However, for DG, natural gas supplied by pipelines should be converted to hydrogen through a reforming process. Low-temperature FCs, such as PEMFCs, are not capable of reforming gas into hydrogen and need an external reformer, which in itself is a major component to invest. On the other hand, high-temperature FCs, such as molten carbonate FCs or SOFCs, can be designed to reform gas into hydrogen internally within the FC stacks. These FCs with internal reformer, however, require balance of plant (BOP) systems to process inputs such as fuel, water, and air, and maintain proper temperature and pressure for the reforming process to take place. Dynamics of the FCs are dictated by the dynamics of the BOP systems, and FC models presented in this book need to be augmented considerably with BOP models to present an accurate picture of FC dynamics and design FC controls. In this respect, I encourage the authors to consider a second edition and add new components such as reformers and BOP systems and advanced topics such as controls and fault diagnostics and accommodation.

In summary, I recommend this book as a good introductory text for a course on FCs in the graduate power engineering curriculum and a handy reference for practicing engineers working in FCs and their integration to power grid as DG sources.

—Kwang Y. Lee

HVDC Transmission: Power Conversion Applications in Power Systems

Chan-Ki Kim, Vijay K. Sood, Gil-Soo Jang, Seong-Joo Lim, and Seok-Jin Lee, Wiley, 2009

This book is for both practicing engineers and researchers, although the former would possibly benefit more. The main topics covered can be divided into four parts: background materials, performance analysis, design issues, and future trends. Some of the interesting topics covered include high-voltage direct current (HVDC) system design, interaction with power systems, fault protection, and a practical example of the HVDC system in Cheju Island in South Korea. Practically all topics have been discussed for the conventional thyristor-fed current source line commutated (LCC) configuration. A brief discussion is provided for other practical current source configurations and voltage source converter (VSC) HVDC.

A large portion of the book covers practical aspects and design methodologies for the main components of HVDC systems.

The book begins with an introduction to HVDC technologies, discusses the advantages of HVDC compared to conventional high-voltage alternating current (HVAC), and presents the main components of a typical HVDC transmission system. The most interesting parts of this chapter are a discussion of HVDC system costs and economic aspects and an assessment of the HVDC system reliability.

The operation principles of thyristor-fed power electronics converters are presented briefly, and three-phase six-pulse and 12-pulse converters are introduced. These topics have been extensively discussed in several power electronics books and could have been moved to an appendix.

The characteristic and noncharacteristic harmonics present at the dc and ac side of the current source HVDC systems are discussed. The noncharacteristic harmonics present in back-to-back HVDC systems connecting two asynchronous systems or can be caused by the HVDC control imperfection or due to the ac system phase imbalance. Noninteger harmonics (interharmonics) can be generated in a similar mechanism. The topics of harmonic cross modulation and harmonic transfer are not discussed in detail but can be found in technical literature. Methods of harmonic mitigation including the use of passive filters on the dc and ac sides, the use of multipulse conversion along with the phase shifting transformers, and active filters are presented. An overview of system harmonic impedance calculation is given. This is used to identify the presence of any potential harmonic resonance point and to ensure that the introduction of harmonic filters do not create any additional resonance point. VSCs make use of pulse width modulation techniques, which results in significant attenuation of low-order harmonics, and harmonic filtering is often less of an issue for the VSC HVDC.

Methods of controlling the firing angle of thyristor bridges and designing controller for HVDC systems are presented. Several control methods including classical and fuzzy-logic based controller design are discussed. The most interesting part of this chapter is a discussion on various functions of HVDC control system. Reactive power compensators are discussed for the minimization of risk of commutation failure and improvement of the power transfer capability and voltage stability.

One chapter is dedicated to the power system integration impact of HVDC. It starts with a definition of short circuit ratio and effective short circuit ratio that determines the strength of the ac power system. Adverse interaction between the dc and ac system can occur when the interconnecting ac systems are relatively weak. A wide range of issues experienced in practical LCC HVDC schemes are presented that include harmonic resonance due to noncharacteristic harmonics, core saturation instability due to the converter transformer saturation, ferroresonance, subsynchronous torsional interaction between the HVDC and shaft system of turbine-generator, self-excitation of adjacent generators,

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interaction between HVDC and FACTS, and interaction between HVDCs. The most interesting issue discussed is the risk of damage to the synchronous generator excitation system, which is not widely discussed elsewhere. These issues have been looked at from a theoretical standpoint, and no power system simulation graph is provided. This makes it difficult for the reader to appreciate how the system behaves during these phenomena. The impact of HVDC on transient stability performance of the interconnected power system and related issues such as reversal of power flow are not discussed.

A large portion of the book covers practical aspects and design methodologies for the main components of HVDC systems. These topics are not covered as extensively in other HVDC related books and would be welcomed by practicing engineers. Design considerations for the LCC converter, converter transformer, smoothing reactor, cooling system, overhead lines and cables, and ground electrodes are elaborated on. Various means of fault protection are discussed, and an example of insulation coordination for the Cheju HVDC system is presented. The control system of the Cheju HVDC system is then discussed in detail.

Up to this point, the focus of the book has been on conventional LCC HVDCs. Other practical current source HVDC systems such as capacitor commuted converter, controlled series capacitor converter, and multiterminal schemes are discussed in a fair level of detail, and their advantages and disadvantages are highlighted. A short discussion on a generic VSC HVDC scheme is presented, though this topic is dealt with in more details later in the book.

One chapter is dedicated to the modeling and simulation of HVDC systems. Different types of simulation programs including transient stability-type programs, full electromagnetic time-domain simulation programs, and real-time digital simulation are introduced. This chapter can be useful for power system engineers to help decide on the choice of simulation program and the level of detail need to be incorporated in the model. These depend on the type of study, associated computational complexity, and the required modeling fidelity. The discussion in the book is generic and can be applied to both LCC and VSC HVDC.

In summary this book succeeds in providing a comprehensive textbook on HVDC system design, planning, and application issues.

A list of present and proposed future installations of HVDC systems worldwide is provided. One interesting project not covered in the book is the 400 MW San Francisco Bay VSC HVDC link using modular multilevel converter (MMC) design referred to as HVDC plus. In general the future trend is toward the use of semiconductor switches with higher rating and lower losses that allows the use of VSC HVDC in the range of 1,000 MW, 800 kV and higher. Another trend not covered in the book is the use of multiterminal VSC HVDC for the transfer of power from remote wind farms to the load centers.

VSC HVDCs are finding increasing popularity especially in offshore wind farm projects as discussed in the book. They exhibit superior performance compared to the LCC scheme but their rating is somewhat limited. Power semiconductor devices suitable for the VSC HVDC are briefly reviewed, but some of the existing semiconductor devices such as integrated gate commutated thyristor and injection enhanced gate transistor and future candidates such as emitter turn off thyristor are not covered. Various VSC converter topologies such as two-level VSC, multilevel neutral point clamped, and floating symmetrical capacitor are compared from the standpoints of capital cost, system size, and losses. These comparisons can be found elsewhere in the technical literature, and the focus could have been on the relative performance of these converters. Other practical multilevel VSC configurations including the cascaded H-bridge and MMC are not covered. It has been reported in the technical literature that issues such as harmonic resonance and risk of torsional interaction can be mitigated with the VSC HVDC. No discussion is provided on these issues in the book.

A list of references has been included at the end of each chapter. The references have been very occasionally quoted in the body text. Some of the key HVDC documents such as CIGRE technical brochures are neither quoted in the body text nor listed in the references. Each chapter could have benefited from a separate introduction and summary.

In summary this book succeeds in providing a comprehensive textbook on HVDC system design, planning, and application issues. A wide range of subjects including power electronics, power systems, substation design, and control system design are covered. A second edition of the book could benefit from an increased number of references, the quotation of the references in the body text, the provision of time-domain plots for power system integration performance of the HVDC, and the inclusion of a more detailed discussion on power system integration performance of VSC HVDC.

—Babak Badrzadeh