

# Bunch by Bunch Intensity Monitor for Fermilab Main Ring

Ralph J. Pasquinelli

Fermilab,\* P.O. Box 500, Batavia, Illinois 60510

## Introduction

A Bunch by Bunch Intensity monitor has been developed for the Fermilab Main Ring with future intended use in the Energy Doubler/Saver. (Fig. 1) The input signal is a beam doublet from a quarter wave stripline pickup that varies from 2 to 8 nanoseconds FWHM. Faithfully integrating this pulse will produce an intensity signal proportional to the number of protons per bunch. The technique used is a fast integrate, hold and dump. The intensity output is then made available for digitizing in the Snapshot Digitizer System. Beam losses at various points of the accelerating cycle may then be monitored on a Bunch by Bunch basis.

## Description

A block diagram of the Intensity monitor is depicted in Figure 2. Two inputs are required, a beam doublet from a strip line pickup and a synchronized VCO. It is important that the group delay of both the VCO and beam input lines be identical so as to not change the phase relationship between the two as the RF is frequency modulated during acceleration.

The doublet input dynamic range adjustment is a switched bank of coaxial attenuators. Their selection is based on predicted beam intensity for each accelerator cycle. A beam doublet output is provided on the front panel for use by the pulse width discriminator which has no dynamic range adjustment capability.

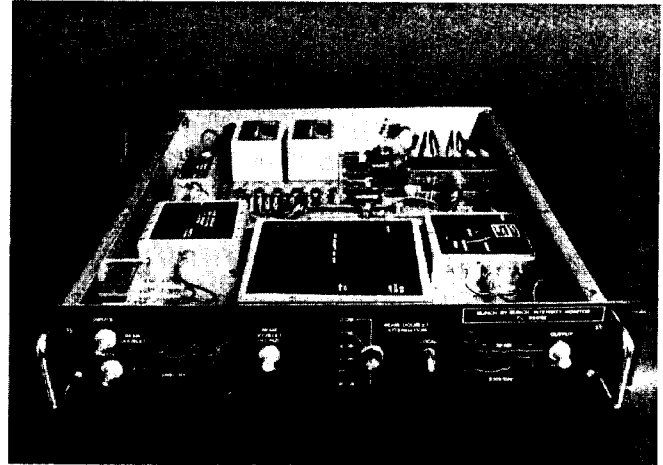


Fig. 1 Photo of Bunch by Bunch Intensity Monitor Hardware.

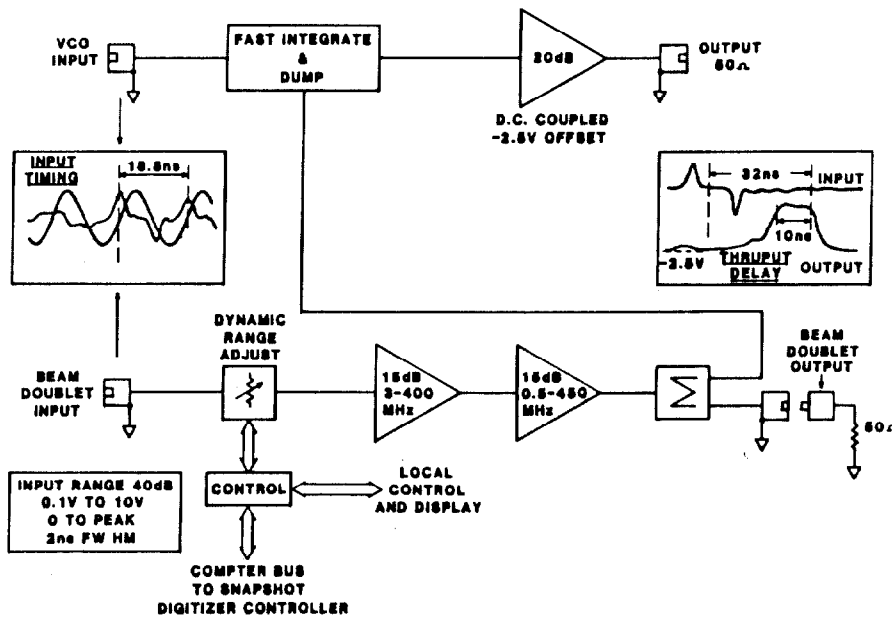


Fig. 2 Block Diagram of Intensity Monitor

\*Operated by Universities Research Association, Inc., under contract with the U.S. Department of Energy.

The fast integrate and hold/dump is the heart of the monitor. (Fig. 3) Beam intensity is directly proportional to the area under the doublet curve. Integration takes place by modulating a voltage controlled current source (VCCS) with the beam doublet input then charging a holding capacitor. The current source is capable of tracking the narrowest beam pulse of 2 NS FWHM yet responds only to one half of the doublet pulse. A doublet has a net area of zero, hence no DC staircasing on the holding capacitor.

The holding capacitor is the parasitic drain source capacitance of 3 MOSFET discharge fets and the buffer's input capacitance. Integration time varies 2 to 8 NS as a function of the beam input pulse widths. Discharge time is 5 NS leaving a hold time of 5 to 11 NS in the 53 MHz period.

The buffered output of the integrator is further amplified and offset to be within a range of  $\pm 2.5V$  for the snapshot digitizer's A/D converter. A sample output is shown on the Block Diagram.

#### Performance

The narrow doublets have more energy in higher Fourier components than do the wide doublets. Although the VCCS is faithful at tracking the beam doublet, the holding capacitance is not constant as a function of frequency. This frequency variation of C's value causes distortion in the integrated output. For this reason a correction factor proportional to doublet pulse width is employed to massage the data before it is displayed. The correction factor is obtained from the pulse width discriminator.<sup>2</sup> Implementation of the correction is nearing completion. Some preliminary results are shown in Figure 4.

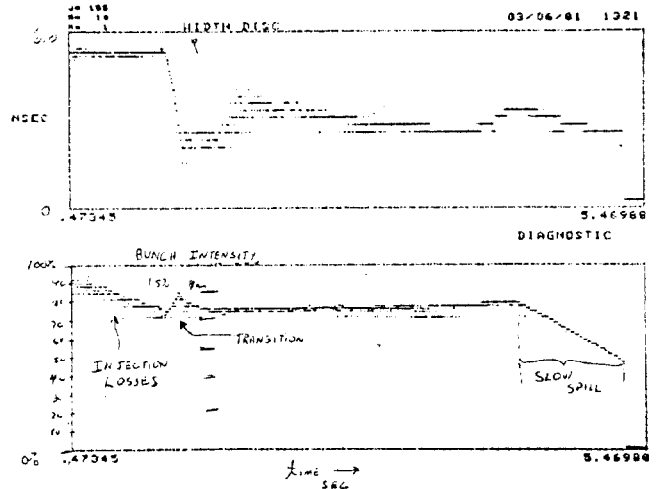


Fig. 4 Preliminary Control Room print out of Intensity and Width for one bunch monitored every 155 machine revolutions.

#### Acknowledgements

The author wishes to thank Peter Seifred for his skillful construction of the monitor.

#### References

1. R.J. Pasquinelli, Snapshot Digitizer System for Fermilab Main Ring Accelerator, IEEE Transactions on Nuclear Science NS-28, No. 3 June 1981.
2. E. Higgins, Longitudinal Beam Signal Processing for the Fermilab Beam Quality Monitor, IEEE Transactions on Nuclear Science NS-28, No. 3 June 1981.

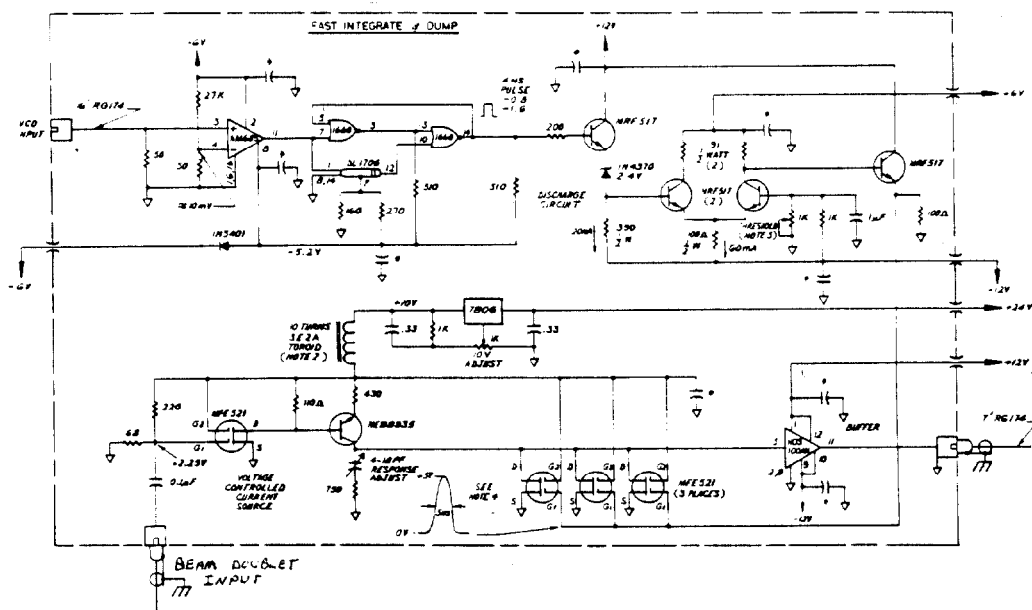


Fig. 3 Schematic for Integrate, Hold and Dump