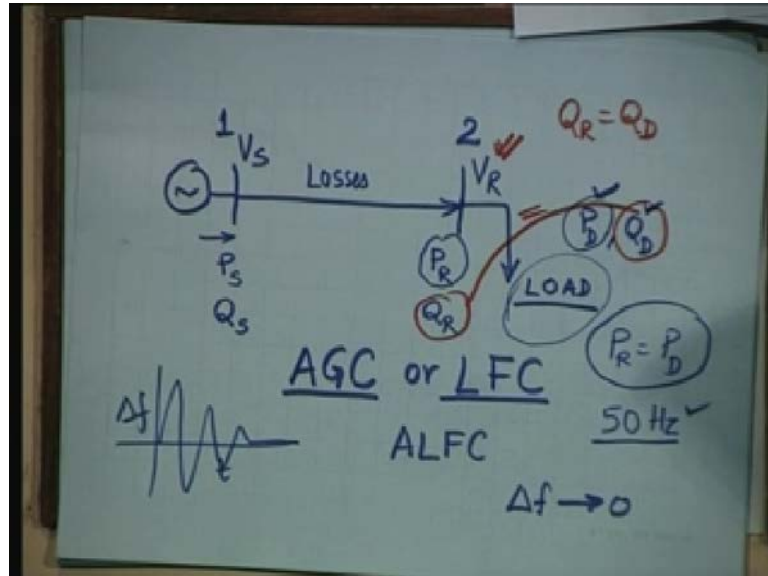
This is the generator, this is transmission line, this is load bus number 1, bus number 2, from here starts P s and Q s sending end real power, sending end reactive power, by the time it reaches load end or receiving end they became P r and Q r, why they became, there is on the way LOSSES, any practical line we have a resistance and anywhere where there is a resistance there will be LOSSES, even if resistance is 0 some resist to consider this is loss less line, electrical engineer do not, but ... If you read field and waves theory in jar dens book, if at all he do your IAS Engineering services and somewhere you should have to need that book and distortion less line and loss less line the chapters

Even if your R is 0 X is there, if X is 0 means you are talking the cube, then nothing is there then how do you interconnect. So, for there is no wireless transmission in power systems it may be there in microwave and telecommunication you have those cell phones and even card less line, land line you know, you can perhaps within one for land or within few 100 yards, you can more around and talk, but you will never see that you can transmit power from hydrogen you cannot place without any leak, without any transmission forgive to not places, even this substation your near bang to your hostel, I do not think you can transmit power without wire, wireless transmission of power system not request.

So, you have to losses in that case P_s and P_r and Q_s and Q_r will be different, by different I mean it they will be lower than this, because you are going to lose something, you are not going to gain something. And hence, once P_r and Q_r reaches this end, there is load sitting here, otherwise it there is no load, no need of an any power system, there are no student no need of IIT, what is the use of IIT, when you all go away in summer time of course, IIT is a Bombay navel sleeps. So, similarly, IIT never rest, there are PG student, there are PhD students, who all the time common talk to the teachers; that is why teachers are here in summer vocation also, because there is a business for that now using the management terminology you know, our business is we are dealing with you and that is why, we are carryings some.

So, if there is no load all electrical engineering courses will be closed that is power system, because no load means, no generation required. Since, load is there, we all there as the power engineers, even control engineers, load keys defined as P_D and Q_D, P_D is the real power load or load demand, Q_D is reactive power load or reactive power demand, you are all path they are friends hand in hand together. Now, P_D should be equal to P_R then there is not a problem, whatever is the real load, real power comes, beautiful, excellent arrangement, whatever you are expenses if your scholarship is due to expenses, what also need, you tell us, what your expenses this month, this is your scholarship, only danger is you can go on increasing your expenses, your or cannot place full increase.

So, can you should be increase correspondingly scholarship per hours 1 day the thought is will say enough is enough, this is your fixed scholarship term, but suppose it is possible then why not similarly, whatever is your load if you have that much generation available, nothing is required beautiful arrangement coffee break, morning to work unfortunately the nature is not so accommodate, to get problems in life, life is not a bad of role is always some problems in every body's life and you are to tackle them, some sickness, some bad news, all these things keep on occurring all the time in life every body's life and the challenge is the thrill is in tackling them had on rather and running away like suicides, in the program in between if you are getting foreign offer then leaving that is the separate thing, you are going for bigger job.
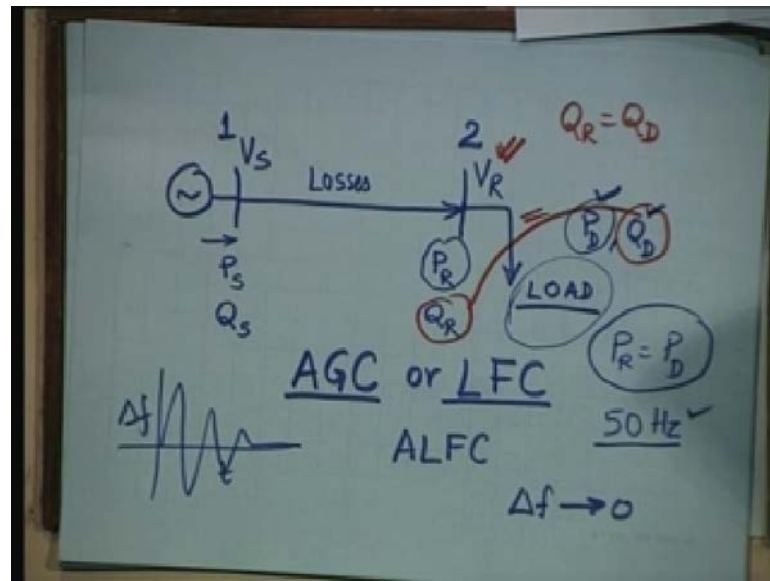
If it is gone, what do you do, we go to AGC, this is the control system, Automatic Generation Control, some people use to call it LFC or even ALFC Automatic Load Frequency Control. What is that, normally the generation will be less in Indian conditions, here everything is less, nothing is more, number of phone connections less, number of houses people more or less most of us live in rented accommodation, as a tenants, most of us try to borrow money, there very few people to give money, borrowers are more than the landed. So, normally in Indian system or in third world system the load is always more than the generation.

So, what we do, we try to increase the steam output, but controlling the governor and as long as we are able to increase the steam input to determine the more power will be generated and the moment is balance is established P R is equal to P D, we stop increasing the steam input, this is called Load Frequency Control, frequency is back to 50 Hertz.

So, delta f versus time deviation becomes 0, here various control system controller P controller, P I controller P I D controller. In P controller it is not necessary that study state arrow will be 0 that may be finite arrow delta f still left, but P I controller will ensure that your delta f with time will tend to 0. The movement it enters at 5 percent zone, this height is ok. It is safe.

Now, suppose is what possible, you have try your level best, no more further increasing still in input possible, physically problem gate opening a hydro power corresponding to steam input, you are opening the gate, you open the full gate, then what else in left, nothing else no further opening, you are going in a car, you want do your hurry, how much speed, 100 kilometer per hour or 60 miles per hour, beyond that you are at risk, you may not be there for there who will be is their destination. So, it is advisable not to cross certain limits in life. So, the speed limit can be only increase to that extend, which you consistent, which your car consistent.

Similarly, here you cannot go on having it will be flat, it do not be power generation it will be flat. So, there comes the concept of load control, load management, energy management there where your control knowledge will be store. While control system people are doing this course; that is a methoding magnets is just note like that or may be somebody matrices energy courses is very easy (()) there is a meaning in control system techniques can be very easily applied to power systems.

So, here you try to text called load side management, demand side management, which is a very important area in energies energy studies, there in situations Full fledged world bank IGDR - Indhira Gandhi Development Research Institute in in near film city in Bombay where they were there in people have working around the clock on these departments, demand side management, how to control this load, how to shift this load somewhere else.

So, that the proper generation is there, nothing else then you do what did Indian do, Indians do what they do, load shading, 2 hours no light so load has been . So, whatever generation is available, we get tune to that raw then we control the generation, usually we cannot control, we are limited resources that is what a poor man does, he forgets about one time fool, it takes only once or no there or no something like that 's load shading equivalent to load shading.

Only VIP area will be served, only hospital will be served, only education institution should be served and their major graduality will be domestic load, because the no other people have now inverters, I have been used or candles. So, this is the whole idea about LFC, but there is another fellow sitting here Q, we are not talk about Q at all, Q means voltage control V R and V S, if whatever is Q D here, let me change the color of the peg,

whatever is Q D here, if you can supply Q R no problem, no voltage problem like no frequency problem there, this Q is connected with the voltage problem, voltage remain V R whatever you want as long as you sure that your Q R is equal to Q D, I think we can change the page, the virgin becomes too much of in mixer.

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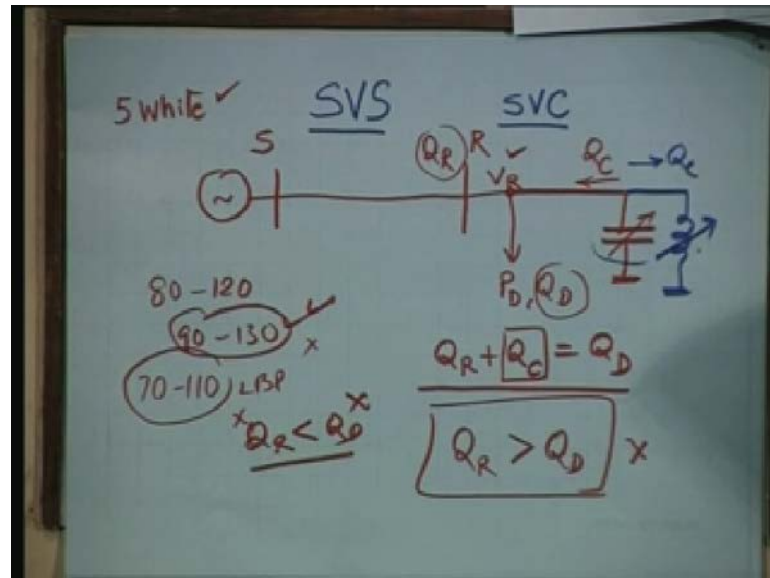
As long as is Q R and Q D are equal your V R is ok. You remain between 0.95 per unit to 1.95, but as I set the nature is not so accommodate, this Q D and Q R are never equal in Indian system and if it is low; that means, Q R is low than Q D the volt is (()). movement is start another bulb in your room or your house, you can feel you can sense dimness in light, have you ever seen that specially, if you started AC the big load, you feel the difference immediately light will be slightly dim, because the extra load has come the Q requirement is gone up and if you do not have that much of Q, the only way the nature adjust itself is voltage , but if it than there is a problem of voltage stability, which is much bigger than angle stability, the stability which you are studied in under graduates is angle stability P delta curve, swing equation, how the a machines swing with each other, these delta is increasing without bound that is a unstable region or you going more than 90 degree unstable region.

So, it to come back you are to say equal area criterion, all these swings you must have done method modified Euler's method, compute draw the table before fault, after fault before you know, all those things voltage stability or voltage security is much more

series problem today in India than angle stability. And the first book in voltage stability came in 1994, Sub level in library those of your interested can read it.

So, how do you make it equal you do by compensation, bang of capacities and this is Q C are then applied Kirchhoff's current law here, Q R plus Q C should be equal to Q D, this here importing extra help, borrow money, some month your money short, your friends, you have some relative, local gradient and can you give me some money on short, I will give you next month from my fellow ship.

So, this is the you are borrowing, this reactive power from external to your system, voltage stabilizer along your TV set, voltage stabilizer along with your AC what for, so that your AC does not go band 15 20000 worth rupees investment, your color TV 15000 worth investment will go bad if you have no voltage stabilizer, but do not think always Q R will be less than Q D like a blood pressure, you could have a low blood pressure. The blood pressure required is 80-120, normally people become 90-130 take lot of salts, take lot of sweets or junk foods, pizza lot of chesses, not your generation, my generation, you will not feel it today, you feel it tomorrow and sometimes that will be late.

So, you are to be very care full and white, 5 white persons, what are 5 white persons, salt, sugar, ghee or butter, a egg the white part of the egg and rice, because still the chapatti come there is a tendency the hostel to go on taking rice, even if you are in not a rice (()) South and Bengal and so on. Anyway, this is medical thing, I do not know talk whole this year that is come back to this blood pressure.

So, sometimes they can get 70-110 more dangerous than 90-130, this is high blood pressure, this is low blood pressure, this is equally dangerous. So, high voltage problem, low voltage problem both are equal in dangerous the voltage current 170 that is , but the voltage between 250, the bulb becomes too bright it will go fuse and that is the . In fact, one there is low load, light load conditions, you may have a condition when Q R is more than Q D; this is equally bad as Q R is less than Q D both is bad.

If this situation occurs, what do you do, you have not switch of that is not the way that is like you have bang of inductors and this swing take some reactive power absorb. So, what is this extra will go here leaking watts, lagging watts. Capacitor generates this inductors absorbs, so that the voltage remains nice V R, this is called voltage control problem. And this is called bang of capacitors and bang of inductors, but this is a static

compensation and this is not a end, how do you control the amount of capacitance and amount of inductance through solid state control those of your studied power electrons drives in undergraduate then over you well what is a thruster, PN - PN junction not you control thruster, easy to control furry angle, how do you control furry angle through computers, through micro processors and hence, this gets automatically control and the whole system is called SVS - Static Var System, SVC - Static Var Compensation of course, now a days you have bigger things coming in the market called facts, flexible easy transmission, which is full flex course in electrical engineering department, I think or somebody station earlier is to teaching whose now happily sitting in this

So, I think, you are come to 1'o clock and we continue our story with FDLF another on next Tuesday, any difficulties so for, but we have done today. Now, you understood, what is the… this is the real heart of power system that is voltage frequency, how do you control it and that is why you need your control system of course, now a days there is a intelligent control, smart control, no body not smart today, everything is smart card, smart window nobody is not smart, our generation everybody was not in smart. Now, today's generation everybody smart, smart control, the fuzzy logic, genetic algorithm, neuro fuzzy, American Indian, Indian American, neuro fuzzy, fuzzy neuro.

Thank you, gentleman.