INSTRUMENTATION FOR LABORATORIAL HIGH CURRENT TESTS OF 3-PHASE COLD DIELECTRIC HTS POWER CABLE

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INTRODUCTION

The LMDS – Laboratory for Materials and Devices with Superconductors at UFRRJ ("Federal Rural University of Rio de Janeiro"), Brazil, is developing the first Brazilian project on HTS power cable. (1st BR HTS Power Cable) [1,2]. The first design was a TRIAD one [1, 2]. However, due to interest of the Power Utilities partners in that project (CEMIG, TAESA, TBE and CTEEP), the project evolve to consider higher voltages (128kV).

So, nowadays the prototype to be built is designed by "D712-TRI-AXIAL-001¨ and it is a cold dielectric HTS cable with 3 phases, each one within its own cryostate [1,3]. Figure 1 shows a model for one phase of that cable.

In order to test that cable it was necessary to develop a high current test facility.

In this work we present the project and detailed operation procedures of that facility, able to perform tests in DC and AC conditions.

The main equipment are a commercially available 3-phase DC power supply, a specially built 3-phase AC power supply, a specially built 3-phase power transformer and a specially built resistor bank (in delta connection). An usual digital oscilloscope and high voltage/high current probes are used to measure the waveforms. The system is controlled by home-made software with improved graphic user interface.

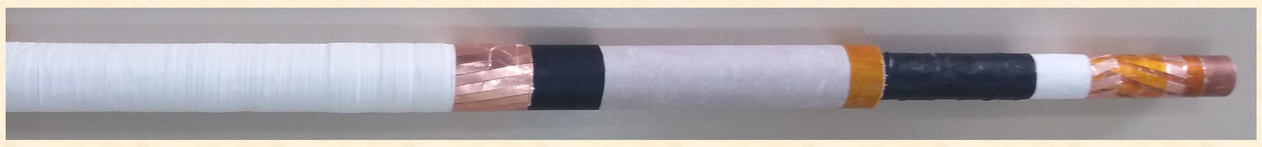


Figure 1: Model of one phase of D712-TRI-AXIAl-01 showing the cable layers

METHODOLOGY

The rated current to be measurement is 300Arms @ 3-phase HTS power cable [1].

In DC one must evaluate de engineering critical current (Ic/e) of the 1st BR HTS Power Cable "D712-Tri-Axial-01" [1].

In AC the measurement circuit must follow the scheme of Figure 2.

A complete set of vacuum lines and cryogenic fluid line must be built in order to sustain the cable in superconducting state throughout the tests [2].

LabView (National Instruments) was chosen as platform to build the DAQ software.

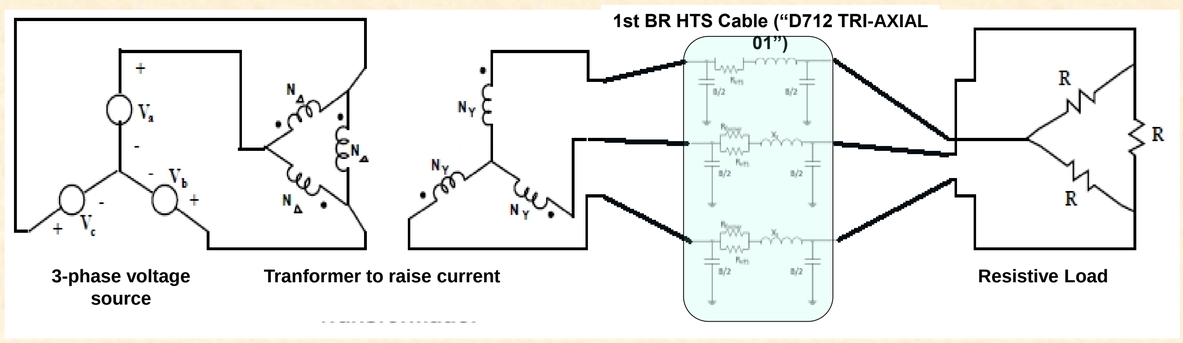


Figure 2: Test circuit wiring.

RESULTS AND DISCUSSION

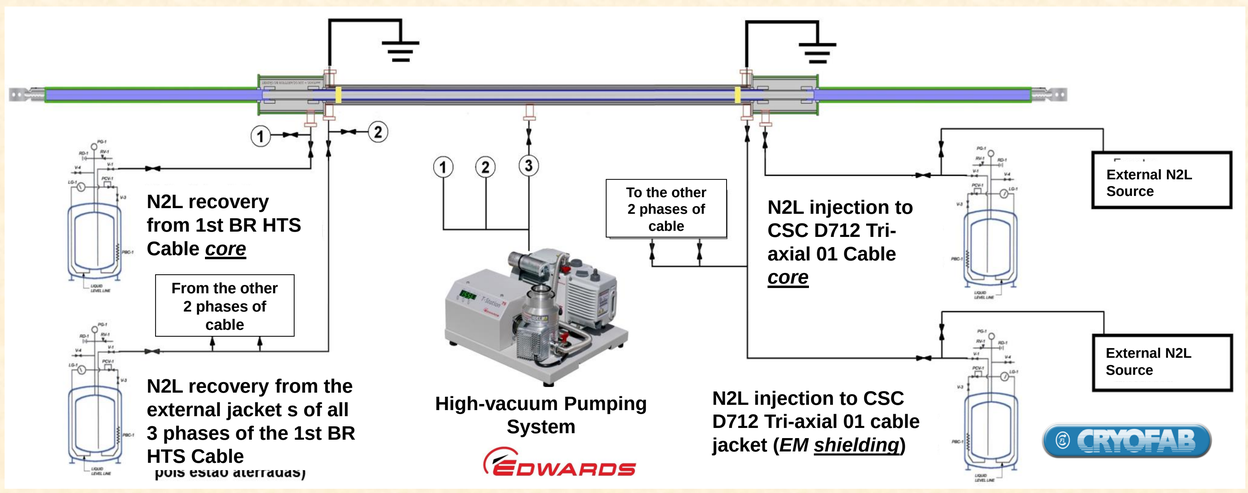


Figure 3: Cooling circuit. It is shown only one of the electrical phases.

RESULTS AND DISCUSSION (cont.)

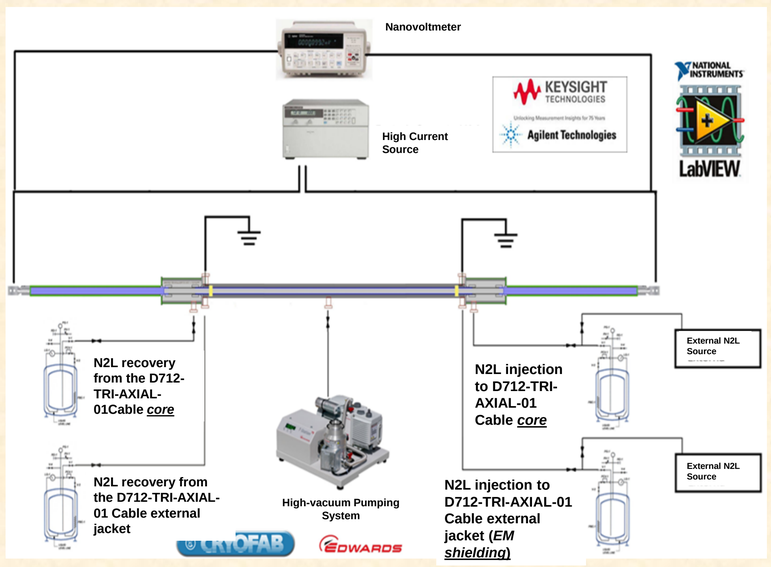


Figure 4: The DC 1 phase $I_{c/e}$ Measurement Equipment

Hardware for DC (440 A) measurements		
#	Name	Characteristics
1	Current Source	Current Source KEYSIGHT/AGILENT mod. 6690A, output CC 0-15 V, 0-440 A, 6.600 W, input 180-235 V 3-phase CA, 50/60 Hz. Interface USB/GPIB.
2	Ampmeter	- Built-in on # 1-
3	Voltmeter	Nanovolt/micro-ohm meter KEYSIGHT/AGILENT mod. 34420A, com resolução de 7 ½ dígitos, 100 pV / 100 nOhm, com dois canais de varreduras embutidos(built-in) de baixo ruído, medidas diretas de SPRT, RTD,Termistores e termopares, com Conector de entrada de baixa temperatura para medidor 34420A e interface USB/GPIB
4	DAQ	Interface USB/GPIB KEYSIGHT/AGILENT 82357B

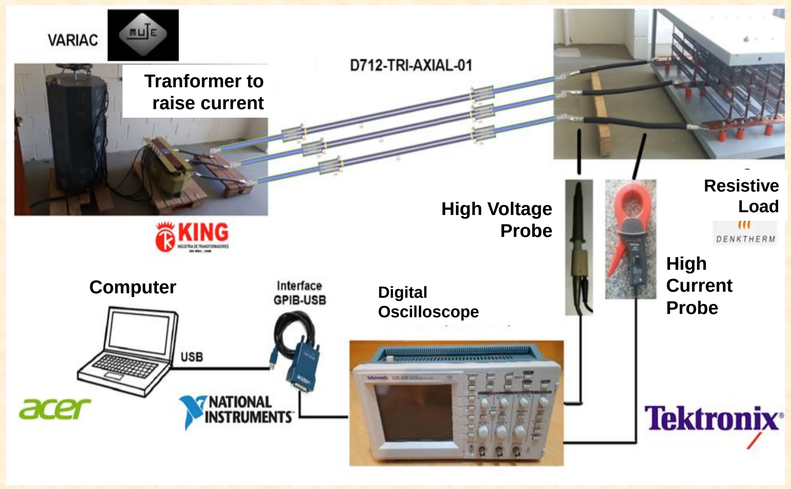
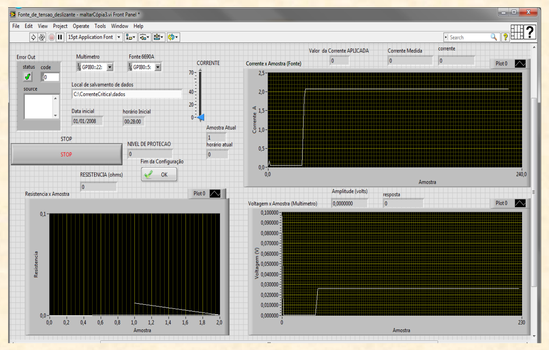


Figure 5: The 3-phase AC Measurement Equipment.
OBS: the cooling circuit is not shown (see Figure 3).

Hardware for AC measurments		
#	Name	Characteristics
1	3-phase Transformer	Power Transformer KING, 27-KVA, 60Hz, input 220V/35 A_{rms}, Y (star) – conection, output 15V/500 Arms, Delta conection, Isol. Class 0,6 kV, Temp. Class B (130°), IP-24 Box
2	Variac	Variac AUJE Tri-phases, input 220V, output 0 – 220/240 V / 100 A_{rms}.
3	Load	Resistive Load DENKTHERM, 0,0173 ohms / phase, 3 phases connection 15 V, 8.66 V/1.5 kA_{rms} each phase, natural cooling, IP00 protection, ~ 60 cm x 90 cm x 1.8 m.
4	Osciloscope	Tektronix TDS210 with GPIB.
5	High-current probe	Tektronix A621 (1000A)
6	Interface	National Instruments GPIB-USB-HS.

(a)



(b)

Figure 6: (a) Control unit , (b) GUI of DAQ software.

CONCLUSIONS

The proposed laboratorial instrumentation was built and works properly to current tests to be performed on the 1st BR HTS Power Cable "D712-Tri-Axial-01" rated to operate at 300 A_{rms}/69kV.

Such test facilities can be used to test other HTS power equipment for operation up to 420 A_{DC} and 500 A_{rms}.

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