Oral Discussions on Session: "Control and protection" – Part I

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Abstract

This paper contains the first part of the transcribed oral discussions of Session "Control and Protection" of the 2013 IREP Symposium - Bulk Power System Dynamics and Control, held on Tuesday morning, August 27, 2013. Papers [1]-[4] were presented.

Discussion

Chair: The floor is now open for questions.

James Lyons (retired General Electric): For the last speaker [4]: There are three start-up companies in the USA right now working on distribution voltage control with low voltage power electronics. Two of them are pursuing UPFC type architecture with voltage series and shunt compensation, and there is also another initiative in California, called smart-inverter initiative, which is built on German experience. I am told that the shunt compensation, just VArs, doesn't work so well. And the fundamental issue on high penetration of PV in Germany etc. is cloud passing and then pumping up and down the distribution voltage. Can you comment on that? Have you thought through these types of controls?

David Hill (Univ. of Sydney)**:** Just really not much more than what I said. There are colleagues around me who are trying. They see the issues and they are taking a fresh approach. They tried some of the existing methods, like scaling down STATCOMs and similar approaches, that didn't work very well. So now, and I think that I know the initiative that you mentioned in California, they are starting all over again in a sense to design new controllers for low voltages. My point was that we need to follow that, and model them and include them in our coordination techniques. Hopefully, those controllers would be decentralized. You can't coordinate millions of things like that or even thousands perhaps but you can include them in your models of the higher voltage.

J. Lyons: One of the claims made is, looking at series compensation that more isolates a sensitive load from the distribution medium voltage directly. That should be quite effective in controlling actual delivered voltage to given customers. So, when you have problematic customers on the distribution feeder and you can isolate a few of those, you can live with wider swing of the feeder voltage and keep everybody on.

D. Hill: I think that is all sensible and I am not dealing with that on a day-to-day basis. I think there is a genuine control problem that we can deal with using a lot of techniques, not actually apply the techniques but use the ideas we got to address these problems.

Stefanos Sofroniou (IPTO, Greece)**:** I would like to comment on the first paper by Professor Kezunovic [1]. First, I would like to say that I have enjoyed the paper. I give credit to this paper and I would like to emphasize some things. I think that the aspect which professor Kezunovic presented is perhaps one of the most challenging issues of the protection and operation today in our networks. I mean that we must all realize that now we have the tools and we have also the background to make our networks better. We can now operate the system based on the available protection and operation data, and I must emphasize that there is a business value, as professor Kezunovic said, in this application. In this context we are considering applications of, let's say, SCADA type systems, where we can exploit all available data from protection, from operation, from automations. As you know in protection we now call the relays IEDs, intelligent electronic devices. I would like to refer to three possible applications. First, we can locate the faults accurately and act faster. Second, we can have adaptive protection, so we can address the problem with fast changes of the topology: we can follow up the network which changes continuously. As you know relay settings are fixed, but we can also exploit also the possibility that the relays have a different group of settings and they can change over in case the topology demands this event. Then, the third application is that we can analyze the events and make better decisions and on top of that to help the operations. For example, as you know the practice in protection is that when a fault occurs, then there is an automatic reclosing. When the fault persists, we have permanent trip. After

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that, the operator is obliged to restore the line. There are many papers, and I think the situation is now very mature, where we can analyze the quadrate files, the transient files, and all the oscillatories we take from the relays, and we can understand what type of fault it was. Whether it is a weather initiated fault, whether it is a lightning, whether it is a contact with the machine etc. And so operators can learn to respond better to future faults. So, I would like to say that we must trigger the utilities. There are many utilities now in Europe that have such systems. Perhaps professor Kezunovic would like to say if there are such applications in the United States and I think now we must pay attention to the quality. We have the tools and we must rely on them.

Mladen Kezunovic (Texas A&M University)**:** I don't have much to add to the examples that were given. They are good examples, people could look at them. They are published in different places. However, I do want to make one point, maybe re-emphasize what I stated in the beginning. The data is available now more than ever and it's not going to go away. It is just going to be bigger, probably. Or there will be bigger use of it. The problem is they are going to grow. And they will grow exponentially. So the question is what is the business value of that? It cannot be ignored because the way data are collected costs money. And so, if you are trying to collect more of it, or if it is available because you installed the equipment, you have to calculate the return of the investment. So, that's a challenge I didn't find addressed by the industry, even suppliers, or anybody like that, let alone the utilities. I think that's an issue where we should focus on as a community.

D. Hill: Can I make a point on that? I'd like first of all to say that I think everything in your presentation [1] was perfectly sensible and looked like good old fashioned principles of having the right data in the right place, at the right time. And you can argue that terms like big data and smart grids are necessary for getting grants and so on. But there is a danger here too. And I'd like to use a personal experience. There was a major project in Australia, a hundred million dollars project, on smart grids. And the people involved were telecommunication engineers because they were the new guys in the utility and IBM and Ericsson. And I remember sitting through meeting after meeting with these IBM and Ericsson guys and they knew nothing about power systems. Absolutely nothing. But they had all their LTEs; this is physical layer telecommunications, and all these big computers. So their view of a smart grid was to collect heaps of data, the more the better, send it over large telecommunication networks and store it somewhere. And they were openly saying, we don't know what people are going to do with it, and there were a few academics on the periphery saying "Hang on, how are going to use this?" So, I think there is a danger in embracing a paradigm that involves just collecting lots of data. And I think in the power community we have a long worked-out tradition of having the right data, that can be more data and more computers, but the right data in the right place at the right time, sensibly accessible, but not just great silos of data, I know that this is not what you are suggesting, but this is what happens in the end when you put it in the wrong hands. Great silos of data and nobody knows how to get them to talk to each other, just by the sheer volume of it all. So, I just wanted to add that this has to be embraced sensibly. And not just as big data that can be good for the sake of it being big.

S. Sofroniou: A second thought is that with all these applications there is an issue about the investments. The utilities must be persuaded on the added value of an investment and I believe that there must be step-wise investment, starting, for example with a pilot program for the major substation, next evaluating the results and finally deciding to proceed with the whole system. And we must not wait for any black-out, because many times the utilities are forced by a major event to make some innovations. Nowadays we have the tools to predict such situations. Thank you.

Chair: This was more a comments than a question.

João Peças Lopes (University of Porto): This is a comment and a question to Mladen Kezunovic [1]. Of course I fully agree with what was presented. I would like to make one point. Now we are not only dealing with big data, those large volumes of data, but those continuous volumes of records that are coming and this requires new solutions, new techniques like data stream analysis. We, in the power system community, are already used to, for instance, machine learning and knowledge extraction techniques, but now we have to face another challenge: this is a continuous stream of data that is coming and so we need new techniques for that. Are you envisaging some specific new data stream analysis technique to deal with that?

M. Kezunovic: Yes, we are working on these techniques. The slide that I have with these slices of processing is the key slide. That's the data analytics that is required to handle the data and that is the big companies are not familiar with, because these data analytics are related to the power systems, that's how you process data to correlate what is happening in the system, that's why they are talking about moving data, storing data at these scales. The implication of my discussion was not to go and store necessarily but process at the source quite often and extract features and deal with the features. But the data contains a lot of information and knowledge depending on how you apply data analytics. The key to this big data problem is the data analytics. There was an article in Power & Energy magazine a few issues back we published on this issue of data analytics, which contains more information for those interested. By the way I don't want to pre-empty the discussion. There are other good papers, so you know…

J. Peças Lopes: May I make a final comment now to the last paper by David Hill [4]? Presently in Europe we are already developing solutions based on distributed control, voltage control solutions, like the one you mentioned in Germany, to deal with large integration of PVs. The Grid Code that is presently being put in operation is such that the DSO is capable to send setpoints to the inverters of the PV panels and they are prepared to deal with that. I also believe that this is not enough. It is necessary to have specific power electronic solutions to make the interface with the grid such that you can limit the amount of power injected into the grid according to the voltage level at the connection point. And we have developed such solutions, but I agree that this has to be matched with centralized control that is local, although in some ways centralized. Thank you.

D, Hill: Thank you.

Claudio Cañizares (Univ. of Waterloo)**:** I have a comment for paper [3]. And then a comment regarding the continuous discussion that David Hill [4] brought up about medium voltage / low voltage regulation, which is an interesting issue. Regarding paper [3], equations (20) of your paper and slide 15, basically those are complementarity constraint representations of the Q-limits, was worked by Bill Rosehart, I think almost 10 years ago, which you may want to take a look at. That work I used 6-7 years ago, with a student of mine who presented a paper in IEEE Trans, on Circuits and Systems discussing the feasibility of a power flow solution represented as an optimization problem, somewhat related to your work. What we tried to do was to see the problem from the semi-definite programming point of view, we couldn't solve it, so I am glad that you were able to address that very smartly, very intelligently, so very good work. Regarding the issue David Hill raised, regarding low voltage / medium voltage regulation and trying to coordinate all of that, I am a bit really worried about that, because what is happening, for example, for low voltage levels is that customers have their own objectives. I am involved in a project with an industrial customer right now in which they are implementing voltage regulation at the low voltage (400-600 V) level and basically they have their own objectives. So what they are trying to do is to reduce the voltage, reduce consumption and reduce peak load, which is advantageous from the point of view of what we are trying to do in the power system, which is basically to reduce load. And then at the medium voltage what is happening with all these PVs, wind turbines, the Code is changing, so now these are being forced to regulate voltage, so that is another advantage for us because that is fixing the voltage at that level. This is not necessarily going to be good for the system because now the load is going to start behaving like constant power, which we don't want from the system point of view. We want that load to reduce with voltage. So, we need to be aware of these issues but trying to coordinate all of these, I think you mentioned that, will be impossible.

D. Hill: You give a better explanation than I did.

C. Cañizares: We need to be aware of these issues and represent that at a higher level but trying to coordinate all that, I don't see that happening really.

D. Hill: Well, I agree. We have to propose solutions, we can't keep talking. I think there was a point on Sunday; I just say that we need some science in this. This is a time when we can't keep talking about renewable penetrations of 50%, 60%, 70% and so on, without scientifically proving that it is going to work. And voltage stability is just one of the issues and I think you have given a very good explanation of how I see it. It is not clear how to deal with high penetration of renewables, the high penetration being at low voltage and high voltage, if we are going to have the sort of voltage security we are used to. It is not absolutely clear to me that we will achieve that. So, we need to work on it and hopefully show that it is possible for very high levels of renewables. So, I think we are agreeing here. We always had this issue. Low voltage regulators, always looked after their own voltage and that's why when we were first looking at coordinated voltage control, we considered strategies like tap locking and load shedding to get rid of those low voltage activities which were working against the preservation of the System voltage, the high voltage.

Emmanuel Thalassinakis (HEDNO)**:** I have a short comment to the last speaker [4]. In the testing scenarios you showed for the IEEE system I see that there is a line tripping at 30 seconds and then at 180 s meaning that 150 s later we have the line reconnection. I just noticed, this is "seconds" not "milliseconds". So it's not the re-closer that operated, it is just manually the line came into the system.

D. Hill: Maybe we can look at this off line, if that's OK. I am not sure I fully understand what you are saying, but I probably forget the detail.

E. Thalassinakis: OK maybe we can discuss it later.

Alex Papalexopoulos (ECCO International)**:** This is a question for the first paper [1] about big data. Now big data equals big money. The question for you is more of a business question, as opposed to technical question, or more regulatory question. There is an intense debate in

Europe and in the US on who is actually controlling these data. For example in Europe are the TSOs or third party providers controlling the data? The outcome of that debate will determine in many respects the future of the utility business model. It is a critical issue and many important considerations ride on the answer to this question. How do you see these things going in terms of who is going to control these data? Are the utilities? For example, in Europe are the TSOs? Or third party providers?

M. Kezunovic: There are two issues with this. One issue is that some of the data we are referring to is readily available to anybody who wants to use it. The weather data, the animal migration data and things like that. These are accessible to anybody. The data that comes from the measurements in the system may have to be actually driven, in terms of the usage and future business models, by the value of that data. If I have a value as an ISO from the data that is coming from the operating company's substation and I have a business case for that, I should negotiate with the company how this return is shared. It's like everything else. You get something from somebody and you make money out of that, you go back to that person and you say "Well, you know let's see how we can share that income." So I think the first step in this, is to actually put the business value on data. And that is not done. If you look at the synchrophasor data for example, this is just one example, synchrophasor data is obtained today in different ways in terms of the ownership. In some instances, the operating companies that have synchrophasor instruments in their substations are the owners of the data. In some other instances in the United States the ISO has invested and installed the equipment in the substation. So, they are the owners of that equipment. The company has agreed to let them do that. So, now you have these two different business models. In the first case, the owner is the one that has the equipment and maintains it and can sell it to somebody else. While in the other case the ISO owns the whole thing and can sell it back to the company for operating reasons. Now, there is no relationship that is established right now on how to trade data. There is a relationship on how to trade energy but there is no relationship on how to trade data. So, I think that's where we need to head. We need to put the money on the data and establish the way how we trade data.

A. Papalexopoulos: I am referring more to third party providers not ISO vs. utilities. To me they are both Utilities. I am revering to Utilities vs. ORACLE, SAP, that type of companies.

M. Kezunovic: In my mind this is all the same. Trading data may be between the cloud computing entity that is going to provide a service based on this data (because I can provide this service for outage management not being part of a utility company; I can actually do it today myself). I can do it because I have software to do it. However I have to trade the data with the company to provide these kinds of services. So, it doesn't really matter who eventually processes the data and provides the service, as long as there is a mechanism to trade data. And that is what is absolutely missing. And I strongly believe we need to start the discussion along these lines, so that we can get the actual value of the data rather than storing the data, as it was mentioned, and moving the data and not knowing what to do with it and hoping that sometime in the future we are going to use it and quite often we realize that we don't even know how to use it. When we get in the future to it, we see that certain things are missing. So, it's useless. As a matter of fact, most of the data that is stored, there is synchrophasor data in many places, is actually useless in many instances. Because nobody has looked into how to use it.

Ian Hiskens (Univ. of Michigan)**:** This is actually a follow-up to the voltage control discussion earlier. One of the big differences we need to keep in mind when are thinking about voltage control, medium voltage and low voltage levels, is the high resistive network. We have grown up with the idea that we can forget resistance, but that's no longer the case and that alters the way voltages are affected by active power flows. Then add to that the fact that we have also grown up with the idea that the output of the generator is constant if we hold the voltage at the terminals constant and everything looks wonderful. Now, if we hold the voltage at the terminals of the renewable sources constant and we are pumping up variable active power pushing the voltage variations out into the network and if you are not coordinating with something else, you are going to see bad things happen in the network. It's a very interesting and different problem to what we have grown up with.

Chair: Was it a general comment or a question to anyone?

I. Hiskens: General comment.

Peter Sauer (Univ. of Illinois): The first question is to Daniel Molzahn [3]. Congratulations. It's always fun to hear things like that, proving that there is no solution to something.

(Laughter).

P. Sauer: I have to ask you though… First of all the power flow equations are not necessarily the equilibrium condition based on constant inputs to the control systems. They are different. They are sort of what you would like to have as equilibrium. Not necessarily what you would have. But I am curious if your method points to any type of remedy. Do you have any residuals that you compute that would tell you to change this parameter and then the solution would exist? Which would be very valuable for perhaps some kind of control.

D. Molzahn: We discussed two methods. The first one using semidefinite programming does give some insight to that question because it gives you the solution at the nose point. The dual variables of the optimization problem give you sensitivities related to that solution. I think there is something to that. With regard to the second method using the sum of squares, so far we haven't been able to determine what sensitivity information, if any, is available in the solution. This is something we are interested into looking further. Certainly there is some sensitivity information for the first method that could be exploited.

Sandro Corsi (Consultant): The question refers to the second paper [2] by Rodrigo Ramos. I follow your proposal to group preventive controls by an off-line computation based on a given system model. As you know the system model changes hour by hour, according to the situation, after contingencies and so on. It seems unbelievable that you can compute all these equations in advance. Probably you also need something on-line, real time and so on. It appears very complex, very heavy for a reliable practical application. Do you have any comment on this aspect?

R. Ramos: First of all, thank you for the question. We are moving towards real time application of these particular methods. One of the reasons we chose to apply the look-ahead method is that it is actually already being used by PJM and CAISO to compute voltage stability margins and this is done in real time. For the remaining actions, I agree with you on the issue of determining the global controls or the set of best preventive controls to avoid voltage instability, we can do it in a very fast manner. The second step, i.e. to determine the amount of control that is going to be used, this has a heavy computational burden so we still have a long way to go on that, but determining the group for eliminating the criticality of the whole set of critical contingencies is something that we can do on a real-time basis, with the proposed approach that we have now.

Costas Vournas (NTUA): I have two questions for the two voltage stability papers [2]-[3]. The questions are very short, I hope I can have also short answers, because we are moving into coffee-break time. Question to Rodrigo Ramos [2]. I have the feeling that your method is a little bit of an overkill, because if in your paper, your application all you do is switch capacitors, then these capacitors will always be switched on unless they create an overvoltage. So, first you have to check if they create an overvoltage. If they don't, then you switch them on anyway, there is no cost to it. Your method should be applied to something that has cost to take into account, so then you optimize; otherwise there is no point in optimizing which capacitors to switch. Question to Daniel Molzahn [3]. You showed something that was very strange for me. And maybe you can explain now, or you can convince me during the coffee break. You said you can have your margin being less than one, and still have a solution for n=1, because you said it is not a necessary condition. I think sufficient and necessary condition is that the margin is at least equal to the present point, but OK. I let you reply. Thank you.

Chair: Can we have a short reply?

R. Ramos: Absolutely. Thank you Costas for the question and for letting me explain this issue. We only used capacitor banks for this particular application, because we wanted to show that the method works regardless of the type of the control that you are adding. This can be extended and will be extended to other types of control in the near future, that's a future direction of this research, so this will be addressed in the near future.

D. Molzahn: The semi-definite programming formulation that we are using in the first condition is itself a relaxation, so that's why we have sufficient guarantees but not necessary guarantees, because it's a relaxation.

C. Vournas: So it is not an actual solution.

D. Molzahn: That's right, it's a conservative boundary.

Chair: I thank all the authors. We are now ready for the coffee break.

References

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