DIAGNOSTIC MODULE FOR THE RADIATION BEAM SYSTEM "TEMP-B"

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The power module designed for the calibration and adjustment of the units and components of microsecond accelerator of relativistic electron beams (REB) "Temp-B" has been developed and manufactured. The noise immune gauge of high charging voltages of the terminal capacitors used by four-channel pulse voltage generator (PVG) and the discharger operating in the broad band of charging voltages have been manufactured. The methods developed using the module and the manufactured noise immune gauge of high charging voltages were applied to the accelerator "Temp-B".

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INTRODUCTION

The diagnostic module was manufactured to adjust updated and new manufactured elements of the "Temp-B" accelerator. It allows for simulation of the processes that occur in the accelerator of relativistic electron beams and it is equipped with all the required control devices and elements.

The available method of charging the high voltage capacitors of pulse voltage generators with the control of input charging voltage fails to provide reliable information on the charge of pulse voltage generator due to voltage losses and leakages in accelerator elements. The operation of the "TEMP-B" accelerator showed the need for the control of the charging voltage of the capacitors of pulse voltage generators. The voltage control at the terminal capacitors of four – channel pulse voltage generator allows for the control of the charging process and the generation of identical charging voltages in each channel of PVG.

DESCRIPTION

The power module was manufactured to develop the methods of diagnostic measurements. It consists of input high voltage transformer URS-70, laboratory transformer PHO 250-5, high-voltage voltage multiplier, thyratron discharger start-up block and the discharger. The thyratron trigger circuit shapes the short pulse of 15 kV and that results in the actuation of the discharger of capacitor bank. The structural design of the discharger allows it to operate steadily in the range of charging voltages of 5 to 90 kV. The gap between the electrodes is 8 mm and the gap between the main electrode and the control electrode is 2 mm. The control electrode is made of stainless steel of 1.5 mm thick in the form of a disk with the aperture in the central region. Fig. 1. gives the external view of the discharger. A decrease in the gap between the electrodes allows us to reduce the discharger inductance and the current buildup front. Maximum parameters of the module are as follows: charging voltage is up to 90 kV, the discharge current is up to 50 kA, and the current buildup front is – 600 ns.

Fig. 2 gives the block-diagram of the diagnostic module. The experimental investigations of the parameters of high-energy slowing down X-radiation carried out using the "Temp-B" accelerator as a simulation device of the reactor zone require to control high charging dc voltage of the capacitors of pulse voltage generators.

Fig. 1. High-voltage discharger

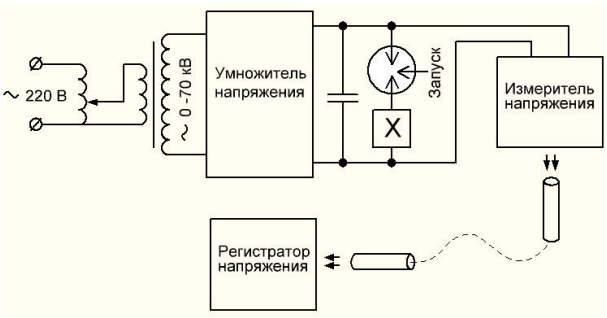

Fig. 2. A block diagram of the diagnostic model

Such modes of operation of the "Temp-B" accelerator require generating high-current beams with the current of tens of kA and the particle energy of ~ MeV [1].

Such parameters are achieved using the four-channel pulse voltage generator. Each channel contains 19 high-voltage capacitors, charging resistances and appropriate dischargers. Charging resistances were made of the sections of vinyl tubes filled with the NaCl water solution. The external view of pulse voltage generator is given in Fig. 3.

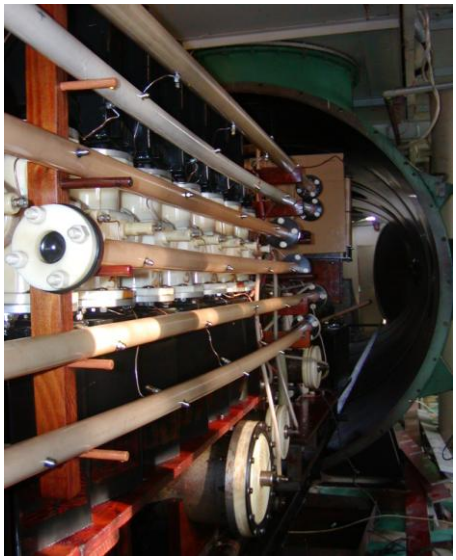

Fig. 3. Pulse voltage generator

The capacitor charging process allowed us to establish that the values of charging resistances are changeable because of changes in temperature and in the chemical purity of solution. This results in different charging time of PVG channels. The measurement of the voltages of terminal capacitors of each channel allows us to control the charging process. The high dc voltage is usually measured using the high-resistance divider fabricated in compliance with the requirements set to the high voltage equipment.

Operation of the "Temp-B" accelerator is characterized by the availability of transient currents and high voltage jumps. As a result, electromagnetic fields are formed near the experimental plant that can create interference inductions in metering devices that considerably exceed the signal measured. Therefore, it is necessary to place the metering equipment at a certain distance from the accelerator arranging it inside the shielded enclosure. The availability of large alternating magnetic fields creates a big problem for communication lines made of screened coaxial cables due to the so-called earth loops. A change in the magnetic field can induce large voltages in such loops. The use of light-emitting diode as the communication line allows for a considerable improvement of the noise immunity and the safety of personnel working in a high voltage environment.

The high voltage meter was fabricated using the relaxation transistor generator in the avalanche mode [2] that allows for a rather easy voltage-to-pulse repetition frequency conversion. Such a circuit allows us to get the conversion accuracy of the order of tenth fractions of the percent. The stable operation of this circuit is achieved due to the self-regulation of the difference in threshold voltages [3].

The high-voltage meter diagram is shown in Fig. 4. To shape the rectangular current pulse that runs through the LED the accumulating LC-line was used that allows us to generate the current pulse of ~ 120 mA with the duration of ~ 5 μs [4]. The light signal receiver was made using the phototransistor and the dedicated microcircuit 1054 HAZ that shapes the standard rectangular pulse. This pulse actuates the pulse repetition rate-to-voltage converter. The frequency converter was realized using univibrator 155 AG1 and the sensing head with the full-scale deflection current of 300 μA. Such a diagram allows for the measurement of capacitor voltages to 80 kV. The measurement accuracy was equal to 0.5 % and the sensing head error was not taken into account.

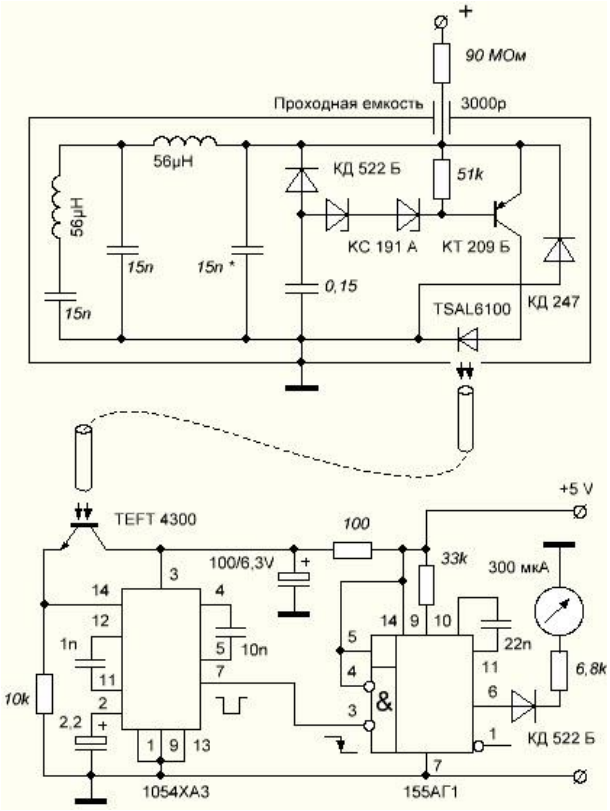

Fig. 4. High-voltage meter diagram

CONCLUSIONS

1. The high-voltage meter is used for the measurement of the charging voltage of PVG capacitors used by the microsecond accelerator "Temp-B" and it allows us to control the charging voltage in each PVG channel. The measurement error is within 0.5 % and the sensing head error is not taken into account.
2. The developed and assembled diagnostic module allows for the operation simulation of the REB accelerator "Temp-B" and it has the following parameters: the charging voltage is up to 90 kV, the discharge current is up to 50 kA and the current buildup front is up to-600 ns.
3. The developed discharger makes it possible to commute the capacitor banks in the diagnostic module in the voltage range of 5 to 90 kV.

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ДИАГНОСТИЧЕСКИЙ МОДУЛЬ РАДИАЦИОННО-ПУЧКОВОГО КОМПЛЕКСА "ТЕМП-Б"

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Разработан и изготовлен силовой модуль для калибровки и отладки узлов и элементов микросекундного ускорителя релятивистских электронных пучков (РЭП) "Темп-Б". Изготовлены помехозащищённый измеритель высокого зарядного напряжения на оконечных конденсаторах четырёхканального генератора импульсного напряжения (ГИН) и разрядник, работающий в широком диапазоне зарядных напряжений. Разработанные на модуле методики и изготовленный помехозащищённый измеритель высокого зарядного напряжения применены на ускорителе "Темп-Б".

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Розроблено та виготовлено силовий модуль для калібрування і налагодження вузлів та елементів мікросекундного прискорювача релятивістських електронних пучків (РЕП) "Темп-Б". Виготовлено перешкодозахищений вимірювач високої зарядної напруги на кінцевих конденсаторах чотириканального генератора імпульсної напруги (ГІН) та розрядник, що працює в широкому діапазоні розрядних напруг. Розроблені на модулі методики і виготовлений перешкодозахищений вимірювач високої зарядної напруги застосовані на прискорювачі "Темп-Б".