AUTOMATION OF THE CONTROL SCHEME FOR IUAC LINAC

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Abstract

Improvement of the Linac control scheme is undertaken for automation with minimum human intervention during beam acceleration. Python language interface with the present control scheme is used in writing automation routines to monitor the status of the phase/amplitude lock during operation and shut-down the locking mechanism to reduce the RF power, if required. Simultaneous pulse conditioning of the resonators is made possible by using dedicated hardware interfaced and Python based client interface. Movement of the drive coupler is enabled from operation console with position read back. The manual control of the slow-tuner electronics module to bring the frequency close to reference during phase locking is interfaced with the present control scheme for remote operation. Monitoring of amplitude and absolute phase of each cavity is made possible from operation console. An alternate tuning mechanism using piezoelectric actuator and stepper motor combination has been successfully tested in the test cryostat.

INTRODUCTION

The superconducting (SC) linac boosters of Inter-University Accelerator Centre with the super-buncher, the first accelerating module and the re-buncher are operational since last few years [1, 2]. The installation of the remaining two accelerating modules of linac is nearing completion. The Linac control scheme [3] has been working successfully during the beam acceleration through linac. However, to ensure a safe operation with minimum human intervention, a number of steps were adopted to automate the operation of linac. The different developments in the automation are (a) the phase and field amplitude monitoring and locking of the superconducting resonators from remote location (b) RF power monitoring of a resonator (c) Computer controlled movement of the power coupler and RF conditioning of many resonators at a time. In a parallel development, a Piezo-actuator based tuning mechanism along with the fast electronic tuner had been tried out successfully on a SC resonator. The various developments related to the automation of the linac control scheme and the alternate tuning mechanism are presented in this paper.

OVERVIEW OF CONTROL SCHEME:

The Linac control scheme works along with the existing Pelletron control system. The scheme consists of a local RF control system for each individual cavity with a provision of remote access from computer server under Linux platform. The Local control powers the resonators through RF amplifiers for required field setting. It also keeps the cavities phase locked against the master clock with help of fast and slow tuning components. The control is interfaced to a CAMAC crate with embedded controller running as a server. The client computers use the X-windows graphics and shaft encoder knobs interfaced to them to provide the operator interface. Local RF control system consisting of Resonator controller and supporting RF modules are used for multipactoring conditioning, high power pulse conditioning and for the phase/amplitude locking of the superconducting resonators. Beam acceleration is done by adjusting the RF phase of each resonator with respect to master oscillator

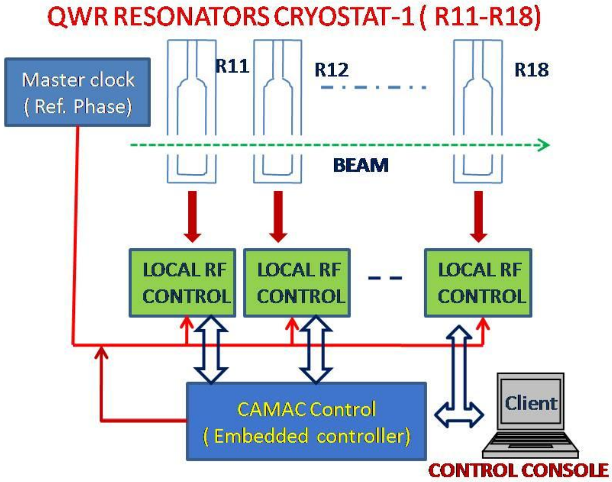

Fig.1 Schematic of IUAC Linac control scheme

AUTOMATION OF CONTROL SCHEME

Monitoring of absolute Phase and Amplitude

During operation of resonators, it is required to monitor the pickup and phase of each resonator separately from remote. This is achieved by multiplexing all the RF signals with a dedicated hardware. The control is done by client using same user console. Absolute phase is measured by down converting the RF signals to AF signal. An offset oscillator having frequency difference of 10KHz than that of the master clock is used to mix with reference clock and pick up to generate it. The reference phase shift is calibrated using an AF phase meter.

Software development for Phase and amplitude lock monitoring

During beam acceleration and beam bunching/re-bunching, all the resonators have to be phase and amplitude locked with respect to the master clock. The fluctuation of resonant frequency due to mechanical vibrations, change of helium pressure etc. acts as the main disturbance to the stabilization process. This fluctuation occasionally is so large that the cavity goes out of lock thereby causing interruption in beam delivery. At this instant, RF power from the amplifier goes to maximum to stabilize the lock. The addition of python language interface [4] has enabled us to write client programs for automatic monitoring and control of the phase lock condition. The program monitors the status of the phase lock condition as well as RF power supplied by the RF amplifiers to all the resonators. Whenever the cavity goes out of lock and RF power from amplifier becomes high for more than a minute, the phase and amplitude lock of the cavities are switched off to protect the rf power cable.

Remote frequency control for phase locking

The phase and amplitude locking of the resonators were done locally near the resonator control station as the coarse frequency tuning performed by the mechanical tuner used to have only manual operation mode. A remote operation mechanism for the frequency control of the resonators has been developed and implemented on the resonators of the first accelerating module of linac [5]. The system uses industrial cost effective modules using MODBUS protocol. A Linux based server connected to the Ethernet based control network communicates with the existing control clients using the same user interface of existing Pelletron and linac control. This system operated from the central control room was used successfully during the last linac beam acceleration.

RF conditioning of the Cavities

The high power rf conditioning of the superconducting resonators is done by triggering the resonator controller by an external pulse with a duty cycle of ~ 1 second and pulse width of ~10-20%. A pulse generator having eight independent channels [6] is developed for simultaneous Pulse conditioning of resonators and a python based software routines is used for control and monitoring. During field measurement of the resonators, adjustment of the coupling coefficient of the power coupler of the resonator is a necessity. The remote movement of the coupler is done using a dedicated hardware with necessary interlocks for indication of fully IN or OUT position of the couplers. The control of movement as well as position read-back is done by CAMAC module.

RF power monitoring of the resonators

During multipactoring conditioning and phase locking of the resonators, read back of power from RF amplifier is done using dedicated hardware and a CAMAC module. Since the resonators are operated at high SWR, the dc voltage read back from directional coupler is calibrated using a commercial RF power reflection meter. Since the calibration is non linear, the data is linearized in a hardware module [6]. The linear dc voltage is given to a CAMAC scanning ADC module with proper lookup to give the correct read back of power.

FUTURE PLANS

Testing and implementation of piezoelectric actuator based tuner

The helium gas operated slow tuner turns out to be a complicated, somewhat unreliable and expensive for long term operation of the linac. In an alternate scheme to handle the slow time part of the phase control, the tuner plate is deflected by using a combination of a stepper motor for course adjustments and a piezoelectric crystal for fine adjustment of the frequency [7]. The piezoelectric actuator is used in closed loop along with existing resonator control scheme to phase lock the resonator cavity. In future the stepper motor based coarse tuner operating from remote console will be used to bring the frequency close to the reference and the piezoelectric actuator bias control minimise the frequency and then phase lock the resonator. This operation from remote console will make the cavity phase locking automated.

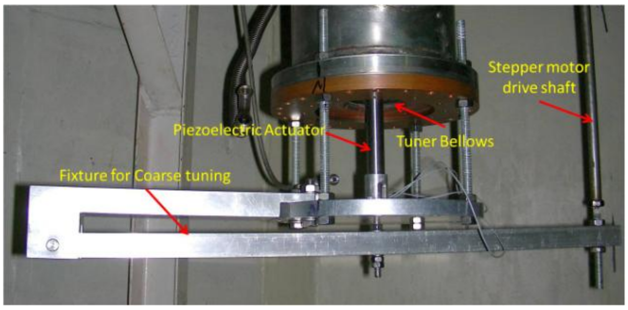

Fig.2 Piezoelectric actuator based control mechanism

CONCLUSION

The linac control scheme is made in a distributed manner with portability along with the existing pelletron control system. The progress in the automation of the resonator control is steadily going on and it has worked very well during operation of linac. Automated phase locking of the cavities along with beam tuning was tested and implemented for the resonators. With Stepper motor based coarse tuning and piezoelectric based fine tuning, phase locking of superconducting QWRs in future linac cryostats will be fully automated.

REFERENCES

[1] S.Ghosh, et al Physical Review Special Topic – Accelerator and Beams, 12, 040101 (2009).
[2] A.Rai et al. Proc. of 14th International Conference on RF Superconductivity (SRF2009), p - 244.
[3] B.K.Sahu et al., Proceedings of InPAC 2009.
[4] Ajithkumar B.P., Proceedings in this conference
[5] R.N. Dutt, et al, Proceedings in this conference
[6] J. Antony, et al, Proceedings in this conference
[7] B.K.Sahu, et al, Proceedings of IPAC2010,May 23-29 2010, Kyoto, Japan.