NEW DEVELOPMENTS FOR THE RF SYSTEM OF THE ALBA STORAGE RING

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Abstract

ALBA is a 3 GeV, 400 mA, 3rd generation Synchrotron Light Source that is in the construction phase in Cerdanyola, near Barcelona, Spain. The RF System will have 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 will include several new developments: 1) DAMPY cavity: the normal conducting HOM damped cavity developed by BESSY and based in the EU design; six will be installed. 2) CaCo: A cavity combiner to add the power of two 80 kW IOTs to produce the more than 150 kW needed for each cavity. 3) WATRAX: A waveguide transition to coaxial, specially designed to feed the DAMPY cavities due to the geometrical and cooling constrains. 4) IQ LLRF: The low level RF will be based on the IQ modulation/demodulation technique, both analogue and digital approach are being pursued. This paper describes the status of the storage ring RF System, and reports about these new developments.

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.

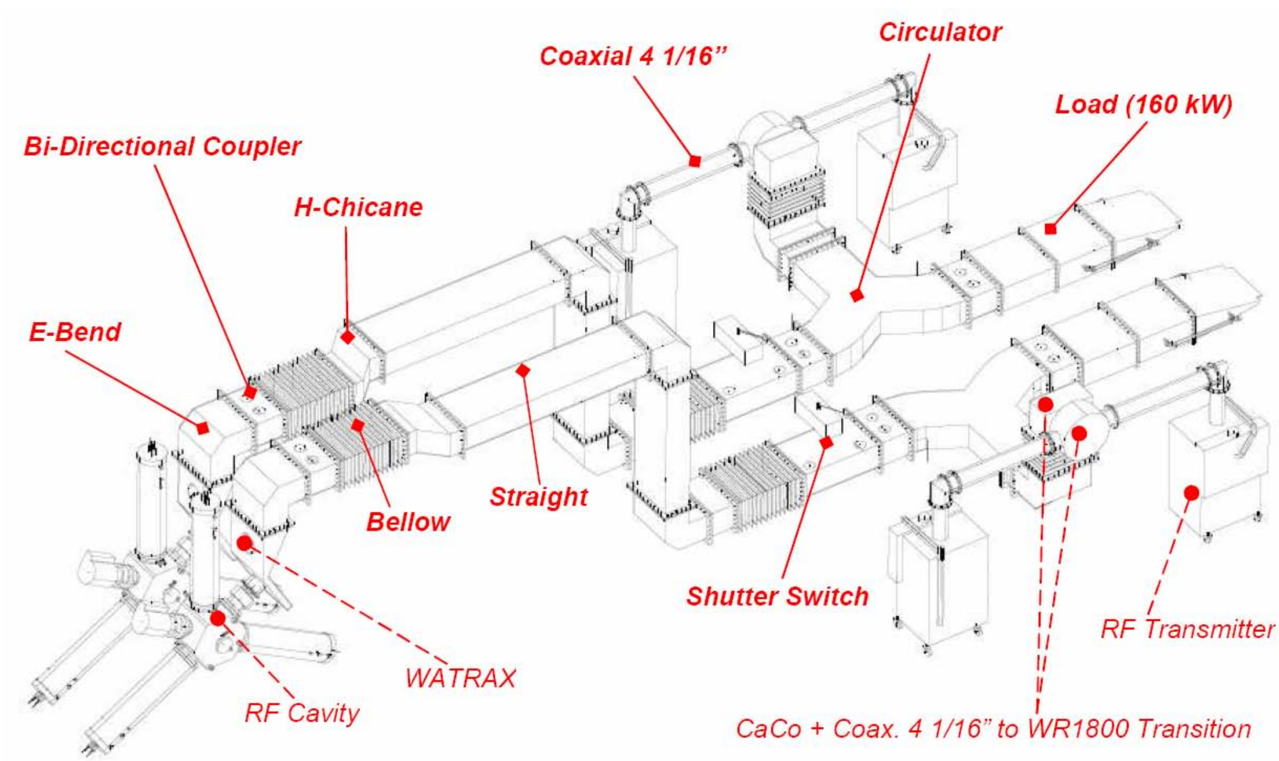

Figure 1: Two RF plants in one straight section.

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 is a drawing of the cavity.

Table 2: Main Dampy parameters

Type	Single cell	
Resonant frequency	500 ± 1	MHz
Insertion Length	0.5	m
Shunt Impedance	> 3.1	MΩ
Longitudinal HOMs	< 2	MΩ.MHz
Transverse HOMs	< 60	kΩ/m
Input power coupler	> 150	kW
Cooling Capacity	> 80	kW
Maximum voltage	> 700	kV

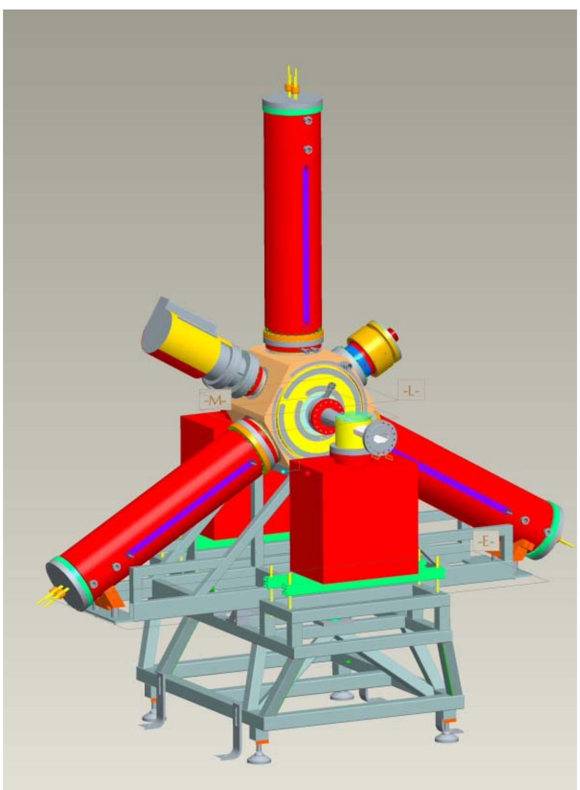

Figure 2: Dampy drawing.

The first of these cavities is being built by ACCEL for the Willy Wien Ring in Berlin. The ALBA cavities have been ordered also to ACCEL.

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.

There were two alternatives, a super power klystron or combine the power of smaller amplifiers. The final decision is to combine the power of two slightly modified TV IOT working at 80 kW. This decision provides higher modularity, off the shelf almost commercial products, higher efficiency of IOT versus klystrons, higher reliability and shorter mean time to repair.

In order to perform the combination of the two IOTs one can use standard combining techniques via magic tees or hybrids. But it was decided to look for a more compact and innovative solution: the combination of power through a Cavity Combiner, CaCo.

The design of the CaCo, based on ALBA guidelines, and a prototype was ordered in June 2005 to Thales Electron Devices (TED).

In March 2006, the acceptance test of the prototype was performed; yielding the expected full performances, i.e. combine the power of two IOTs to produce more than 150 kW of total power [3]. Figure 3 shows the CaCo in the installation at TED during the high power final acceptance test.

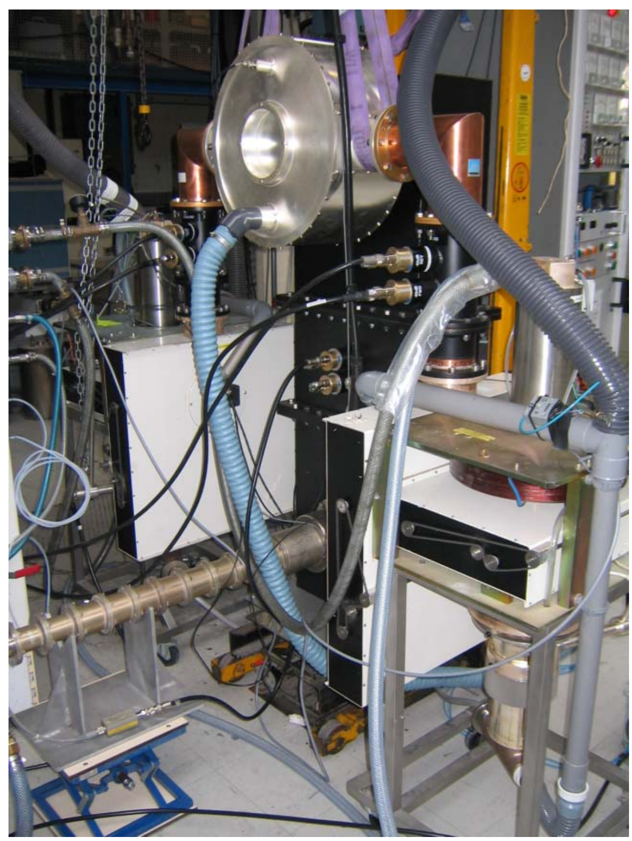

Figure 3: CaCo under high power test at TED.

The tender for the CaCo series production for the six RF plants is foreseen in Autumn 2006.

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.

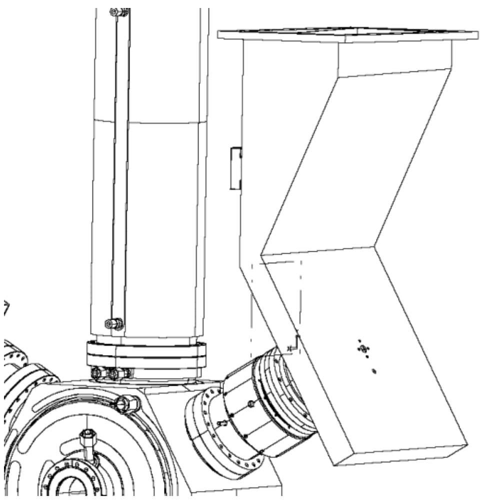

Figure 4: Drawing of WATRAX installed in Dampy.

The CST MICROWAVE STUDIO® code was used to perform the electromagnetic simulations [4]. The instantaneous map of the electric field is shown in Figure 5 and the main results of the simulation in Table 3.

A prototype is now under construction at AFT, Germany.

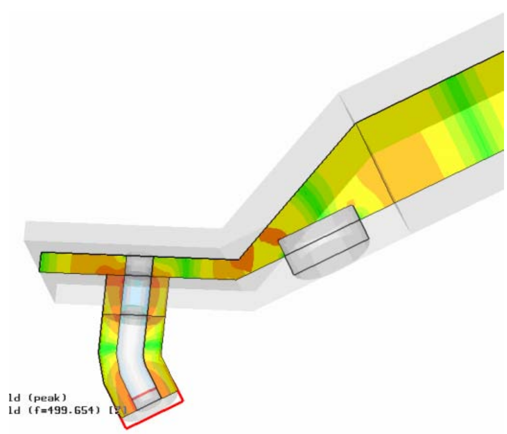

Figure 5: CST MICROWAVE STUDIO® simulation of WATRAX.

Table 3: WATRAX simulation's results

Maximum CW power	150	kW
VSWR	1.02	
Max. peak electric field	265	kV/m
Power dissipated	132	W

IQ LLRF

While in the past traditional amplitude and phase loops were used for RF field regulation, today the IQ (In-phase, Quadrature) demodulation technique is favoured for modern systems. IQ regulation is advantageous because of the symmetry of the I/Q signal paths, less-complicated nature of the electronics and wider phase control range. Figure 6 shows the conceptual design.

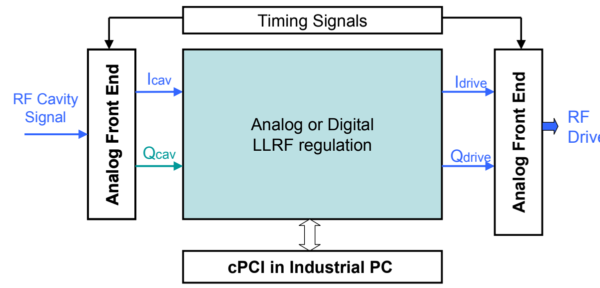

Figure 6: IQ LLRF concept.

Following this concept, and with the aim of building RF Analog and Digital expertise in house, it was decided to build two LLRF prototypes: one analog and the other digital [5]. The two LLRF prototypes are conceptually quite similar; they are both based on the IQ method and PID regulation. The specifications are shown in table 4.

Table 4: Main LLRF specifications

Amplitude stability	±1 to ±0.1	%
Phase stability	±1 to ±0.1	°
Bandwidth	> 200 kHz	kHz
Dynamic range	> 23	dB

SUMMARY

For the RF system of ALBA several new developments are under way, and we foresee that all of them will be ready and operational on time with the expected specifications. The Dampy cavity will be tested at the Willy Wien Ring this summer. The CaCo has been successfully tested. The WATRAX is under construction and will be tested in summer at DESY. Both LLRF are in the final stages and will be tested under real conditions in a high power RF lab that will be ready at ALBA at the beginning of 2007.

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