BEAM POSITION MONITOR FOR THE LNLS UVX SYNCHROTRON LIGHT SOURCE

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The beam orbit measuring system for the LNLS UVX ring is presented. The system consists of 24 strip-line beam position monitors and associated electronics. The beam position monitors (BPM's) are capable of detecting down to 10 mA of stored beam current or 100 ns-long LINAC injection pulses (single pulse detection mode) with 0.05 mm resolution. Acquisition electronics is divided into two parts: four fast-acquisition channels for the pulsed mode operation (used during injection) and a single PIN-switch multiplexed channel for CW operation (closed orbit measurement). Experimental results obtained on a characterization bench are presented and compared with theoretical estimates.

I. INTRODUCTION

The LNLS is building a 1.15 Gev electron storage ring. The injector is a 100 MeV, traveling wave LINAC and the RF frequency is 476.000 MHz when accelerated up to final energy. One of important parts of the diagnostic system is the BPM, which is used to measure two important machine characteristics: the path of the pulsed beam during injection and closed orbit in the normal operation modes. These two different requirements led us to construct two separate electronics. Both electronics are discussed in this paper, along with the mechanical characteristics. The main parameters of the LNLS BPM are listed in Table 1

Parameters	Minimum	Maximum	units
Beam current	2	200	mA
Horizontal range	-20	20	mm
Vertical range	-20	20	mm
Resolution	< 0.050		mm
Accuracy	< 0.050		mm
Harmonic frequency	476.000		MHz
LO Frequency	466.000		MHz
Acquisition rate	500		Hz
Pulsed mode			
Pulse length	100	-	ns
Acquisition rate	-	100	Hz

Table 1 - LNLS beam position monitors parameters

II. MECHANICAL CHARACTERISTICS

The BPM is made up of four cylindrical strip-lines of 45° with respect to plane of orbit to avoid synchrotron radiation. The inner diameter is the same as the ring vacuum chamber diameter as is shown schematically in Figure 1. The pick-up length is a compromise between the desired sensibility to measure the pulsed beam from the LINAC and the available physical space.

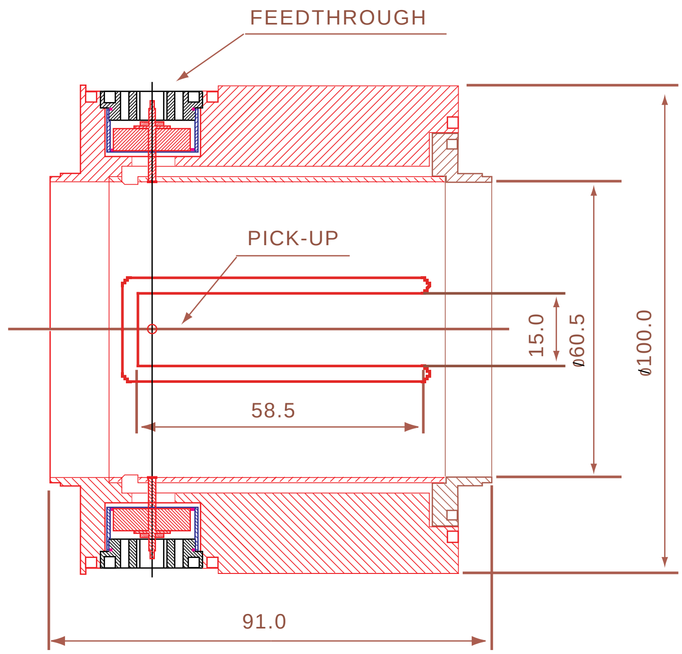

Figure 1a - BPM schematic drawing

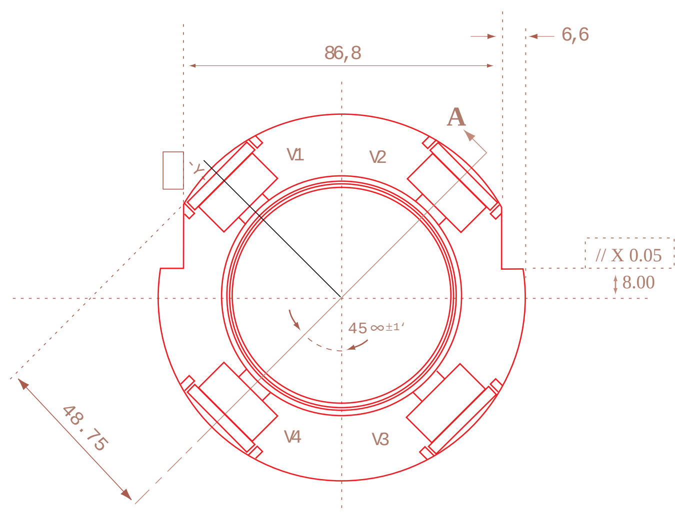

Figure 1b - BPM schematic drawing

The pick-up signals are collected by means of special bakable, vacuum compatible, 50 Ω male-SMA feed-throughs. The feed-throughs are made of stainless steel in order avoid damage after a standard brass SMA-female has been connected to it many times. The feed-through drawing is showing in Figure 2.

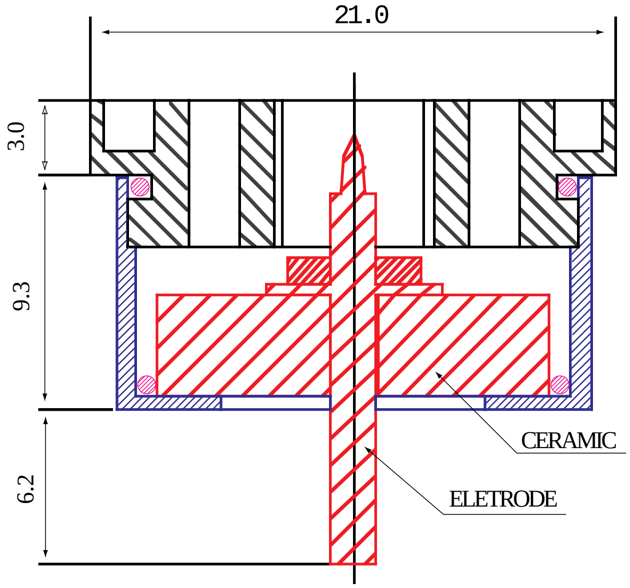

Figure 2 - BPM schematic drawing

III. CHARACTERIZATION BENCH

The characterization bench was specially constructed to move an RF antenna inside the BPM. The maximum resolution is 5 µm in both axes X and Y, and movements are possible using two stepper-motors. The schematic drawing is shown in Figure 3. To minimize electromagnetic interference the bench was placed inside of a shielding box.

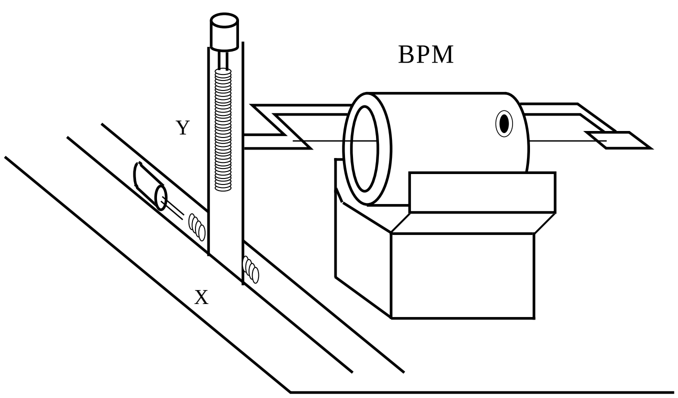

Figure 3 - Characterization bench

In order to detect mechanical zero, a DC voltage is applied to the antenna and the stepper-motors are used to displace the antenna along the horizontal and vertical axes, until it touches either side of the detector's wall. The accuracy of this procedure is limited by the accuracy of the digital rule (0.005 mm) used to determine the position of the antenna. Four semi-rigid 0.141" standard coaxial cables, transfer the signal from the pick-ups to the electronics.

IV. ACQUISITION ELECTRONICS

The RF signals from the pick-ups are equalized separately using 3 dB on-board attenuators and PIN-switches (part number MSWA-2-20, Mini-Circuits) which operate up to 1 Ghz with 1.2 dB attenuation @ 500 MHz.

The BPM electronics for the pulse mode operation consists of four fast-acquisition channels. All signals from the switches are selected and amplified simultaneously in four wide-band amplifier, and the pulse recovered by an integrator. A track-hold and a sample-hold circuit, working in conjunction, convert the pulse into a proportional DC signal. The BPM electronic block diagram is shown in Figure 4. This circuit is able to operate, synchronized with the same clock, and at the maximum LINAC repetion rate (30 Hz).

The closed orbit measurement (CW operation) uses a different circuit. The topology adopted is a super-heterodyne tuner with conventional detection. This circuit delivers the X,Y and sums signal (rather than merely four signals proportional to the voltages induced on the antennas) for further processing by a computer. This approach allows shorter acquisition time.

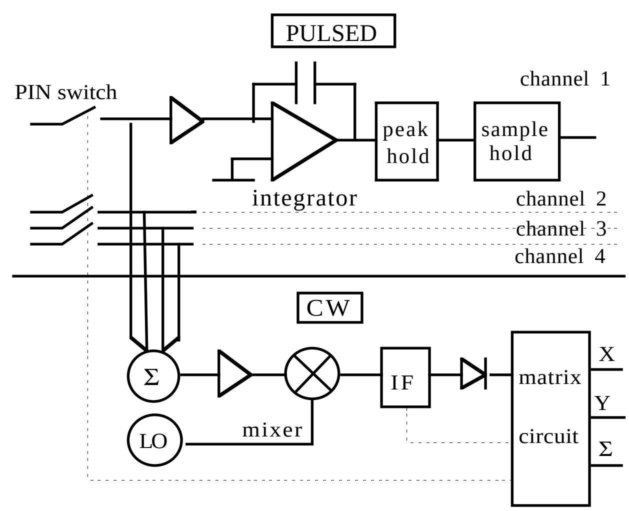

Figure 4 - Electronic block diagram

V. MEASUREMENT RESULTS

Figure 5 shows the absolute value of the measured impedance of a single pick-up as a function of frequency.

$$Z_{pu}(\omega) = \frac{V_{pu}(\omega)}{I(\omega)}$$

Were, $V_{pu}(\omega)$ is the voltage on the antenna and $I(\omega)$ the excitation current. The theorical value is also shown.

$$\left|Z_{pu}(\omega)\right| = \frac{\psi_0}{\pi}\frac{Z_0}{2}\sin\left(\frac{\omega L}{c}\right)$$

Were ψ_0 is half of the angle of the strip-line, Z_0 is strip-line impedance and L the strip-line length.

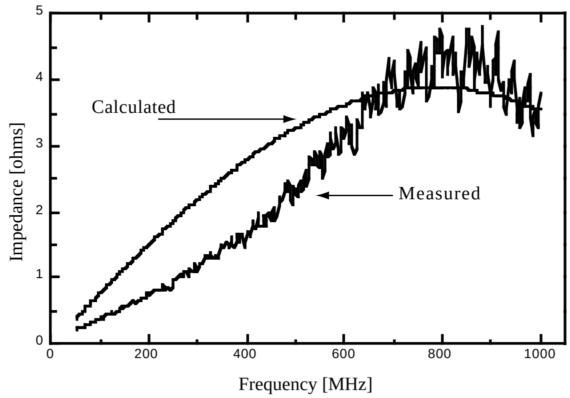

Figure 5 - Impedance response

The Figure 6 shows the contour lines of functions:

$$V_x(x,y) = \frac{V_2 + V_4 - V_1 - V_3}{V_1 + V_2 + V_3 + V_4}$$

$$V_y(x,y) = \frac{V_1 + V_2 - V_3 - V_4}{V_1 + V_2 + V_3 + V_4}$$

Where V_1, V_2, V_3 and V_4 are the voltages induced in the pick-up antennas as shown in the Figure 1 a. These functions were obtained by means of a two-dimensional spline fit to a grid of measured points (step size = 5 mm).

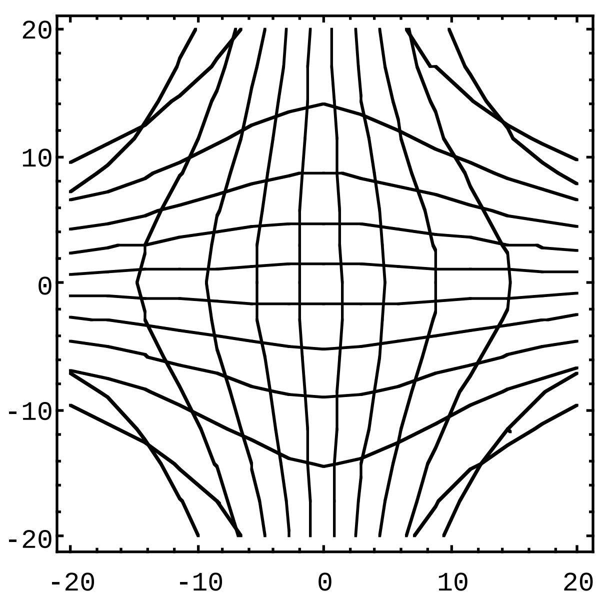

Figure 6 - BPM calibration mapping, showing the relation (x,y)/(vx , vy) in an area of 40 X 40 mm

Figure 7 shows the relative desviation (respect straight line) of the horizontal V_x (x,0) as function of position inside the monitors. The graphic shows one side of the monitor in the X direction, and the same is observed in other directions.

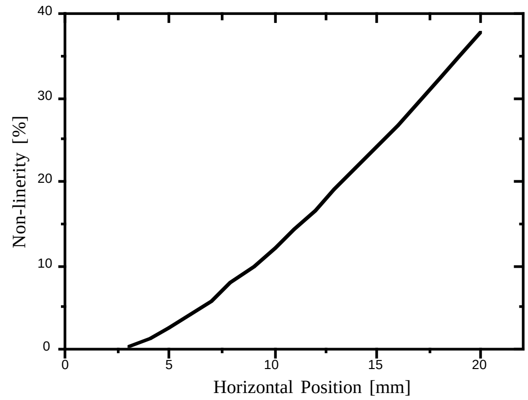

Figure 7 - Non-linearity mapping

VI. Conclusion

The measurements made in the BPM system constructed at LNLS, show the ability to measure the closed orbit at the desired accuracy. The resolution of the electronic system can be increased for a smaller working region, just by changing the gain of the matrix circuit in the output stage. The non-linearity will be compensated by means of pre-mapping of the monitor cavity as shown before, where the polynomial coefficients, necessary to solve the position equations in the computers were obtained.