Framework for assessment of DC grid protection systems

Feasibility, performance and risk evaluation methods and tools

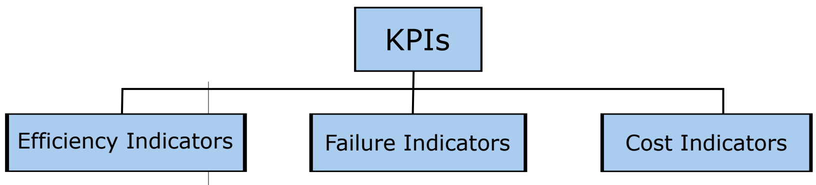
CONTEXT

HVDC grids based on VSC technology are emerging all over the world in radial and meshed configurations such as in China, Scotland and likely in the future in North European Seas. Several protection strategy solutions can be employed to protect the DC lines against possible short circuit faults and each of these solutions differ in terms of performances, reliability and cost. There is therefore an urgent need to define a methodology to compare and evaluate such protection strategies in order to make the right decision for each project.

TECHNOLOGY DESCRIPTION

Key Performance Indicators (KPI) are proposed to evaluate performances of different protection strategies. Efficiency indicators are the KPIs related to how the protection strategy manages the fault clearing and the grid restoration processes. Failure indicators are KPIs that assess features related to the probability of the malfunctioning of a protection strategy. Cost indicators evaluate CAPEX and OPEX of protection strategies.

KPIs can be evaluated based on a library of DC component models (as performance and reliability indices) and on the following prerequisites:
- Detailed description of protection sequences (primary and backups)
- EMT modelling of DC grid with protection components and algorithms



As an example, KPIs have been calculated for a 4-terminals test benchmark for the following three protection strategies:
- Full selective strategy with hybrid DC breakers
- Converter breaker strategy
- Non-selective strategy using AC circuit breakers

The results are depicted in the table below for efficiency and Failure KPIs:

KPI	Protection strategy		
	ACCB	Converter Breaker Strategy	Fully-Selective
Fault interruption time (ms)	1100	25	15.3
DC voltage restoration time (ms)	1480	80	34
Reactive power restoration time (ms)	1507	27	19
Active power restoration time (ms)	1625	180	97
Transient energy imbalance (MW·s)	805	100	14.3
Primary sequence failure probability	0.65%	0.6%	0.56%
Protection strategy failure probability	0.59%	0.16%	0.16%

APPLICATION DOMAIN

Multiterminal HVDC systems
HVDC Point to point links

ADVANTAGES

Expert decision tool support

Applicable to several grid technological solutions

TRL SCALE

1 2 **3** 4 5 6 7 8 9

Workflow based on in-house software modules and commercial EMT simulation tools

DELIVERABLES

PhD dissertation report: "*Development of a methodology for DC grid protection strategies comparison*"
Additionnal applications could be studied upon request (OpenGrid, full bridge)

SCIENTIFIC REFERENCE

PROMOTioN project deliverable D4.3

Guilherme Danta De Freitas et. al. "*Assessment methodology and performance indicators for HVDC grid protection strategies*" DPSP 2018

WAY FORWARD

Know-how to be used for future consulting services

Can be used for development purposes
- FMEA and risk analysis allow to identify weak points and improve overall reliability of a given protection system

Can be used for marketing purposes
- decision for new product introduction strategy (feasibility, performance)
- Tools to promote one solution towards customers on a generic basis or on a project basis

Can be used for projects

Realization of a pilot study together

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