A REVIEW ON HIGH PHASE ORDER TRANSMISSION SYSTEM OVER THREE PHASE DOUBLE CIRCUIT TRANSMISSION SYSTEM

MUKESH
Electrical engineering department,
D.A.V.I.E.T. Jalandhar,
Punjab, INDIA

SUDHIR SHARMA
Associate Professor,
D.A.V.I.E.T. Jalandhar,
Punjab, INDIA

AKHIL BHATIA
Electrical engineering department,
D.A.V.I.E.T. Jalandhar,
Punjab, INDIA

RAGHAV SHARMA
Electrical engineering department,
D.A.V.I.E.T. Jalandhar,
Punjab, INDIA

SHIVANI MEHTA
Assistant Professor,
D.A.V.I.E.T. Jalandhar,
Punjab, INDIA

PARDEEP KAUR
Electrical engineering department,
D.A.V.I.E.T. Jalandhar,
Punjab, INDIA

Abstract: - With the increasing demand of Electrical energy in the present time with the development of the new and advanced technologies, engineers are dealing with the problem of bulk power transmission over the large distances, for which a number of technologies have been used till now. Some of which includes HVDC transmission, HVAC transmission and HPO Transmission system. Of all these transmission systems HPO transmission system is the emerging option for the bulk power transmission over the long distance transmission lines despite the fact that HVDC has many advantages over the conventional AC system like less losses in the transmission lines, less number of conductors used, and non-synchronous ties etc. because, HVDC incorporate the following disadvantages like high cost of terminal equipment, inability to step-up and down, and inability to transfer reactive power between the two ends which are fulfilled by conventional HVAC transmission system but with the increase in demand of energy requirement our conventional HVAC system needs to be upgraded to higher number of phases which can be the future of the transmission system for bulk power transmission over the long distances. This paper reviews the Advantages and Disadvantage of upgrading the present Double circuit three phase transmission lines to six phase transmission lines with the results from the different researches and test results and different types of faults that occur in HPO transmission system.

Keywords: - High voltage direct current, High voltage alternating current, High phase order

1. INTRODUCTION

Conventionally the high power transmission system uses three phase as for power transfer with each phase displace by an angle of 120 degrees and line voltage equal to √3 times the phase voltage and power equals to $2*3 V_{ph} I_{ph} \cos \phi$ while the six phase system has the
phase difference of 60 degrees and line voltage equal
to the phase voltage, since the angle between the
adjacent phase is 60 degrees, it forms an equilateral
triangle, and hence \( V_{\text{phase}} = V_{\text{line}} \) and power equals to
\( 6*V_{ph}I_{ph}\cos\phi \) and thus the six phase system can deliver
as many as 73% more power ie. 1.7 to 1.74 times more
power than the existing three phase system depending
upon the line configuration if we use same phase to
phase voltage [6] ie. line voltage and conversely if we
use the same phase to neutral voltage the line voltage
for HPO will decrease thus less space is requires
between the phases for installation this also reduces
the right of way of the transmission lines and the size
of tower to build the HPO lines [1].

Furthermore the HPO transmission system has some
other advantages like:-

- The HPO transmission system ie. the six phase
conversion gives better voltage regulation because of
higher SIL for the same amount of power transferred
[6].
- HPO can transfer more power with less audio noise
levels as compared to conventional three phase double
circuit transmission lines [2].
- HPO has higher reliability potentially [2].
- HPO system is easily compatible with the existing
three phase double circuit transmission system since
they can be tapped with three phase connections [3].

HPO system has low radio interference levels
compared to conventional system.
HPO transmission system also has certain limitations
like:-

- Increasing the number of phases makes the system
more complex.
- The fault detection system and the protection system
may need further research for the practical operation
of HPO lines.
- The regulation for the six phase transmission is poor
for more power transfer if the six phase conversion is
adopted, this problem can be solved by using the
available FACT’s devices [1].

2. CONVERSION METHODOLOGY

The existing three phase system can be converted into
six phase system by using the single phase or three
phase transformers which can be studied on the
software like MATLAB, PSCAD/EMTDC etc. [5].
First, six identical single phase two winding
transformers may be connected to form a three to six
phase bank.
Secondly, three identical single phase three winding
transformers can be connected to form a three to six
phase bank.
Different winding connections may be used on both
the sides ie. Primary and secondary depending upon
which the magnitude of current and voltage may vary.
The primary and secondary of a three to six phase
conversion system can be connected in any
combination of star (Y) or delta (Δ) which makes five
possible connection forms which are star-star star-
inverted star (Y-Y Y-inverted Y) connection, Delta-
star delta-inverted star (Δ-Y Δ-inverted Y), diametrical
connection, two delta connection and two star
connection.
The results shown here have been obtained from the study on the two soft-wares that are PSCAD/EMTDC and MATLAB software. PSCAD/EMTDC used for six phase system simulation and MATLAB software to accelerate and check the theoretical measurements.

The results shows that from the five connection form only three connection validate the phase difference of 60 degree and the phase voltage is same as the line voltage which are delta-star delta-inverted star connection, star-star star-inverted star connection and diametrical connection.

Tests were conducted on three samples, Test System I, Test System II and Test System III. Each test system contains six phase system analyse through mathematics and simulation [4].

### TABLE 1: six-phase transformer connections with schematic diagrams

<table>
<thead>
<tr>
<th>Types of Connection</th>
<th>Schematic Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wye-Wye Wye-Inverted Y</td>
<td><img src="schematic1.png" alt="Schematic Diagram" /></td>
</tr>
<tr>
<td>Delta-Wye Delta-Inverted Y</td>
<td><img src="schematic2.png" alt="Schematic Diagram" /></td>
</tr>
<tr>
<td>Diametrical</td>
<td><img src="schematic3.png" alt="Schematic Diagram" /></td>
</tr>
<tr>
<td>Double Delta</td>
<td><img src="schematic4.png" alt="Schematic Diagram" /></td>
</tr>
<tr>
<td>Double Wye</td>
<td><img src="schematic5.png" alt="Schematic Diagram" /></td>
</tr>
</tbody>
</table>

### TABLE 2: Parameters of Test System I, Test System II and Test System III

<table>
<thead>
<tr>
<th>Generator</th>
<th>Test System</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. The Supply Voltage</td>
<td>138kVA</td>
<td>115kV</td>
<td>22kV</td>
<td></td>
</tr>
<tr>
<td>ii. MVA Base</td>
<td>600MVA</td>
<td>150MVA</td>
<td>60MVA</td>
<td></td>
</tr>
<tr>
<td>iii. Frequency</td>
<td>50Hz</td>
<td>50Hz</td>
<td>50Hz</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transformer</th>
<th>Test System</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. The primary voltage</td>
<td>138kV</td>
<td>115kV</td>
<td>22kV</td>
<td></td>
</tr>
<tr>
<td>ii. The secondary voltage</td>
<td>138kV</td>
<td>161kV</td>
<td>132kV</td>
<td></td>
</tr>
<tr>
<td>iii. MVA Base</td>
<td>600MVA</td>
<td>150MVA</td>
<td>60MVA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmission Line</th>
<th>Test System</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. The impedance</td>
<td>0.3108+ 0.544Ω</td>
<td>0.1554+ 0.272 Ω</td>
<td>0.775+ 1.3642 Ω</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Load</th>
<th>Test System</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. The impedance</td>
<td>1000Ω</td>
<td>1000 Ω</td>
<td>1000 Ω</td>
<td></td>
</tr>
</tbody>
</table>

The results obtained from the tests (Not shown here) shows that the voltage increase had stepped up six phase power and obtainable delta-star delta-inverted star acquired 70.74%, diametrical connection acquire 70.76% and stat-star star-inverted star from only -1.85%. then both the six-phase connection systems approaching 73% and is an increase over three phase system.

### 3. FAULT ANALYSIS

The results from the MATLAB simulation of the GETCOs (Gujarat energy transmission co.) 400KV TPDSC line and its conversion into six phases by using two 12-terminals three phase transformers have been shown here. Six phase conversion is made by displacing the two three phase supplies by 180
degrees. On the receiving end the same pair of transformers is mirrored for six to three phase conversions.

The graphs for different types of faults are obtained for different types of faults at different locations and the results from the fault current and fault voltage shows that the magnitude of fault current is less the three phase double circuit system in the six phase system with the same value of fault resistance, fault type and fault location.

Also the four-phase to ground fault is the most severe fault in case of six phase system.

The curves between the load voltages for line to ground fault on mid of transmission line shows less distortions in the six-phase system than the three-phase double circuit system [6].

FIG. 1 fault current for fault four-phase to ground in TPDC at mid-point

FIG. 2 fault current for fault four-phase to ground in six phase at mid-point

4. CONCLUSION

From the research and facts shown above it can be concluded that the HPO system i.e. Six-phase transmission system is better alternate for the transmission system than the conventional three phase double circuit system and also from the literature study it has been proven that the Six phase transmission system has the many advantages over the conventional three phase double circuit system.

The following conclusion can be made out from the research:-

1. As we know that the power of a six-phase system is equal to $6*V_{ph}I_{ph} \cos \phi$ which is about 73% more than the conventional three phase double circuit system because in case of six-phase the line voltage is equal to the phase voltage [4].
2. If we keep the phase voltage same for both the systems (HPO system and TPDC system) for same amount of power transfer, the line voltage for six-phase system (HPO system) will be less, therefore cause a reduction in the overall dimension of the system, including Size of towers, foundation cost, right of way of the lines and other problems related to adverse biological effects.

3. For the same amount of transfer of power the six-phase system (HPO system) has better regulation as it has higher SIL.

4. HPO system will result in reduction in the corona effect, audio noise level, television and radio interference and also reduction in the magnetic field will have good impact on the environment.

5. In the case of six-phase transmission, the fault current is for the same fault resistance, fault type, and fault location as compared to three-phase double circuit transmission system.

6. From the fault analysis for both the six-phase system and three-phase double circuit system, it can be concluded that the three-phase to ground fault is most severe in TPDC system, while in six-phase transmission system (HPO system) four-phase to ground fault is most severe.

7. From the curves of load voltages for line to ground fault at the mid-point of the transmission line, it can be concluded that the distortion in case of six-phase transmission line is less than the TPDC system

8. HPO system is easily compatible to the existing TPDC system.

9. HPO structures, insulation and hardware, present no limiting design problems.

Although the high phase order system has lot of advantages which are proven theoretically, the results from these studies implementing towards power system practically must be given attention. A number of factors are to be taken into consideration to see if the HPO system especially six-phase system is practically good. For example, three-phase to six-phase converters which is the most critical in the design of six-phase system. After studying all these factors, a mathematical model can be further shaped to enable analysis of load flow committed against the HPO system (six-phase system).

Thus the HPO system has certain limitations apart for all the advantages stated above that are:-

1. If the conversion from three-phase to six-phase is adopted, for more power transfer the regulation of the system will be poor, but this problem can be very well solved with the help of available FACT’s devices.

2. If the conversion from three-phase to six-phase is made by the use of transformers, then the number of transformers in the system will increase increasing the overall cost of the system and making the system more complex.

REFERENCES


