Study Committee C2

Power system operation and control

10873_2022

Development of Innovative Power Flow Controller-compatible RTCA Decision Support Tools for Enhancing Control Centre Operations

Medha Subramanian[1], Marie Hayden[1], Mark Rafferty[1], Ayda Esfandyari[1], Fatima Ali[1] , Dionysios Stamatiadis[1], Marta Val Escudero[2], Roberto Tegas[2], Eoin Kennedy[2], Michael Power[3], Adrian Kelly[4]

Smart Wires Inc.[1], EirGrid[2], University College Dublin[3], EPRI[4]
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Objective 1
Initial Real Time Contingency Analysis (RTCA) tool development with & without PFC

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Objective 2
Develop optimisation of PFC functionality

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Objective 3
Dissemination and pathway to integrate tool into control centres

Motivation and Objectives

- Large changes are expected on the transmission power systems to meet 2030 and 2050 clean energy targets
- Substantial operational challenges will need to be overcome to ensure security of power systems
- Grid enhancing technologies like advanced Power Flow Control (PFC) to play a key role in managing grid congestion
- PFC is a cost-effective solution utilising grid capacity by dynamically controlling power flows to mitigate congestion
- Centralised methods for the co-ordination of many distributed PFC devices are required
- Enhanced situational awareness and decision support tools are needed
- Development of software tools that optimise the dispatch of PFC devices can enhance control room operation

Setup and tool architecture

- *Network Data/Model:* EMS snapshots of the network
- *Connectors:* Interfaces with network data and extracts relevant information from it
- *Situational Awareness:* applies default or previously assigned setpoints to PFC devices in network models, and runs Contingency Analysis
- *Optimisation:* If default set points are insufficient to resolve overloads, the optimisation is triggered and identifies new set points
- *Reporting and Visualisation*: Output of optimised setpoints provided to network operators and graphical representation

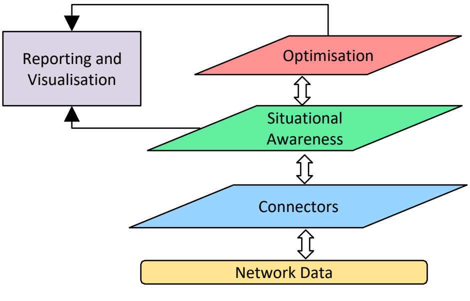

Figure 1: Modular architecture of the tool

Power Flow Control Technology

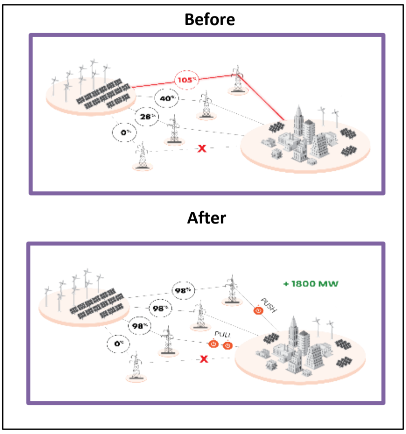

Figure 2: Example depicting a use-case for M-SSSC technology

- ✓ **M – SSSC:** Modular Static Synchronous Series Compensator used for dynamic PFC
- ✓ **Power electronics-based device:** injects a controllable voltage in quadrature with line current (leading or lagging) into a circuit (manually or by using automated controls)
- ✓ **Voltage agnostic:** a unit can be used at any voltage level
- ✓ **Wide range of use-cases:** it can be operated remotely and can react dynamically, so it can solve small near-term and large long-term problems

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Tool Application and Associated Inputs

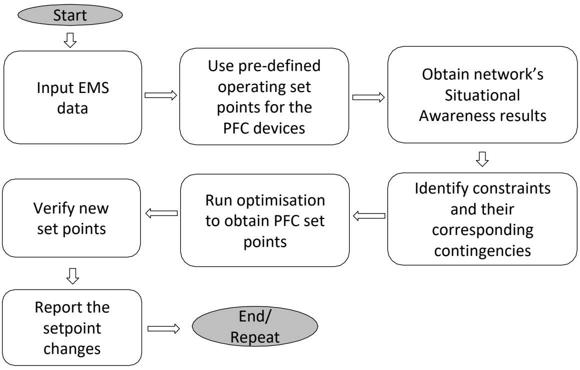

Figure 3: workflow of the tool in use

- EMS snapshot with embedded PFC models
- Associated contingency and monitoring files
- Default or previously calculated setpoints
- Choice of load flow solver
- Associated Connector module for chosen load flow solver

Preliminary Results

Optimization results for the IEEE 39 bus test system with the associated parameters

No. Buses	No. Lines	No. Gens	Load	Gen	Iteration Cap	Target flow
39	46	10	6097 MW	6097 MW	100	100%

Table 1: Parameters of IEEE 39 bus case

Contingency	PFC Lines	Volt range	Volt Inject	Initial Overload	Final Overload	Iterations
de-energize Line 6-7	17-18 13-14 10-11	± 0.0820 p.u. ± 0.0820 p.u. ± 0.0820 p.u.	0.0518 p.u. 0.0820 p.u. 0.0184 p.u.	225 MW	52 MW	11
de-energize Line 11-6	17-18 13-14 10-11	± 0.0820 p.u. ± 0.0820 p.u. ± 0.0820 p.u.	-0.0118 p.u. 0.0820 p.u. -0.0467 p.u.	200 MW	0 MW	1

Table 2: Summary of numerical results

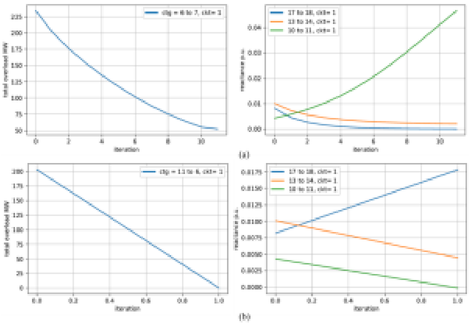

Figure 4: Total overload (MW) and PFC line reactance (p.u.) for three monitored lines. Contingencies: Line 6 -7 (a); and Line 11-6 (b), on the left panels. Monitored lines: Line 17 -18 (blue); Line 13-14 (orange); line 10-11 (green), on the right panels.

Conclusions and Future Work

- This paper focuses on building a decision support tool to maximise the impact of PFC technology on a power system
- The modular approach used in the tool architecture removes dependence on a singular load flow solver
- The architecture is also modular in terms of having a new optimisation module solving a different objective
- The optimisation function identifies set-points for the PFC devices on the network for N and N-1 conditions
- Initial results were obtained for the tool on standard and publically available IEEE cases
- Currently, the tool is being tested on real-world EMS snapshots of the Irish system
- Next, benchmarking the tool to assess computational requirements, speed, and accuracy, to ensure that the added functionality is not creating drastic changes
- Testing the robustness of the tool against different control room practices

Acknowledgment

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