UPGRADE OF LOW LEVEL RF FEEDBACK SYSTEM FOR PLS STORAGE RING *

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Abstract

The upgrade of the low-level RF feedback system for the PLS storage ring is now in progress, which will be finished in Dec. 2001. The previous system has single loop of amplitude and phase control each, which stabilizes the variations due to the klystron high voltage power supply. And the VME for the RF system measures the cavity gap voltage and compares with the setting voltage, and gives a control signal to the amplitude loop, which causes a large variation of the gap voltage. The new system employs two pairs of amplitude and phase control loops. One is for the variation of the klystron high voltage power supply, called the inner loop, which is a fast loop with the bandwidth of about 1 kHz. The other is for the gap voltage and phase variation in the RF cavity, which is a slow loop with the bandwidth of about 100 Hz. The new system incorporates NIM type modules, which enable the easy maintenance of each module, and provides a large number of diagnostic points for the RF and control signal monitoring. In this paper the detailed description of the new system will be described together with the performance test results.

1. INTRODUCTION

The upgraded low level RF system at PLS storage ring consists of dual feedback control loops such as dual automatic phase control(APC), dual automatic level control(ALC), a automatic tuner control(ATC) circuits. These circuits will ensure the required stability condition for the PLS RF system operation.

Low power electronics control circuits was assembled by using NIM modules. The RF power for four cavities is provided by four independent RF stations with a 60kW klystron amplifier system per each station. The output power from each RF station is fed via high power circulator to drive the RF cavity. In the 2.5GeV operation, the dissipation of the RF cavity is 20kW for 400 kV of accelerating voltage with a coupling factor of 1.8. The RF cavity dissipation should remain constant through the entire range of operating beam current zero to 180mA.

When the beam is demanding more power from the RF cavities, the automatic gain control loop should adjust the drive signal of the RF system providing more power for the beam and keeping the RF cavity voltage constant. As the RF signal must go through the low level RF system including three automatic control circuits and finally the klystron amplifier system, the phase of RF signal will vary with the RF output power level. Since the phase variation may give some effects on beam stacking, the phase control circuit has to correct it precisely to keep the phase constant throughout the whole range of the operating power. In order to keep the four RF cavities on-tune during the operation, each RF cavity tuner control loop controls a stepping motor to move the plunger in and out of the RF cavity to keep it on tune.

2. RF CONTROL SYSTEM

The upgraded low level RF system in an RF station consists of an automatic level control(ALC) and phase locked loop(APC) of RF signal, a cavity tuning(ATC), an interlock, and various monitor parts. The ALC and APC loops are implemented to stabilize the amplitude level and phase of the klystron output. They reduce phase variations due to cathode high voltage variations and eliminate the power supply ripples and noise around the synchrotron frequency.

A block diagram of the upgraded low level rf system for one RF station for RF cavity is shown in Fig. 1. An RF station for PLS storage ring is basically the same, as other RF stations. ALC and APC has a function to level klystron output power(inner loop) and cavity voltage(outer loop), and to lock klystron output and cavity phase, respectively. ATC is to keep cavity resonating at 500.082MHz with slight detuning offset by using a moveable tuner. A interlock is to protect equipments and human life from break down, beam abort, and radiation safety. Various monitor parts are to measure the running condition and to respond to system failure

Low level control & monitor parts in low power electronics modules is manually input on the module too. It's another role is monitoring the status of each high power circulators and cavities such as reflection power from the cavities and vacuum pressure. The upgraded low level RF system incorporates NIM type modules, which enable the easy maintenance of each module, and provides a large number of diagnostic points for the RF and control signal monitoring. Fig. 2. shows the photograph for the upgraded low level RF system 1 for RF station 1 in beam operation. At present, first upgraded low level RF system for RF station1 is operating with 3 attached old RF Stations in beam operation, and working well now. The upgraded low level RF system is ready to control through ether-net port using microprocessor with a flash memory and VME I/O.

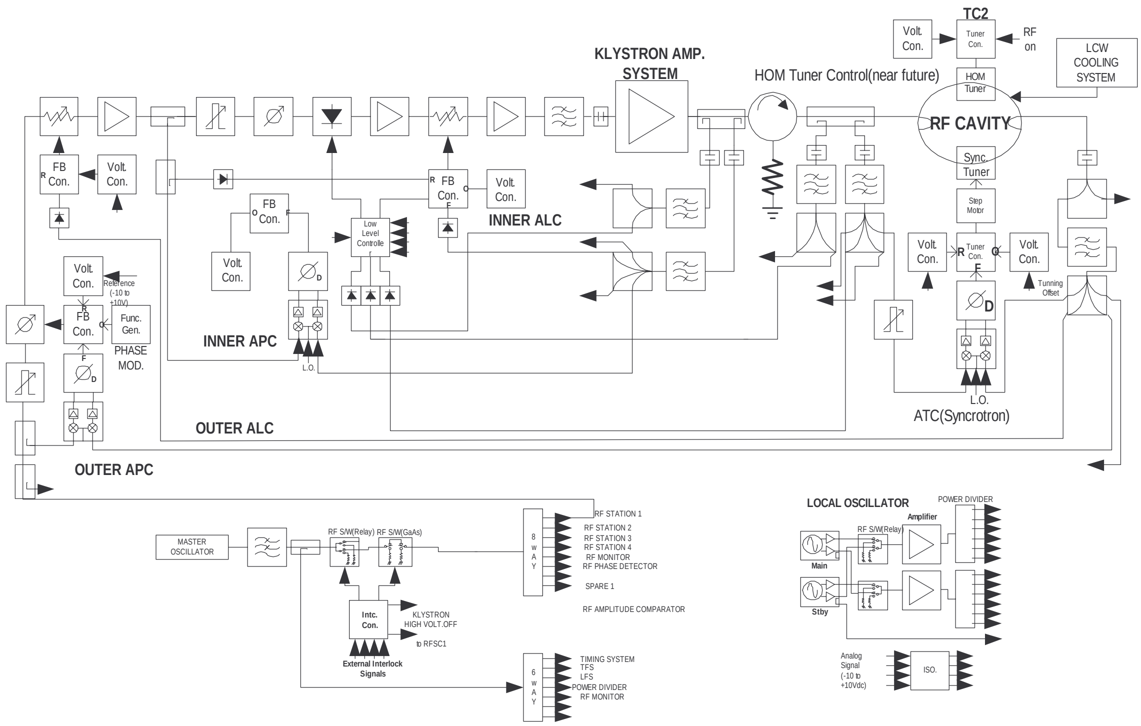

Figure 1. Block diagram of upgraded low level RF system of one RF station for RF Cavity

Then it is capable to input control values such as RF power, phase through Ethernet using personal computer.

The RF system will be operated by the computer control system based on EPICS in the near future. The computer through network monitors the operating parameters such as the RF power, cavity gap voltage and phase of every part, and takes appropriate action to keep the system working properly. For example, it can detect phase differences among the RF stations from unbalanced beam loading and will correct a phase of each station so that the balance can be restored. the computer interface also monitors the operating environment of the klystrons, circulators, cavities and so on.

The maximum voltage and current of the klystron power supply is 27kV and 6.5A, and AC power line frequency is 60Hz. Each power supply is a twelve-phase rectifier circuits(with ripple noises occurs at multiples of 720Hz): and the klystron power supplies in the four RF stations are phase-shifted by 7.5° from each other at their input transformer. Therefore, if each station is finely tuned and the four stations are balanced, equivalent 48-phase rectifier could be expected(with ripple noises in multiples of 2880Hz). In fact, there are some causes that disturb the balances, so that the extra harmonic components are excited in the power supply. Fig. 3 shows the stability of feedback loops of low level RF system in beam operation. During the test with beam, the amount of phase variation of the system is more than 5 degrees between operating power level of 20kW and 60kW. With the automatic phase feedback loop, the phase variation is reduced to less than ± 0.5 degree. With an automatic level control feedback loop, the amplitude variation of RF power into the RF cavity is measured to be less than ± 0.5% (0.039dB). At the initial phase, the operating power for the four cavities is 80 kW without beam. With beam current of 180mA at 2.5GeV, the total RF power required is about 200kW

3. SUMMARY

Low level RF system of the storage ring employs two pairs of amplitude and phase control loops. One is for the variation of the klystron high voltage power supply, called the inner loop, which is a fast loop with the bandwidth of below 2.5kHz. The other is for the gap voltage and phase variation in the RF cavity, which is a slow loop with the bandwidth of below 1KHz. In order to reduce the ripple effects, it is necessary to fine tune each power supply and balance the four stations; and to improve the feedback systems so that it can adapt to a wider frequency range. In the near future, 3 attached old low level RF stations will be replaced with the upgraded system, and then will be optimised operating condition by fine tuning the parameters such as frequency bandwidth of feedback loops, phase differences of each stations.

4. ACKNOWLEDGMENTS

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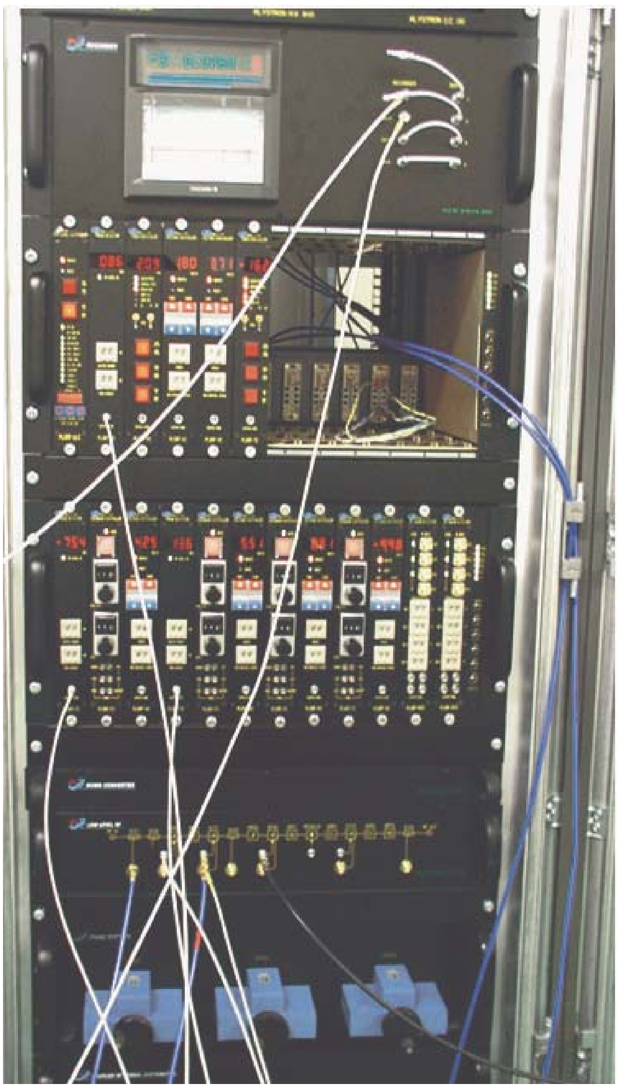

Figure 2. Photograph of upgrade low level RF system

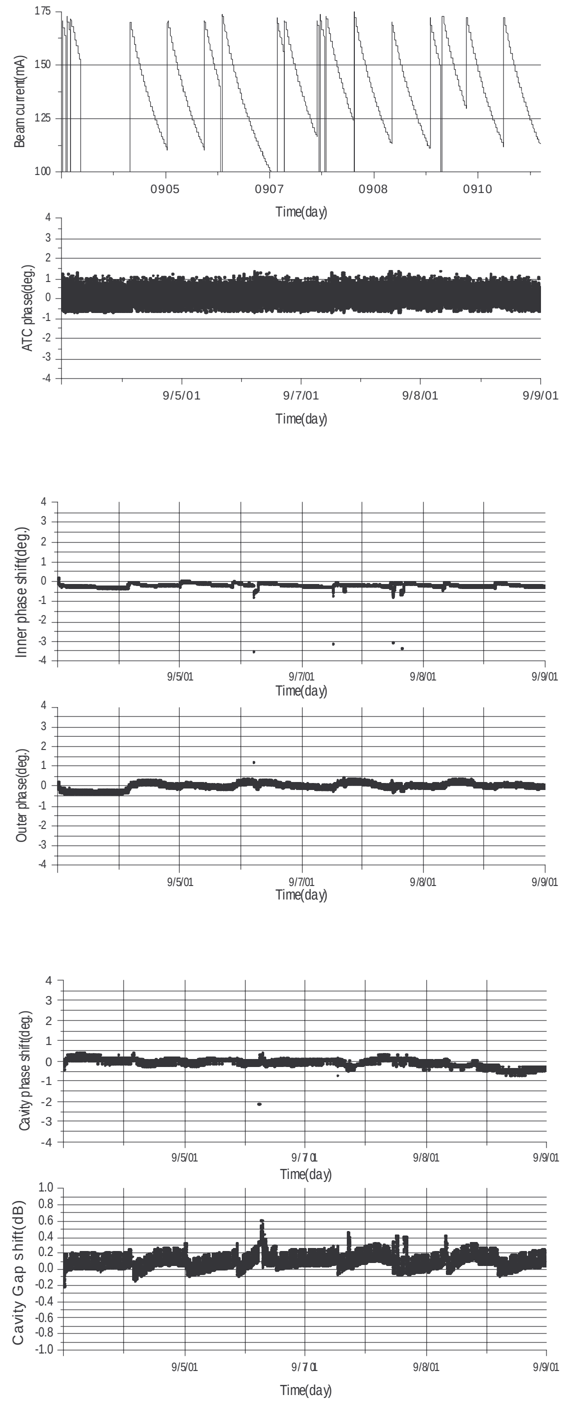

Figure 3. Stability of feedback loops of low level RF system in beam operation