NEW PC-BASED CONTROL FOR THE RF SYSTEM AT INFN-LNS

A. Caruso#, F. Consoli, A. Spartà, INFN-LNS, Catania, Italy
A. Longhitano, ALTEK, S. Gregorio di Catania, Italy
Xia Le, CIAE, Beijing, P. R. China

Abstract

The control of the radio frequency systems at Infn-Lns, since the first 1988 version, has been a combination of analog and digital techniques. The analog systems still maintain a certain priority in the control of amplitudes and phases of the RF voltages, while for the remaining operative blocks, the approach adopted is mostly digital. A new computer-based control of the RF system is going to be fully developed. The first results are already installed in parallel mode with the old RF computer control. At the moment, two parallel computer controls are working together. Both systems are complementary. Gradually, the new computer control system will take the place of the old more dated one. This report shows the new computer architecture, including the new panel controls, the communication bus, the interfaces between the PC and the RF blocks and the custom and the industrial solutions adopted for this new RF computer control.

NEW RF CONTROL SYSTEM

The new PC-based control system is the evolution of the old RF control system developed more than 20 years ago [1]. This new RF control, together with the old one, controls the radiofrequency of the superconducting cyclotron, the low and high energy chopper and the axial buncher [2-4]. The general architecture block diagram of the new PC-based control system is shown in Figure 1.

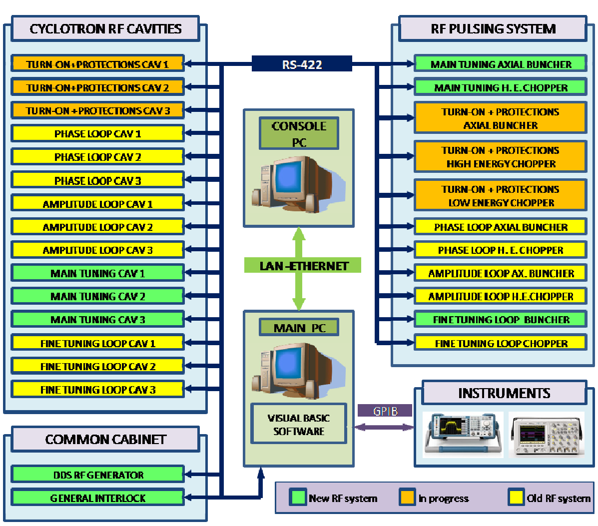

Figure 1: RF control system block diagram.

Figure 1 shows the communication bus, a couple of PC-units and the functional blocks. The RS-422 master-slave multi-drop bus allows the communication between the functional blocks and the main PC-unit. The distance, up to a hundred meters, between the PC-unit and the blocks, the full duplex characteristic and the fact it is easy to use, are the main reasons for choosing this RS-422 bus. The blocks are mostly divided into two frames, the cyclotron and pulsing system. From the hardware point of view, the cyclotron blocks are divided into three different electronic cabinets, one for each single cavity. The cyclotron control cabinets are very close to the main PC-unit, while for the pulsing system some of the blocks are close to the related devices, along the beam line, many meters away from the same PC-unit. A couple of further blocks, only the RF generators and the general interlock at the moment, are placed in another cabinet near the PC-unit. This is the common electronic cabinet where the blocks have general functions.

Each specific block is a standard 19" electronic rack with a Programmable Interface Controller (PIC) on board. As regards the complexity of the specific device to be controlled, different PIC are used, including the dsPIC family; all these PIC devices are made by Microchip [5]. If the PIC is the constant part inside each block, other components differ according to the block function. The block functions are: turn-on and protections, main tuning, fine tuning, amplitude loop, phase loop, and amplifier.

The main program, an in-house software written in Visual Basic© programming language, allows users to fully operate the blocks via a menu-driven control panel in a Windows© environment displayed on the PC-unit monitor. The same program has been diversified and developed for each single family block. Once the specific program has been uploaded on the single block, the process is worked out directly by the µcontroller itself. If the PC inexplicably stops working, the system will continue to function because the PIC is used. The block can be remote controlled by the PC control panel or through a front key pad panel, placed on the rack, to operate in local mode.

The colour caption in Fig.1 shows the blocks already under the new control system, the blocks under test and the blocks still under the old system. A further personal computer, connected by a LAN Ethernet, is installed in the accelerators main console like a remote PC-unit, which works in parallel mode with the main PC of the RF console. This is very useful in accelerator tuning and during the normal running of the beam. The main PC-unit parallel bus GP-IB (IEEE488) reads the RF measuring instruments.

Two separate PC-based systems, core of the old and new RF control systems, are working together at the

#caruso@lns.infn.it

moment. Both computers are complementary in setting, checking and controlling the RF system. The separate communication network prevents any interference or conflict. A brief description of the new control system blocks follows.

DDS Synthesizer as RF Generator

The RF generator is a high frequency source based on the Direct Digital Synthesis technique (DDS) [6].

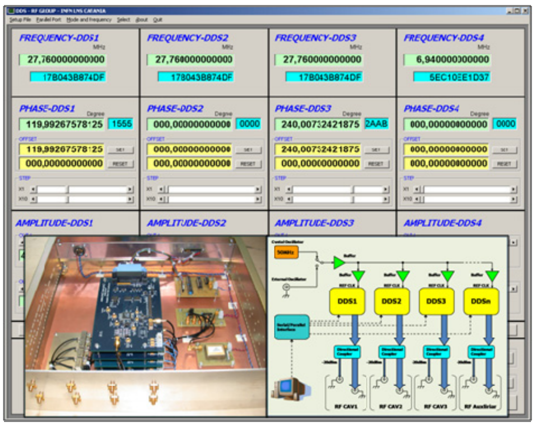

Figure 2: Control panel, rack and block diagram.

The DDS technique has been adopted to generate all the sine waves: three for the RF cavities, plus other auxiliary channels available for the axial buncher or other pulsing systems. Figure 2 shows the PC control panel, the block diagram and the electronic rack of the DDS synthesizer as RF generator. The initial amplitude and phase are set by the new PC-based control system without any phase shifters or linear attenuators. The main PC-unit is connected to the DDS devices, through the RS-422 bus. The PIC18F2585 is used in this block, while the DDS boards are based on the electronic component AD9854 by Analog Devices [7]. The system provides a 48 bit frequency resolution together with a high stable frequency system clock of 300 MHz giving a resolution of 1 μHz, 0.02° in phase, 43 μV in amplitude with a maximum frequency output of up to 120 MHz.

General Interlock

The status of the RF system in terms of vacuum level in the acceleration chamber, cooling system, environment temperatures, radiation safety, etc, is controlled by the general interlock block. The core of the system is the PIC18F4580. All the input parameters are processed and displayed on the PC control panel and on the local LCD display at the same time. Any failures from the input parameters disable the DDS RF generator, through a hardware connection immediately. A master switch placed on the front panel of the cabinet enables or disables the RF signals. The in-house software allows users to fully operate the general interlock via a menu control panel on the PC-unit. The vacuum threshold setting and the status of the input parameters are continuously displayed. The PC-unit control panel and block diagram of the new control interlock system is shown in Figure 3.

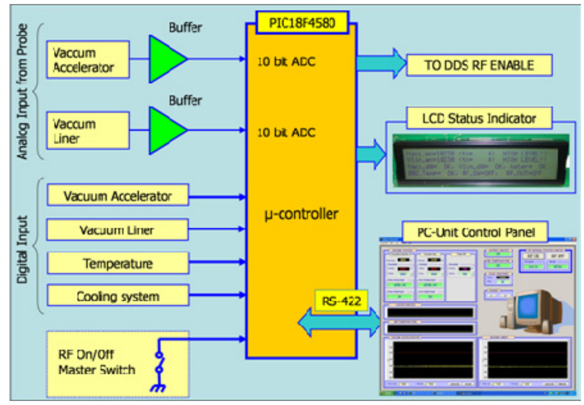

Figure 3: The control panel and the block diagram.

The Main Tuning System of the Cyclotron

The main tuning system of the superconducting cyclotron consists of six sliding shorts of three ½λ coaxial resonators. The position of the sliding shorts determines the main tuning of the RF cyclotron in the bandwidth of 15-50 MHz. The main tuning control panel sets and controls the position of the sliding shorts. The tuning resolution is 0.1 mm.

Figure 4: The control panel, hardware and DC motors.

The control panel, the electronic cabinet, the mechanics and the DC motor are shown in Figure 4. This block has been renewed without any use of PIC on board. The electronic interface between the PC and the Faulhaber DC motor driver system uses a standard commercial interface. In the near future this block will be converted into the new control system, with the PIC on board, same bus, etc.

Axial Buncher Tuning and Matching System

The axial buncher consists of a drift tube, placed in the axial hole of the cyclotron yoke, at 0.5 meter before the electrostatic beam inflector. A matching box is placed between the drift tube and the RF amplifier. Three variable capacitors and a fixed coil inside the matching box determine the resonance and the 50Ω matching of the buncher between 15-50MHz. Through a PC control panel, the system sets the capacitance value of the three motorized variable capacitors until tuning and matching are achieved. The core of the system is the PIC18F2585. The tuning and matching positions are stored in a database with the relative cyclotron beam. A by-pass of the RF amplifier allows for the checking of the matching and tuning through a network analyzer if necessary. An analog loop ensures the tuning stability after the setting and power-on. Figure 5 shows the block diagram and the hardware of the matching box.

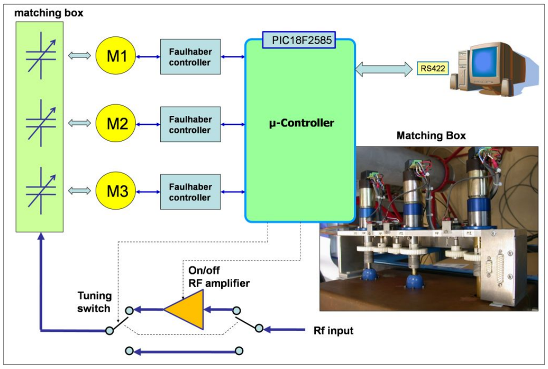

Figure 5: Tuning-matching system block diagram.

New Turn-on and Protections

The turn-on and the protections system are based on a µcontroller of dsPIC family, for the digital part and a wide bandwidth RF amplitude modulator for the analog part.

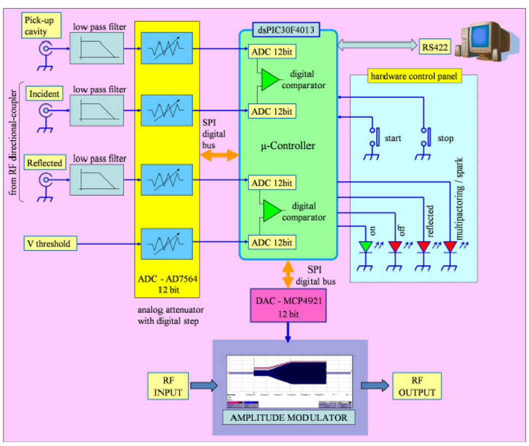

Figure 6: Turn-on and protections block diagram.

Figure 6 shows the turn-on block diagram. The relative complex functions of this block need a dsPIC on board. The inputs, already demodulated, are the incident and reflected waves from the directional coupler, the pick-up signal from the RF field (cyclotron resonators or pulsing system) and a voltage threshold. After the low pass filter, the inputs meet a 12bit DAC to maximize the dynamic signals. Under the multipactoring threshold, mainly in the cyclotron resonators, the protections work at very low input signal levels, while exceeding this phenomenon the input levels are very high [8]. The dsPIC analog-to-digital converters can exploit all the 12bit of the comparators to manage the protection and turn-on operations. The RF modulator is polarized from the PIC, through a further 12bit DAC. The trapezoidal envelope, shown in Figure 6, allows the turn-on to feed the RF power into the cavity in one-shot generally. An external front panel cabinet hosts the main functions and indications, such as the main alarms and turn-on/off push-buttons. The step and ramp envelope can be adjusted through the PC control panel according to the frequency. This facility is extremely useful in overtaking the resonator's multipactoring effect during the conditioning. The pulse conditioning can be set, if necessary. This kind of turn-on procedure and modulation technique is a copy of the old RF system. This digital upgraded version allows more freedom in setting and checking the protections and turn-on. The bus RS-422 connects block and PC-unit as usual, while the SPI digital bus are used inside the block. Some preliminary tests have been done successfully. The block diagram of Figure 6 can be a good example of the entire philosophy of the new RF control. It is mostly digital but with some analog exceptions, as the mini-circuit PAS-3, wideband modulator still used as RF switch/modulator.

FINAL REMARKS

The aim of RF control system is setting, checking and tuning all the wideband RF apparatus of Figure 7.

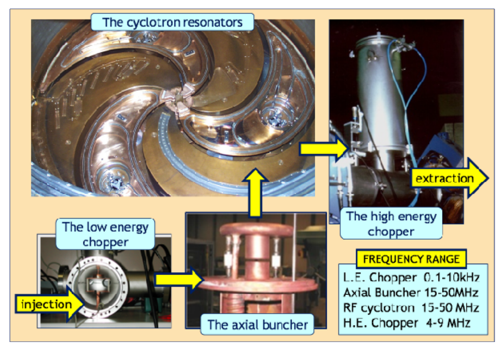

Figure 7: The RF devices along the beam line.

The move from an old to new PC-based control system is in progress. The new blocks are tested during the cyclotron beam time operation. This can either be considered an advantage because the test is directly inside the accelerated beam, or a disadvantage because replacing the old blocks with the new ones cannot be synchronized always with the scheduled beam operation. The new hardware and software are developed mostly in-house. The upgrade of amplitude, phase and tuning stabilization loops, in an FPGA environment, is under study [9]. The RF control system upgrade is in progress. In time, all the RF will be controlled by the new PC-based system.

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