RF CONTROL SYSTEM FOR 400 keV RFQ

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Abstract

An RF control system has been developed for the 400 keV, 350 MHz RFQ coming up at BARC. This single cavity system consists of the functionalities of amplitude stabilization and frequency tracking for both continuous and pulsed mode of operation. The amplitude stabilization is implemented by modulating the attenuation across a fast modulator placed in the drive path. The frequency tracking is achieved by driving the FM port of a signal generator with a signal proportional to the phase shift across the resonator. The whole system is under computer control via CAMAC hardware. The paper describes the system architecture, housing & wiring of the system in a single instrumentation rack and development & testing of computer control.

INTRODUCTION

A 400 keV, 350 MHz Radio Frequency Quadrupole (RFQ) accelerator is being built at BARC, Mumbai as part of LEHIPA project. An RF control system is under development for this accelerator, which has only a single resonator, at Electronics Division, BARC [1]. The functionalities of amplitude stabilisation and frequency tracking are incorporated in the system [2]. The amplitude stabilisation is needed for a stable energy gain from the resonator. Frequency tracking system keeps the drive source-resonator system at resonance, leading to an efficient utilization of RF power to set up electric field in the resonator. Close to the resonant frequency, the phase difference between the transmitted wave and the forward wave is a sensitive indicator of the resonance condition. The system utilizes this phase difference to track the resonant frequency of the resonator by modulating the output frequency of the signal generator.

The RF control electronics is divided in a number of simple signal processing modules. This sub-division has made a number of signals available for monitoring during operation and setting up and also allowed parallel development of the hardware. These signal processing modules are under computer control via CAMAC interface.

SYSTEM DESCRIPTION

Figure 1 shows the block diagram of the overall RF control. The signal generator, operating at a constant output level, feeds RF power to the resonator via amplitude control elements. The amplitude loop compares the pick-up in the resonator with set point and generates the drive signal for the amplitude modulator. The quiescent values of the drive to the two power amplifiers used in the system can be independently set in both amplitude and phase. For frequency tracking the resonator pick-up and the drive signal are down-converted to a convenient value of 10 MHz. The vector modulator generates the 10 MHz offset frequency required for down-conversion. The frequency loop generates the drive signal for the fm port of the signal generates by comparing the phase difference between these 10 MHz signals. The pulse generator, a part of the RF signal generator, is used for the pulsed operation of the system. All the control and monitoring signals of the amplitude and frequency loops are under computer control via CAMAC interface. The system utilises a number of functionalities available in the signal generator. These are under computer control as well. In Fig. 2 we show the control system view of the Low Level RF (LLRF) system.

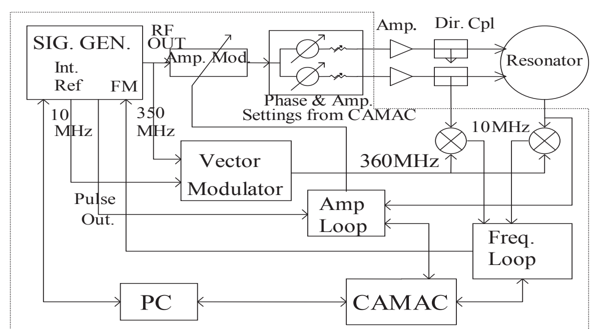

Fig. 1: RF Control System – hardware

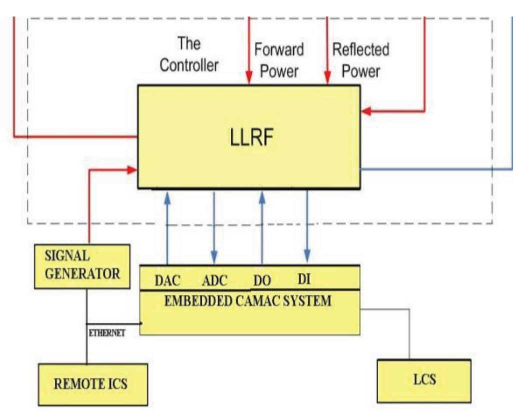

Figure 2: RF Control System – computer control.

CONTROL ARCHITECTURE

The control system is designed as 3 tier architecture as depicted in Fig 3. The OWS layer hosts the presentation applications and run manager which is used by operators

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for machine run. The middle layer is the server layer where servers like command control, parameter and configuration are hosted. The command control server is responsible for permitting commands to the equipment server depending upon macro level machine state logic. Parameter server is data concentrator which collects data from different equipment servers, arrange data as per properties and present it to OWS layer. The equipment layer is the lowest layer. It is presented to the server and OWS layer through standard interface, it receives commands from higher layers and multicast its parameters. It hosts the access to the hardware.

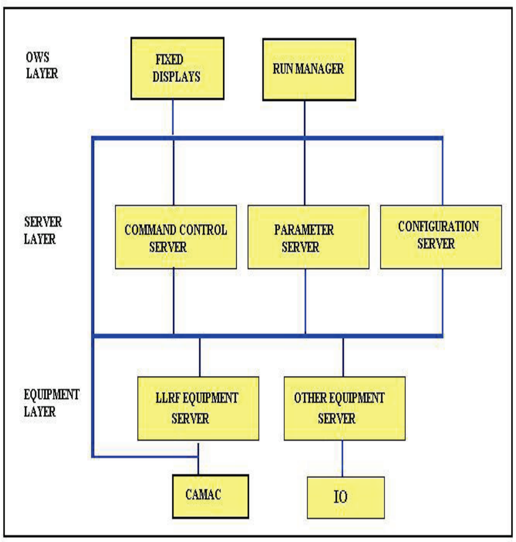

Figure 3: Control Architecture.

LLRF EQUIPMENT SERVER

The LLRF equipment server is implemented using standard equipment server framework as depicted in Fig. 4. The LLRF equipment server downloads system configuration from Configuration server. The system configuration contains system parameters information like physical connection, type, safe output value, conversion etc. The Network Manager listens on command port and multicast parameters on parameter port. The scanner thread when spawned will scan input parameters with configured periodicity and stores them at shared memory. The Command Executor thread processes command and drive output parameters. It also stores changed output parameters in the shared memory. Shared Memory usage initially helps for getting safe output parameters for the system. Secondly for some reason thread exit and re-spawns then the current machine context is retained in shared memory, so the system can resume its functionality without disturbing present machine state. The hardware interface thread listens on message channel; it allows setting and getting parameters. This helps in making interface hardware independent. Presently the LLRF crates are CAMAC system. CPCI and VME based DLLRF hardware is under development. This design will ensure minimal effort transition to the new hardware system in future.

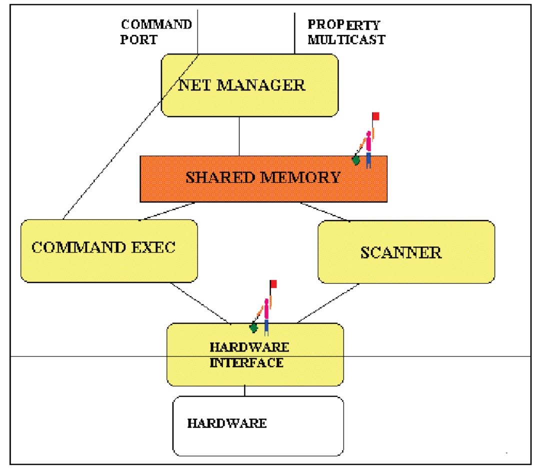

Figure 4: Equipment Server.

LLRF INSTRUMENTATION RACK

The complete signal processing is divided into a number of simple modules. These modules are housed in an instrumentation BIN as shown in Fig. 4. This sub-division has made a large number of signals available on the front panel for monitoring. This has proved very useful during testing in the lab. It has also made possible a parallel development of simple signal processing modules. The RF bin is part of an instrumentation rack, which also houses, a signal generator, signal router, control computer and CAMAC bin. The signal router collects various monitoring and control signals from all the modules and depending on the type of the signal (analog I/O, digital I/O) sends it to the respective CAMAC module. The organisation of these hardware blocks is shown in Figure 5. Figure 6 shows the instrumentation rack, housing the required subsystems.

Figure 5: RF BIN.

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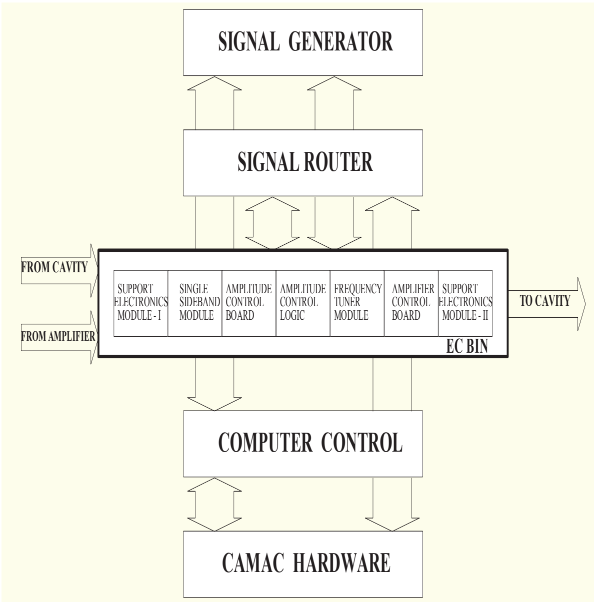

Figure 6: Organisation of RF Instrumentation RACK.

Figure 7: Instrumentation RACK.

LAB TEST SETUP

Various parameters such as system state - continuous/conditioning, feedbacks on/off, signal generator frequency/level, signal path attenuation, phase shift, feedback gains etc., are set using the front-end application. A number of system parameters, such as, Cavity field, Forward power, Frequency error or detuning etc. are displayed on the control computer. Figure 8 shows the operator screen. RF and high band-width analog signals are available on the front panel of the modules. The system has been tested at low power in the lab using a simple test 350 MHz resonator. Presently the system is being used for the pulse-conditioning of the RF power coupler, coupled to a test cavity.

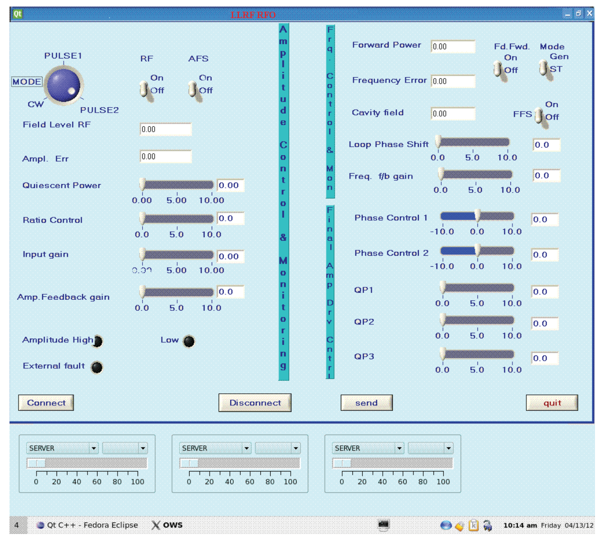

Figure 8: Operator Screen.

ACKNOWLEDGMENT

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