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Laboratory with highest impulse current and 50 Hz-short-current parameters specially designed for the qualification-testing of SPDs

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ABSTRACT

The “class I and II operating duty tests” according to IEC/EN 61643-11 is an essential test for the qualification of surge protective devices (SPDs) connected to low-voltage power systems (LVPS). To perform this test a setup is required which offers the possibility to stress the SPD with defined surge-current impulses while it is connected to a power supply simulating the characteristic of the real LVPS in which the SPD should operate. In this regard, a new test facility is designed and constructed. One of its feature is a 50 Hz power system (PS) which provides unique fine adjustment possibilities for the test voltage, the short-circuit current and the power factor in a wide range of values. Its technical design and performance are described and discussed in detail. Furthermore, the technical implementation of the required coupling of this PS with a surge-current generator is presented. This addresses technical measures to protect the PS against electrical stress due to partial surge currents which can occur under certain circumstances during the above mentioned test procedure. Finally, test results obtained from lightning current arresters are presented to demonstrate the performance of the test facility.

1. Introduction

An effective protection of electrical systems and electronic equipment against surge voltages and lightning currents requires the use of surge protective devices (SPDs) with specifically tailored properties for the respective field of application. Therefore, a wide variety of SPDs with specific properties has been and will be developed. With regard to SPDs connected to low-voltage power systems (LVPS) the qualification-testing of these types of SPDs has to be carried out under test conditions which meet the real operating conditions of the power systems in which these SPDs should be installed. This is because of the fact that the electrical properties of a power system have a strong effect on the operational behavior of installed SPDs. In this regard a test-setup is required which offers the possibility to stress the SPD with defined surge-current impulses while it is connected to a power system simulating the characteristic of the real LVPS in which the SPD should be installed (comp. Fig. 1). An essential test procedure for the qualification-testing of SPDs connected to LVPS is described in IEC/EN 61643-11, chapter 8.3.4.3 which it is called *“class I and II operating duty tests”* [1,2].

In practice LVPS have large differences in their characteristic values. Therefore, the availability of a power system (PS) in the laboratory providing a high power performance in combination with fine adjustment possibilities for its characteristic values is a key-factor for an efficient and comprehensive qualification-testing of SPDs for different areas of use. The work presented describes a newly designed test facility for the mentioned test purposes which is a main part of a newly built technology center for surge protection. The main focus is set on the following aspect:

- The general design of the newly developed power system (PS) used for the qualification-testing of SPDs according to IEC/EN 61643-11, chapter 8.3.4.3 [1,2].
- Fine-adjustment possibilities for the test voltage, the prospective short-circuit current and the power factor in a wide range of values.
- Surge-current generator design for the generation of surge-currents with the wave-shape (8/20) μs.
- The realization of appropriate protection measures for the power system against partial surge-current stress may occur during the qualification-testing.
- Accreditation of the laboratory acc. ISO/IEC 17025 [3].
- Performance study of the test facility in case of testing a lightning current arrester.

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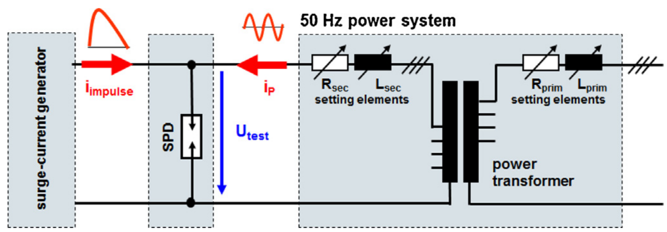

Fig. 1. Principle of the test-circuit for surge-load testing of SPDs under operating conditions according to IEC/EN 61643-11, chapter 8.3.4.3.

2. Power system with highest power performance parameters and unique fine adjustment possibilities

2.1. Requirements

In practice, low-voltage power systems (LVPS) have large differences in their characteristic values. Accordingly, for the development and the qualification-testing of SPDs a power system which can simulate the electrical conditions of the different LVPS under defined laboratory conditions is mandatory. Based on the analysis of the world wide existing LVPS, the requirements given by standards in the field of surge protection [1,2,4] and the assessment of future trends, the main target parameters for the power system (PS) to be developed are set to:

- Range of the fine-adjustable test voltage U_{test} = 100 V up to 1000 V.
- Prospective short-circuit currents up to I_P = 50,000 A_{rms} at U_{test} = 500 V_{rms} and a power factor cos(φ) = 0.25 according to the requirements given by EN 61643-11, Table 8 [2].
- Tree-phase design.

2.2. Realization and performance

As the first step, the electrical performance of the locally available power grid was determined. This has a nominal voltage of 30 kV and a short-circuit power of 280 MV A. The results of short-circuit measurements have shown that the defined target parameters (comp. chapter II. A.) could be achieved by the use of this power grid. Based on its specific characteristics the design of the PS to be used for the qualification-testing of SPDs took place.

A three-phase transformer with a nominal power of 8.4 MV A and a weight of 30 t (Fig. 2) builds the core of the test facility.

Fig. 2. Three-phase transformer with a switch panel for the fine-adjustment of the test-voltage.

Fig. 3. Resistor and inductance setup (R_{prim}, L_{prim} and R_{sec}, L_{sec}) for the adjustment of the current and power factor.

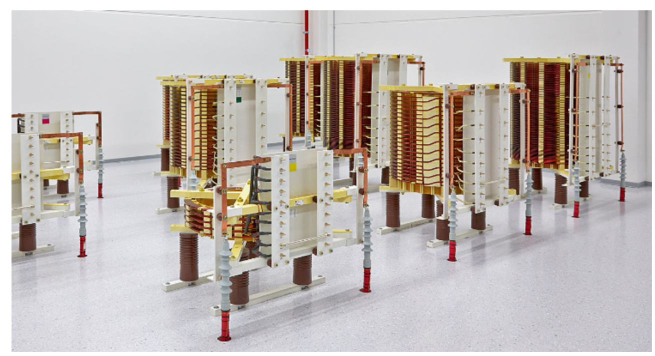

Fig. 4. Inductance setup L_{prim} at the 30 kV-level.

The transformer is primary connected in delta and secondary in star configuration. The adjustment of the test voltage is done via the variation of the number of the effective transformer windings. This applies both, at the secondary and at the primary side of the transformer. At the secondary side of the transformer six taps with the nominal voltage levels (rms) U_{n1} = 122 V, U_{n2} = 244 V, U_{n3} = 366 V, U_{n4} = 488 V, U_{n5} = 610 V and U_{n6} = 854 V are let out. The fine-adjustment of the test-voltage is done via the variation of the effective winding number at the primary side. Related to the respective nominal value U_{ni} with i = 1–6 the test-voltage can be varied in 20 steps linear in a range between −18% and +18%.

The adjustments of the prospective short-circuit current I_P and the power factor cos(φ) is also done both, at the 30 kV- and at the low-voltage side of the power system (comp. Fig. 1). For this purpose resistor and inductance subassemblies also providing unique fine-adjustment possibilities are used. These four units with the designations R_{prim}, L_{prim} and R_{sec}, L_{sec} are shown in Fig. 3 (overview). Fig. 4 shows the setup of L_{prim} and Fig. 5 one part of the setup of R_{prim} in detail. The adjusting ranges and accuracies of R_{prim}, L_{prim} and R_{sec}, L_{sec} are given in Table 1.

The design of the electrical connection between the spatially distributed components of the test facility is also one aspect of

Table 1
Adjusting range and accuracy of the resistor and inductance subassemblies (comp. Fig. 1).

	30 kV-level		LV-level	
	R_{prim} (Ω)	L_{prim} (mH)	R_{sec} (Ω)	L_{sec}
Range	1–5000	1–899	0.2–29.7	10 μH–9.99 mH
Accuracy	1	1	0.2	10 μH