

High Voltage Direct Current (HVDC) Power Systems

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ABSTRACT :The development of transmission systems closely follows the growing demand on electrical energy. With the increasing size and complexity of transmission networks, the performance of power systems decreases due to problems related to load flow, power oscillations, and voltage quality. High-voltage direct current (HVdc) technologies offer some effective schemes to meet these demands. This paper focuses on benefits over high voltage dc transmission and its applications.

KEYWORDS : Applications of HVDC transmission ,Bipolar links ,Converters

I. INTRODUCTION

High voltage dc transmission system (also called a power super highway or an electrical super highway) uses direct current for the bulk transmission of electrical power, in contrast with the more common alternating current(AC) systems. For long-distance transmission, HVDC systems may be less expensive and suffer lower electrical losses. For underwater power cables, HVDC avoids the heavy currents required to charge and discharge the cable capacitance each cycle. For shorter distances, the higher cost of DC conversion equipment compared to an AC system may still be justified, due to other benefits of direct current links.

HVDC allows power transmission between unsynchronized AC transmission systems. HVDC also allows transfer of power between grid systems running at different frequencies, such as 50 Hz and 60 Hz. This improves the stability and economy of each grid, by allowing exchange of power between incompatible networks.

The modern form of HVDC transmission uses technology developed extensively in the 1930s in Sweden (ASEA) and in Germany. Early commercial installations included one in the Soviet Union in 1951 between Moscow and Kashira, and a 100 kV,20 MW system between Gotland and mainland Sweden in 1954. The longest HVDC link in the world is the Rio Madeira link in Brazil, which consists of two bipoles of ± 600 kV, 3150 MW each, connecting Porto Velho in the state of Rondonia to the Sao Paulo area. The length of the DC line is 2,375 km.

II. HVDC COMPONENTS AND CONFIGURATIONS

The main components of hvdc are converters smoothing reactors ,harmonic filters, reactive power supply, electrodes, dc line, ac circuit breaker are shown in following fig.1.

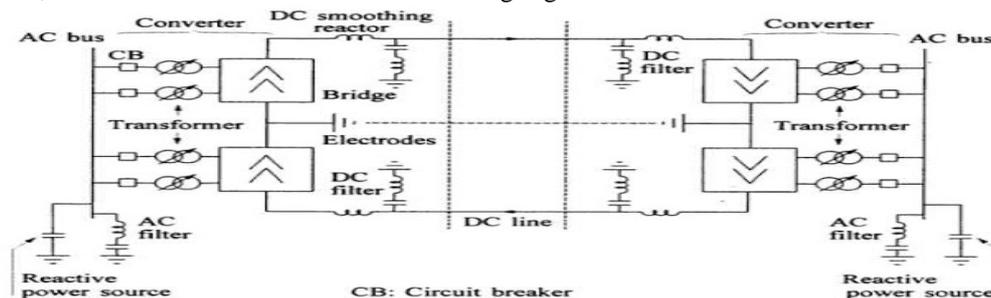


Fig.1.components of HVDC

Configurations: HVDC transmission which is economical for long distance power transmission, and for the interconnection of two or more networks that has different frequencies or voltages. For connecting two networks or system various types of HVDC links are used.

Monopolar link – It has a single conductor of negative polarity and uses earth or sea for the return path of current.

Bipolar link – A bipolar link has two conductors, one positive and the other negative with respect to earth. Homopolar link– It has two conductors of the same polarity usually negative polarity, and always operates with earth or metallic return.

back-to-back station- (or B2B for short) is a plant in which both converters are in the same area, usually in the same building. The length of the direct current line is kept as short as possible. Multi-terminal HVDC links- connecting more than two points, are rare. The configuration of multiple terminals can be series, parallel, or hybrid (a mixture of series and parallel).

A. BIPOLAR LINK

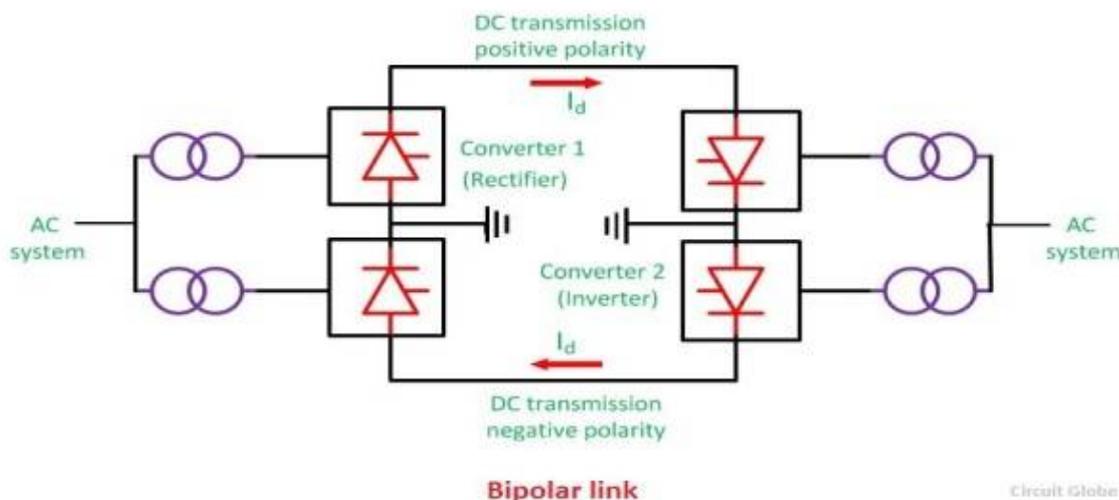


Fig.2. Block diagram of a bipolar HVDC.

A bipolar scheme as seen in above fig.2. can be implemented so that the polarity of one or both poles can be changed. This allows the operation as two parallel monopoles. If one conductor fails, transmission can still continue at reduced capacity. Losses may increase if ground electrodes and lines are not designed for the extra current in this mode. To reduce losses in this case, intermediate switching stations may be installed, at which line segments can be switched off or parallelized. This was done at Inga–Shaba HVDC.

III. ADVANTAGES AND DISADVANTAGES

The advantage of HVDC than AC is ability to transmission big amount of power on long distances with lower wastes.

- undersea connections.
- power transmission and stabilization between unsynchronized AC distribution system.
- connection generating plants remote from power grid.
- stabilizing AC grid.
- connection between countries with different current frequency/voltage.
- synchronize AC produced by renewable energy sources.

Long underwater lines have a high capacitance. In AC transmission is required process of charging and discharging, what is causes of power losses. HVDC has minimize this effect. In AC lines occurs also dielectric losses.

The disadvantages of HVDC we can include conversion, switching and control. Static converters are expensive. In short distances losses in static inverter may be even bigger than in AC transmission. In the future static converters will be replaced by thyristors.

In DC system controlling of multi terminal configuration is quite hard, because required good communication between terminals. Also circuit-breakers are difficult than AC.

IV. ECONOMICAL ASPECTS

It is not simple to estimate a cost of buildings HVDC transmission line and operations unit. Cost are very different and depends on power of line, length connection, environment of track wires (air or water) and so on. Usually the biggest producers of high-voltage direct current transmission as Areva, Siemens or ABB don't reveal financial information about investments. Despite narrow basement of information, we can estimate some costs of built DC line, which is show on Fig.3.

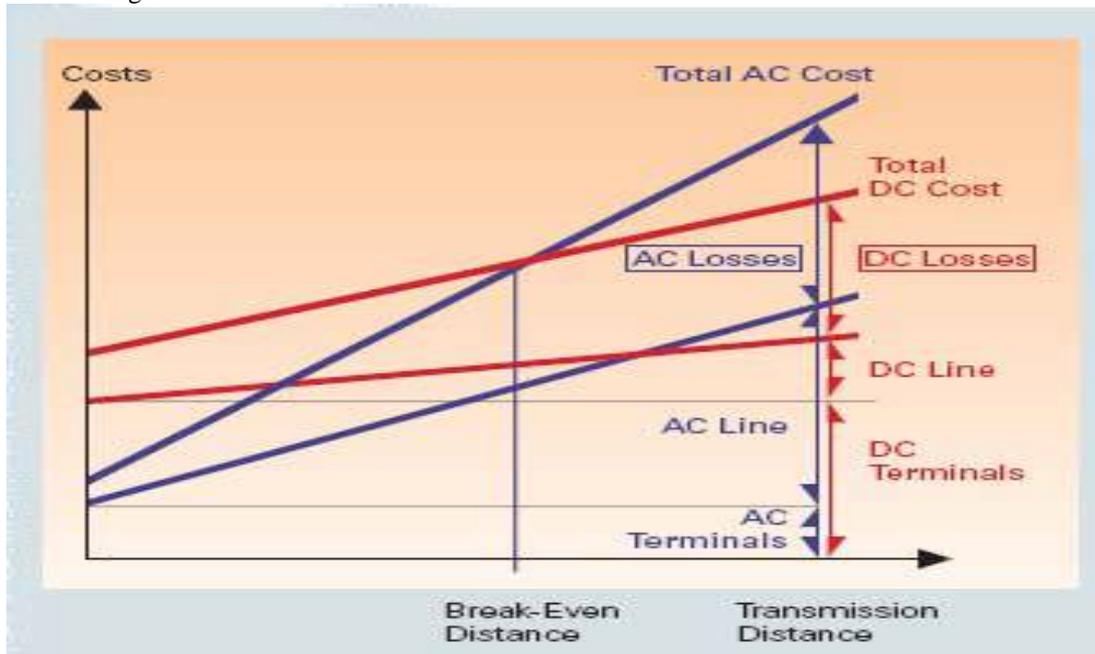


Fig.3. Relation between length of line and costs in AC and DC line.

About 50% cost of DC structure are converter transformers, valves and infrastructure as buildings.

V. APPLICATIONS

HVDC system can connected unsynchronized grids, therefore such lines very often are natural boundaries between countries. DC line is also meeting in places where is require undersea transmission (e.g. wind farm) and between two long distant points. From such reasons was built grids e.g. in Siberia, Canada, Australia or Scandinavia.

Problem of synchronized AC because of different frequency system occur e.g. in Japan, North America, South American (enormous hydroelectric power plant) – between Brazil and Paraguay In Europe the most lines are between UK, Scandinavia and continental Europe.



Fig.4. Nicolet convert station in transmission line Quebec - New England

The below table gives an idea about overall HVDC applications.

Table:1 Overview of HVDC Applications

	Long distance transmission over land	Long distance transmission over sea	Interconnections of asynchronous networks
Natural commutated HVDC with OH lines	X		X
Natural commutated HVDC with sea cables		X	X
Capacitor Commutate Converters (CCC) in Back-to-Back			X
Capacitor Commutated Converters(CCC) with sea cables		X	X
VSC Converters in Back-to-Back			X
VSC Converters with Land or sea cables	X	X	X
Capacitor Commutated Converters(CCC) with OH lines	X		X

VI. CONCLUSION

Today HVDC is very important issue in transmission energy. In near future this technology probably will be develop very intensive. Influence on future may have intensive spread of renewable energy source, also wind farm which need undersea connections. Also problem of cascade blackout, can be reduced by application of HVDC. Intensive, very large investments in e.g in China and India shows that high-voltage direct current will very important in the future, especially in big, new-industries countries.

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