BEAM SIGNALS FOR RF PHASE CONTROL OF KEK PROTON SYNCHROTRON

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Abstract

The harmonic number of KEK Proton Synchrotron[PS] is nine. So the beam revolution frequency is one ninth of accelerating frequency[RF]. To eliminate the phase distortion by cross-modulation, it is better to compare both phases at RF rather than at revolution frequency in the beam-RF phase-locked loop[PLL].

For this, a system was developed, in which nine wall current monitors[WCMs] were installed on the beam duct around PS at the same intervals. The system works well for both single and nine pulse acceleration modes.

1. General Description

In principle, one monitor head is enough to get the beam signal for PLL at RF in nine pulse mode. But, up to now, due to the beam loss after the injection, the beam pulse of the first injection decreases several times smaller than the ninth(last) pulse before acceleration(see Fig.4(a)). So, if only one monitor is used, the beam signal is deeply modulated in amplitude at revolution frequency. It becomes an origin of phase error. Moreover, on the single pulse mode, a frequency multiplier of nine times should be needed(or one should compare the beam signal with one ninth of RF). The nine WCM system does not bear such problems.

The block diagram of the system is shown in Fig.1. PS is composed of equally spacing 56 subcells. Fortunately, the beam ducts are coupled with electrically insulated flanges at the fixed position in each of the subcells. By using these electrical gaps, the WCMs cam be made easily. Though the beam path lengthes from a pair of flanges to the next pair are exactly the same around PS, 56/9 is not an integer. So, nine WCMs could not be located in equal spacing. The location errors are noted in Fig.1 as errors in RF phase. These errors are reduced to one seventh by adjusting the cable lengthes to get all beam signals in phase at 7 MHz(RF varies from 6 to 8 MHz during the acceleration). Then the maximum location error becomes less than 4°(at 6 and 8 MHz).

The beam signals from nine WCMs are mixed at the OR circuit and, through the tracking filter, only the RF Fourier component of the beam signal is fed to the phase detector. This means that RF is phase-locked approximately to the center of charge.

2. Details of Apparatus

2.1. Monitor Head(WCM)

Figs.2 and 3 illustrate a WCM. It picks up the wall current induced by the beam along the duct. Two 3300 pF capacitors are inserted to reject the induced voltages by dB/dt and by the earth potential differences among nine WCMs. One 47 ohm resistor is for the impedance matching to suppress the standing waves along the cable. Fig.4(a) shows the beam signal observed at the RF control station.

2.2. OR Circuit

As shown in Fig.3, it is a diode OR circuit. The nine signal are mixed in the manner that the maximum amplitude is dominant. Then the output signal is nearly the same for single and nine pulse modes. The merit is that there is no need of switching between these two modes. Fig.4(b) shows the output of the circuit.

2.3. Tracking Filter

The tracking filter is a current controlled resonance circuit. The control current is generated by the reference input from RF oscillator. The output is a sinusoidal wave.

2.4. Phase Detector

The phase detector is composed of two saturable amplifiers and a balanced mixer. The use of a balanced mixer is advantageous because the output is zero when the phase difference is $\pm 90°$ (this means that the beam is on 0° or 180° in RF phase).

Acknowledgement

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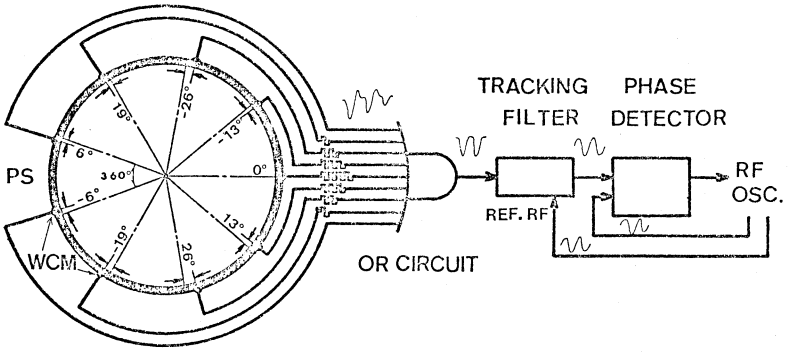


Fig.1 Block diagram of the system with WCM location errors in RF phase.

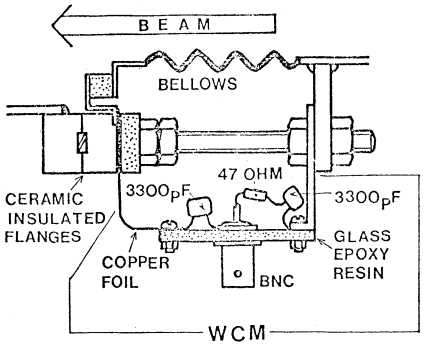
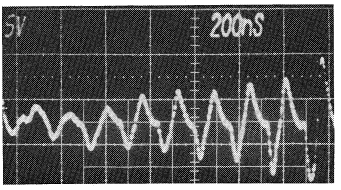
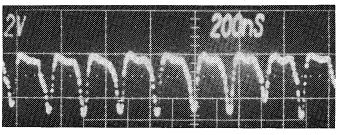


Fig.2 WCM installed at the insulated flanges.



(a) Output of WCM.



(b) Output of OR circuit.

Fig.4 Beam signals.

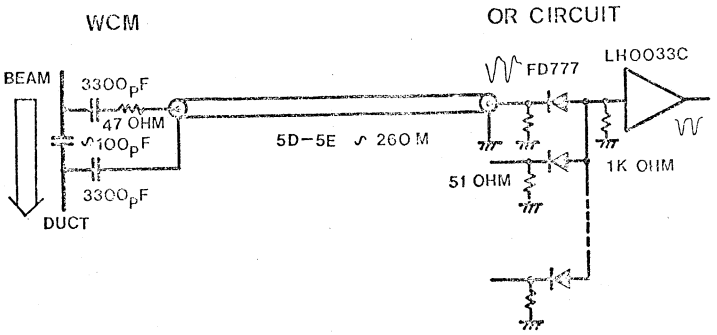


Fig.3 Circuit of WCM and OR circuit.