1.3 Application of DC transmission

Due to their costs and special nature, most applications of DC transmission generally fall into one of the following three categories.

Underground or underwater cables:

In the case of long cable connections over the breakeven distance of about 40-50 km, DC cable transmission system has a marked advantage over AC cable connections. Examples of this type of applications were the Gotland (1954) and Sardinia (1967) schemes. The recent development of Voltage Source Converters (VSC) and the use of rugged polymer DC cables, with the so-called "HVDC Light" option, are being increasingly considered. An example of this type of application is the 180 MW Direct link connection (2000) in Australia.

Long distance bulk power transmission:

Bulk power transmission over long distances is an application ideally suited for DC transmission and is more economical than ac transmission whenever the breakeven distance is exceeded. Examples of this type of application abound from the earlier Pacific Intertie to the recent links in China and India.

The breakeven distance is being effectively decreased with the reduced costs of new compact converter stations possible due to the recent advances in power electronics.

Stabilization of power flows in integrated power system:

In large interconnected systems, power flow in AC ties (particularly under disturbance conditions) can be uncontrolled and lead to overloads and stability problems thus endangering system security. Strategically placed DC lines can overcome this problem due to the fast controllability of DC power and provide much needed damping and timely overload capability. The planning of DC transmission in such applications requires detailed study to evaluate the benefits. Example is the Chandrapur-Padghe link in India.

Presently the number of DC lines in a power grid is very small compared to the number of AC lines. This indicates that DC transmission is justified only for specific applications. Although advances in technology and introduction of Multi-Terminal DC (MTDC) systems are expected to increase the scope of application of DC transmission, it is not anticipated that the AC grid will be replaced by a DC power grid in the future. There are two major reasons for this:

First, the control and protection of MTDC systems is complex and the inability of voltage transformation in dc networks imposes economic penalties.

Second, the advances in power electronics technology have resulted in the improvement of the performance of AC transmissions using FACTS devices, for instance through introduction of static VAR systems, static phase shifters, etc.

Types of HVDC Links

Three types of HVDC Links are considered in HVDC applications which are

Monopolar Link:

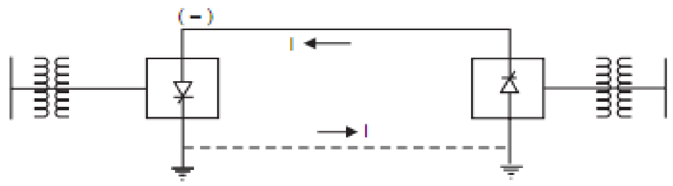

Figure 1.3.1 Monopolar DC link

[Source: "HVDC Power Transmission Systems" by K.P.Padiyar, page-10]

A monopolar link as shown in the above figure has one conductor and uses either ground and/or sea return. A metallic return can also be used where concerns for harmonic interference and/or corrosion exist. In applications with DC cables (i.e., HVDC Light), a cable return is used. Since the corona effects in a DC line are substantially less with negative polarity of the conductor as compared to the positive polarity, a monopolar link is normally operated with negative polarity.

Bipolar Link:

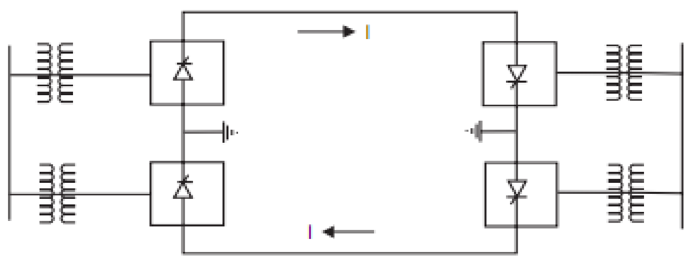

Figure 1.3.2 Bipolar DC link

[Source: "HVDC Power Transmission Systems" by K.P.Padiyar, page-10]

A bipolar link as shown in the above figure has two conductors, one positive and the other negative. Each terminal has two sets of converters of equal rating, in series on the DC side. The junction between the two sets of converters is grounded at one or both ends by the use of a short electrode line. Since both poles operate with equal currents under normal operation, there is zero ground current flowing under these conditions. Monopolar operation can also be used in the first stages of the development of a bipolar link. Alternatively, under faulty converter conditions, one DC line may be temporarily used as a metallic return with the use of suitable switching.

Homopolar Link:

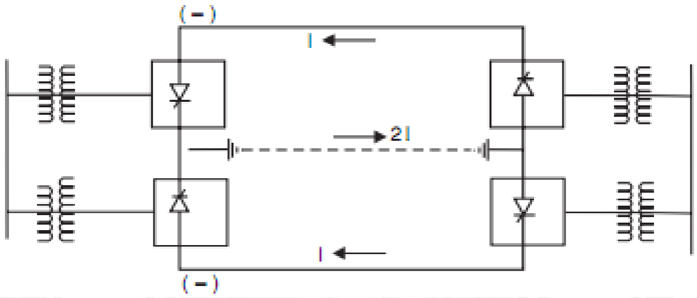

Figure 1.3.3 Homopolar DC link

[Source: "HVDC Power Transmission Systems" by K.P.Padiyar, page-10]

In this type of link as shown in the above figure two conductors having the same polarity (usually negative) can be operated with ground or metallic return.

Due to the undesirability of operating a DC link with ground return, bipolar links are mostly used. A homopolar link has the advantage of reduced insulation costs, but the disadvantages of earth return outweigh the advantages.