

# CVVOZE Power Laboratories

(CVVOZEPowerLab)

## 1 Centre for Research and Utilization of Renewable Energy

Centre for Research and Utilization of Renewable Energy (CVVOZE) was established in 2010 and supported by the Research and Development for Innovations Operational Programme with an amount of over 10 mil. EUR. The Centre is a research institute of the Faculty of Electrical Engineering and Communication, Brno University of Technology.

The Centre aims to become a leading research institute concentrating research and development capacities for involvement in complex research, development and exploitation of renewable energy sources, including electrochemistry, electromechanics, electrotechnology, electrical power engineering, electrical drives, mobile robots and industrial electronics.

Global targets of the Centre:

- Introduction of top-level basic and applied research on renewable energy sources including applications.
- Training of highly-qualified staff, PhD graduates, for industrial sector.
- Wide cooperation between university and application sphere.

## 2 Research infrastructure CVVOZE Power Laboratories (CVVOZEPowerLab)

The RI CVVOZEPowerLab comprises of two CVVOZE's strategic laboratories – High Current Laboratory and High Voltage Laboratory. Of the two, High Current Laboratory is a unique one due to its high-tech facilities for AC and DC heavy current tests of low and middle voltage equipment. This laboratory represents quite a departure from that found in the usual engineering school. By nature the laboratory requires equipment of special design. There are possibilities of standard AC short-circuit tests of low voltage devices up to 150 kA (250 V - 0.2 s), short time current withstand tests up to 40 kA (100 V – 3 s). The uniqueness of the laboratory consists also in ability of DC tests up to 50 kA (1000 V – 200 ms). The last source is large capacitor bank with highest voltage 12kV for special tests. The complete electrical measurement chain is also accompanied by optical diagnostics together with high speed camera with recording frame rate up to 12 000 frames per second at full HD resolution and maximum frame rate up to 1 000 000 frames per second with reasonable frames resolution. High-dynamic pressure sensors for arc diagnostic and fast and sensitive laser sensors for movement evaluation are also available. This laboratory will make possible to perform all the experiments under real conditions using modern diagnostic methods. Consequently, experimental results of very high quality and originality can be expected.



Fig.1: LV part and testing bench of the High Current Laboratory



Fig. 2: High voltage part of the High Current Laboratory



Fig.3: Generator of the High Current Laboratory

At High Current Laboratory, low and middle voltage equipment are analyzed in terms of thermal and dynamic short-circuit performance, opening, breaking, and insulation capacity after short-circuit breaking, and operational behavior. Short-circuit tests with surge arresters in conformance with standards and including predamage can also be performed.

The short-circuit generator can be connected flexibly with a total short-circuit current of up to 150 kA at 250 V for individual tests. Voltage is adjusted to the particular requirements by power transformers.

Parameters of AC tests:

AC 50/60 Hz - 200 ms:

- 150 kA / 250 V
- 100 kA / 500 V
- 60 kA / 750 V
- 40 kA / 1000 V

AC 50/60 Hz - 3 s:

- 40 kA / 100 V

AC 16 2/3 Hz - 200 ms:

- 50 kA / 1000 V

Parameters of DC tests:

- 50 kA / 1000 V - 200 ms ( $\tau \leq 30$  ms).

Tests comply with appropriate IEC, GOST and UL standards, e.g.

- IEC 60947 Low voltage switchgear and controlgear
- IEC 60269 Low voltage fuses
- IEC 61439 Controlgear and switchgear
- UL 489 Molded case circuit breakers
- GOST-R (ГОСТ Р) 50030 Low voltage switchgear

Diagnostics equipment

- 12 channels of 16-bit depth DAQ 50 kHz certified,
- 2 channels of 8-bit depth and 50 MHz bandwidth,
- High-speed digital camera up to 1 mil. frames per second,
- Measurement of dynamic pressures up to 10 MPa.

The main hall of the High Voltage Laboratory has a floor area of 15 x 10 m and a minimum ceiling height of 9 m. The hall is completely shielded. The attenuation of the laboratory shielding equals 90 dB in the frequency range 30MHz to 1GHz for the electric field and over 60dB in the frequency range 10kHz to 30MHz for the magnetic field.

The main equipment are AC high voltage source 300kV (Fig. 5), impulse generator 1000kV (Fig. 4), conventional voltage impulse dividers, impulse oscilloscopes, digital oscilloscope/waveform analyzer and partial discharge analyzer.

The High Voltage Laboratory provides a wide range of possibilities in the field of short and long-term insulation testing. It has testing hall and two smaller testing laboratories where is possible perform voltage tests, such as lightning impulse voltage, alternating voltage, direct voltage, and switching impulse voltage, as well as combined voltage tests.



Fig. 4: Impulse generator in the High Voltage Laboratory



Fig. 5: AC high voltage source in the High Voltage Laboratory

In parallel with the voltage tests, other examinations can be performed, among them measurements of conventional and UHF partial discharge (PD). Also the water treatment plant is prepared for future artificial rain tests. If required, monitoring camera systems and microscopes are used.

The test hall and one small test room are shielded. This makes possible sensitive PD measurements with a very low noise level of less than 1 pC. The High Voltage Laboratory also permits tests of the capacitive breaking capacity of GIS breakers. Furthermore, surge current test circuits for surge arrester tests are available.

Maximum test voltages of technology of High Voltage Laboratory:

- Alternating voltage (50 Hz) 300 kV, 1A
- Lightning impulse voltage (1.2/50  $\mu$ s) 935 kV, 100 kJ
- Switching impulse voltage (250/2500  $\mu$ s) 750 kV, 100 kJ
- Direct voltage 140 kV, 11 mA
- Maximum lightning impulse current (8/20  $\mu$ s) 25 kA
- Maximum switching impulse current (30/60  $\mu$ s) 3 kA



Fig. 6: External view of the CVVOZE PowerLab



Fig. 7 Ground plan of CVVOZEPowerLab building

### 3 CVVOZEPowerLab present research activities

The main aim of research infrastructure is to support research activities especially focused on

- Optimization of the parameters of switching power devices for extinction systems including extinction process diagnostics
- Optimization of the device for distribution of electrical energy from renewable sources and SmartGrids
- Electrical energy quality and EMC in supply systems.
- Increased efficiency of lighting, heating and cooling electrical devices
- Increased reliability and safety of supply systems

From the begin of 2014 research infrastructure CVVOZE started collaboration with producers of

- low voltage circuit breakers
- LV and MV cables
- electron microscopes
- MV power electronics for electrical trains
- small aircrafts
- fault indicators for MV grids
- instrument transformers for MV power systems

and also with three research teams focused on research of properties of electric arc and partial discharge from different universities around Europe.

In the last period of RI operation, new devices and instruments were designed and constructed either to improving of current laboratories equipment or to giving new experimental possibilities:

- the automated demagnetizing and pre-magnetizing apparatus for the main testing transformer that will enable achievement of more favorable parameters of voltage sinusoid for certain voltage levels,
- the special MV test cell for short circuit tests of devices up to 6 kV with a system of current measurements based on LEM sensors,
- the modification of test circuit of shifting transformer TT3, to be able to serve as the source of current for heating tests up to 6300 A,
- the half wave rectifying set for AC high voltage system 300 kV with resistive divider and measuring system was designed and constructed,
- the system for efficient induction heating of MV cables with galvanic separation from the HV test source, which incorporates an automatic loop for measurement and regulation of the cable core temperature and can be used for combined tests on MV cables,
- the current limiter for 300 kV AC source with the maximum short-term power 100 kW for combined withstand tests and the wet tests,
- the measuring system determining the parameters of the water for wet tests (conductivity and pH),
- the digital optical detector of liquid dielectrics degradation,
- the system for measuring dielectric strength of liquid dielectric materials with mushroom shape electrodes,



- ➔ the device for automotive magnetization and demagnetization of the short-circuit transformer TT2, in order to satisfy new experiments conditions from the recovery voltage point of view,
- ➔ the automated driver for operational capabilities with electric current including evaluation of faults that accelerates testing of operational capabilities and protects the technology as well.

CVVOZEPowerLab is a member of the international association DERlab (European Distributed Energy Resources Laboratories e. V.) and its research leads directly to increasing the prestige of the RI and potentially to extending the cooperation in solving international projects.

Since 2016 CVVOZEPowerLab is included in Roadmap of Large Infrastructures for Research, Experimental Development and Innovation of the Czech Republic for the years 2016–2022.