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STATUS AND RESULTS OBTAINED ON A RF CONDITIONING TEST BENCH FOR 704 MHz COUPLERS IN THE FRAME OF ESS PROJECT

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Abstract

Thales and GERAC are developing a test bench able to make the RF conditioning of the Fundamental Power Couplers at 704 MHz in the frame of the ESS project for CEA. The status of the development of the test bench is described, including the modulator, klystron and all relative equipment. We describe also the results obtained at this date.

OVERVIEW OF THE TEST BENCH

The RF test bench consists of a fully integrated power station including:

- RF power station,
- High power modulator,
- A 1.5 MW klystron TH2182A at 704 MHz,
- Interlocks and acquisition system
- RF power network including High power circulator.

KLYSTRON

The TH2182A klystron has been designed to comply with ESS specification [1]. Main characteristics of the klystron are:

- Built-in electromagnet (water cooled)
- Built-in X-ray shielding (easily removable)
- Built-in oil tank with heater transformer
- Diode gun
- 6 cavities with 3rd one on second harmonic
- Coaxial window and cross-bar coax to wave-guide transition
- Low cathode loading
- Low DC gradient on beam forming electrode

The 3D model (Fig. 1) shows the disposition of klystrons sub-assemblies, from the diode gun to the collector.

This Klystron has been design with a low beam perveance of 0.6 $\mu A/V^{1.5}$ generated by a diode gun, at an operating point of 108 kV and 21.4 A. In order to have a safe value at the operating point, the electrical gradient on the beam forming electrode remains below 4.7 kV/mm. Due to the large cathode size, the cathode loading is low (< 2A/mm²), with low temperature cathode for a long lifetime, more than 100.000 hours and low Barium evaporation rate.

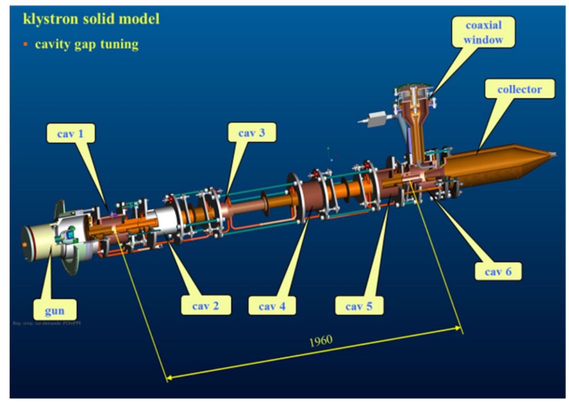

Figure 1: klystron.

The klystron is mounted in a built-in electromagnet water cooled (Fig. 2) composed of 14 independent coils on a supporting frame which allow to install X-ray shielding which could be easily removed.

Figure 2: assembly of the Klystron.

MODULATOR

Modulator is composed of an AC/DC power supply charging the capacitor bank up to 2 kV. Then RF converters at 25 kHz allow setting the pulse shape at the primary of pulse transformers. At the secondary of these pulse transformers, addition of redressed voltages allows to give the desired voltage and current to the Klystron (Fig. 3).

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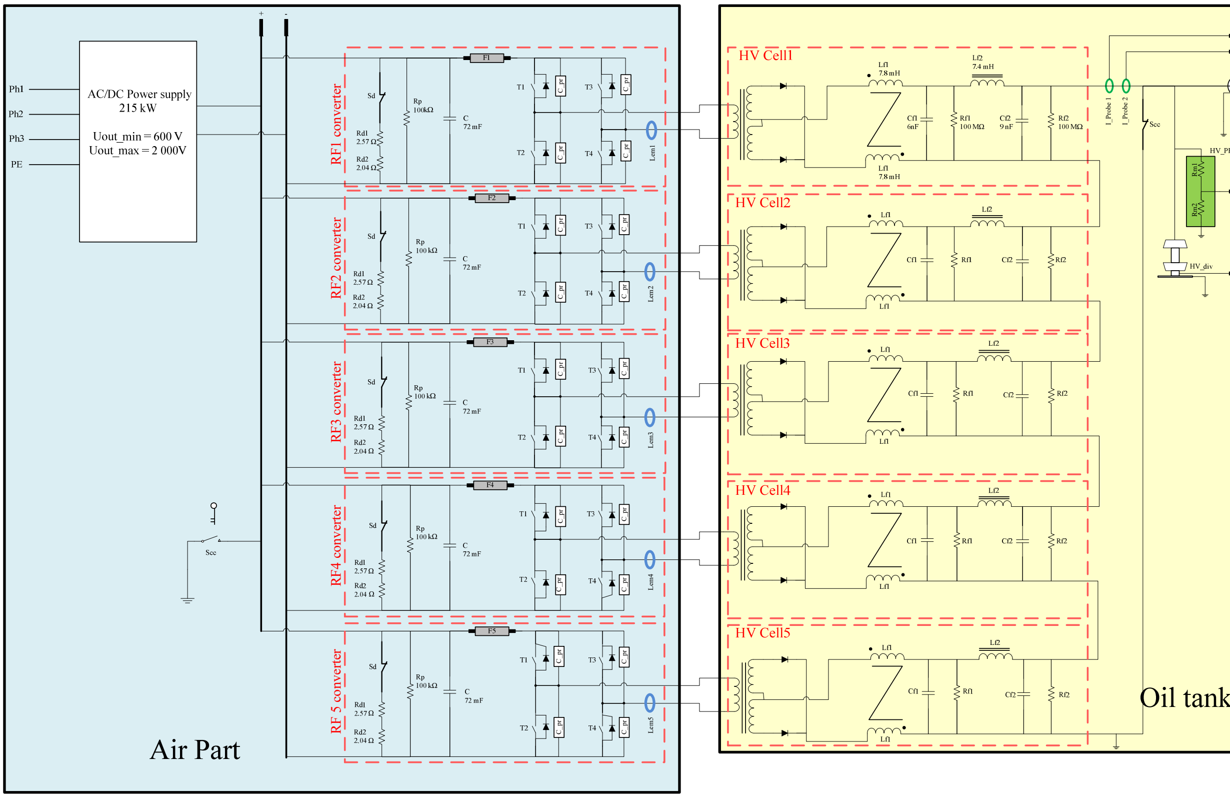

Figure 3: Electrical Diagram Of The Modulator.

In order to minimize oil volume and make maintenance easier, the modulator is composed of two separate parts. All primary circuits up to 2kV are in air. Pulse transformers (Fig. 4) and secondary circuits are in an oil tank

Five “independent” identical circuits are used for managing High Voltage from low voltage. Each individual RF converter is based on 4 IGBTs working at 25 kHz and allowing to set the pulse to the desire value and transmit the voltage at the primary of the pulse transformer. Transformers with a ratio of 13 have been fully simulated and designed internally by the Gerac.

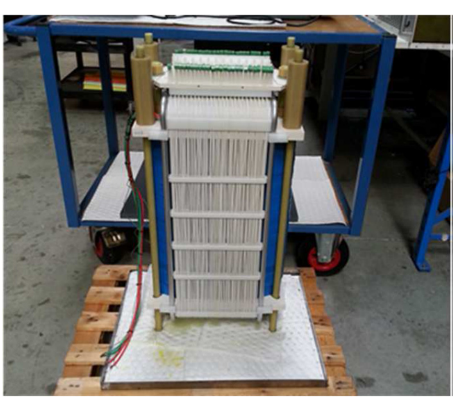

Figure 4: Pulse Transformer.

The modulator has been assembled and is under high power test at Gerac site on a dummy load (Fig. 5) in order to set parameters and verify performances.

Figure 5: Modulator Under Tests.

High voltage pulse have been measured (Fig. 6) at 100 kW and 1300 V dc at the primary of pulse transformer. The output pulse flatness is of 1.17 %. Due to the difference between the impedance of dummy load and the klystron one, this will be improved in the future and after having achieved full power.

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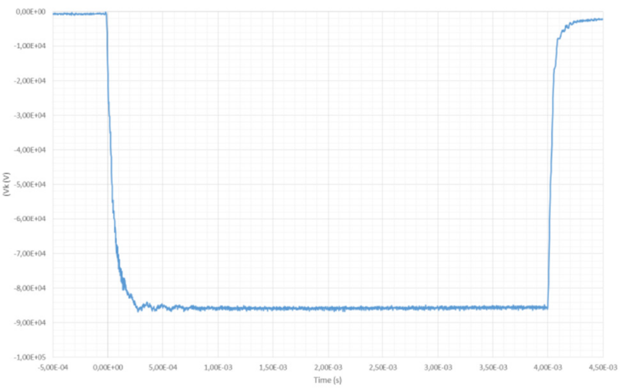

Figure 6: High Voltage Pulse Measured at 100 kW.

CONTROL COMMAND SYSTEM

In order to achieve all command needed for running the test bench a control command system has been developed.

On the General User Interface (Fig. 7) operator can change parameters of the test bench like pulse repetition rate, high voltage applied to the Klystron. It can also have all status for parameters from faults to current status.

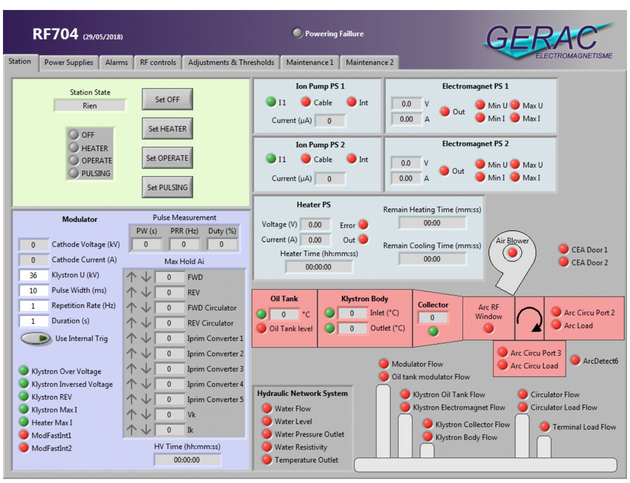

Figure 7: Example of GUI of the Test Bench.

GENERAL STATUS

The Modulator is under test at the GERAC factory on a dummy load. An output higher than 100 kW has been achieved. Klystron has been accepted at the Thales factory. With ancillaries and RF chain, it is installed at CEA site and ready for tests (Fig. 8).

RF power tests on RF loads, including the one for the circulator have been achieved independently

Figure 8: Klystron and Ancillaries distribution.

A dedicated cooling system (Fig. 9) is also installed in order to be independent of the overall installation at the exception of a primary cooling.

Figure 9: Dedicated Cooling System.

Tests are ongoing at the Gerac factory, up to 200 kW. After completion, the modulator will be sent to the final site and connected to the klystron in order to achieve the commissioning and final tests of the overall test bench.

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