AUTOMATIC RF CONDITIONING TEST BENCH OF FUNDAMENTAL POWER COUPLERS FOR THE EUOPEAN XFEL ACCELERATOR

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Abstract

In order to perform the RF conditioning of the fundamental power coupler for the XFEL accelerator, Thales and LAL developed together a test bench being able to make the automatic RF conditioning. The capability of this test bench is of 4 pairs of coupler at the same time with automatic sequences of increasing the RF power.

The test bench is composed of the overall RF station providing up to 5 MW peak power at 1.3 GHz. The waveguide distribution allows 4 individual RF lines for conditioning, and the automatic sequence applied to the couplers in respect with all signals monitored and controlled during the RF process.

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INTRODUCTION

LAL contribution to the XFEL project is the delivery of 670 fundamental power couplers to equip 80 Cryomodules.

The fundamental coupler is composed of the following parts[1] as illustrated in Fig.1.

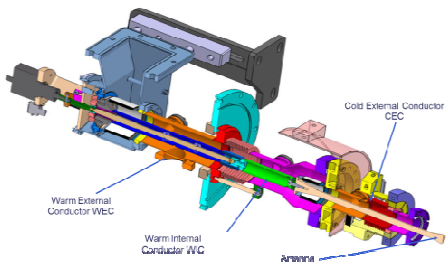

Figure 1: Schematic of XFEL fundamental power coupler.

The preparation and RF conditioning of XFEL couplers are done at LAL ORSAY in a dedicated ISO5 clean room (70m2).

The Automatic conditioning test bench provided by Thales and developed jointly with LAL is part of the industrial capabilities developed for mass production of XFEL RF couplers. The test presented and all auxiliaries are compatible with a production rate from 8 to 10 couplers/week.

GENERAL DESCRIPTION OF THE TEST BENCH

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

- High voltage modulator
- A 5 MW klystron TH2104C
- Interlocks controls and data acquisition system.

An automatic control system manages the conditioning procedure with diagnostics, monitoring and analysis of signals.

The 1.3 GHz power station could provide a maximum output power of 5 MW. The RF signal is divided in 4 channels which allow a conditioning of 4 coupler pairs in parallel, Fig.2.

Figure 2: General layout of four channels for coupler conditioning.

The general layout of test bench is presented in the figure n°3.

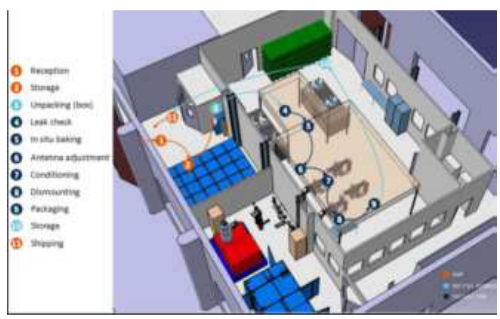

Figure 3: General layout of test bench.

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Conditioning Procedure [2]

After in-situ bake out at 150°C and RF tuning, coupler are installed on the test bench [3] &[4].

Couplers are mounted by pair on a waveguide box, as illustrated in Fig.4 and Fig.5. The conditioning is done in traveling wave with the following configuration:

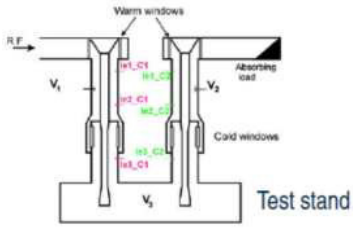

Figure 4: Schematic of FPC on waveguide box.

Figure 5: Real implementation of couplers on waveguide box.

The vacuum is controlled by Ion Getter pumps (cold and warm part). Cold inner wall outgassing is monitored by Residual Gas Analyser.

Due to the configuration of the test bench, vacuum controlled is for individual warm part and a common control for cold part.

The conditioning sequence has been already tests by LAL [3] on former TTF3 couplers and it had been adjusted in cooperation with Thales to the XFEL couplers.

The conditioning is done in traveling wave at a maximum peak power of 1 MW up to 400 µs and then limited to 500 kW from 400 µs to 1.3 msec, Fig.6.

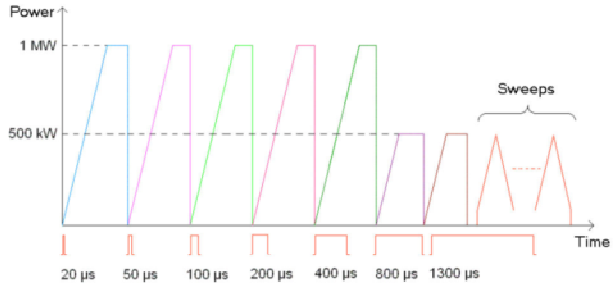

Figure 6: Conditioning sequence applied on couplers.

To limit the energy deposition and in order to prevent a too high level of vacuum in case or activity, the sequence starts in short pulse at 20 µsec. peak power is controlled and monitored and progressively increase from 1 kw to a value of 1 MW peak. The ramp up of power is done by step of 0.1 dB each thirty seconds until the full power is obtained. When the desired power is obtain, the full power is maintain for one full hour. The pulse length is increased with the same ramping sequence until a pulse length of 400 µs is achieved, Fig.7.

After the step of 400 µs achieved, pulse length is still increased, but with a limited full power of 500 kW. The same timing ramp up is applied until pulse length of 1.3 msec. is achieved.

The automatic control and data acquisition of the RF conditioning are based on Labview software from National Instruments.

	Parameter	Value	Comment/action
	frequency	1.3 GHz	Not adjustable
	RF power	0 to 1 MW	Adjustable by RF Driver of 0.1 dB step
	Pulse length	20,50,100,200,400, 800, 1300 µsec.	
	Repetition rate	4 Hz	Adjustable: 1,2 or 4 Hz
	Control loop phase	30 sec	
Interlock/threshold	1st vacuum threshold	SV1=6.10^{-7} mbar	Δp=-0.1 dB
	2nd vacuum threshold	SV2=1.10^{-6} mbar	ΔP_{secu} = -0.4 dB
	Interlock level for vacuum	SVil = 5.10^{-5} mbar	Stop and automatic restart
	Multipactor level (e-pick up current at 50 V)	5 mA	Stop and automatic restart
	WG Arc	If any > 1 lux	Stop and manual restart

Figure 7: Main parameters for automatic sequence.

During conditioning operator could observe all signals from coupler pairs and from the test bench itself using a dedicated user interface developed for the project, Fig.8.

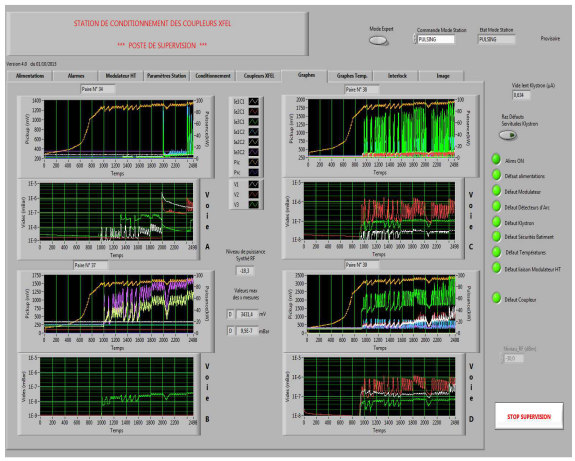

Figure 8: Example of user interface.

CONCLUSION

The installation and commissioning at LAL Orsay of the automatic RF test bench has been done in cooperation between LAL and THALES.

After a rump up phase, the nominal delivery rate of 8 couplers per week has been successfully demonstrated along a large period, and has been increased to 10 couplers over few months, Fig.9.

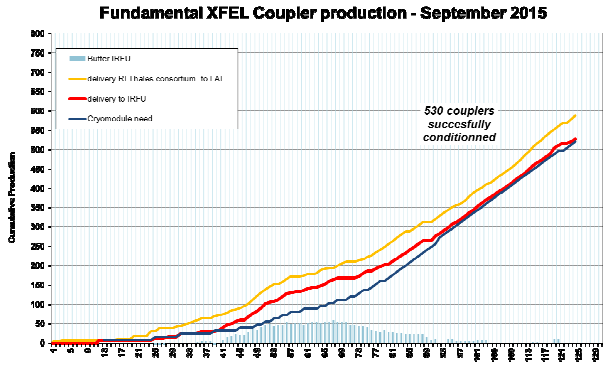

Figure 9: FPC coupler production.

The reliability of the test stand based on rugged technology and the Labview interface provide a simple operation of the system.

More than 5000 hours of RF operation, 200 conditioning sequence done without interruption.

Production of 670 fundamental XFEL RF couplers should be completed on December 2015.

Improvement of the conditioning procedure for higher production rate has been discussed and could be realised for future projects.

ACKNOWLEDGMENT

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