cigre | PARIS 2022

Hitachi Energy

B4 - DC SYSTEMS & POWER ELECTRONICS

PS 1 / HVDC SYSTEMS AND THEIR APPLICATIONS

Paper ID_10467

FAULT RIDE THROUGH INVESTIGATIONS IN A VSC BIPOLE HVDC SYSTEM CONNECTED TO RENEWABLES USING AN AC CHOPPER

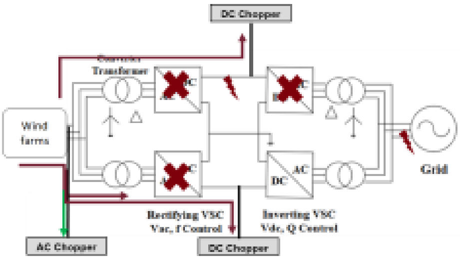
Teja BANDARU[1], Vinothkumar K[2], Ying-Jiang HAFNER[3], Per HOLMBERG[4]

[1,2]Hitachi Energy Technology Services Private Limited, India

[3,4]Hitachi Energy AB, Sweden

Motivation

- The increasing trend of on-land windfarms capacity (> 3 GW, e.g. SunZia link) demands the use of Bipole over-head line (OHL) based HVDC links.
- Compared to the cables, the OHLs are subject to frequent faults (temporary / permanent).
- During DC OHL faults which are frequent, the faulted pole in the bipole link is tripped which leads to the diversion of entire power to the healthy pole and could trip in the event of overload.
- This necessitates the need of AC Chopper along with robust control for desired fault ride-through (FRT) performance.

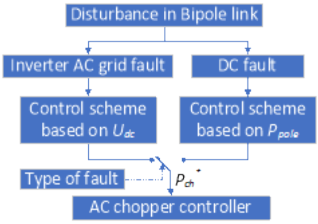


Method/Approach

- AC chopper, also referred as thyristor braking resistor, can effectively divert the excess power during DC fault scenarios.
- AC chopper is connected at the AC side (PCC) through a stepdown transformer.
- A robust control scheme for the operation of AC chopper to achieve desired fault ride through (FRT) of the bipole HVDC link is proposed.

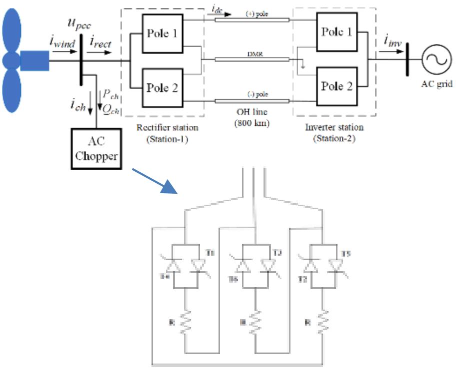
Objects of investigation

- It is to be noted that, for desired FRT of bipole link as per the grid code, different control schemes for the AC chopper may have to be adopted under different fault conditions.
- The objective of this work is to investigate the performance of the proposed control schemes for AC chopper during,
  - inverter AC grid faults
  - DC faults (permanent & temporary)



Test setup

- AC chopper connected at the PCC of rectifier station in a bipole HVDC link is shown below.



- In general, the AC chopper may consists of few step-down transformers and several chopper subunits.
- This is to meet the total AC chopper rating requirement with the available Thyristor ratings commercially.

B4 - DC SYSTEMS & POWER ELECTRONICS

PS 1 / HVDC SYSTEMS AND THEIR APPLICATIONS

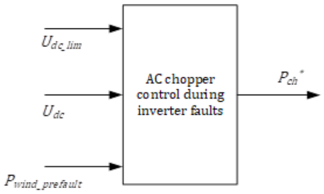
Paper ID_10467

FAULT RIDE THROUGH INVESTIGATIONS IN A VSC BIPOLE HVDC SYSTEM CONNECTED TO RENEWABLES USING AN AC CHOPPER

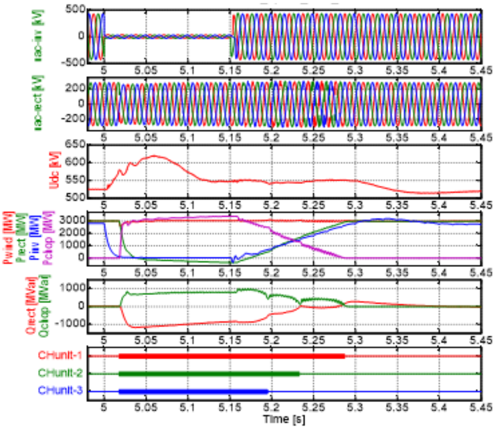
continued

Control during inverter AC grid faults

- During disturbances in inverter AC grid, the power output of the inverter gets reduced
- As a consequence, with continuous feed of renewable power at the rectifier, the cell capacitor voltages and hence the voltage of DC link (U_{dc}) increase continuously.
- The control of AC chopper considers U_{dc} as feed-back variable and generates the power reference (P_{ch}^{*}) to AC chopper when U_{dc} exceeds U_{dc_lim}.

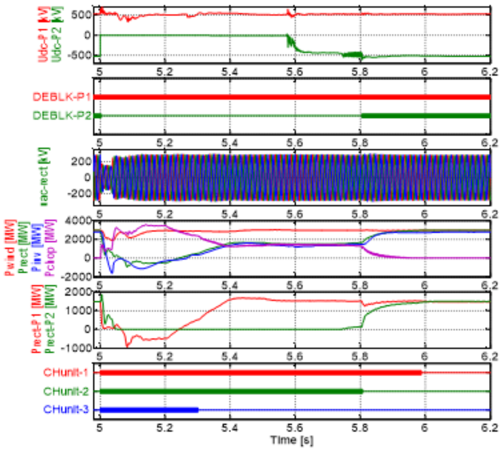


- **Results:** 3-ph fault is initiated at the PCC of the inverter at 5 s and inverter power reduces to zero which leads to rise in U_{dc}.
- Detecting U_{dc} rise above 1.1 pu (U_{dc_lim}), all the three units of AC chopper are activated by the action of chopper controller through its power reference (P_{ch}^{*}).
- This action limits further increase of U_{dc} and avoids tripping of the HVDC link due to over voltage protection.
- At fault clearance (at 5.15 s), inverter power restores gradually and the AC chopper power reduces to zero by the action of its controller.
- During chopper operation, reactive power need by the AC chopper is supplied by the HVDC converters.



Control during DC faults

- Fault (permanent/temporary) in DC line of one of the pole of a bipole link leads to tripping of the corresponding pole
- Now, the entire power from the renewable source tend to flow through the healthy pole which leads to overload trip of healthy pole also (if renewable source power > pole capacity)
- To avoid this, AC chopper is activated detecting the DC fault / pole trip and the power from the renewable source which is in excess of the healthy pole is diverted to chopper.
- Upon restarting the faulted pole (during temporary fault), the power is transferred smoothly from the AC chopper to restarting pole.



- **Results:** A temporary DC fault is initiated in negative pole (pole-2) at 5 s and the faulted pole (pole-2) is tripped.
- Based on the trip signal of pole-2, AC chopper is activated.
- Initially the AC chopper dissipates entire wind power.
- Then with some delay (after tripping of pole-2) the power in the heathy pole (Prect-P1) is restored (between 5.2 – 5.4 s).
- After clearance of the DC fault (temporary fault case), the faulted pole is restarted (at 5.8 s)
- Gradually the power in restarted pole is restored to prefault value (at 6 s) by the action of AC chopper controller.

B4 - DC SYSTEMS & POWER ELECTRONICS

PS 1 / HVDC SYSTEMS AND THEIR APPLICATIONS

Paper ID_ 10467

FAULT RIDE THROUGH INVESTIGATIONS IN A VSC BIPOLE HVDC SYSTEM CONNECTED TO RENEWABLES USING AN AC CHOPPER

continued

Conclusion

- AC choppers can effectively adress the FRT grid code requirements in bipole HVDC links connected to islanded AC grids (like windfarms).
- AC choppers can also be used where two or more symmetric monopole links are connected to common PCC.
- The proposed control for AC chopper in this work avoids the trip of entire HVDC link due to disturbances either in inverter grid or in DC line.
- Also, the proposed control enables smooth control of power in HVDC link during inverter AC grid faults and DC faults (permanent/temporary)

References

- J. Maneiro, S. Tennakoon, C. Barker and F. Hassan, "Energy diverting converter topologies for HVDC transmission systems," (2013 15th European Conference on Power Electronics and Applications (EPE), Lille, 2013, pp. 1-10).
- S. Schoening, P. K. Steimer and J. W. Kolar, "Braking chopper solutions for Modular Multilevel Converters," (Proceedings of the 2011 14th European Conference on Power Electronics and Applications, Birmingham, UK, 2011, pp. 1-10).
- https://sunzia.net/project-details/