DCLab

A high-performance test circuit for components in DC grids

With the increasing use of DC technology in high and medium voltage applications, the necessity to develop and test equipment under normal operation and in the event of a fault increases. Amongst other things, this includes DC circuit breakers, fault current limiting devices, disconnectors, converter components and measurement technology for fault detection and selective fault handling. The experimental investigation of such DC components puts new requirements on testing circuits, which existing test circuits for AC switching devices do not fulfill. Therefore, a new test circuit is developed which allows the testing of components of DC technology. The new test circuit consists of a high-power circuit in combination with a high-current source.

Characteristics of the test circuit

The high-power circuit can be used to simulate fault currents in DC systems, which are characterized by a nominal current before fault detection of up to I_N = 5 kA. The fault current amplitude in a point-to-point system can be up to $I_{k,max}$ = 30 kA and is dependent on the grid and the error configuration. At the time of the fault entry, high current rates of rise of di/dt > 2 A/µs occur. Depending on the fault treatment, the fault current can be interrupted within Δt = 50 ms. These characteristic values serve as a basis for the design of the high-performance test circuit. The high-current source makes it possible to carry out long-term tests. The source can provide a continuous current of up to I_N = 5 kA to allow for lifetime and aging tests on different components.

The high-performance test circuit is designed as a modular step-down converter. A total number of 120 capacitors discharge via a circuit inductance. Each capacitor is equipped with a semiconductor module and referred to as a cell. All 120 cells connect in two stages, each with 60 parallel units. Using the semiconductors, the Control and Measurement System (CMS) controls the discharge current by applying pulse-width modulation (PWM) based gate control signals. This way, different current waveforms can be generated. As a control input to the CMS, mathematical functions or simulation results from grid calculations can be used.

Preliminary examinations are necessary

Since the concept of the modular step-down converter has not yet been tested for currents up to $I_{k,max}$ = 30 kA, preliminary tests are carried out. These include the development of a simulation model for reviewing the test circuit concept and defining the test circuit parameters. This is followed by a validation based on real components. Low-voltage components are used to test the parallel and serial connection of the cell-based layout. Subsequently, various power semiconductor devices for high-voltage applications are tested in order to select a suitable semiconductor type and model. Furthermore, possible problems in the later laboratory setup are identified in this preliminary tests. Based on the results from the preliminary investigations, an approach with so-called chopper modules is selected for the final design of the cells. Chopper modules unite an IGBT and a diode within one housing. This makes it possible to achieve a very compact cell design for the high-power test circuit.

Project information

Partner
- Institute for High Voltage Technology

Facts
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Contact

Dr.-Ing. Sven Schumann
Head of Department Energy System Technologies
Tel.: +49 241 80 90270
schumann@ifht.rwth-aachen.de

Matthias Heidemann, M.Sc.
Academic Staff
Tel.: +49 241 80 99501
heidemann@ifht.rwth-aachen.de

Thomas Krampert, M.Sc.
Academic Staff
Tel.: +49 241 80 92949
krampert@ifht.rwth-aachen.de