LLRF system for superconducting SPOKE cavities

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Abstract: Within the framework of the current European research programs EUROTRANS and EURISOL on High Intensity Proton Accelerators, and particularly on the R&D on superconducting SPOKE cavities, a Low Level Radio Frequency Digital system is developed at IPN Orsay in collaboration with LPNHE Paris, both IN2P3-CNRS laboratories. Due to Lorentz's forces, mechanical vibrations or RF power perturbations, the amplitude and phase of the electromagnetic wave inside the cavities need to be controlled. Other goals are a better reliability, a high level of integration and a fast response time of the feedback control system. Digital techniques should allow to meet all of these goals and provide an improved flexibility compared to analog techniques, with the integration of the main algorithms and functions into an FPGA. The main design options and some preliminary results are presented.

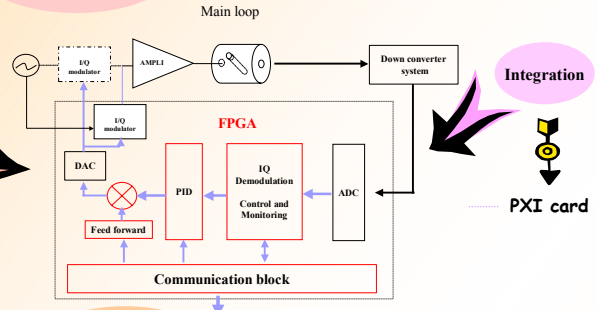
GOALS

- Stability of the amplitude :0.1%
- Stability of the phase of the accelerating field : 0.5°
- Response time : less than 10 µs
- Reliability close to 100% implying a strong integration and an efficient monitoring and control software

TECHNICAL TRENDS

Development of Cavity IQ and PID models → MATLAB SIMULINK

Use of ADC, DAC, and digital processors

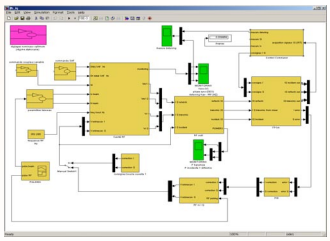


ALTERA STRATIX FPGA with internal fast blocks

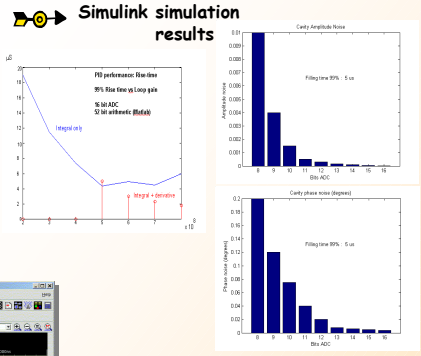
Use of standard instrumentation Hardware structure → PXI crate using a PCI bus link for the monitoring and control of the FPGA's algorithms parameters

SIMULATIONS

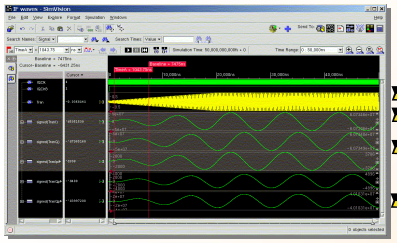
SIMULINK modeling of the cavity and feedback loop



Simulink simulation results

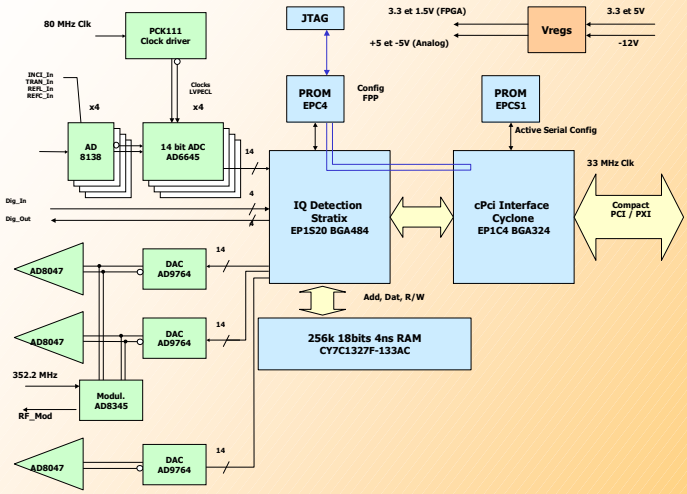


VHDL simulation of the PXI card

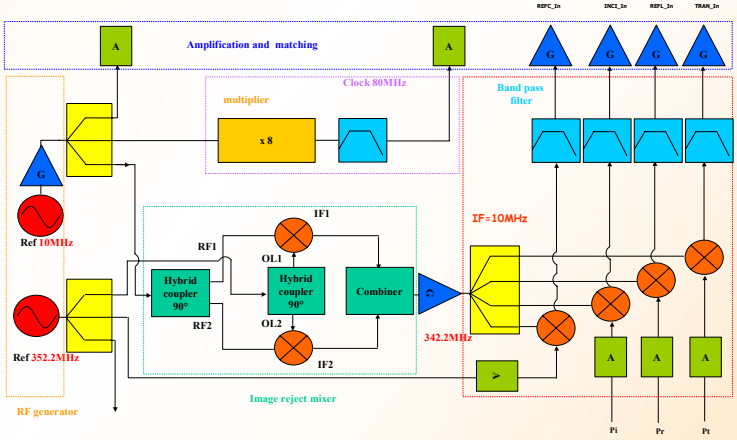


- 14 bits ADC and DAC Tr ~ 5µs with PI
- IQ Demodulation with 8 interleaved samples
- Digital processing latency: 100ns 35 x 9 bit multipliers

PXI CARD



DOWN CONVERTER SYSTEM



SCHEDULE

- Tests of the global system with a copper cavity at T°=290K
- Tests of the global system with a SPOKE cavity at T°=4.2K
- Development of a second PXI card for the research program EUROTRANS :fault-tolerance