NEW FEATURES OF THE ELETTRA BPM SYSTEM

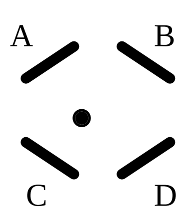
R. De Monte, M. Ferianis
ELETTRA, Sincrotrone Trieste, Italy

Abstract

The detector for the ELETTRA Beam Position Monitor (BPM) system is based on a multiplexed receiver which demodulates the beam induced signals at 500 MHz.
During routine operation a strong dependence of the single BPM readings on the actual beam conditions has been observed particularly when low frequency oscillations (LFOs) are present in the longitudinal plane. In this paper the observed data are presented and the proposed solution is described. The method consists of measuring the LFOs with the already installed annular electrode and applying a correction signal to the newly developed IF stage of the BPM receivers. To allow a more flexible commissioning and operation of this system, a dedicated micro-processor based board has been developed. This newly designed unit manages the annular electrode receiver as well as its communication with the BPM Equipment Interface Units (EIUs). Preliminary results of the new system are also presented.

1 THE PROBLEM'S ORIGIN

The detector for the ELETTRA BPM system detects the electric field intensity originated by the electron beam. The position is detected demodulating the signal's amplitude difference from the four electrodes. This function is actuated by a pin diode multiplexer. The timing's sequence is A, B, C, D, each electrode for 1mS.



Since the Elettra's beam under certain conditions presents some size and longitudinal instabilities at low frequencies (less 2 kHz), the signal sampled by the multiplexer isn't the same for the four electrodes also when the beam centre isn't moving. In addition to this it's important to remember the typical shape of this instability. In fact the typical shape is the sawtooth, as is possible to observe in the digital scope diagram above

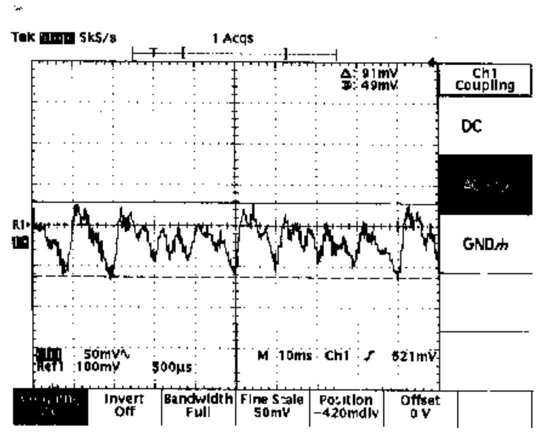


Diagram 1

This signal has been observed demodulating in amplitude the signal from an annular electrode. The most important characteristic of the annular electrode is (as the names say) that the beam signal is picked up all around, so the amplitude of this signal is position independent. Referring to the BPM detector simplified block diagram, this signal has been observed putting the signal of the annular electrode in place of the electrode 'A' input signal, and stopping the multiplexer on this input.

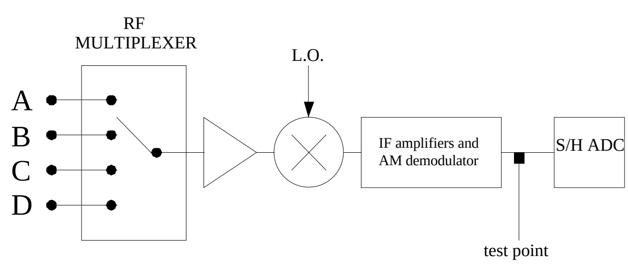


fig.1

Reporting this signal in to a multiplexed-electrode sequence (as shown in fig. 2)we obtain an instability in position reading also when the beam centre is still.

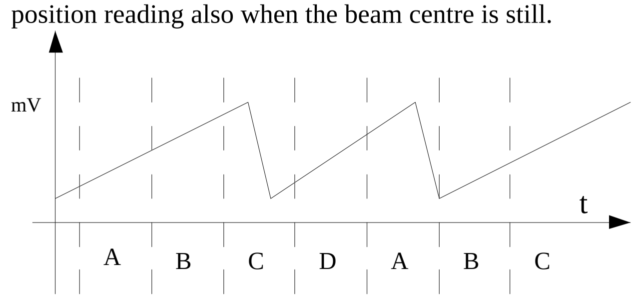


fig.2

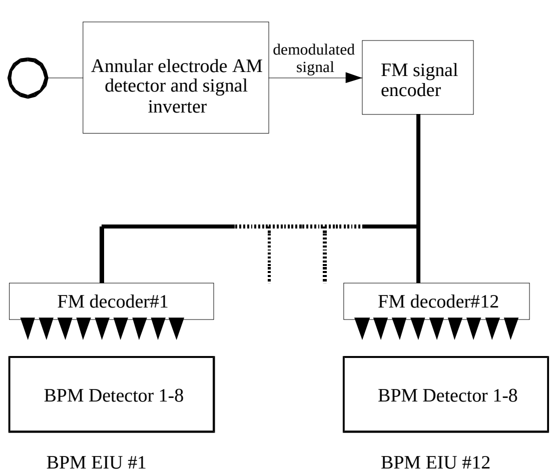
2 THE FIRST SOLUTION

This effect has been reduced via low level software, so the position value returned to the system request is a mean of n (from 10 to 1000) samples. This method isn't always sufficient to reach the 5μm position reading stability. These depend from multiple factors: oscillation's frequency, phase versus the multiplexing frequency, instability's shape and intensity. Since the BPM system return the mean value, an RMS value is also calculated. This value represents the current amplitude of the beam instabilities and it's used to adjust the Elettra's beam to the best performances. Till now this system has been used successfully, but sometimes, due to particular user's requirements more position reading stability has been requested.

3 THE INNOVATIVE SOLUTION

3.1 System overview

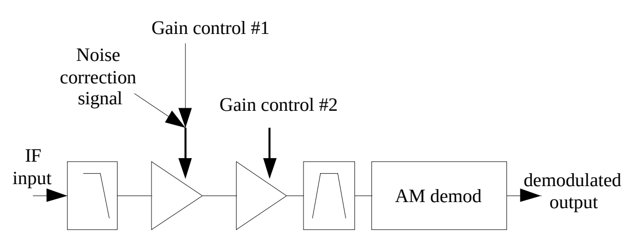
We have observed that these instabilities have the same shape with different amplitude around all the storage ring. These mean that it's possible to detect this noise only in one point of the ring using one annular electrode. It is possible also to rotate by 180 degrees the signal and sum it on the IF signal of all the 96 BPM detectors around the ring to compensate directly on the analog detected signal the beam instabilities. To transport this signal around the service area, to all BPM EIUS, multiple solutions have been considered. The most important characteristics for the signal transport system around the ring are the ultra high noise immunity and the minimum phase delay. For this reason before some studies and tests a previously digital data transmission has been discarded because it exceeded the phase delay requirements (less 5μ Sec). Transmitting with a coaxial cable a Frequency Modulated signal with a carrier around 100 MHz offer a warranty of very short propagation delay, a good noise immunity versus the service area electrical noise and versus possible grounding loops. This system is currently under development and test.



3.2 New Intermediate Frequency module

The actual IF stage (shown in the simplified diagram above) uses two adjustable gain amplifiers made with discrete components. One low noise, dual gate mosfet transistor (BF966) has been used for each amplifier stage, and each stage is tuned around the 10.7MHz IF frequency. In this circuit the gain versus the control voltage isn't constant, the gain varies with a quasi logarithmic function. The software running on the EIU performs the low-level adjustments via successive approximation algorithm.

The best point where to sum the noise signal inverted by 180 degrees is the gain control voltage. But to do this with a good accuracy, a linear and stable response of the gain versus the gain control voltage is required. So we have decided to change the amplifier part using an Analog Devices monolithic IC AD602 that contains two 40dB gains controlled amplifiers. This low noise variable gain amplifier has a gain variation response of 40dB for 1V on gain control input pin, laser trimmed. With this circuit we have increased a little the noise figure (approximately 10% at the maximum gain) but this means that the measures with beam currents less than 1mA are affected and it's acceptable. Also the AM demodulator has been changed from TDA2148 to XR2208. This change has increased the phase shift noise immunity. In fact, the old TDA2148 circuit uses a LC "tank" to lock the carrier and demodulate the signal, so every phase variation in the signal is seen as an amplitude modulation. Vice versa, the XR2208 circuit is configured as a self extracting carrier from the signal itself, so any frequency or phase variation in the signal doesn't affect the AM demodulated signal output.



4 THE ANNULAR DETECTOR

4.1 General overview

The annular detector is a custom BPM detector controlled by a special CPU. In fact this detector needs a CPU to control the AGC signals and to maintain it always at the maximum circuit's signal to noise response.

4.2 The analog part

The analog part is very similar to that of the BPM detector except that the RF multiplexer is missing. This is requested by the fact that the noise signal has to be detected in the same way, and above all with the same bandwidth response as the other 96 BPM detectors. The signal from the annular electrode comes in to an RF stage that filter the signal with a bandwidth of 10 MHz as the standard BPM RF input block, then with a RF mixer and a Local Oscillator at 510.7Mhz the frequency is scaled down at 10.7Mhz. Then this signal is putted in a standard IF stage module.

4.3 The digital part

The digital part has been developed, as the rest of the system, by the Elettra Instrumentation group. The core of this part is a RISC single chip CPU SH-1 by Hitachi. This 20 Mhz single chip CPU has inside two RS232 communications ports, four general purposes programmable timers, eight 10bit AD converters, a complete DMA system, a complete Programmable Interrupt Controller (PIC), a complete bus controller and 3 per 8 bit general purpose ports. The software running in an EPROM and with two 14bits Digital to Analog converters, it controls the IF gains, and with digital ports the RF input gain switch. The software, written in ‘C’ language is able to perform also various tasks as a statistic, means and some others' computations and communicate the data via the RS232 port to the Elettra Control system.

5 CONCLUSIONS

Since Elettra is now working in “High brilliance mode” that means the beam is very stable with an acceptable life time, this system is normally not necessary. However, in certain cases when the beam users require some others beam conditions, or during some machine physics experiments, this system may be useful to maintain a stable orbit.

6 REFERENCES

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[3] R. De Monte et al., “Elettra BPM system (Hardware and Software); first results”, proceedings of the EPAC 94 London.