Principles of Control of HVDC Transmission

The current in a dc link depends mainly on the resistance and the difference in voltage at the two ends of the HVDC transmission line, according to Ohm's law. The voltage at the converter station depends on the number of converter groups in series, ac system voltage, converter tap-changer position, circuit impedances and firing angle of the valves. The tap-changer position and firing angle of the valves can be changed for control purposes. For efficient operation, the voltage is maintained high, For minimizing the reactive power consumption of the converters, the firing angle at the rectifier and the commutation margin angle at the inverter side are generally kept low. The inverter firing angle is controlled to maintain the commutation margin angle between 150 to 200,

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and the inverter tap-changers controlled to give the rated dc voltage. The rectifier firing angle is then controlled to obtain the required transfer of current or power and the rectifier tap-changer is adjusted to keep the firing angle between 10^{o} to 20^{o} . If due to a sudden change in ac system voltage, it is not possible to increase the voltage above the requirement at the rectifier end, the voltage at the inverter end can be reduced by increasing the commutation margin angle at the receiving-end thus obtaining the necessary power transfer.

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DC links have the ability to switch on or off all or varying amounts of power in a few milliseconds. This facility is used to protect dc equipment against, faults. In some cases dc converters are switched off for approximately 0.8 s and full load can be taken again in a few milliseconds. Thus, block-block sequence is possible with HVDC, transmission.

Applications of HVDC Systems

The application of HVDC transmission may be of the following types. In practice, combination of the types of application will exist:

1. Power transmission over long-overhead lines.
2. Power transmission through underground or submarine cables.
3. Interconnection of the individually controlled ac systems.
4. AC and DC lines in parallel.
5. DC transmission with ac distribution.
6. Frequency conversion.

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The cost of a dc transmission line is less than that of an ac line while the cost of the terminal equipment in case of dc is highest In case of long-distance transmission lines, dc at high voltage becomes economical. The exact economy should be worked out for comparison under local conditions. However, in general, it may become economical for distances of over 500 Km and voltage ranges of 400 KV and above.

The other advantages of HVDC transmission have already been discussed under 4.6.3. In general, a two-pole, two-circuit dc line costs about two-thirds of the single-circuit ac line carrying the same power and designed for the most economical voltage and current density in each case.

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The cost per kilowatt of power transmitted is inversely proportional to square root of the kilowatt capacity of the line. Thus, high-capacity transmission lines are economical.

Power Transmission Over Long Overhead Lines: With the possibility of using HVDC transmission over long distances in comparison with ac as well as where it is not possible to transmit power over very long distances by ac, it is now possible to exploit large hydro-resources which may be very far from the load centers and transmit power by HVDC. Also, it is possible to develop thermal stations at coal pies at suitable economical sites and transmit power over long distances by use of HVDC transmission.

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Power Transmission through Underground or Submarine Cables: For working out the economics of underground or submarine cables, the extra cost of the terminal equipment in case of HVDC should be paid for by the saving, in cable costs to justify the dc operation compared to ac operation. The difference in the cost of ac cables and dc cables is pronounced, as compared to overhead transmission. It is practicable and economical for distances of 50 Km and more to go in for dc cable transmission.

DC cables are easier for construction and laying. Large submarine ac cables are oil-or gas-filled under pressure. DC cables can have simple paper insulation impregnated with a high viscosity compound.

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Interconnection of Individually Controlled Systems: HVDC transmission is used for interconnecting two ac systems, even of different voltages. This becomes economical when there is diversity between the two systems either on the production side or on the consumption side. The interconnection also reduces the spinning capacity (reserve capacity) of the plan required in the systems. The interchange of power can be effected to or from either system required using the interconnection.

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The interconnection has a small capacity compared to the capacity the systems interconnected. This introduces difficulties in the stability and power control if interconnection is by means of an ac link. Instead of an ac link, if a dc link is used for interconnections an advantage is that the two ac systems remain independent in their voltage and frequency control.

As the system grows bigger and bigger, the short-circuit power increases more and more. Then the cost of switchgear is also high and this often makes the desirable interconnection of power blocks uneconomical, when

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using an ac link. A dc link does not increase the short circuit capacity of interconnected power systems. This is a great advantage in the use of dc link for interconnection. Only when it is necessary to introduce synchronous compensators for the control of reactive power with dc interconnection is there some addition of short-circuit capacity in the system.

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The dc link has asynchronous nature and presents the possibility of running pump-storage stations with different speeds for pumping and generating operations of the plant. This would increase the efficiency of operation and this could also obtain without any switching in the main circuits.

AC and DC Lines in Parallel: It is possible to transmit a part of the power by interconnection with a dc link while the rest of the power is transmitted over an ac line. High voltage ac line an HVDC line can be used in parallel as an ac-dc system. The dc link can be used with advantage for control of power. Figure 4.4 shows a simple arrangement

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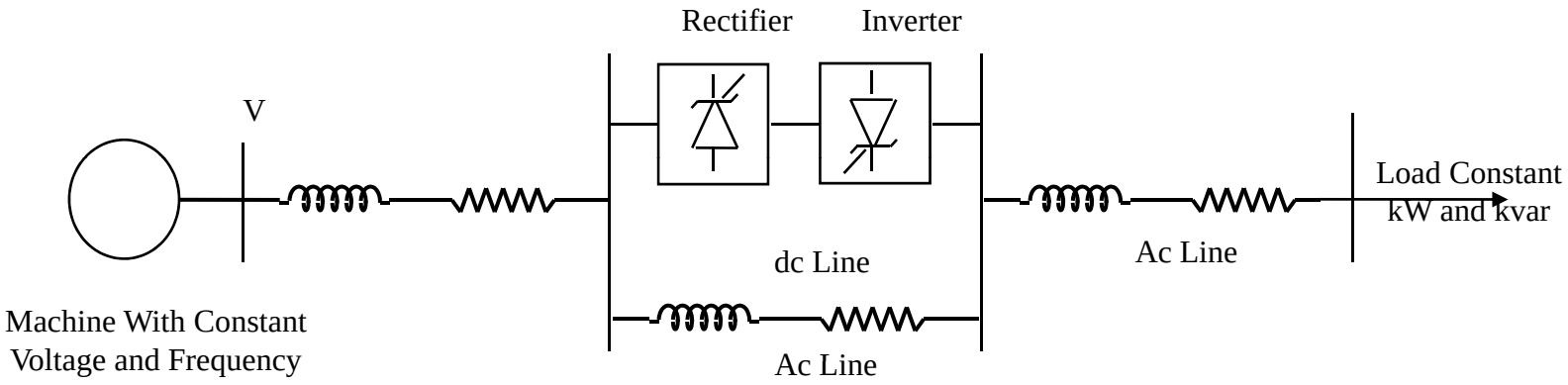

Fig. 4 Simple parallel ac-dc system

With My Best Wishes
Transmission and Distribution
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