
Protection of Multi-Terminal VSC-MTDC Grids

Ph.D. Dissertation
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Curriculum Vitae

Mani Ashouri



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Curriculum Vitae

Abstract

English abstract

Abstract

Resumé

Danish Abstract sssss

Resumé

Contents

Curriculum Vitae	iii
Abstract	v
Resumé	vii
Preface	xiii
 I Report	 1
Report	3
1 Introduction	3
1.1 Introduction to VSC-HVDC Grids	3
1.2 Fundamentals of DC Protection	3
1.3 Basic requirements of designing protection algorithms for VSC-HVDC grids	4
1.4 Signal-Processing Techniques for Designing Protection Algorithms	5
1.5 Literature Review and State of the Art	5
1.6 Thesis Objective	6
1.7 Thesis Outline	6
1.8 Publication List	6
2 Modal Analysis of HVDC Cable Bundles	6
2.1 Including the Bibliographies	7
2.2 Formatting Guidelines	7
3 Proposed Protection Algorithms for VSC-MTDC Grids	8
3.1 STFT-Based Protection of VSC-MTDC Grids	8
3.2 Basic Morphological Method for Fault Location in VSC- HVDC links	8
3.3 Modal Online Fault Locators for VSC-HVDC Links	8

Contents

3.4	Protection of VSC-MTDC grids Based on Polarity Comparison Using a Combined Morphological Method . . .	9
3.5	Hardware in the Loop test of the Proposed Combined Morphological Method	9
4	Selective Protection of Large-Scale VSC-MTDC Grids using Shunt Busbar Capacitors	9
4.1	Introduction	9
4.2	Shunt Busbar Capacitors as High-Pass Filters	9
4.3	Optimal Shunt Busbar Capacitor Placement in Large-Scale VSC-MTDC Grids	9
5	Conclusion	10
	References	11
II	Papers	13
A	Paper A title	15
B	Paper B title	17

Todo list

Contents

Preface

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Name
Aalborg University, October 31, 2019

Preface

Part I

Report

Report

1 Introduction

1.1 Introduction to VSC-HVDC Grids

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Superiority of HVDC transmission over traditional HVAC transmission systems

Preference of VSC-HVDC links compared to LCC-HVDC systems

Deployment of VSC technology has multiple advantages for the HVDC system, which are inaccessible in LCC technology, as follows [?]:

- Independent active and reactive power flow control with the help of fully controllable switches.
- Improved power quality of the connected AC network
- Proper technique for connection of weak AC grids
- Enabling the multi-terminal HVDC grids

Advantages of VSC-MTDC grids over VSC-HVDC links

1.2 Fundamentals of DC Protection

Designing DC protection algorithms may be different than traditional AC protection system design. Although there maybe similarities like type of fault data used for the protection algorithm, but the majority of the parts like the measuring equipment, the circuit breakers, the algorithm calculations and the signal processing technique may be significantly different, requiring more advanced technology than HVDC protection systems. Like traditional HVAC systems, a full protection system for VSC-HVDC/MTDC grids, usually consist of a fault detection algorithm, a switching system , and an online/offline

fault localization technique. The fault detection algorithm must be very fast, and selective. The switching system must be fast to discriminate the faulty section from the rest of the grid in the minimum time. The fault localization algorithm must locate the fault in the minimum time and with the least possible amount of error. Additional protection functions like faulty pole detectors, busbar protection, Circuit breaker failure, etc... maybe included in the protection algorithm

Challenges in DC Protection

Protection of both point-to-point and multi-terminal VSC-HVDC grids is one of the major challenges in the evolution of this industry worldwide. Some of the main issues in this topic are:

- The overall protection system must be very fast to have minimum damage to the converter switches. From the moments of the fault occurrence in the transmission section, the overall delay time in the detection of the fault by the algorithm and the operation of the DCCB must be more than around 5 milliseconds.
- Traditional impedance-based protection methods may not be suitable for HVDC links.
- HVAC circuit breakers are not fast enough to discriminate the faulty section and keep the rest of the VSC-MTDC grid online.
- Currently developed DCCBs are expensive.
- Localizing faults on HVDC transmission section, particularly for underground/submarine cable transmission are challenging and time consuming, which may result long shut downs of the grid.
- The need for a communication link in some of the techniques may lead to a lag in pilot protection schemes, which will be added to the total delay time in the detection of the fault and discrimination from the healthy part of the grid. Use of wide-area protection is also challenging for VSC-HVDC links due to the probable GPS communication delay and the importance of delay time in fault discrimination.

1.3 Basic requirements of designing protection algorithms for VSC-HVDC grids

Traveling waves in HVDC transmission

1.4 Signal-Processing Techniques for Designing Protection Algorithms

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The role of artificial intelligence

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1.5 Literature Review and State of the Art

In this section, a brief review of the latest works on different aspects of protection in VSC-HVDC grids is presented. The majority of the published research in VSC-HVDC protection, can be included in three main categories: Publications investigating faults on the converter side and their fault ride through capabilities, research works investigating on proposing fault detection, localization and pilot protection algorithms for the DC transmission section, and research works that introduce latest topologies technologies for HVDC circuit breakers. [?]

Faults analysis on VSC-HVDC/MTDC converter side

Authors in [?]

Protection algorithms for the HVDC transmission section

Latest research on HVDC circuit breakers

1.6 Thesis Objective

This thesis mainly focuses on designing protection algorithms for the HVDC transmission section.

- The overall
- Traditional impedance-based protection methods may not be suitable for HVDC links.
- HVAC circuit breaker
- Currently developed DCCBs are expensive.
- Localizin
- To develop ideas for having a selective protection system for VSC-HVDC/MTDC grids, which helps to accurately separate the faulty section and maintain the healthy section of the transmission grid online.

1.7 Thesis Outline

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1.8 Publication List

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2 Modal Analysis of HVDC Cable Bundles

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3 Proposed Protection Algorithms for VSC-MTDC Grids

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4. Selective Protection of Large-Scale VSC-MTDC Grids using Shunt Busbar Capacitors

3.4 Protection of VSC-MTDC grids Based on Polarity Comparison Using a Combined Morphological Method

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3.5 Hardware in the Loop test of the Proposed Combined Morphological Method

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Real-time digital simulator

Controller

4 Selective Protection of Large-Scale VSC-MTDC Grids using Shunt Busbar Capacitors

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5 Conclusion

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References

Part II

Papers

Paper A

Paper A title

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Paper B

Paper B title

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