AC NETWORK INTERCONNECTIONS

AC transmission lines can only interconnect synchronized AC networks that oscillate at the same frequency and in phase. Many areas that wish to share power have unsynchronized networks. The power grids of theUK, Northern Europe and continental Europe all operate at 50 Hz but are not synchronized. Japan has 50 Hz and 60 Hz networks. Continental North America, while operating at 60Hz throughout, is divided into regions which are unsynchronised: East,
West, Texas and Quebec. Brazil and Paraguay, which share the massiveItaipu hydroelectric plant, operate on 60Hz and 50Hz respectively. However, HVDC systems make it possible to interconnect unsynchronized AC networks, and also add the possibility of controlling AC voltage and reactive power flow.

A generator connected to a long AC transmission line may become unstable and fall out of synchronization with a distant AC power system. An HVDC transmission link may make it economically feasible to use remote generation sites. Wind farms located off-shore may use HVDC systems to collect power from multiple unsynchronized generators for transmission to the shore by an underwater cable.

In general, however, an HVDC power line will interconnect two AC regions of the power-distribution grid. Machinery to convert between AC and DC power adds a considerable cost in power transmission. The conversion from AC to DC is known as rectification, and from DC to AC
as inversion. Above a certain break-even distance (about 50 km for under sea cables, and perhaps 600-800 km for overhead cables), the lower cost of the HVDC electrical conductors outweighs the cost of the electronics.

The conversion electronics also present an opportunity to effectively manage the power grid by means of controlling the magnitude and direction of power flow. An additional advantage of the existence of HVDC links, therefore, is potential increased stability in the transmission grid.

Rectifying and inverting

Rectifying and inverting components

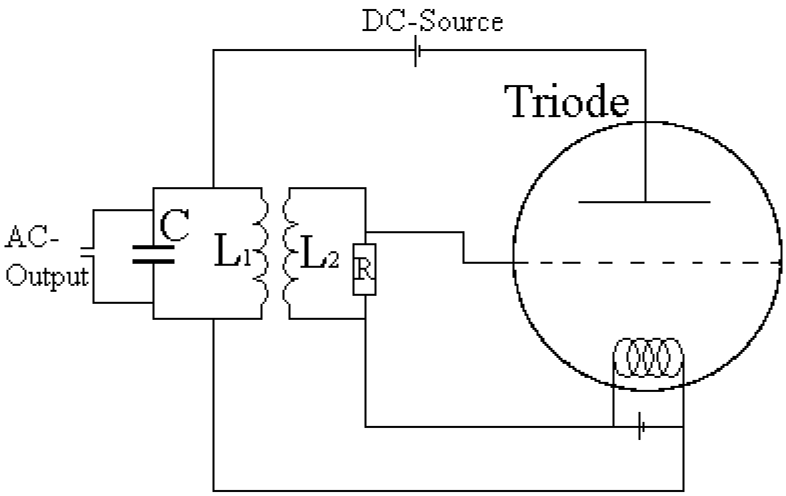
Early static systems used mercury arc rectifiers, which were unreliable. Nevertheless some HVDC systems using mercury arc rectifiers are still in service in 2005. The thyristor valve was first used in HVDC systems in the 1960s. The thyristor is a solid-state semiconductor device similar to the diode, but with an extra control terminal that is used to switch the device on at a particular instant during the AC cycle. The insulated-gate bipolar transistor (IGBT) is now also used and offers simpler control and reduced valve cost.

Because the voltages in HVDC systems, up to 800 kV in some cases, exceed the breakdown voltages of the semiconductor devices, HVDC converters are built using large numbers of semiconductors in series.

The low-voltage control circuits used to switch the thyristors on and off need to be isolated from the high voltages present on the transmission lines. This is usually done optically. In a hybrid control system, the low-voltage control electronics sends light pulses along optical fibres to the high-side control electronics. Another system, called direct light triggering, dispenses with the high-side electronics, instead using light pulses from the control electronics to switch light-triggered thyristors (LTTs).

A complete switching element is commonly referred to as a 'valve', irrespective of its construction.

Rectifying and inverting systems



A simple DC to AC converter using 2 solenoids, a capacitor and a triode

Rectification and inversion use essentially the same machinery. Many substations are set up in such a way that they can act as both rectifiers and inverters. At the AC end a set of transformers, often three physically separate single-phase transformers, isolate the station from the AC supply, to provide a local earth, and to ensure the correct eventual DC voltage. The output of these transformers is then connected to a bridge rectifier formed by a number of valves. The basic configuration uses six valves, connecting each of the three phases to each of the DC rails. However, with a phase change only every sixty degrees, considerable harmonics remain on the DC rails.

An enhancement of this configuration uses 12 valves (often known as a twelve-pulse system). The AC is split into two separate three phase supplies before transformation. One of the sets of supplies is then configured to have a star (wye) secondary, the other a delta secondary, establishing a thirty degree phase difference between each of the sets of three phases. With twelve valves connecting each of the two sets of three phases to the two DC rails, there is a phase change every 30 degrees, and harmonics are considerably reduced.

In addition to the conversion transformers and valve-sets, various passive resistive and reactive components help filter harmonics out of the DC rails.

Source : http://engineering.wikia.com/wiki/HVDC