A3 - PS1: Miscellaneous T&D equipment and systems.
Q2: HVDC switching equipment is on the way to become 'standardized' technology, while discussions are continuing based on the experiences in the field or laboratories as presented in 10545 and 10773. Can experts provide relevant issues or proposals for the standardization of HVDC switchgear?

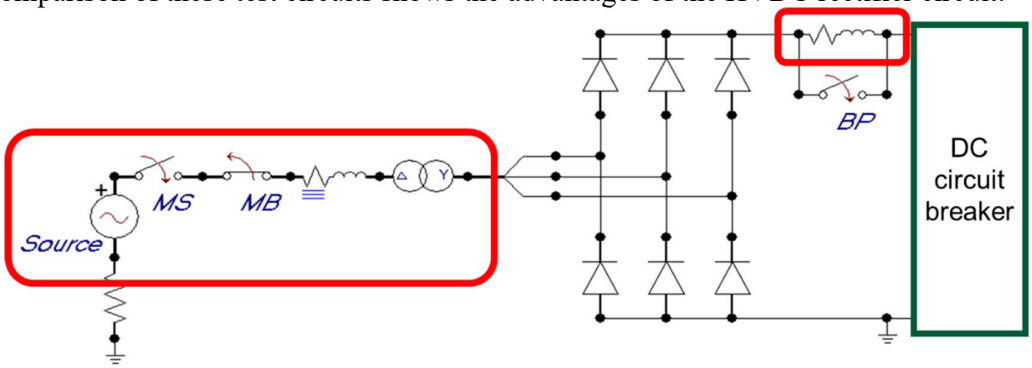
The power source of choice for DC CB testing: high-voltage, high-power rectifier

So far, each HVDC circuit breaker project had to search for a power source to test the prototypes and develop appropriate test procedures. As a result, a variety of test circuits and associated procedures have been developed using mostly preexisting AC test equipment to perform HVDC interruption tests:

- Oscillating circuits with pre-charged capacitors,
- Charged inductors
- Low frequency generators,
- A three-phase rectifier circuit.

The first three types of circuits were mostly used for interruptions with single opening operations while the last one was used for triple CO operations of a load commutation switch under lower medium voltage (Japan, 2013).

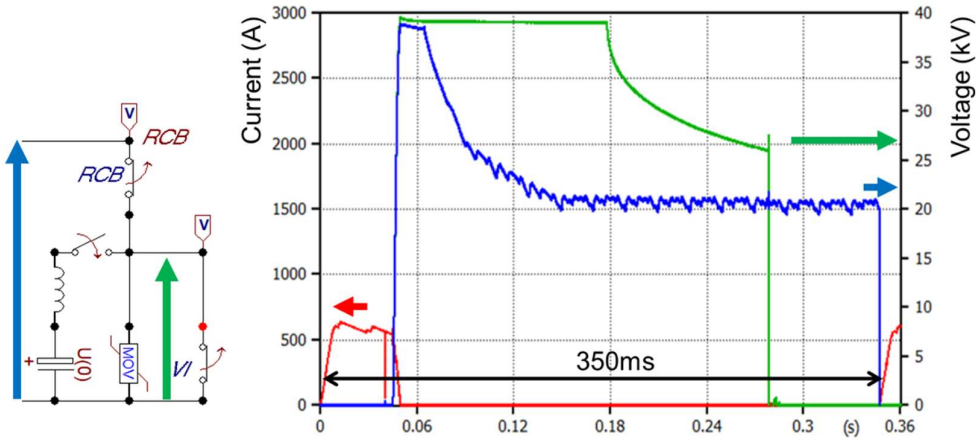
A comparison of these test circuits shows the advantages of the HVDC rectifier circuit:



1. Generator excitation, AC side inductance, transformer ratio and DC side inductance can be adjusted to meet the DC voltage, rate of rise of current and magnetic energy in the DC network.
2. At all current levels, the interaction between source and DCCB is most accurately represented. During regular interruptions, reignitions or even restrikes with subsequent interruptions, the TIV has the right magnitude and duration in the single shot.
3. A rectifier as source guarantees a seamless transition from the Transient Interruption Voltage to the DC recovery voltage and its application for an arbitrary duration.
4. Auto-reclosing tests: reclosing of the tested breaker can occur at any time, there is no need to delay the making of current to a specific generator phase angle. The true operational speed of the DC switchgear can be demonstrated.

All these reasons tend to prove that this test circuit mimics best a HVDC network.

Such a HV high-power rectifier source is being commissioned in our laboratory for testing HV DC circuit breakers. Here is an insight into the commissioning tests with an O-CO operation at partial load current of an active current injection breaker.



The current through the tested breaker is in red. The blue curve shows the voltage across the complete breaker with a smooth transition from Transient Interruption Voltage to DC recovery voltage. During this phase, the voltage across the vacuum interrupter (green) drops to zero as a result of preparation for the next interruption. The load current interruption is repeated 350 ms after the first one. This time interval would be difficult to match with other test circuits.

To conclude: A HV high-power rectifiers is the best way to test DC circuit breaker modules up to 170 kV at currents up to 40 kA and with magnetic energy up to 55 MJ per interruption.