COMISSIONING OF THE ALBA STORAGE RING RF SYSTEM

F. Perez, B. Bravo, CELLS - ALBA, Cerdanyola, Barcelona, Spain.
P. Sanchez, F4E, Barcelona, Spain.
A. Salom, ELETTRA, Trieste, Italy

Abstract

ALBA is a 3 GeV, 400 mA, 3rd generation Synchrotron Light Source under commissioning in Cerdanyola, Spain. The RF System has to provide 3.6 MV of accelerating voltage and restore up to 540 kW of power to the electron beam. For that six RF plants, working at 500 MHz, are foreseen. The RF plants include several new developments: DAMPY cavity; the normal conducting HOM damped cavity developed by BESSY and based in the EU design; six are installed. CaCo; a cavity combiner to add the power of two 80 kW IOTs to produce the 160 kW needed for each cavity. WATRAX; a waveguide transition to coaxial, specially designed to feed the DAMPY cavities due to the geometrical and cooling constrains. Digital LLRF; fully designed at ALBA using commercial components. This paper shortly describes these systems and reports their performance during the ALBA commissioning.

INTRODUCTION

The main parameters of the RF system for the ALBA Storage Ring are summarised in Table 1.

Table 1: Main RF Parameters of the Storage Ring

Frequency	499.654	MHz
No. of cavities	6	
RF voltage per cavity	600	kV
Energy loss per turn	1.3	MeV
RF power per cavity	150	kW
RF Transmitter	2 x 80	kW
Total Beam Power	540	kW
Synchrotron Frequency	7.5 – 9.5	kHz

The six cavities will be located in three short straight sections, two cavities per section; each section is 2 meter long. This way all 12 medium and 3 long straight sections are available for the Insertion Devices [1]. Figure 1 shows the drawing of two RF plants of one section.

DAMPY

The main requirement imposed to the RF cavity for ALBA was that it should not create HOM's induced instabilities. Second, it should fit in the 2 meter short straight sections of ALBA. Third, it should provide up to 600 kV of RF voltage. The best solution, which complies with these conditions, is the normal conducting HOM damped cavity designed by BESSY following the EU design [2], we name it "Dampy". Table 2 gives the main parameters and Figure 2 show two cavities installed in the ALBA tunnel.

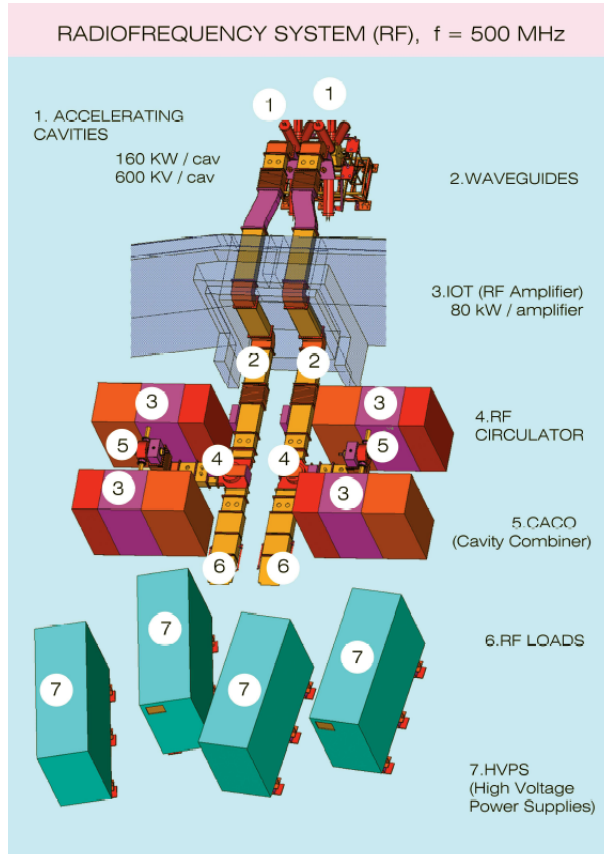

Figure 1: Two RF plants in one straight section.

Table 2: Main Dampy Parameters

Type	Single cell	
Resonant frequency	500 ± 1	MHz
Insertion Length	0.5	m
Shunt Impedance	3.3	MΩ
Longitudinal HOMs	< 2	MΩ.MHz
Transverse HOMs	< 60	kΩ/m
Input power coupler	150	kW
Cooling Capacity	80	kW
Maximum voltage	700	kV

All six cavities installed in the tunnel performs accordantly to specs.

The only problem with the cavities has been the recurrent appearance of small vacuum leaks in the ceramic dome of the pick up loops. A new pick up loop design is under test in order to cope with this problem.

Figure 2: Two Dampy cavities installed in the tunnel.

CACO

ALBA RF system should provide 3.6 MV of total voltage and feed 520 kW of total power to the beam, which is accomplished with six Dampy cavities. Each cavity has to be fed with more than 150 kW. To obtain this power per cavity we decided to combine the power of two IOTs amplifiers of 80 kW through a new cavity combiner, this new device was named CaCo, see figure 3.

CaCo is now installed in the six RF plants of ALBA working well and performing the power combination without problems.

Despite this, new development is under way to allow the use of CaCo with only one IOT active. See reference [3].

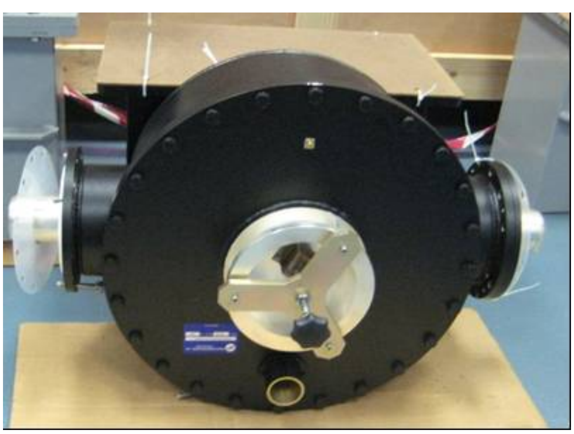

Figure 3: CaCo, a Cavity Combiner.

WATRAX

The transmission line after the CaCo is a standard WR1800 waveguide. The input power coupler to the Dampy cavity has a standard 61/8" coaxial interface. In addition, it is tilted 60º respect the vertical, as can be seen in Figure 2. And finally, it has to stand 160 kW of power.

A specific WAveguide TRansition to coAXial (WATRAX) had to be designed. Figure 4 shows the design developed by ALBA [4].

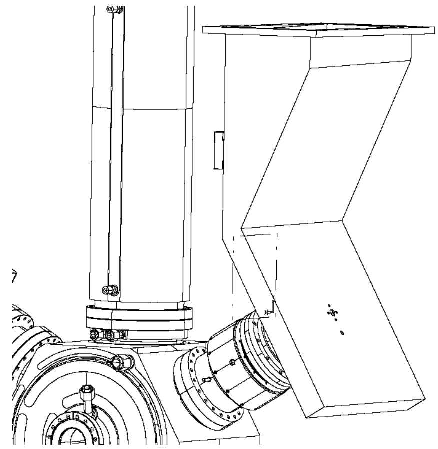

Figure 4: Drawing of WATRAX installed in Dampy.

The prototype was tested at DESY up to 250 kW and the series units, now installed in the tunnel (see figure 2), perform without problems up to 160 kW.

DIGITAL LLRF

A Digital LLRF system has been developed for the ALBA Storage Ring and Booster cavities. The LLRF is based on the IQ modulation-demodulation technique and it has been implemented using a commercial cPCI FPGA board, see table 3, figure 5 and reference [5].

Eight systems have been installed, one in the RF lab, one in the Booster and six in the Storage Ring. All of them have been tested and are working well: control loops (amplitude, phase and tuning), fast interlocking and fast data logger, automatic start up, automatic conditioning, etc.

Table 3: Main LLRF Performances

Amplitude stability [rms]	< 0.1	%
Phase stability [rms]	< 0.1	°
Bandwidth [PID dependent]	1 - 100	kHz
Dynamic range [inside specs]	~ 23	dB

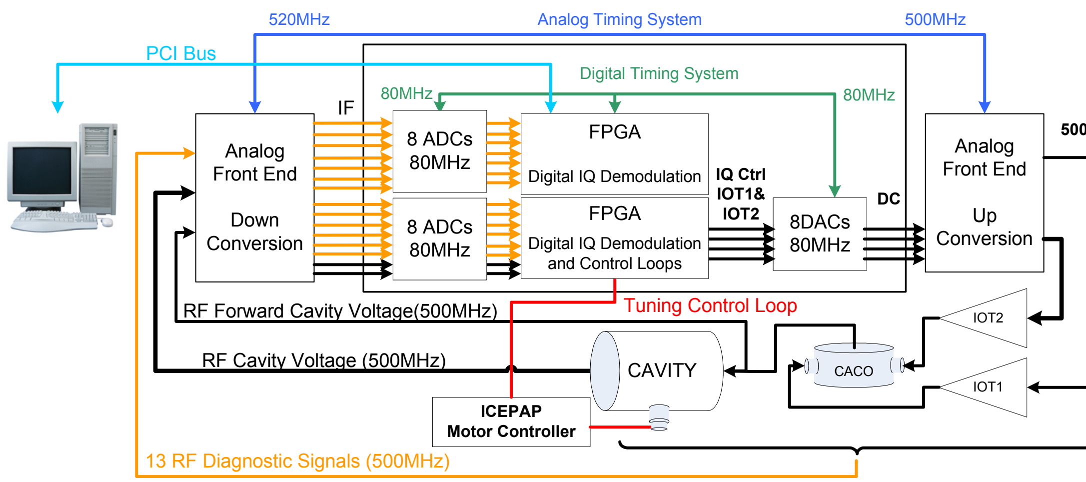

Figure 5: Digital LLRF Hardware Scheme.

RF SYSTEM COMMISSIONING

The cavities were installed in the ring, baked out in situ and conditioned in the tunnel up to around 60 kW of cavity wall's dissipated power. Since the coupling factor was set to 2.5, around 20% of power was reflected during conditioning. Some interlock signals had to be bypassed for this situation.

The twelve IOTs transmitters have been previously adjusted and tuned at full power by closing the waveguide shutter, which send back the RF power to the circulator's load.

The LLRF loops have been adjusted at low power and calibrated partially. Still pending is a full calibration of all the RF signals.

Since two IOTs are combined by CaCo in order to deliver power to each cavity, a careful adjustment of the CaCo and the Circulator parameters have to be done prior reaching high power. The fine adjustment of phases and amplitudes is done with the Digital LLRF.

ALBA COMMISSIONING

For the ALBA storage ring commissioning six full RF systems were ready.

The first step in order to accelerate the beam is to adjust the phases of each cavity with respect the incoming beam and with respect each other.

This was done in two steps, first, switching only one cavity each time and adjusting the phase in order to allow the beam to survive some ms.

Afterwards, the cavities were switched on two by two in order to adjust the phases in between cavities, also, maximising the surviving time of the beam. Figure 6 shows the case of no RF (red line) and after switching on two cavities (blue dots).

Stored beam, low current, can be achieved at ALBA with only three cavities switched on; this allows a large margin of redundancy for the commissioning.

This has been especially useful since during the commissioning time several problems have limited the number of operational cavities.

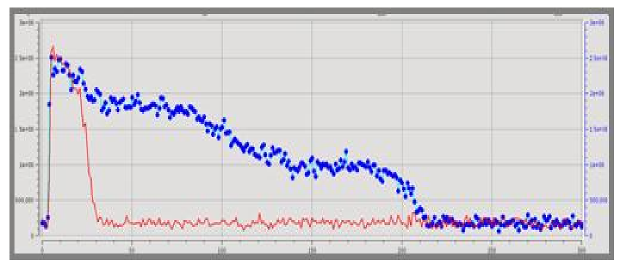

Figure 6: Beam current vs time, with no RF (red curve) and with two RF plants on (blue dots).

There have been two vacuum leaks in the ceramic dome of the pick up loops. Since this problem seems recurrent a new pick up loop design is now implemented in two of the cavities and ready to high power test.

Also, a water leak in the cooling pipes of one transmitter has maintained one system not operational for several weeks.

Finally, some cable short circuits and one malfunctioning board have given problems in two of the Digital LLRF systems.

SUMMARY

For the design of the RF system of ALBA several new developments have been done satisfactorily. They are now installed and operational at the ALBA Storage Ring.

During the ALBA commissioning the RF system has had several problems but they have not major impact in the successfully commissioning of ALBA.

REFERENCES

[1] M.Muñoz and D.Einfeld, "Optics for the ALBA Lattice", PAC 2005.

[2] F.Marhauser and E.Weihreter, "First Tests of a HOM-Damped High Power 500 MHz Cavity", EPAC 2004.

[3] B.Bravo et al. "CaCo, A Cavity Combiner for IOTs Amplifiers", IPAC 2011.

[4] P.Sanchez, "CST simulations of WATRAX", Internal ALBA Report, 2006.

[5] A.Salom and F.Perez, "Digital Low Level RF for the ALBA Storage Ring", EPAC 2008.