UNIVERSAL BCT MONITOR FOR INR PROTON LINAC PULSE BEAM

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The INR Proton Linac accelerated beam is now in the range of 10…12 mA pulse current, 0.3…200 µs pulse duration and 1…50 Hz repetition rate. The various beam pulse durations are important for nuclear experiments and medical applications. To provide both short and long beam pulse measurements special current monitor is developed. New Universal Beam Current Transformer (UBCT) monitor and electronics are described. The results of beam pulse measurements are presented.

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1. INTRODUCTION

To satisfy both fundamental and applied research requirements it is necessary to accelerate in INR Proton Linac beam pulses in the range 0.3…200 µs with edge times from 100 ns to 10 µs. The measurements of these pulses should be realized by means of a special beam current transformer. New Universal Beam Current Transformer (UBCT) monitor is developed and implemented in the linac. It should measure beam pulses in the full range of the beam parameters.

UBCT construction and electronics are described. Results of UBST testing on the beam are presented.

2. UBCT CONSTRUCTION

The simplified scheme of UBCT construction is shown in Fig.1.

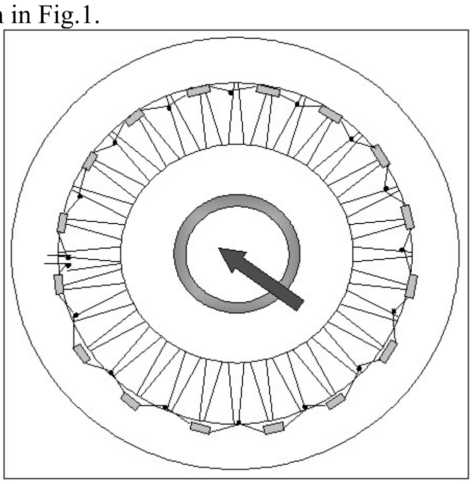

Fig1.Simplified construction of UBCT

It has 64 turns winding on ferromagnetic tape toroidal core. Every 4 turns are shorted by 15 Ohm resistors. This set of resistors enables to decrease oscillations of BCT output signal [1]. Electromotive forces and currents of all turns are equal to each other if a beam is in a centre of a core. But there is no equality if beam position is not centred. Beam displacement is the reason of output signal oscillations because turn currents are not equal in this case and some waves arise in spiral line of beam transformer. These waves interference do not permit to see a time structure of a short pulse. The set of resistors should suppress this interference. Main conditions for the interference suppressing are 1) R<<Z_w, where R is resistor value between turns, Z_w is wave impedance of BCT spiral line without the set of resistors, 2) nR>>r, where n is quantity of R in UBCT winding, r is resistance of UBCT loading.

3. UBCT MONITOR ELECTRONICS

The schematic diagram of electronics is shown in Fig.2. The electronics consists of 20 MHz preamplifier installed in the vicinity of the UBCT and main amplifier and calibrator located outside the linac tunnel.

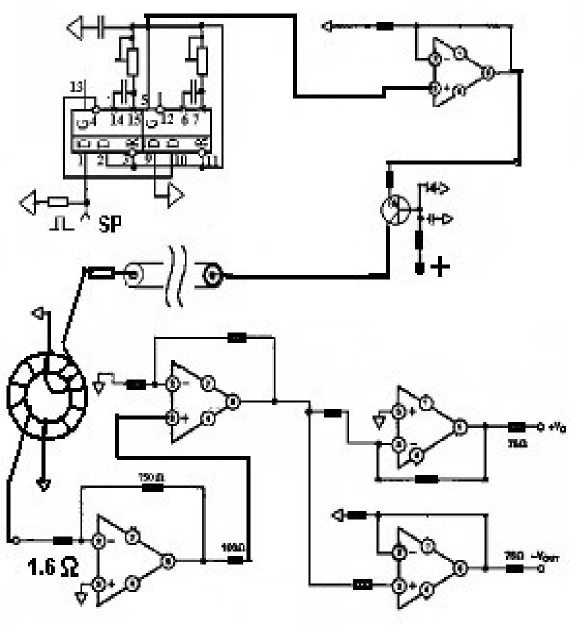

Fig.2. UBST electronics simplified circui

The preamplifier has one input and two symmetrical outputs for subtraction of cable interference at the input of main amplifier. The time constant τ of flat top damping is equal to L/R_{in}, where L is inductance of BCT and R_{in} is input resistance of the preamplifier. This time is long enough in our case to observe beam pulses up to 200 µs without distortion. The high frequency distortions are defined by time constant of wave spreading in UBCT. The waves pass through set of resistor and this process takes a few ns. Main amplifier has bandwidth 15 MHz and symmetrical input. Hence, the bandwidth of the system is defined by the amplifier. The circuits of the preamplifier and the amplifier are similar. The controlled calibrator tests UBCT and electronics. The level of the calibration signal on the UBCT, defined by the source of current on bipolar transistor, is equal to 20 mA and can be changed by means of regulation of emitter circuit resistor. The calibration pulses with duration 0.25 μs and 200 μs are used for the UBCT monitor verification.

4. RESULTS

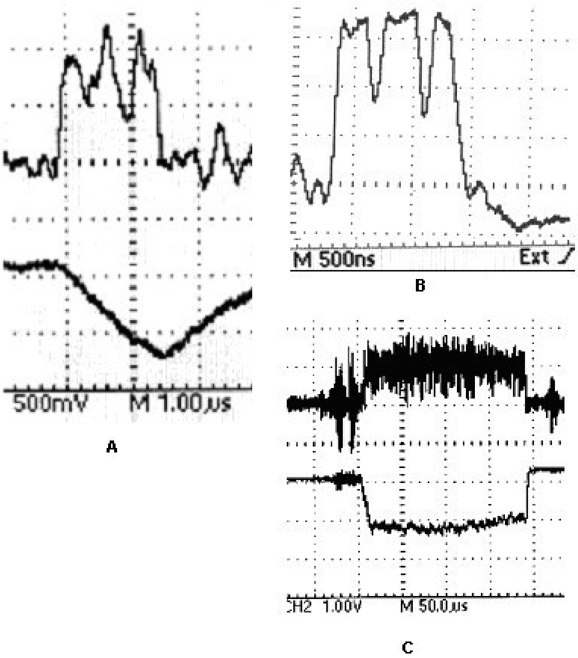

Fig.3. Time structures of different beam pulses

Short pulses (0.3…5 μs) are formed in the injection line by means of beam pulse shaping system. Amplitude of the accelerated beam pulse equals to 10…12 mA. Time profiles for different beam pulse durations are shown in Fig.3. **A** and **B** figures are 1.5 μs and 1 μs beam pulses, respectively; **C** figure is 190 μs beam pulse. **B** figure is the beam pulse measured by wall-current monitor (WCM), installed in the 400 keV injection line. **A** and **C** figure is the 160 MeV beam pulses.

The comparisons between UBCT and standard BCT signals are shown in Fig.3**,A,C**. As easy to see standard BCT with its electronics cannot measure edges of short pulses and top fluctuations of short and long beam pulses. The constant of flat top damping of WCM is too short to observe pulses with durations more than a few microseconds. UBCT observes edges and top fluctuations in the full range of the beam pulse durations from 0.3 μs to 200 μs.

5. CONCLUSION

The new UBCT monitor allows observing of the structure of short and long beam pulses with high time resolution and should be used for beam adjustment and regulation.

REFERENCES

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УНИВЕРСАЛЬНЫЙ МАГНИТОИНДУКЦИОННЫЙ МОНИТОР ИМПУЛЬСОВ ПУЧКА ПРОТОНОВ ЛИНЕЙНОГО УСКОРИТЕЛЯ ИЯИ РАН

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В настоящее время на линейном ускорителе ИЯИ РАН ускоряются импульсы протонов с амплитудой 10…12 мА, длительностью 0.3…200 мкс и частотой посылок от 1 до 50 Гц для проведения различных физических экспериментов. Для измерения параметров как коротких, так и длинных импульсов разработан и установлен на ускорителе специальный индукционный датчик тока пучка. В работе приводится описание этого датчика и его электроники. Представлены результаты измерений импульсного тока протонов.

УНІВЕРСАЛЬНИЙ МАГНІТОІНДУКЦІЙНИЙ МОНІТОР ІМПУЛЬСІВ ПУЧКА ПРОТОНІВ ЛІНІЙНОГО ПРИСКОРЮВАЧА ІЯІ РАН

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У цей час на лінійному прискорювачі ІЯІ РАН прискорюються імпульси протонів з амплітудою 10...12 мА, тривалістю 0.3...200 мкс і частотою посилок від 1 до 50 Гц для проведення різних фізичних експериментів. Для виміру параметрів як коротких, так і довгих імпульсів розроблений й установлений на прискорювачі спеціальний індукційний датчик струму пучка. У роботі приводиться опис цього датчика і його електроніки. Представлено результати вимірів імпульсного струму протонів