BUNCH PHASE MONITOR

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To know the beam phase on rf voltage is very helpful for the fine tuning of accelerators such as the RILAC (RIKEN linac) and the RIKEN SSC (under construction). Sometimes, however, bunch signals have a bad SN ratio when the beam currents are weak (during the tuning process, for example) or when the measurement with probes inside the SSC are made in the presence of severe rf noises. It is necessary to develop the device which enables the beam phase measurement under such bad conditions.

A bunch phase monitor using the mixing (heterodyne) scheme has been made. The basic principle of it is same as that in Ref. 1: namely, the information on the beam phase is transfered to the signal with a fixed intermediate frequency f_o. But this system involves the automatic tuning circuit for the frequency range of 17 $\sim$ 45 MHz. No additional adjustment is necessary when the acceleration frequency is changed.

A block diagram of this system is shown in Fig.1. Two kinds of signals (one is a reference signal from a rf cavity and the other is a bunch signal from a bunch probe) are fed to the two inputs, respectively. The reference signal, after its frequency is doubled ($f \rightarrow 2f$), is mixed with the output signal of a voltage controlled oscillator (VCO) in a double balanced mixer (MIX1). The mixer output, after filtered, is sent back to the phase lock loop. When the circuit is in tune the VCO generates the signal of $2f + f_o$ and the reference signal f_o is phase-locked in refernece to the signal from an oscillator OS1. The refernece signal in the intermediate frequency stage is filtered again by a narrow band filter and fed to a phase detector PD2 and also to another phase detector PD3 after being phase-shifted by 90° with a coaxial delay line. When the circuit is out of a tunable range of the phase lock loop, it is automatically tuned with the other loop including an oscillator OS2 by scanning the frequency of the VCO output ($2f_{min} + f_o \sim 2f_{max} + f_o$, $f_o = 10.7$ MHz)

The bunch signal is also mixed with the VCO output at MIX2 in the same way as the reference signal. The mixer output is filtered with a narrow band filter f_o which removes the effects of other frequency components of the bunch signal than the doubled acceleration frequency 2f. The bunch signal in the intermediate frequency stage is fed to the other inputs of the phase detectors PD2 and PD3.

The two dc outputs are obtained; one is $A\sin 2\theta$ and the other is $A\sin 2\theta$, where A is a factor with relation to the beam intensity and θ is the beam phase.

Ref.1) W. Bräutigam et al, IEEE Transaction on Nucl. Sci. NS-26 1979 p2375

Fig. 1 Block diagram of bunch phase monitor