The 6th Symp. on Accelerator Science and Technology, 1987, Tokyo, Japan (© Ionics, Tokyo, 1987)

BEAM POSITION MONITOR SYSTEM OF TRISTAN MAIN RING

H. Ishii, M. Tejima, T. Ieiri, J. Kishiro,
Y. Mizumachi, K. Mori, A. Ogata and T. Shintake

KEK National Laboratory for High Energy Physics
Oho-machi, Tsukuba-gun, Ibaraki-ken, Japan 305

Introduction

The position monitor system of the TRISTAN main ring (MR) is basically the same as that of the preceding TRISTAN accumulation ring (AR) [1]. However, position accuracy must be better because the ring size of MR is 8 times as large as that of AR and the monitor sensitivity must be higher because the beam current is much lower in MR than in AR. Hence, the detector circuit and the setting of the monitor chamber had to be considerably improved. In addition, since the number of the monitor is very large (392 in MR and 83 in AR), reduction of maintenance work or easiness of troubleshooting has been pursued.

Monitor Chamber

Fig. 1 shows the dimension of the monitor chamber in the bending section and in the straight (RF) section [2]. The structure of the pickup electrode is the same as in AR except that SMA connector is capped with stainless steel. Although the beam duct fits tightly in the bore of Q magnet it is still possible to make some movement by the external force or temperature change due to baking process. Therefore, we have designed an aluminum frame assembly to hold the chamber as in Fig. 2. After the welding work the frame is secured to the end of the Q magnet by its four legs. The frame has another important role. It has standard horizontal and vertical planes with which we fix the position of the monitor chamber on the table in the calibration work and we also measure the position of the chamber in the ring tunnel.

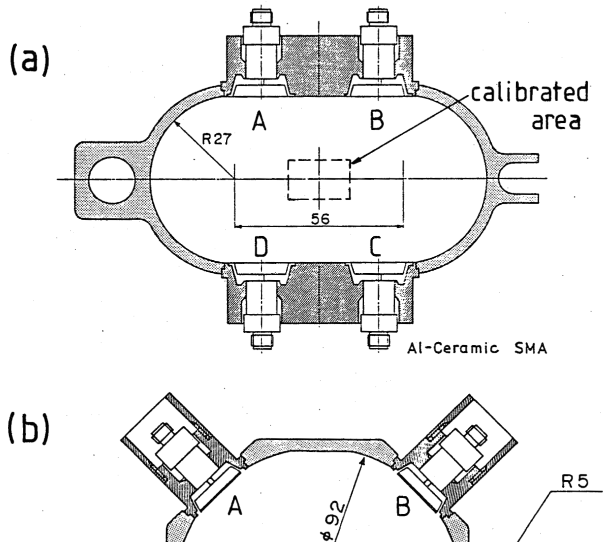

Fig. 1 Position monitor chamber and calibrated area (a) bending section (b) straight section

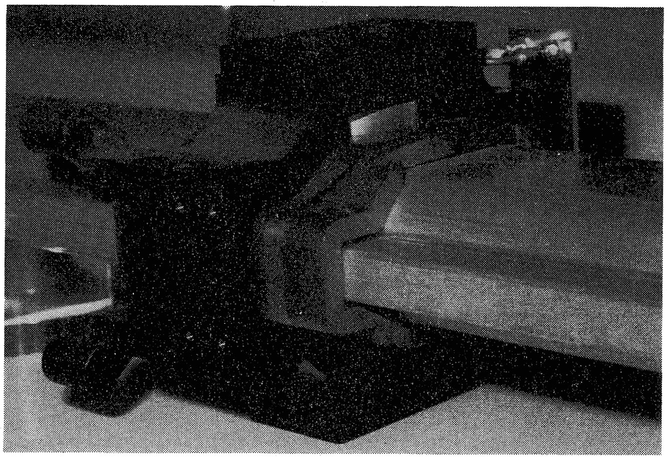

Fig. 2a Full assembly of the position monitor chamber in a bending section with a frame, lead shield, head attenuators and a connector panel at the back side

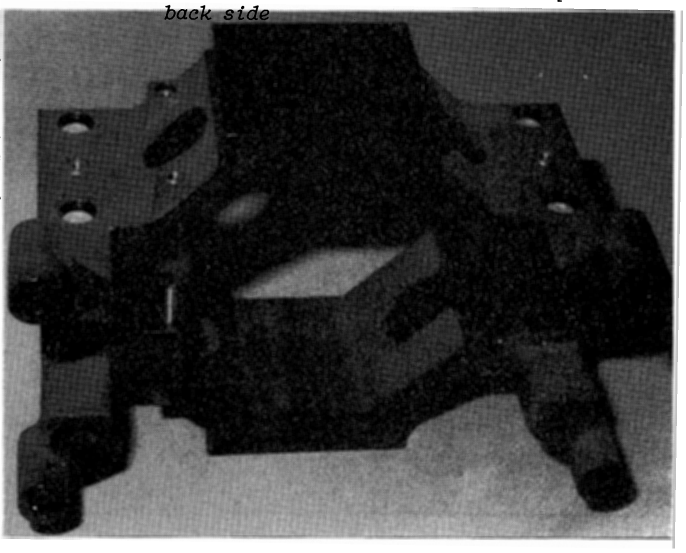

Fig. 2b Monitor frame of the straight section

Calibration

Calibration of all monitors was made in the laboratory with 380 MHz signal. We set an antenna at the position (X,Y) and measured the four electrode outputs A,B,C,D and obtained the normalization of the signals (H,V) as H=(A+D-C-B)/(A+B+C+D) and V=(A+B-C-D)/(A+B+C+D). Measurement was made at the 273 mesh points in the central area (20 mm * 12 mm with 1 mm step, as indicated in Fig. 1). The setting of the antenna and the data taking procedure were controlled by a microcomputer and the whole process takes 10 minutes for one monitor. We fitted fourth order polynominals of two variables for these 273 mesh data to describe the relation between (X,Y) and (H,V) for each monitor. Using the same data, we also obtained the polynominals of three electrode calibration. It gives the relation between (X,Y) and (H',V'), where H'=(D-C)/(D+C) and V'=(B-C)/(B+C) if we take three electrodes B,C,D. Fig. 3 shows the mapping of the four electrode (normal) calibration and the three electrode calibrations.

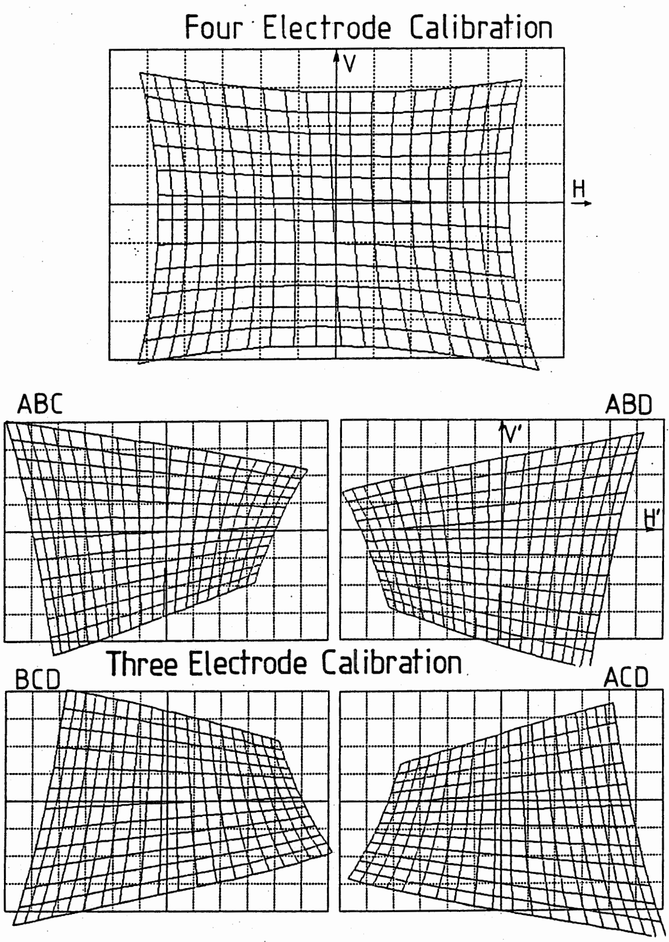

Fig. 3 Calibrations of a monitor chamber

Electronics

The configuration of position monitor electronics is shown in Fig. 4. There are 12 local control buildings around the MR ring and in each of them there are a CAMAC system and a detector circuit. They are linked to the minicomputer in the center control building with a serial highway. Each local control takes care of 30 (or 40) position monitors. Coaxial relay system selects an electrode of each monitor one after another. Then, the beam signal is sent from the selected electrode to the detector circuit through a 3db attenuator and a programable attenuator. The detector circuit consists of a triple stage superheterodyne circuit and a synchronous detector as shown in Fig. 5. The circuit is tuned to 380 MHz, that is, the 3832th harmonics of the revolution frequency (99.3 kHz). The typical parameters of the circuit block are summarized in Table 1. The gain of the head RF amplifier has been reduced to avoid saturation effect since many harmonics components are involved in this stage. On the other hand, the final stage gain has been increased where the single spectrum is expected. The detector output is sent to the ADC circuit (with a module AD1130, Analog Devices) which converts the voltage range from -10V to +10V to 14-bit binary data. The READ data format of the ADC is shown in Fig. 6. The overall output fluctuation is less than 1 LSB. If necessary, we can make the average of the data of 2,4,8,16,32,64 measurements to improve S/N ratio.

Table 1 Circuit characteristics

Stage	Frequency	Amp gain	Filter bandwidth	Mixer loss
RF	380 MHz	14 db	4 MHz	
1st IF	50 MHz	30	1 MHz	9 db
2nd IF	10.7 MHz	30	150 kHz	9
3rd IF	455 kHz	50	19 kHz	9

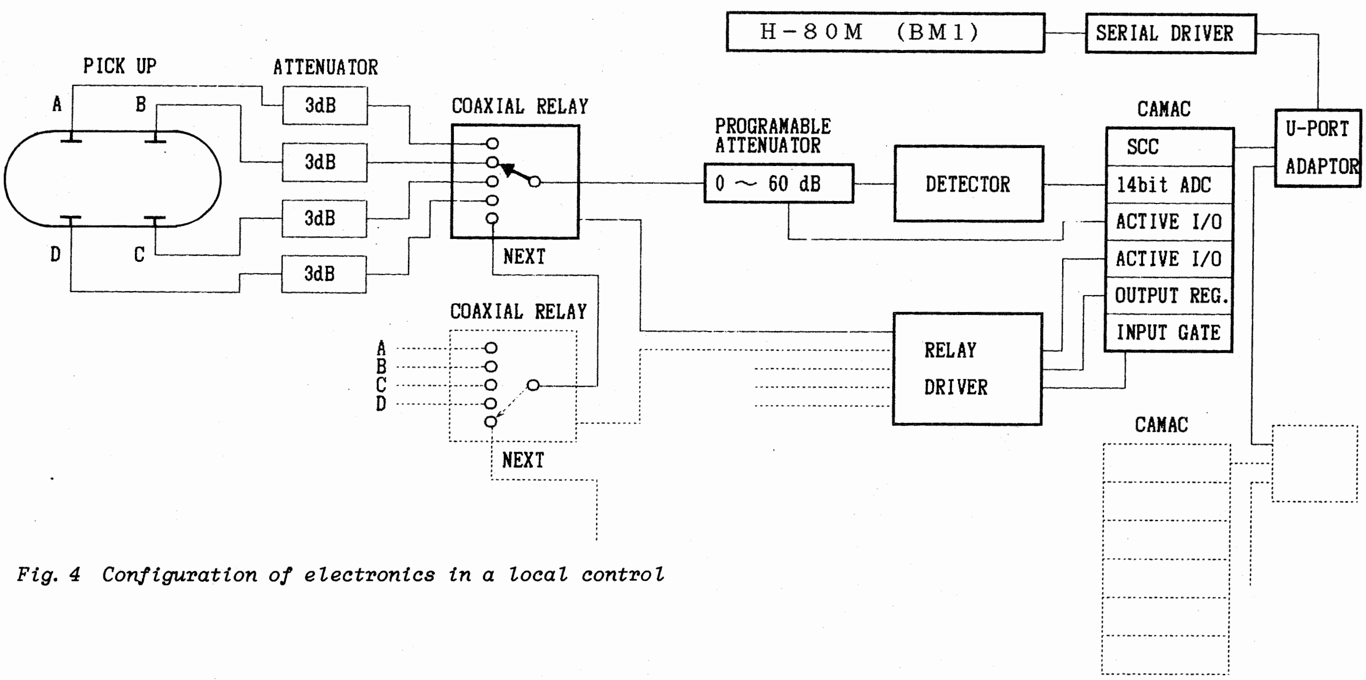

Fig. 4 Configuration of electronics in a local control

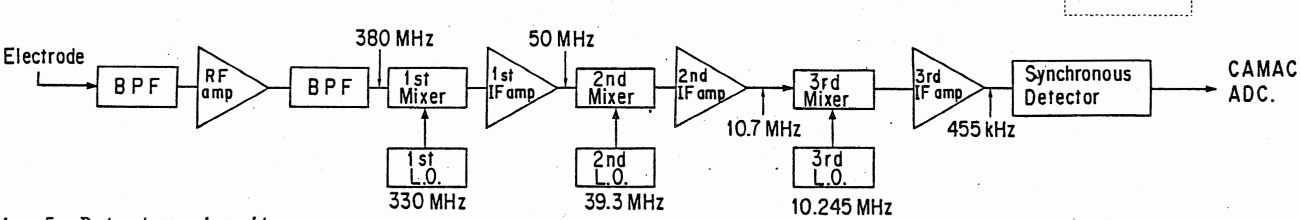

Fig. 5 Detector circuit

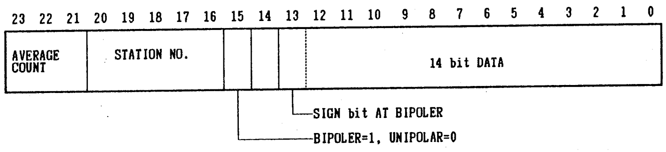

Fig. 6 READ data format of 14bit ADC

Performance

Closed orbit measurement

In the closed orbit measurement, that is, the position detection at all the monitors in the ring, measurement goes on parallelly in twelve local control rooms. The whole measurement takes about 72 seconds. Occasionally we have a false position data because an error occurs in the measurement of one or other electrode voltage. In order to avoid the error we always compare the position obtained by four-electrode normalization and the ones from other three-electrode normalizations. They do not agree if the error occurs. In such a case we repeat the measurement.

Multibunch operation

The harmonics detection system has been designed originally for a single bunch operation. When, in the physics run, counterrotating two electron and two positron bunches exist in the ring, the monitor gives the average position of all beams. If the four bunches have the same intensity, the harmonics component of the beam signal varies along the ring as shown in Fig. 7. We notice that we can measure the beam position even in the colliding area where the independent observation of colliding beam pulses is usually difficult. This feature is very useful because we can make a fine orbit adjustment in the collision region to optimize the luminosity or reduce the detector noise. In the actual operation we adjust the programable attenuator to keep the same signal level for each monitor.

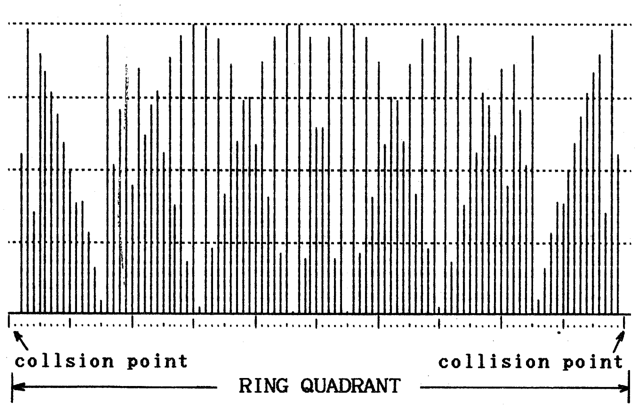

Fig. 7 Relative intensity of 380 MHz component in a superperiod (ring quadrant)

Software program

The operation of the monitor system is controlled by a 16-bit minicomputer (HIDIC 80M). Closed orbit measurement procedure is executed by simply calling a single NODAL function as "CALL BMCOD(X,Y,S)". The NODAL function then refers several data tables which contain the calibration functions of all the monitors, addresses of the CAMAC modules, the attenuation setting and the relay address of each monitor. When the function is called, the number of relay operations and the number of errors are counted up in the data table.

Maintenances

Experience indicates that most measurement errors are due to the trip of coaxial relay contact. Therefore, the accumulated history of error occurrence helps us find wrong relays. Fig. 8 shows an example. Errors are found almost equal frequency in the region governed by the local control D-8. (Several monitors are dead from the beginning and give always false results.) In such a case it is most likely that the relay at the last of the signal line is wrong. Actually this trouble disappeared by replacing the doubtful relay.

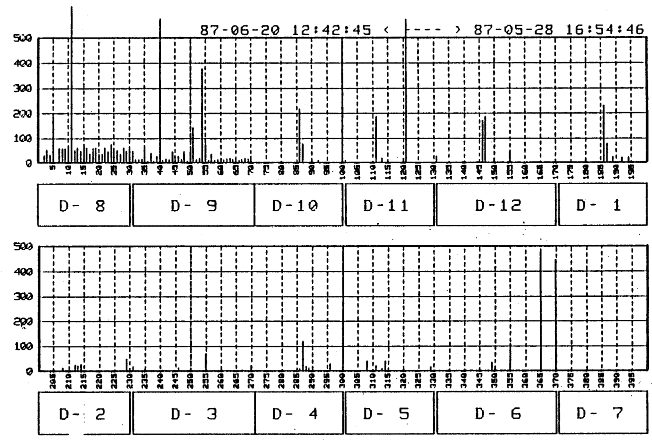

Fig. 8 Error occurrence in two weeks (High peaks appear at the dead monitors. D8 etc. means the local control building which covers the area indicated by the frame.)

The relay trouble or some other problem in the signal line is also monitored by a 'cable tester' circuit as Fig. 9. It sends current into the signal line and monitor the voltage at the input If there is some problem in the cable connection, impedance of the line changes and the voltage deviates from the normal value. We can check the whole monitor in the center control room in 10 minutes.

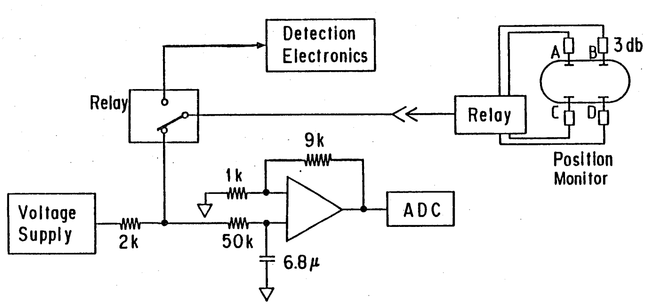

Fig. 9 Cable tester circuit

References

[1] T.Ieiri, H.Ishii, Y.Mizumachi, A.Ogata, T.Shintake andM.Tejima, "Performance of the Beam PositionMonitors of the TRISTAN Accumulation Ring", Proceedings of the 5th Symposium on Accelerator Science and Technology p.154 (Sept. 1984) Tsukuba, Japan

[2] H.Ishimaru, T.Momose, K.Narushima, H.Mizuno, K.Kanazawa, H.Watanabe and M.Shimamoto"All-Aluminum Alloy Vacuum System for TRISTAN e+e- Colliding Beam Ring", ibid p.239