VACUUM SYSTEM OF FEL

N.A. Vinokurov, G.Ya. Kurkin, L.E. Medvedev, L.A. Mironenko, A.D. Oreshkov, T.V. Salikova, M.A. Scheglov
Budker Institute of Nuclear Physics, 630090, Novosibirsk, RUSSIA

Abstract

This article describes the vacuum system of powerful teraherz free electron laser constructed in the Siberian Center for Photochemical Research, on the basis of new unique hardware and software developed in our institute. The control system provides monitoring vacuum and conditions of safety at round-the-clock work of the equipment.

EQUIPMENT OF VACUUM SYSTEM

The vacuum chamber of the first stage of the FEL [1] is a closed channel with a volume of approximately 20 m^3, which is served by 34 pumps providing high vacuum. Location of the pumps and vacuum gate valves is shown in Fig. 1. The vacuum gate valves are intended for fast blockage of a damaged vacuum section. The vacuum channel is divided by 31 vacuum gate valves into separate segments, which allows one to block a required segment of the vacuum chamber and to pump the segment independently. Separate pumps serve sites of higher gas evolution:

- The electron gun. The emissive capacity of the hot cathode depends on vacuum conditions.
- RF resonators. The working voltage on a gap of RF resonators reaches 700 kV. Rise and descent of voltage is accompanied by multipactor, which makes vacuum lower.
- The bending magnets. Where the part of beam is lost on walls of the vacuum chamber.
- The dump. Where the recuperated beam with energy 1.5 MeV is absorbed.

Table 1: Parameters of "the reserve block" power supply

output voltage	3 ÷ 7 kV
load current	~ $3*10^{-3}$ A
power consumption	20 W

A group of 5 pumps is connected through a diode uncoupling to a "reserve block" power supply; parameters of the "reserve block" are given in Table 1. Low power consumption and absence of inflammable materials in a design of "reserve blocks" power supply allow to exploit "reserve blocks" continuously round-the-clock without control of duty personnel.

At FEL operation, the vacuum pumps are connected to powerful industrial power supplies BP-138. If the industrial power supplies are switched off, the vacuum pumps automatically connect to the "reserve blocks". The output voltage of the "reserve blocks" is set on 200-400 V lower than that of the industrial power supplies, and thus current consumed from the "reserve blocks" equals zero under FEL operation. A 200 V of voltage decrease at a level of 6 kV practically does not influence the productivity of the pumps. The automatic switching is carried out through a diode uncoupling.

VACUUM MONITORING

At FEL operation, the control system executes monitoring of vacuum and provides protection. The vacuum value (P [Pa]) is defined by the current of the pump (I [A]), since the current is proportional to the pressure of residual gases in the volume (see Eq. 1). The factor C is a technological parameter of the pump.

$$P=I/C \quad (1)$$

Every pump is equipped with an individual current transducer included in the high-voltage circuit between the power supply and the vacuum pump. The transducer transforms current to frequency; technical parameters of the transducer are presented in Table 2.

Table 2: Technical parameters of the current transducer

Linear range with accuracy of 5%	0.5 μA– 20 mA
Conversion factor	5 kHz/mA
Leakage current	< 20 nA
Maximal allowable current of the pump	< 1A

This equipment has been developed to control vacuum inside the RF resonators. The current limit is set by the hardware. If the current of the pump reaches the limit, the RF generator is switched off. The software of the control system has useful features. The program "Vacuum" provides full information about the vacuum system. The arrangement of the vacuum transducers is presented in figure 1, the vacuum profile drawn under the scheme. The program "Vacuum" maintains a logbook; a record is created for each transducer. Periodically, the program "Vacuum" writes the timestamp and maximal and average values of vacuum for each transducer. The "Vacuum" makes sampling from the transducers with a frequency of 1 Hz. If the vacuum value exceeds an individual "yellow" level, this event is fixed in the logbook. If the vacuum value reaches the "red" level, the program switches off the beam.

Besides, the program "Vacuum" allows watching the electron beam passing, since insignificant losses of electrons on the walls of the vacuum channel leads to lowering of vacuum.

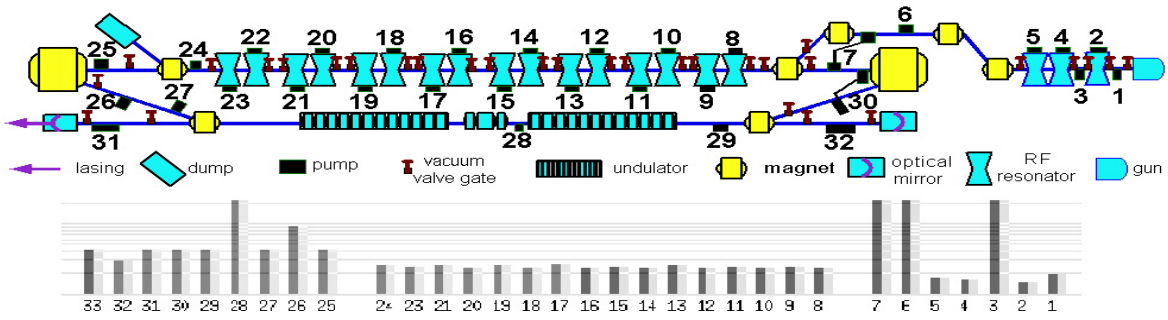

Figure 1: Layout arrangement vacuum pumps and ”vacuum profile”.

The program "Vacuum" has three regimes to visualize the state of vacuum:

- The first regime reflects values of vacuum in the locations of the pumps.
- The second regime shows the difference of the instant and previous values of vacuum (the derivative $I_{(t)} - I_{(t\text{-}1sec)}$).
- In the third regime, At a certain moment all vacuum’s values are taken for «control points», differences between the current values of vacuum and «control points» are display. For example, a moment when there is no beam in the microtron can be taken as «control point», and then one can trace on the «vacuum profile» the places of partial losses of the beam. Besides, it is possible to search the places where the vacuum chamber has been damaged.

FURTHER DEVELOPMENTS

It is planned to construct the second stage of the FEL. four paths will be mounted, which will allow working with 50 MeV beam. The design of the second stage of the FEL bases on the same principles as its first stage. 11 pumps will be installed:

- 1 pump for 3 meters of the vacuum channel.
- 5 pumps are served by 1 “reserve block” power supply.
- Hardware and program check vacuum values and provide protection.

REFERENCES

[1] Bolotin V.P., Vinokurov N.A., Kayran D.A., Knyazev B.A., Kolobanov E.I., Kotenkov V.V., Kubarev V.V., Kulipanov G.N., Matveenko A.N., Medvedev L.E., Miginsky S.V., Mironenko L.A., Oreshkov A.D., Ovchar V.K., Popik V.M., Salikova T.V., Serednyakov S.S., Skrinsky A.N., Shevchenko O.A., Scheglov M.A. “Status of the Novosibirsk terahertz FEL”. Nuclear instruments and methods in physics research. Sec. A. 2005. Vol. A543, No. 1. - pp. 81-84.