VME COMPUTER MONITORING SYSTEM OF KEK-PS FAST PULSED MAGNET CURRENTS AND BEAM INTENSITIES

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Abstract

For beam transfer from the KEK-PS Linac to the Booster synchrotron ring and from the Booster to the Main ring, many pulse magnets have been installed. It is very important for the machine operation to monitor the firing time, rising time and peak value of the pulsed magnet currents. It is also very important for magnet tuning to obtain good injection efficiency of the Booster and the Main ring, and to observe the last circulating bunched beam in the Booster as well as the first circulating in the Main. These magnet currents and beam intensity signals are digitized by a digital oscilloscope with signal multiplexers, and then shown on a graphic display screen of the console via a VME computer.

1. INTRODUCTION

There are many pulsed magnets and beam monitors which concern beam injection and extraction of the KEK-PS-Booster as well as beam injection of the Main ring. In order to tune the machines and to search trouble points, it is very important to display these signals using proper trigger timing. Because we must select a proper signal and trigger among many connectors and choose a proper time scale, voltage range and trigger level, only a few trained crew members had been able to observe the expected signals within a short time. By using signal multiplexers, a digital oscilloscope with GPIB and a VME computer system, however, we can now observe the expected signals without any great effort using a touch panel of a console desk in the PS-control room.

*When you observe rapid changing figures as a kicker current and a fast beam intensity in the control room, the figure deterioration through a long co-axial cable becomes problem. We have re-shaped the deteriorated figure to the original by the "equalizer" made by Dr.S.Ninomiya. We would like to acknowledge him for his offering of his instrument.

2. PURPOSE OF THIS SYSTEM AND REQUIRED SIGNALS

A. Observing pulsed magnet current

In order to observe the operating conditions of the pulsed magnets, the following magnet currents should be observed with proper time scale:

- For Booster Injection:
  - four Bump magnets in series
- For Booster Extraction:
  - Bump(#1,#2)
  - Septum(#1,#2)
  - Kicker(#1~#4)
- For Main Injection:
  - Septum(#1,#2)
  - Kicker(#1~#5)

B. Checking the magnets' firing timing

For beam transport from the Booster to the Main ring, just after firing the Booster extraction septums and carrying out time-matching of an RF bucket of the Booster ring with one of the Main ring, Booster extraction bumps are fired; after about 20μsec, four kickers are fired at the same time. After a transfer time from the Booster to the Main, firing of five Main injection kickers follows. In order to check these timing, it is convenient to display the concerning magnet currents and a bunched beam intensity with a "mountain view"*.

- For Booster extraction:
  - a mountain view of currents of four kicker magnets and a pulsed beam measured by a wall current monitor (see Fig.1)
- For Main injection:
  - a mountain view of currents of five kicker magnets and a pulsed beam measured by a wall current monitor
- For all pulse magnet fire timing:
  - a mountain view of currents of septums, bumps and a kicker (see Fig.2)

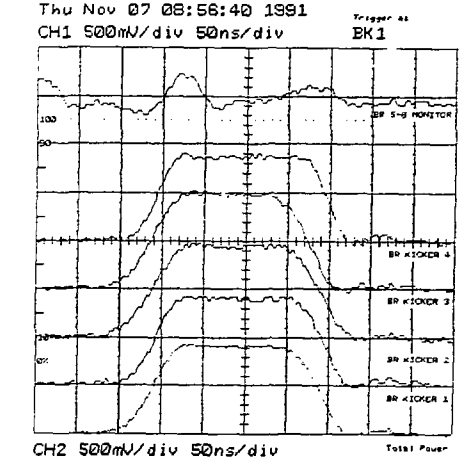

Figure 1. (from top figure to bottom)
A mountain view of currents of a pulsed beam measured by a wall current monitor, currents of four kicker magnet and averaged those four kicker currents

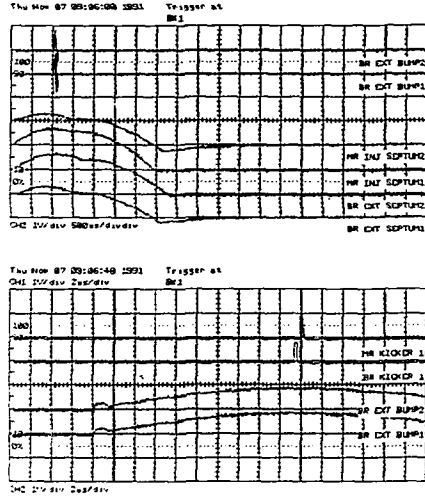

Figure 2. A mountain view of all kinds of pulsed magnets in PS-BT (from top figure to bottom)
Booster Extraction Bump (#2, #1)
Main ring Injection Septum (#2, #1)
Booster Extraction Septum (#2, #1)
Main ring Injection Kicker (#1)
Booster Extraction Kicker (#1)
Booster Extraction Bump (#2, #1)

C. Tuning machine

After tuning positions and emittance figures of a beam at the transport line, final tuning should be carried by observing the injection efficiency of the Booster and the Main. By dividing the Booster circulating beam particle number at injection by the Linac beam particle number, which is calculated by integrating the Linac beam current with time duration, the injection efficiency of the Booster is obtained. And by dividing the circulating particle number at the Main injection by that at Booster extraction, the injection efficiency of the Main is obtained. The fire timing of the kicker magnet should also be adjusted by observing the height of the Booster

bunched beam at extraction and of the Main at injection. The trigger used to observe these monitors can be selected among nine successive Booster extraction beams which inject to the Main ring in the Main injection porch:

- For Booster injection efficiency:
  - Linac beam intensity and Booster particle number measured by a slow intensity monitor (see Fig.3)
- For Main injection efficiency:
  - Booster particle number measured by a slow intensity monitor and the Main particle number
- For Booster kicker firing timing:
  - fast intensity monitor at Booster extraction
- For Main kicker firing timing:
  - fast intensity monitor at Main injection

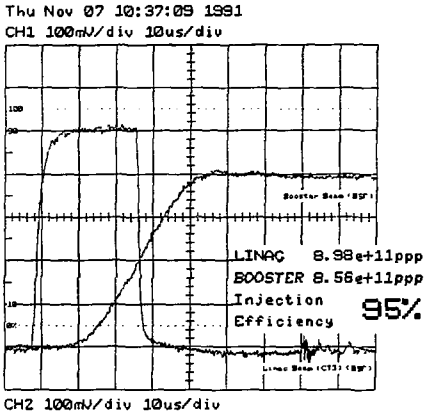

Figure 3. Linac beam intensity, Booster particle number at injection and Injection efficiency

D. Searching for trouble points of the bump and kicker systems

The thyratron used in a bump and kicker power supply has a lifetime when the turn-on timing becomes delayed. When one of the two Booster extraction bump magnets happens to show such a deterioration, the betatron amplitude arising from the bump firing increases. Therefore, two bump currents and ΔR monitor signal in the Booster are needed to check the problem.

Every kicker has a separate delayed trigger circuit, which has low reliability, and sometimes becomes out of order. When one of the kicker currents begins to be delayed, we can distinguish which causes the trouble (thyratron or delayed module) by changing the following trigger:

- For Booster extraction bump trouble (signal):
  - Booster extraction bump currents and ΔR monitor signal
- For kicker trouble (trigger):
  - origin of the trigger to fire all kickers
    - for Booster extraction kicker
    - for Main injection kicker
  - output of delayed trigger module after branching from the origin trigger
    - Booster kicker(#1 ~ #4)
    - Main kicker(#1 ~ #5)

3. BLOCK DIAGRAM OF THIS SYSTEM

In order to obtain the injection efficiency precisely, the Linac and Booster intensity, or the Booster and Main intensity, should be evaluated at the same time. Therefore, the Linac and Main intensity are connected to different inputs of an oscilloscope from that of the Booster intensity. The figures changing rapidly as a kicker current are connected to the input via the "equalizer" mentioned in the footnote. All of these input figures are displayed by using a proper trigger, as shown in Fig.4.

4. FUTURE IMPROVEMENT

We are using an oscilloscope with a sampling rate of 250MS/sec; the memory number is 1K words. This number is too small to display the synchrotron oscillation by taking the envelope of the height of the bunched beam train (because of "areasing" of digital oscilloscope).

We will purchase an oscilloscope with greater memory, so that we can display not only the synchrotron oscillation, but also a "mountain view" of a bunched beam train at the Main ring injection with an interval of a quarter of the synchrotron period.

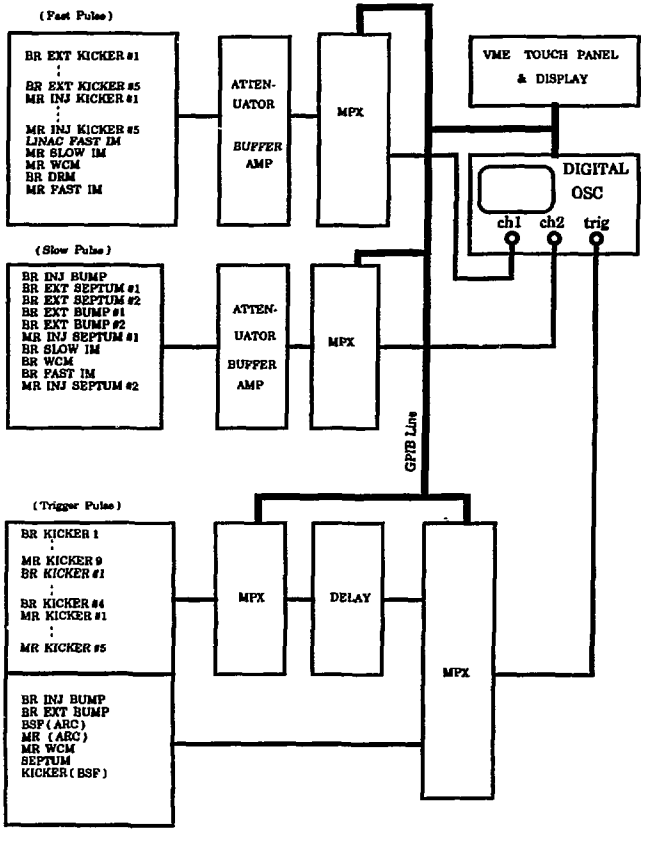

Figure 4. Block diagram for observing system of pulse currents
(BR:booster ring, MR:main ring, IM:intensity monitor, WCM:wall current monitor, DRM:delta R monitor, BSF:booster facilities, MPX:multiplexer)