Abnormal beam-induced signals in the button-electrodes of the beam position monitors of TRISTAN MR

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Abstract

When the bunch intensity of the TRISTAN Main Ring exceeds the level of about 1mA (6E9 ppb), abnormal burst pulses appear in the position monitor electrodes from about 10 nsec after the passage of beam bunch. They cause errors in the beam position measurements. The polarity of abnormal signals are mostly negative and they appear mainly in the RF cavity regions. We can suppress them with the bias voltage of about 290 Volts of either polarity. The cause of the abnormal signals is not clear yet.

Introduction

It is three years since the operation of TRISTAN Main Ring (MR) started. During this period, the beam position monitor system has worked reliably and beam orbit measurement has been made more than 2700 times. The reliability is partly due to the error rejection software in the orbit measurement procedure [1]. The record of error occurence is stored in the computer and it provides us with useful informations for the maintenance work.

From about last year (1988) we noticed the increase of error occurrence. The record shows that the error is far more frequent in the RF straight sections than in the bending sections as shown in Fig.1. Usually, the cause of error has been false contact in coaxial switches or some other problem in the circuit components. However, we found that the measurement error is induced by the abnormal signal which appear in the monitor electrode itself when the beam intensity is high. Therefore, the problem has got evident with the advance of machine performance.

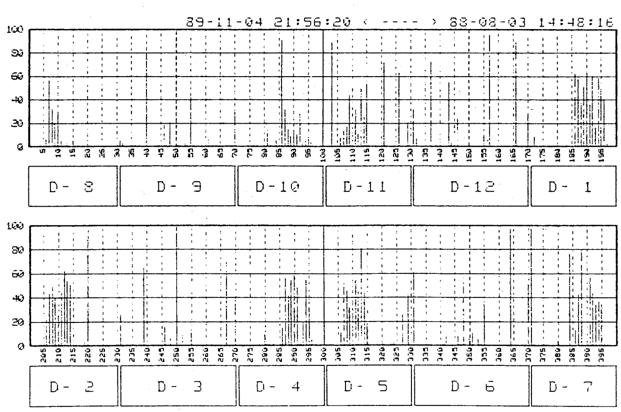

Fig 1 Error percentage in the position measurement in the TRISTAN MR

Observation of abnormal signal

Fig 2 shows an example of the abnormal electrode signal at high beam intensity. Overall observation on whole monitors are summarized in Table 1, from which we notice the following general features;

(F1) The abnormal signal appears when the bunch current exceeds the level of about 1mA.

(F2) They appear with time delay of about 10 nsec after the beam, and then repeats several times.

(F3) The polarity of the abnormal signals are negative either for electron or for positron beam.

(F4) They appear mainly in the straight sections and specifically near RF cavities.

(F5) The magnitude of the abnormal signals seems to be sensitive to the bunch shape; it grows as the beam energy goes up and is largest nearly when the bunch length is minimum. The abnormal signal becomes very small or disappears when two beams are brought into collision at the top energy.

(F6) Waveforms of the abnormal signal are not the same for e+ and e- beams.

(F7) Waveforms of the abnormal signals in the four electrodes of one monitor are not the same as is shown in Fig. 3.

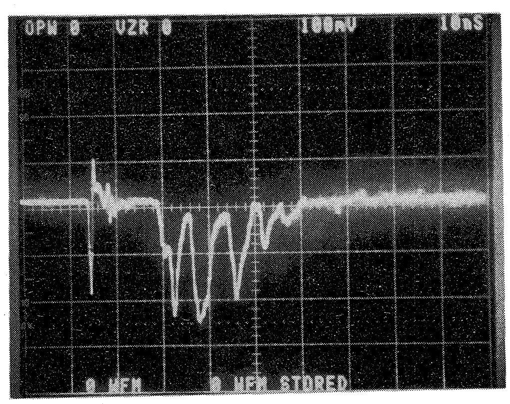

Fig. 2 Waveforms of beam signals and abnormal signals in a button electrode

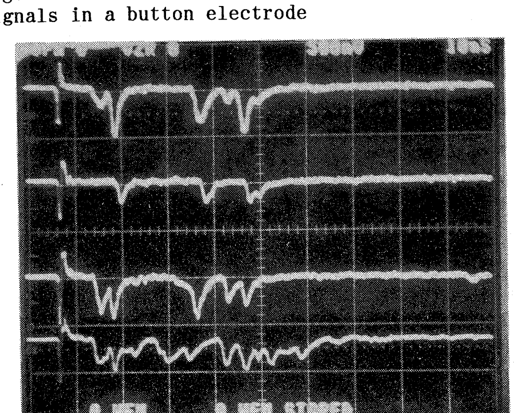

Fig. 3 Waveforms of beam signals and abnormal signals in a button electrode

Although above features are observed for the majority of monitors, there are exceptions for the items (F3) and (F4) as are indicated in Table 1; There are a few number of abnormal monitors in the bending sections. They seems to gather around several particular places in the lattice (QS5, QF11 etc). Two monitors at the location of QC3 quadrupole are in the straight but not RF section and they give positive signals. .

Table 1 Distribution of abnormal output in the MR position monitors

Position	Ring Octant								
	Tsukuba		Oho		Fuji		Nikko		
Monitor	L	R	L	R	L	R	L	R	
QCS									
QC1		N	N	N	N	N	N	N	DC Separater
QC2		N	N	N	N	N	N	N	
QC3	N	+	+	N	N	N	N	N	
QC4	N	N	N	N	N	N	N	N	
QC5	-	-	-	-	-	-	-	-	RF Section
QC6	-	-	-	-	-	-	-	-	
QRD1	-	-	-	-	-	-	-	-	
QRF2	-	-	-	-	-	-	-	-	
QRD3	-	-	-	-	-	-	-	-	
QRF4	-	-	-	-	-	-	-	-	
QRD5	-	-	-	-	N	N	N	-	
QRF6	-	-	-	-	N	N	-	-	
QRD7	-	-	-	-	N	N	-	-	
QRF8	N	N	N	N	N	N	-	N	Bending Section
QS1	N	N	N	N	N	-	N	N	
QS2	N	N	N	N	N	N	N	N	
QS3	N	N	N	N	N	N	N	N	
QS4	N	N	N	N	N	N	-	N	
QS5	-	-	-	N	N	N	-	N	
QS6	N	N	N	-	N	N	N	N	
QS7	N	N	N	N	N	N	N	N	
QF1	N	N	N	N	N	N	N	N	
QD2	N	N	N	N	N	N	N	N	
QD3	N	N	N	N	N	N	N	N	
QD4	N	N	N	N	N	N	N	N	
QD5	N	N	N	N	N	N	N	N	
QD6	N	N	N	N	N	N	N	N	
QD7	N	N	N	N	N	N	N	N	
QD8	N	N	N	N	N	N	N	N	
QF9	N	N	N	N	N	N	N	N	
QD10	N	N	-	N	N	N	-	N	
QF11	N	N	-	-	N	-	N	-	
QD12	N	N	N	N	N	N	N	N	
QD13	N	N	N	N	N	N	N	N	
QD14	N	N	N	N	N	N	N	N	
QF15	N	N	N	N	N	N	N	N	
QD16	N	N	N	N	N	N	N	N	
QF17	N	N	N	N	N	N	N	N	
QD18	N	N	N	N	N	N	N	N	
QF19	N	N	N	N	N	-	N	-	
QD20	N	N	N	N	N	N	N	N	
QF21	N	N	N	N	N	N	N	N	
QD22	N	N	N	N	N	N	N	N	
QF23	N	N	N	N	N	N	N	N	
QD24	N	N	N	N	N	N	N	N	
QW1	N	N	N	N	N	N	N	N	
QW2	-	-	N	N	N	N	N	N	
QW3	N	N	-	N	N	N	N	N	
QW4	N	N	-	N	-	N	N	N	

N:Normal Waveform
-:Abnormal Waveform of Negative Porality
+:Abnormal Waveform of Positive Porality

Experiments

Since the observed features suggest the presence of some kind of discharge phenomenon, we applied the bias voltage on the electrode as shown in Fig. 4. Fig. 5 shows the change of electrode current with bias voltage. When the electrode is short-circuited to the ground (V=0), negative DC current flows. When the bias voltage reaches + or - 290V, DC current disappears and, at the same time, abnormal signal disappears. On the other hand, we don't see any effect of the bias voltage on the other electrodes.

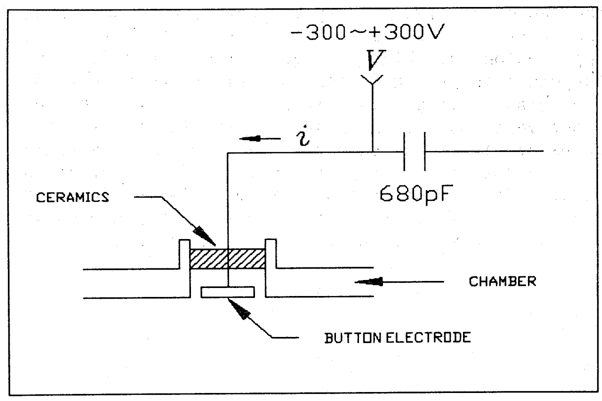

Fig. 4 Measurement scheme with bias voltage

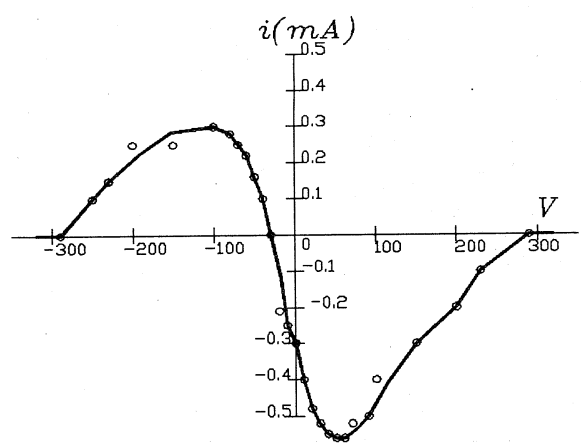

Fig. 5 Effect of bias voltage on electrode current

Discussions

There are several possibilities that might explain the origin of the abnormal signal;
(P1) Propagation of higher order modes of RF cavities,
(P2) Discharge due to wake fields in the monitor electrode structure,
(P3) Ionisation of residual gas along the beam path,
(P4) Photoelectrons from the chamber wall, particularly from notches to protect bellows.
Each hypothesis has its own advantage and disadvantage with respect to the observations (F1 - F7) and the experiments;

The location of abnormal monitors (F4) seems to give strong evidence for P1 and is also favorable for P3 but against P2 and P4. Explanation of the delayed appearance of the abnormal signal (F2)is particularly difficult with P2 and not easy with P1 but possible with P3 and P4. Apparent existence of threshold (F1) and bunch width effect (F5) is favorable for P1 and P2 but unfavorable for P3 and P4. The bias characteristics of Fig. 4 is not easily explained by any possibility.

Practical solutions

Two solutions are possible to avoid the effect of the abnormal signal in spite that we have not found the perfect explanation for it. One is the application of bias voltage to the electrodes and the other is gating of beam signal. The effect of the bias voltage is clear as is shown in the experiment but lots of work in the tunnel will be necessary in the actual installation. Gating seems to be easier from the viewpoint of installation work. On the other hand, we must investigate if there are sufficient interval between the beam pulse and the abnormal signal for any beam intensity.

References

[1] H.Ishii, M.Tejima, T.Ieiri, J.Kishiro, Y.Mizumachi, K.Mori, A.Ogata and T.Shintake:"Beam Position Monitor System of TRISTAN Main Ring" Proc. 6th Symp. on Accelerator Sci. and Tech. p207 (1987), Tokyo