A Pseudo Real Time Tune Meter for the Fermilab Booster

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Abstract

A tune meter has been developed and installed for the Fermilab Booster. It is capable of measuring the tunes in two planes over the energy ramping cycle with an accuracy of 0.001 and measuring chromaticicities in pseudo real time. For each plane this system uses one stripline pick-up type BPM and one single turn ferrite kicker. Data acquisition, processing and control is implemented in a VMEbus based system as an integrated part of the Fermilab Accelerator Controls Network (ACNET)[1] system. The architecture enables the tune measurement and control to be contained in one intelligent system. Here we will present architecture, software, results

I. INTRODUCTION

The Fermilab Booster [2] presently operates over an energy range of 200 Mev to 8 Gev at 15 Hz cycle. The nominal betatron frequencies in the horizontal and vertical planes are $\nu_x = 6.7$ and $\nu_y = 6.8$ respectively but vary substantially over the cycle because of changes in the synchrotron lattice functions. A correction-magnet assembly consisting of a horizontal and vertical dipole, a quadruple and a skew quadruple is placed in each short and each long straight section. The quadruples and skew quadruples are designed to accommodate the space-charge tune shift at injection and to control the tune against inherent resonances and the coupling resonance of the horizontal and vertical oscillations over the entire cycle. Historically tune control in the Booster has been a difficult job because the tune measurement is slow and unreliable. Also, the tune measurement and tune control was not implemented in an integrated system. The new tune meter described here measures both the horizontal and vertical tunes over the entire energy ramping cycle in pseudo real time. The new architecture provides tune measurement and control in an integrated system with the control system.

II. ARCHITECTURE

Fig. 1 is a block diagram showing architecture of the tune meter. A CAMAC controlled sub-system pulses the kicker at a programmed frequency, duration and amplitude to keep the beam excited throughout the cycle. The turn-by-turn beam position analog signals for the entire cycle, after passing a band-pass filter are captured and digitized in the ADC board[3]. The data for a whole cycle is moved to a DSP memory board and is Fourier transformed into frequency spectrum of consecutive windows. The DSP board also finds amplitudes and positions of peaks in the frequency spectrum. After this is done the results are buffered and the system is enabled again for next beam cycle. All these activities are controlled by the VME host processor, a Motorola VME133XT, which is in

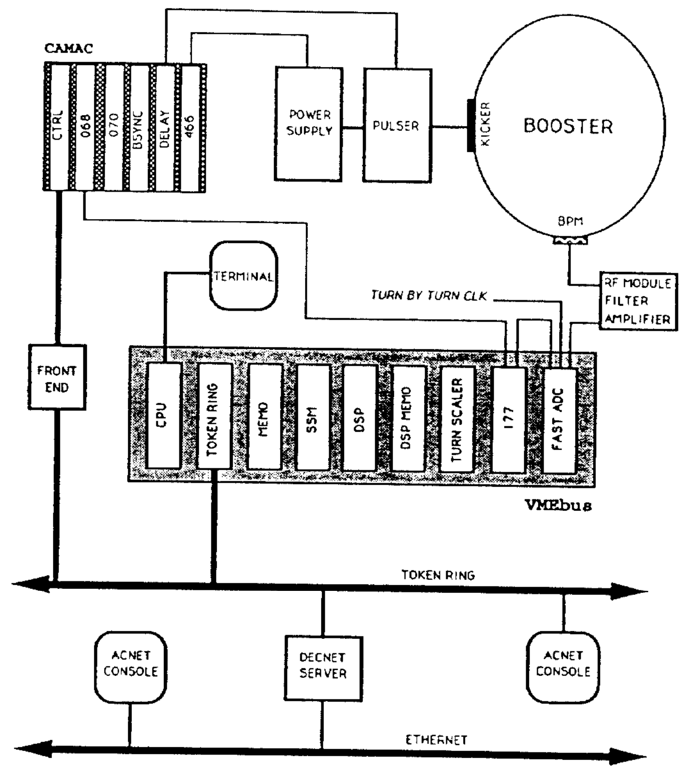

Fig. 1 The tune meter system diagram

turn commanded by an interactive application program running on one of ACNET consoles. Communications (commands, status information and data) between the console and the VME crate are done by the standard ACNET system.

III. SOFTWARE

Two user programs make the system function as desired. One is a micro-processor program which resides in the VME133XT and the other is a application program in a VAX console. Fig.2 shows the basic flow chart of the micro-processor program. The software environment of the tune meter consists of a standard set of tasks for data acquisition running under the MTOS operating system. The interface between these standard tasks and the micro-processor program written by the user is a protocol called Object Oriented Communications (OOC)[4]. The console program acts as a master while the micro-processor program is the slave. The micro-processor program performs sequential operations coordinating actions of all the VME boards; acquiring, processing and moving data according to commands received

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from the console. The menu driven console program sends

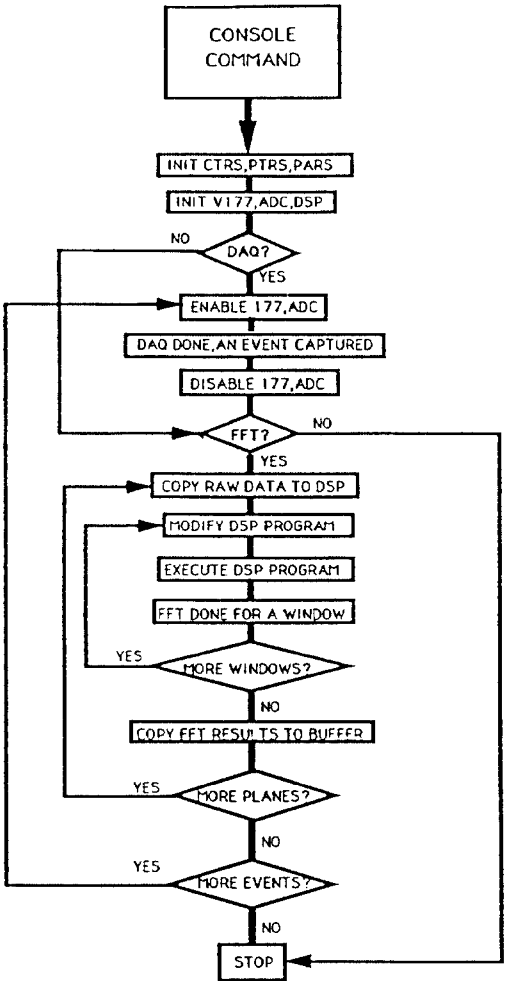

Fig. 2 The micro-program flow chart

command settings and reads status or data from the micro-processor program. Thus, the console program has access to control devices so it can control the kickers for tune measurements and change correction quadruples strength setting to excise tune control over the cycle.

IV. RESULTS

The tune meter is now being used regularly for measuring tune and chromaticity. Shown in Fig. 3 are on-line displays of the fractional tune in horizontal plane. In Fig. 3-a about 50 beam cycles were measured at the same beam conditions. For Fig. 3-b, as the beam intensity changed so did the tune. Fig. 3-c shows the tune responding to the changes in ramping current in the correction quadruples. For these measurements, the beam was kicked every 1 millisecond or about every 550 turns, the high voltages applied to the single turn kicker magnet was about .5 KV at the beginning of cycle and 1.5 KV at the end. With such kicker strength (about .87 Gauss at the beginning and 2.57 at the end) the effect on the beam transmission throughout the cycle is negligible. For each cycle of data (about 20000 turns), the DSP did the Fourier Transformations 40 times, each time 512 words to give one tune measurement. The system's dead time, when operated

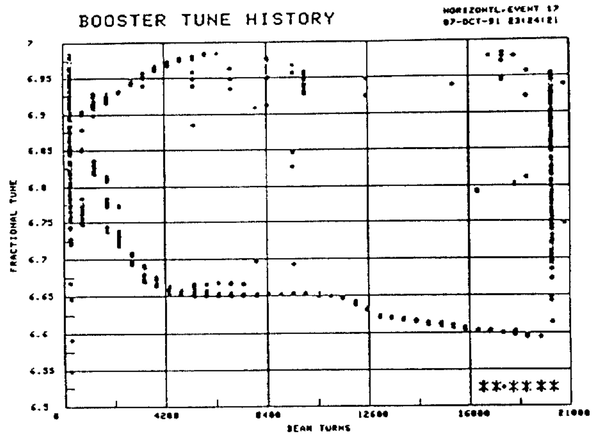

Fig. 3a on-line display of horizontal tunes,50 cycles

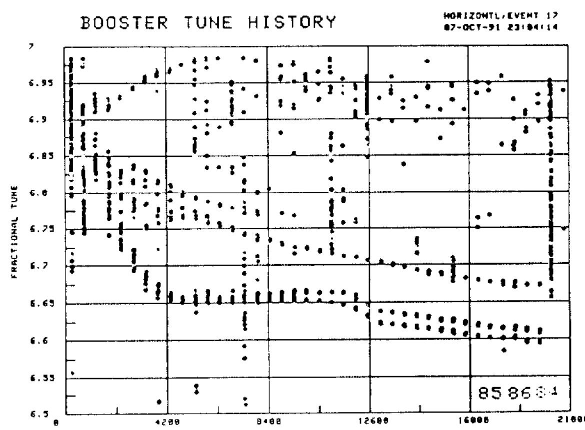

Fig. 3b Tune display as beam intensity changed

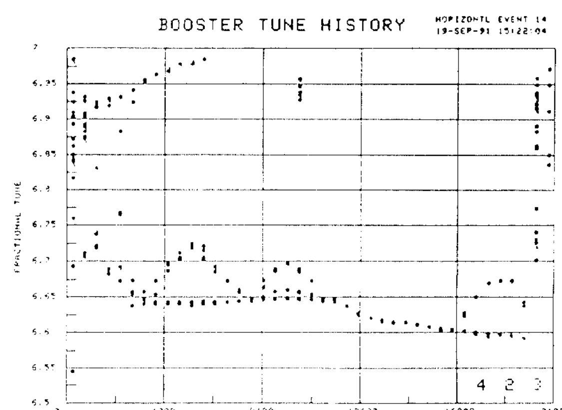

Fig. 3c On-line display of tunes responding to the changes in corrector ramping current.T.

under these conditions, is about one third of a second during which the DSP is processing data and the ADC is prohibited data taking for next beam cycle. While there are rooms for further optimizations, the quality of tune measured and speed of the measurements as shown are practically good enough for both tune measurements and controls

Fig 4 shows horizontal chromaticities throughout a Booster cycle, containing data for seven RPOS (a low level

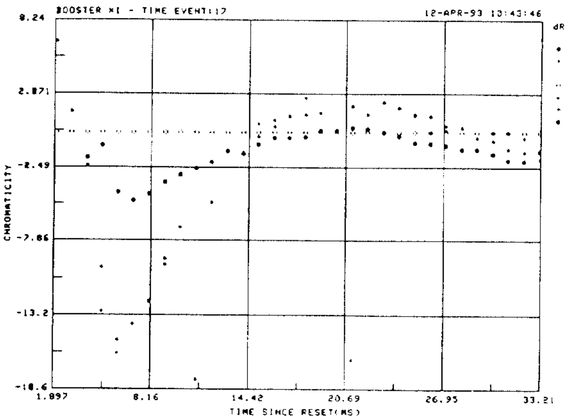

Fig. 4 On-line display of chromaticities.

RF program that controls radial beam position) curve settings. One notice that the data for two RPOS curve settings at extreme are standing apart from the rest. This is clearly an effect of higher order multiple fields where the beam were positioned. In a regular diagnostic measurement of chromaticity we need only take data for two RPOS curve settings, both are near normal orbits but one offset from the other.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

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