1.5 GHz Low Level RF for the ALBA 3rd Harmonic Cavity

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ABSTRACT

The ALBA Synchrotron is a 3rd generation synchrotron light source located in Cerdanyola del Valles, Spain. The 4th generation upgrade of ALBA is expected to have a lower lifetime, as many other next generation machines. In order to increase the lifetime of the beam, an active normal conducting 3rd harmonic cavity has been developed and constructed, together with a 1.5 GHz DLLRF system for the control of the voltage phase and amplitude. The system has been successfully tested at BESSY on the last week of September, demonstrating the stability of the control system with beam and full power.

Introduction

The 3HC system consists of a 1.5 GHz SSPA feeding a single 3rd Harmonic Cavity.

The cavity voltage is sampled by a pickup loop inside the cavity, and the forward power by a directional coupler on the waveguide before entering the cavity.

All the acquired signals connect directly to the DLLRF downconverter board, needing only an RF, LO and CLK input signals for the operation.

µTCA.4

The uTCA system was built by Struck, consisting of 3 main components:

SIS8300KU
A digitizer board, with 10 ADCs and 2 DACs, together with a Kintex Ultrascale FPGA

SIS8864
This board provides 64 GPIO channels used for interfacing with different equipments.

DWC8VM1
This board takes the RF signals coming from the couplers directly, and produces a 1.5 GHz output that is directly fed to the amplifier.

Frontends

Thanks to the DWC8VM1 board, the external hardware is minimal

GPIO PAPA
A small intermediate board was developed to interface with the ALBA DLLRF GPIO patch panel used for the main cavities.
It also provides 4 possible isolated inputs.

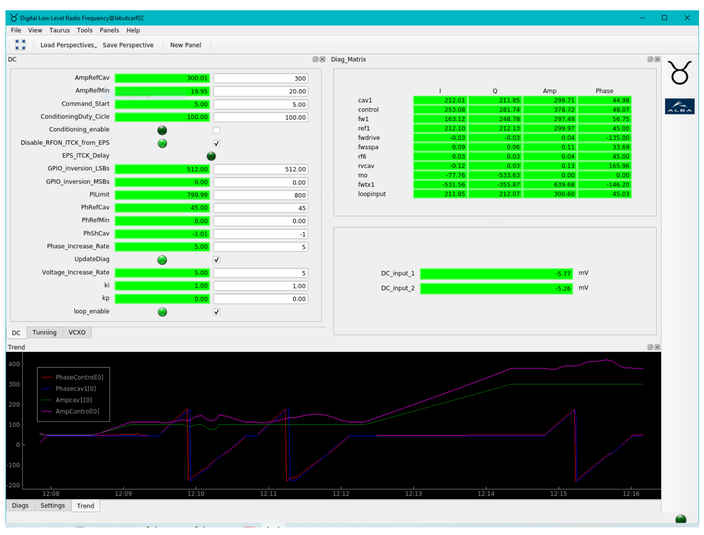
LOFE
A single LOFE for the CLK, LO and RF signal generation. The RF reference is generated from the Master Oscillator of the main RF system. The LO and CLK frequencies are chosen for an undersampling ratio of 5:4

Firmware

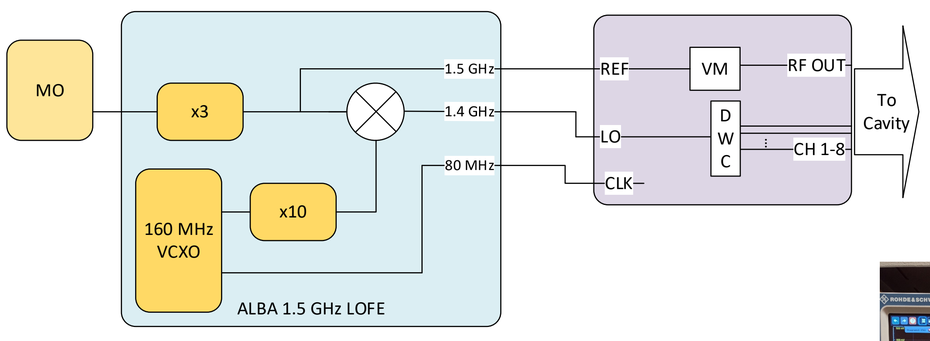
The firmware developed for the system was based on the ALBA DLLRF code for the main harmonic cavities, including ramping and pulsed modes (useful for conditioning).

The phase and amplitude loops are controlled with a PID acting on the I-Q components of the signal, and the tuning loops drive the plunger motor to maintain a fixed phase relation between the Fwd power and the voltage inside the cavity.

A dynamic Tango device and GUI was developed. It grabs a list of the different settings and the corresponding register address and conversion function, which speeds up the deployment of new firmware, from VHDL to operation.



ALBA DLLRF GUI



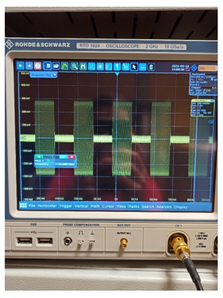
LO frontend diagram

Measurements

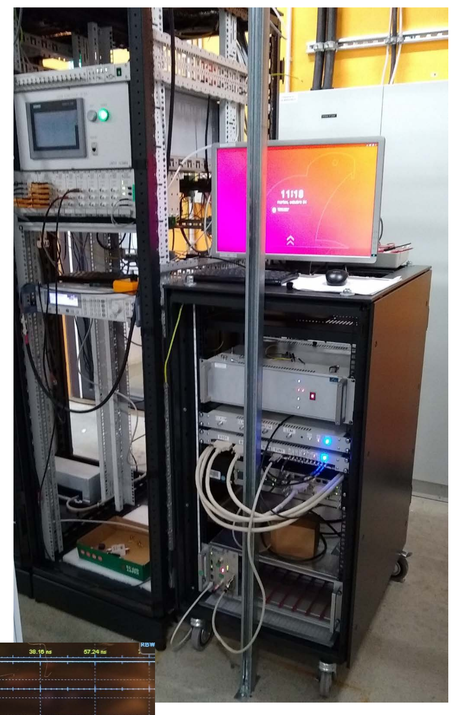
Connecting the system to the cavity for conditioning, tuning and control loops were closed successfully in CW and pulsed mode.

The output of the VM showed 30 dB of harmonics attenuation on the output, which is more than enough for our purpose.

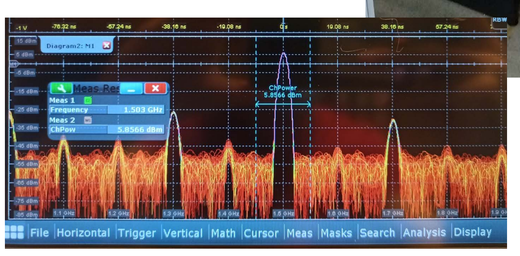
At BESSY, in single bunch operation, the bunch lengthening was observed, demonstrating the amplitude and phase stability in the short and long term, and the correct integration of the 3rd harmonic system with the main RF system.



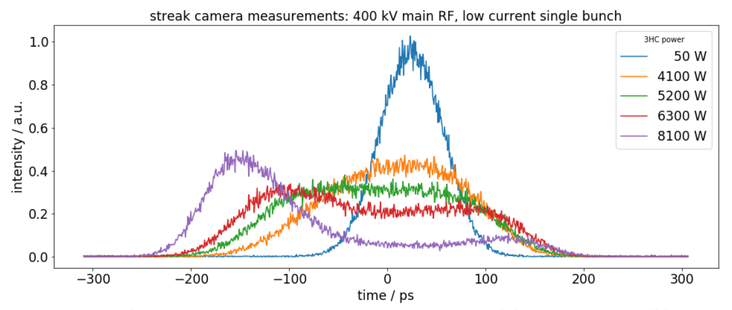
Pulsed Mode



ALBA 1.5 GHz DLLRF



VM output spectrum



Streak camera measurements of beam profile

CONCLUSIONS

The DLLRF for the active 3HC system has been successfully installed and commissioned. The voltage and phase stability allows the system to present the beam with the correct voltage required for bunch elongation.

It has been demonstrated the feasibility of the system working with single bunch, and the effects on the beam corresponds with what was expected from the simulations.

Acknowledgements: