Expanding Transmission Capacity: A Low-Cost Hybrid AC/DC Scheme for Increased Transmission Capacity

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INTRODUCTION:

- With ever-increasing electricity consumption, conventional thermal power plants have been renovated and new generations from renewable energy resources have been built to address environmental concerns.
- This has added operational stresses to the existing transmission corridors, making some of the transmission lines operating at or near to their rated transmission capacity..
- Building new transmission corridor (HVAC or HVDC) or converting existing HVAC into HVDC systems is either restricted by high implementation cost or delayed due to the land licensing process, low public acceptance, and environmental issues.
- In this project a hybrid AC/DC power transmission method is proposed particularly for thermally constrained short transmission line, which directly uses the existing ROW to transport both AC and DC power.
- The objective is to achieve increased transmission capacity by up to 50% of the existing AC transmission, with less than 50% implementation cost

Philosophy and Approach

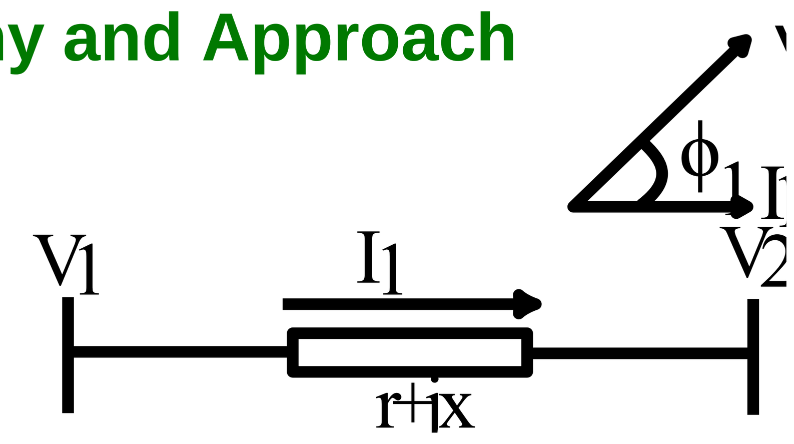

Fig. 1. Single Line Diagram of HVAC Transmission

- For AC Transmission: $P_{ac} = 3V_1 I_1 cos\phi_1$
- For Hybrid Transmission: $P_{hybrid} = P_{ac} + P_{dc}$
- Replacing P_{ac} and P_{dc} : $P_{hybrid} = 3V'_1 I'_1 cos\phi_2 + 3V_{dc} I_{dc}$
- The power Transmission Ratio: $\frac{P_{hybrid}}{P_{ac}} = \frac{[3V'_1 I'_1 cos\phi_2 + 3V_{dc} I_{dc}]}{3V_1 I_1 cos\phi_1}$
- In case of pure HVDC it becomes: $\frac{P_{HVDC}}{P_{ac}} = \frac{V_{dc} I_{dc}}{V_1 I_1 cos\phi_1}$
- For transformed Voltage same as peak, and Current as rms of HVAC
- Power Transmission Ratio: $\frac{P_{HVDC}}{P_{ac}} = \frac{\sqrt{2}}{cos\phi_1} \geq \sqrt{2}$
- For hybrid: $\frac{P_{hybrid}}{P_{ac}} = \frac{cos\phi_2 + 2\lambda^v_{dc}\lambda^i_{dc}}{cos\phi_1} \times \frac{1}{1+\lambda^v\_dc} \times \frac{1}{\sqrt{2\lambda^{i2}_{dc}+1}}$
- Where: $\lambda^v_{dc} = \frac{V_{dc}}{\sqrt{2}V_{ac}}$; $\lambda^i_{dc} = \frac{I_{dc}}{\sqrt{(2)}I_{ac}}$

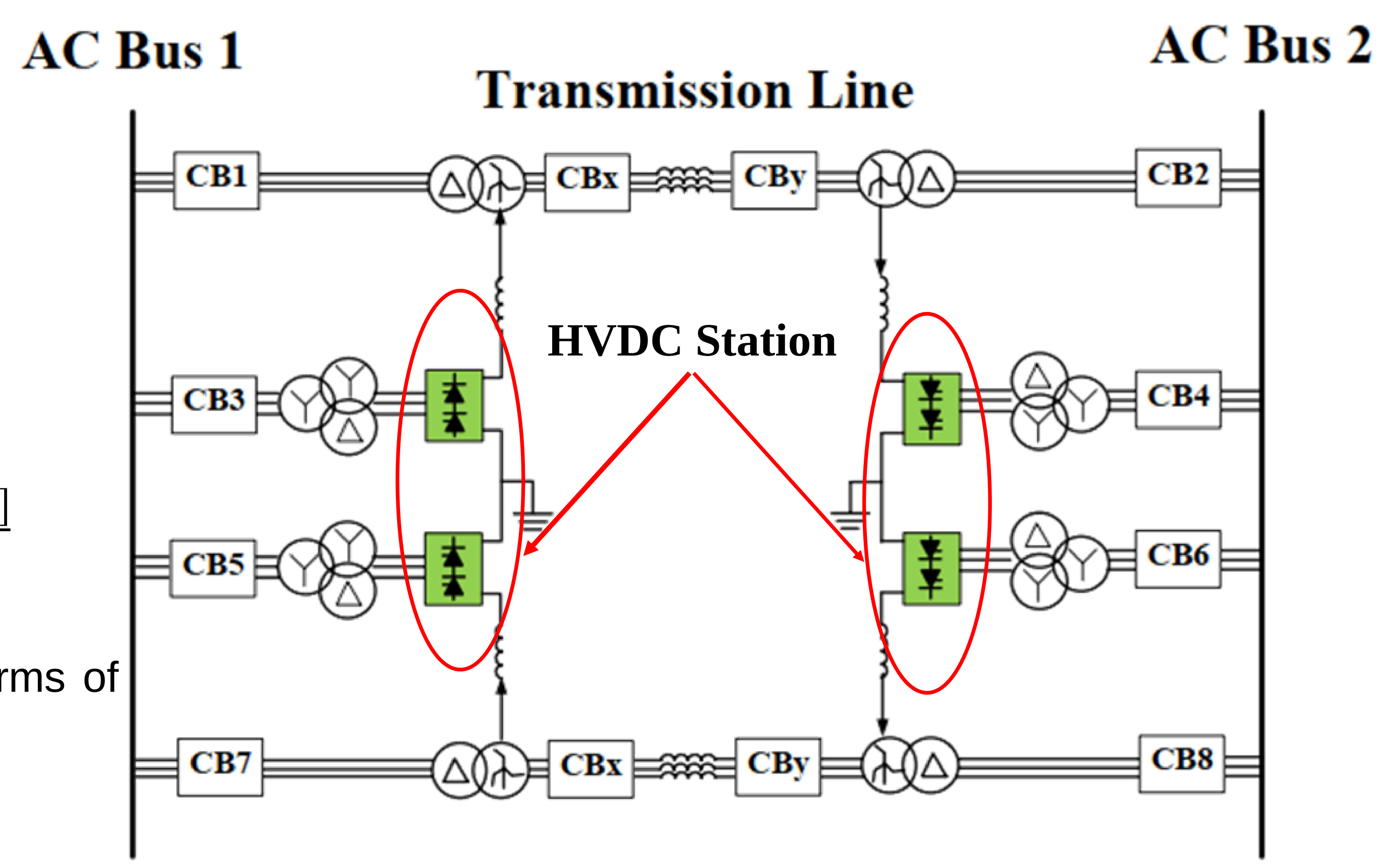

Fig. 2. Hybrid AC/DC Power Transmission Approach

Results and Selection of Parameters

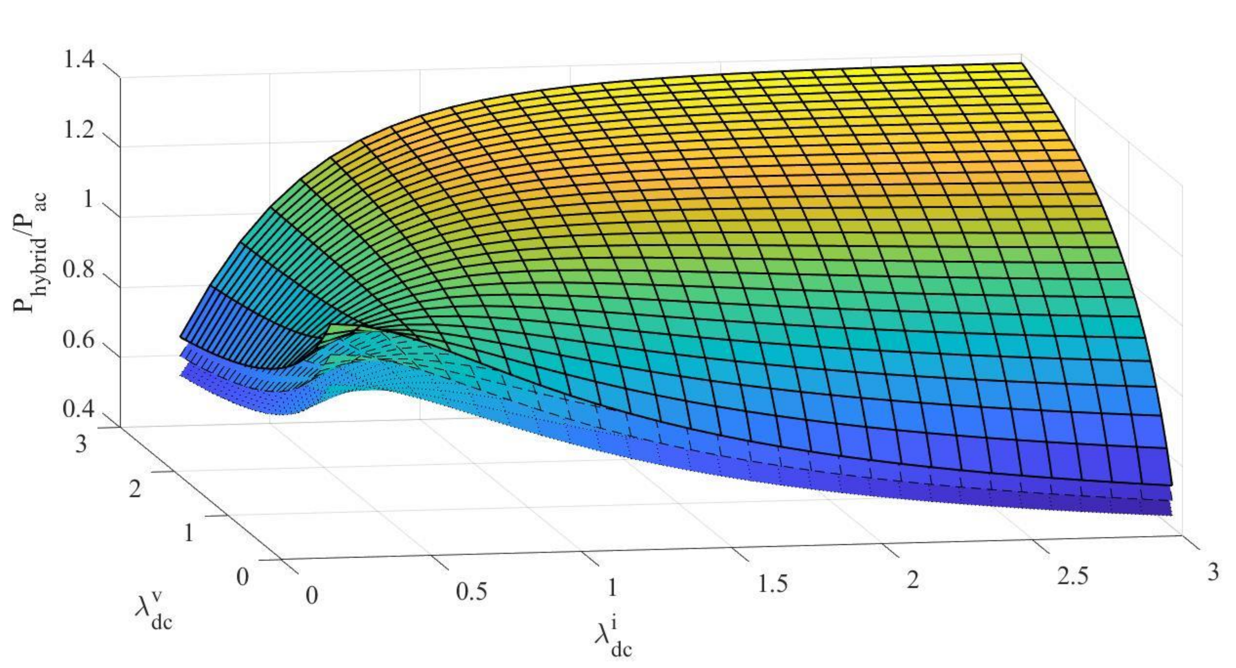

Fig. 3. Power Transmission ratio vs λ^v_{dc} and λ^i_{dc}

- Power Transmission ratio increases significantly with the voltage level
- With 20% increase in the system voltage around 40% improvement in power transmission is achieved

System Constraints

- Unchanged tower structure and geometry
- Minor change in insulator
- Decreased/Unchanged ROW
- Existing Conductor
- No re-alignment
- Clearance as per NESC
- Permissible AN and RF
- Permissible Electric and Magnetic Field

Selection of Voltage

- Lightning Impulse Withstand Voltage (LIWV)
- Switching Impulse Withstand Voltage (SIWV)
- Power Frequency overvoltage
- Pollution
- Altitude
- Tower Geometry

Selection of Current

- Conductor thermal limit
- Environment (ambient temperature, air flow)
- Sag Limit
- Altitude
- DC and AC resistance
- Solar Irradiation

Increased Power Transmission
Lower Cost

CONCLUSION

- This poster presents the approach of the hybrid AC/DC transmission for short transmission system
- Power transmission ratio largely depends on voltage level
- With the proposed approach a significant increase in power transmission with low cost can be achieved