C2 – PS1

POWER SYSTEM OPERATION AND CONTROL

11100

Ad-Hoc Determination and Activation of Remedial Actions in Electro-Thermal System Operations

Andreas KUBIS[1], Jasper LAMMERING[1], Jan KEMPER[1], Jan HACHENBERGER[1], Richard KÜSTERS[1], Stefan DALHUES[1], Dominik WILLENBERG[1], Christian REHTANZ[2] and Ulf HÄGER[2]

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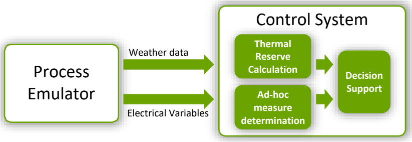
Motivation

- Pre-fault measures (applied before a failure) are costly and need high transmission capacity reserves
  - » use post-fault measures (applied after a failure) to reduce cost and increase utilization of transmission capacity
- Line has thermal reserve in case of increased power flow due to contingency
  - » use this time to calculate post-fault ad-hoc measures

Test setup

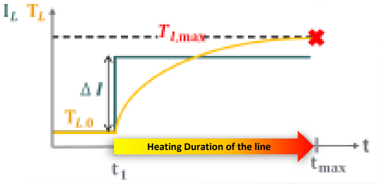
- Process emulator simulates electrical network with 29 nodes
- Delivers data over IEC-104 to Control System
- Thermal Reserve and relieve measures are calculated and displayed



Theoretical background

Thermal reserve

- Current increases immediately due to failure
- line takes time to reach maximal admissible temperature Tl,max
- Calculate thermal reserve Δt = tmax-t1 with numerical methods



Ad-Hoc Measure Determination

- Calculation triggered after contingency
- Consideration of fast responding measures (e.g. grid boosters)
- Integration of different optimization approaches to get several measure bundles with different qualities
- Assess bundles with key performance indicators to support decision

Implementation and Proof of Concept

Process

- Process emulator simulates overload situation in network
- Load of one line at 134%
- Control system recognises overload
- Calculations start
  - a) Thermal reserve
  - b) Ad-hoc measures
- Rated bundles are presented
- Bundles are validated

Results

- Tested in artificial test network
- Thermal reserve is strongly weatherdependent

Season	Ambient Temperature	Global Irradiance	Wind Speed	Thermal Reserve [min:secl]
Summer	35°C	900 W/m²	0,6 m/sec	0:59
Transition Time	15°C	450 W/m²	3,0 m/sec	1:36
Winter	^5°C	100 W/m²	6,6 m/sec	2:02

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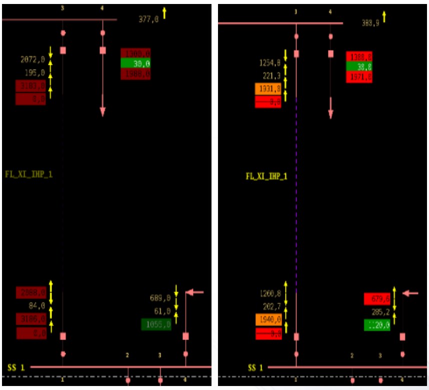
continued

Results

- All three implemented grid boosters part of the relief measure

Name Element	Change
Grid Booster 1	+ 1257 MW°C
Grid Booster 2	- 698 MW
Grid Booster 3	-559 MW



- Measures are simulated to validate the impact
- Figures show screenshots from control system
- Measure values are active power, reactive power, current and temperature from top to bottom
- Overload on left figure
- Simulated measures relief overload on right figure

Discussion

- Determination of ad-hoc measure successful
- Prototypical implementation
- Only one algorithm
- Static load flow calculation for validation
  - In future validation with a dynamical process emulator
- Initial temperature of lines is now ambient temperature
  - In future calculation with electro thermal power flow

Conclusion

- Thermal reserve of line delivers time to react on overload situations
- First implementation of ad-hoc calculated relief measures in a control system presented
- Measures deliver time for operator to analyze the situation further
- Important concept for transitioning to more renewable energy sources