2013 IREP Symposium-Bulk Power System Dynamics and Control –IX (IREP), August 25-30, 2013, Rethymnon, Greece

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

Edited by Costas Vournas and Tasos Bakirtzis

Chair: Antonio Simões Costa (Federal University of Santa Catarina, Brazil)

Abstract

This paper contains the second 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:
Are there any questions?

Thierry Van Cutsem (Univ. of Liege): With the chairman's permission, I would like to ask questions to two of the presenters. To the first presenter [1], I would like to ask, maybe I missed it in your presentation, and I apologize if this is the case, what is the type of control that you assume for your HVDC link and how it impacts the survival of the small system? With regard to Sakis' (Meliopoulos) presentation [2], basically you said very briefly about the voltage stability application that things are local. But you still need to have information from some remote generators in order to assess stability, so it's not so local. Maybe one feeling I have is that the kind of very interesting dynamic state estimator you developed could be used for fault-induced delay voltage recovery, which is more the short-term voltage instability issue. Could you maybe comment on this?

Omid Alizadeh Mousavi (EPFL): About the controllers of HVDC here, it is just simply assumed that they respond like generators. It is assumed that they have a droop, like the generators, they just simply respond when there is a frequency deviation. But I use this occasion to refer to the work of another colleague who worked in his PhD on the topic of DC-segmentation. He used a more detailed model for the controllers of DC links using proportional response of DC links with two limits, a lower bound and an upper bound, to limit these effects.

Sakis Meliopoulos (Georgia Tech): Thank you, Thierry. The idea of "local" is not really local in the substation. We still need the data as the data is transferred to the control center. Still, the control center has to send back to the other substations and also an equivalent of the rest of the system. The idea is that if we form a subsystem that has the substation of interest plus "n" substations away ("n" can be variable) and then represent the rest of the system with Thevenin equivalents, the idea is that if it is far away, it is not going to affect very much the stability. And how far this subsystem should be, is a matter of research and as a matter of fact we have submitted a proposal, to just investigate this. Should we go two substations away, five substations away and so on and hopefully we are going to get this project and investigate this. And you are right that the model can be also used for fault-induced voltage recovery phenomena. As a matter of fact, three-four years ago we completed a project, and there is a report on that, where basically we used the same model, the SCAQCF, to do the analysis. This analysis requires of course time-domain simulations. And the point I want to drive is that with the form of the model we have we can do the time domain simulation. We can address this issue as well. So, I fully advocate that we really need to standardize the models so one model can do every analysis task. Then we devote time to improve how we do the analysis, but the model should be a unified model. Thank you.

Stefanos Sofroniou (IPTO): I would like to comment and I have a question for professor Meliopoulos [2]. First, I would like to give my credits to the paper. I would like to state that in my opinion the trend in protection and control is indeed in the direction you presented. My first comment is that you must keep in mind that we are in the beginning of an era when the job of the power engineers will be transformed. There is a need for transformation and transition. And you must be prepared to face the prejudices, the tradition and the inertia of the utilities. Utilities have some traditional procedures etc, which are reluctant to change. I would like to state only two examples. First, you mentioned setting-less protection. I agree with you. However, this could draw opposition from people who are involved in protection settings, or companies who develop software for protection settings, simulation software, etc. I could also propose an answer to this. The

978-1-4799-0199-9/13/$31.00 ©2013 IEEE

answer is that although we will adopt the setting-less protection that you propose, we will not neglect the traditional one, because we always need a back-up. In the protection we must have back-up. So, the protection you propose is the "object-oriented" protection because it protects directly the object and it uses primary criteria but on the other hand, since it relies on communication, and there may be problems in the communication, you know all these communication protocols etc, we need to also have the traditional protection to act as a back-up, in case the object-oriented protection fails. So, you must say to people involved in protection settings and also to the companies who develop protection software that they must not fear. On the other hand, of course, there must be great effort in the simulation, as you presented. The second let's say "strange" point is the idea of "uniform device". In other words, you propose what we call an all-in-one device. This may also raise some arguments because, as you know, normally operation data, metering data, protection data, are under the supervision of different departments. In this case, I also have the answer.

(Laugher).

S. Sofroniou: The answer is that we can have duplicate devices. One device will be dedicated for the operational, stability and metering data and the other device is for the protection data. This is also good from a technical point of view because protection must be secure, must act to trip etc. Of course there is a problem about commissioning and maintenance. In this case I think that we must be prepared that there must be let's say a common task. OK. These are the two comments. Finally I agree, I think the trend is in this direction but you must be prepared to face the objections. Finally, I have only one question. You said this is a project sponsored by the American government or by a big institution. Could you please tell us which was the driving event and if there are any applications?

S. Meliopoulos: I have to be very brief I guess.

Chair: These are three questions, but two of them come with their answers attached, so there is one left.

S. Meliopoulos: Since the answers are there, you should have been our co-author! I will try to be very brief. You pointed basically the same points that we point in the paper. There are driving forces to simplify the protection and also what we do in the control center. Things have become so complicated. Earlier today there was a presentation on big data. The idea of this whole project is to keep the big data within the substation. Today we collect in a typical, medium-sized substation (if we count how much data the relays collects, the DFRs, the sequence of event recorders and so on) several million pieces of data per second. We cannot send this data to the control center. Somehow, we have to apply some science there. And the science is this: can we get a state of the substation that will describe, everything that is going on in the substation, for whatever applications we want? Thierry Van Cutsem mentioned fault-induced voltage recovery, or state estimation and so on. Can we extract from all this data the information and then communicate the information upstream? Only the information. And I agree with everything and I want to make one more comment. Any new technology is going to have obstacles. And we have to overcome the obstacles. You mentioned that some manufacturers may not heed that they're going to replace the relays. But look what GE is doing. Their relays now are just a computer. Already they are doing this. Any other company will follow. If the technology prevails, then companies will adapt. They are not going to be driven out of business. They are going to have different business. That's all.

João Peças Lopes (Univ. of Porto): My question is regarding the paper on "Detection and Visualization of Power System Disturbances using Principal Component Analysis" [3]. So you assume the data you get has normality structure and for that you do a χ-square test method just to test the hypothesis So have you found any situations where this normality condition does not apply, and if that happens how do you still rely on the approach based on the principal-component analysis?

Emilio Barocio (Imperial College): Thank you very much. It's an interesting question. This is an initial development. We must test the approach. Because when we get the PMU information we have a natural trend of the system. This trend has an impact on the principal component analysis because we assume that the system is linear. So that the thresholds are fixed. It means that we have a natural trend and we are going to have false alarms. We are required to perform a lot of simulations and consider a lot of cases. Maybe one solution could be to use Monte Carlo simulation and try to reproduce a lot of probable operation conditions and try to develop our principal components.

Alex Papalexopoulos (ECCO International): This is a question for professor Meliopoulos [2]. This is` a promising technology, indeed. The question is: Can this technology help us solve protection problems that arise from the massive penetration of the distributed generation sources? As you know, there is a major push for distributed generation sources that create many problems in markets, in the grid, specifically for protection. They create reverse power flows so you need to isolate the fault not only from upstream, from the substation, but also from the DG source. You have fault current contribution from DG, you have what we call "relay desensitization". So, what utilities are looking today to solve this problem is what we

call transfer trip schemes.I If I remember correctly in one of your slides, you have relays that are sitting between the process bus and the station bus. What utilities are looking basically is to make sure that the relays actuate or not actuate, based on information, not only that they sense at their location, but also at multiple locations in order to deal with the power flows from multiple locations, which requires communications with other relays, advanced algorithms and so forth. Do you allow this in your technology, or do you care to comment about this specific problem for DGs?

S. Meliopoulos: That's a very good question. We are working on this with PG&E. This is on their system protection. Basically, what I showed here is only what we call zone or component protection. But then we send the data to the central location and then the decisions there on protection that depends on the system, or system protection, are communicated back. As you know PG&E (you were working for PG&E) has one of the best system protection schemes. Their problem is that the information getting into the system is not fast enough. So, this system cuts the latency on this information by something like 80% and we are working with PG&E to improve this. And we are also working with GE to address the issue of distributed resources in the same way. So, what I am saying is that the structure of the approach is applicable to all of these. Of course, there is a lot of work to be done and only 24 hours in the day.

A. Papalexopoulos: But it seems your relays respond, actuate based on the information they sense locally.

S. Meliopoulos: No, no. They also receive controls from the upper level. There is two-way communication as in any other relay.

A. Papalexopoulos: From multiple locations?

S. Meliopoulos: That's right.

A. Papalexopoulos: OK. Thank you.

Emmanuel Thalassinakis (HEDNO): I have a question for professor Meliopoulos [2]. In your interesting work you propose an integrated scheme for control operation and for protection. Two main principles of nowadays protection are: it should be distributed and localized. Localized, since it should involve as few devices as possible, in order to be more reliable, and distributed so that if you lose one protection, you don't lose them all. Aren't these principles violated with this integrated scheme?

S. Meliopoulos: No, they are not violated. And I would be glad to talk to you later, I don't want to monopolize the discussion. We honor both of these conditions. That was the previous question I guess. There are two-way communications. And you have both conditions in that structure.

Le Xie (Texas A&M): I have a question for the third paper [3]. The Principal Component Analysis (PCA) one. It is very interesting. I think there is great potential in dimensionality reduction for this streaming on-line data. We presented similar things last month in Vancouver PES General Meeting, using the PCA to detect anomaly events. What is interesting in your paper is that anomaly events refers to the communication failures on the cyber level and what we were doing was more on the physical layer. One of the questions though is: you can detect that something is going on, but there can be millions of possibilities of what are the events. So a natural question was how do we classify or categorize these events. Do you have any thoughts on that?

E. Barocio: We are thinking to apply the multi-way principal component analysis. This is a way to collect information in 3-dimensions, but we need to do a lot of tests. Initially we must do this classification off-line.. The paper that you mentioned is very close to this work, but works in a different way because it uses predictions; this means it works like auto-regressive algorithms and this is a different perspective from this paper.

S. Sofroniou: Two more comments again after the last question, if I am allowed, regarding professor Meliopoulos' work [2]. The first point is that we must consider also the problem we have with the renewables and all these converters. And all these power electronics that are inserted in the network. And the reduction of short circuit capacity as we heard in many other papers. I think that the solution relies also in such devices, where we are obliged to adopt new protection principles, not the traditional ones, because with all this DG penetration, finally we have short-circuit currents, which are frequently in the level of the nominal current. So, as we see in the paper there are new functions that we can exploit so that we can detect that there is a fault and not a normal condition. And the second comment regarding Dr. Papalexopoulos: I would like to say that I agree with professor Meliopoulos, in that there are applications because this is a two-way communication and there is a matrix behind this. For example in the classical protection principle, when a fault occurs there are many devices that see these faults. In this application we have the possibility to have a logic behind this. And so, I think, the solution is feasible. Thank you.

S. Meliopoulos: I would like to say something. These systems are interfaced with the utility through inverters. And the manufacturers of inverters have different technologies depending on the level of the inverters. So they have low power inverters with no control at all. They

have everything internal. And they have the large inverters, with a tremendous amount of instrumentation inside the inverter, but they do not allow the utility to look at the information they collect. So, we are working with one of the converter manufacturers, SOLARMAX, to allow the utilities to have access to the information, because if we don't have access we have to build another data acquisition system around the inverter and do our own protection. Or more important to use the inverters to control whatever we want to do in the power system and that's an area where we really need to work with the inverter manufacturers and integrate the systems. The same principles apply, but we need to coordinate with the manufacturers, otherwise you have duplicate systems that will increase the cost. We cannot afford not to be able to control the inverters in a power system.

Ian Hiskens (University of Michigan): Another thing that really scares utilities is the security and any signals that cross the substation boundary. They are very careful about that, and with your proposal to enhance the communications there is the possibility of greater opportunities for spoofing and cyber-attack. Presumably you thought about that. Can you tell us something about that?

S. Meliopoulos: I assume you are referring to the system we have with the cell modems and so on. Right? These are only for research, to bypass the IT department. When these systems…

I. Hiskens: The IT department of the utility?

S. Meliopoulos: Yes. So, this is only for research to make our work easier, because you know interacting with the IT of power companies is a nightmare.

I. Hiskens: Actually for your system to truly become operational, you need to address the cyber security issues.

S. Meliopoulos: Yes, absolutely and that's what I am saying. When this system will be implemented, it will be within the network of the utilities, which address these cyber security issues. So it's going to be part of the integrated approach of the utility for the cyber security.

Chair:
Are there any more questions? ... If not, let's thank the authors and go for lunch.

References

[1] O. A. Mousavi, L. Bizumic and R. Cherkaoui, "Assessment of HVDC Grid Segmentation for Reducing the Risk of Cascading Outages and Blackouts," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece.

[2] A. P. S. Meliopoulos, G. J. Cokkinides, S. Grijalva, R. Huang, E. Polymeneas, P. Myrda, E. Farantatos and M. Gehrs, "Integration & Automation: From Protection to Advanced Energy Management System," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece.

[3] E. Barocio, B. Pal, D. Fabozzi and N. Thornhill, "Detection and Visualization of Power System Disturbances using Principal Component Analysis," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece.

[4] Choque Pillco, L. Alberto and N. Bretas, "Association of the Stability Region with Time Scale Analysis to Study Voltage Stability," Bulk Power Systems Dynamics and Control – IX (IREP), August 25-30, 2013, Rethymnon, Crete, Greece.