RADIATION DOSIMETRIC DIAGNOSTIC SYSTEM OF A FEL

E.A. Kuper, A.D. Oreshkov, A. V. Repkov, T.V. Salikova, D.A. Sklokin, S.V. Tararyshkin, N.A. Vinokurov
Budker Institute of Nuclear Physics, 630090, Novosibirsk, RUSSIA

Abstract

This article describes the radiation monitoring system of the powerful teraherz free electron laser constructed at the Siberian Center for Photochemical Research on the basis of new unique hardware and software developed at Budker institute. The control system provides environment monitoring and radiation safety.

INTRODUCTION

The full-scale free electron laser is to be constructed on the basis of a four-orbit 50 MeV microtron-recuperator [1]. The first stage of the FEL is working now. It contains a full-scale RF system but has only one orbit. The arrangement of the microthron-recuperator is shown in Fig. 1. The electron gun creates electron bunches with an energy of 300 keV, which enter the injector. The 2 MeV beam from the injector passes through RF resonators, acquires the energy of 12 MeV, and arrives to the FEL (undulator). After interaction with radiation in the FEL the beam passes through the accelerating structure once more, returning the power, and arrives to the dump. Parameters of the microtron are listed in Table 1. The places of higher dose rate are the RF resonators, bending magnets, and dump. Radiation sensors are installed there.

Table 1: Mcrotron-recuperator parameters.

RF frequency	180 MHz
Number of RF cavities	16
Amplitude of accelerating voltage at one cavity	700 kV
Injection energy	2 MeV
Final electron energy	12 MeV
Maximum average current	20 mA

Our institute has developed a radiation monitoring system using two types of radiation sensors on the base of ionization chambers. The first type transducers register radiation at the natural background level of 10 μR/h. They are located in the rooms where people work. The second type transducers register radiation at the level of 1 R/h. They are located in the accelerating hall.

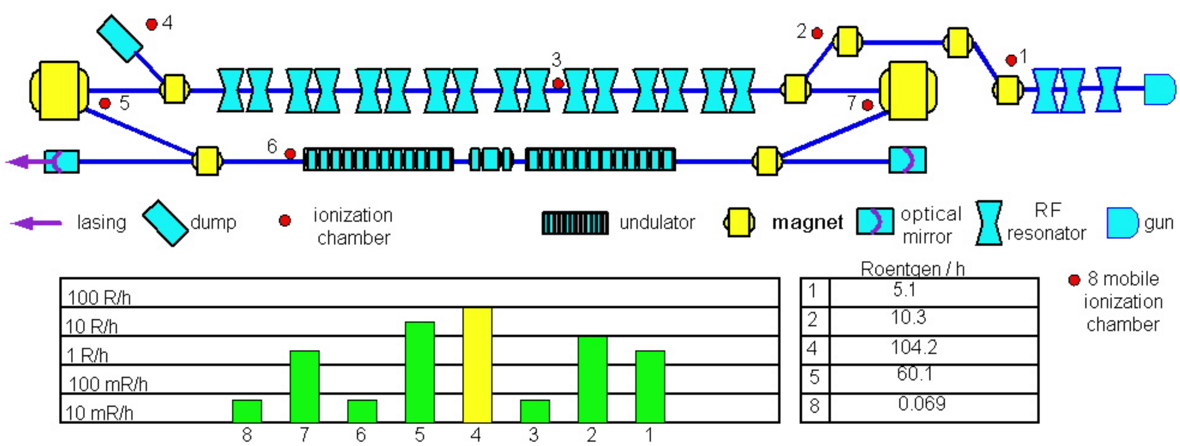

Figure 1: Arrangement of the radiation transducers in the accelerating hall.

HARDWARE AND SOFTWARE OF THE RADIATION CONTROL SYSTEM

The radiation sensor consists of an ionization chamber and electronic block converting ionization current into frequency. The lower limit of current to register is 10^{-14} A. The distance between the radiation sensor and radiation sensor interface can be as big as 100 m. The radiation sensor interface (see Fig. 2) serves up to 8 ionization chambers. The radiation sensor interface is created on the basis of microcontroller TINI (Tiny InterNet Interface) of Dallas Semiconductor (Maxim) [2] and FPGA type ACEX 1K of Altera [3]. FPGA periodically executes serial polling of all 8 channels and moves the data to a peripheral segment of the TINI address space.

TINI is a microcontroller that executes codes for the embedded web server. TINI has Ethernet, CANbus and RS232 ports, a full TCP/IP stack, and an expanded Java runtime environment, which simplifies development of network-connected equipment. TINI has advanced tools for development. The API of the runtime environment contains packages Java Developer's Kit and program packages for work with peripheral devices.

Parameters defining the working regime of the radiation sensor interface are in a file of the configuration "setting". The software bases on the client-server model. The server works at a platform of the TINI operating system. The user client works at a platform of the operating systems Linux or Microsoft Windows.

The electronic block converts the ionization chamber current to a sequence of pulses C_n. Each ionization chamber has individual coefficients α, Z_0 (mR/h) - background, D (mR/h) - dose rate (see Eq. 1) and T (sec) - exposure time.

$$D = \alpha \frac{Cn}{T} + Z_0 \qquad (1)$$

RADIATION MONITORING

At FEL operation, the control system executes monitoring of dose rate and provides protection with the help of the user client "Xray". The program "Xray" maintains a logbook; a record is created for each radiation transducer. Periodically, the program "Xray" writes the timestamp and maximal and average values of dose rate for each transducer. The "Xray" makes sampling from the transducers with a frequency of 1 Hz. If the value exceeds the individual "yellow" level, this event is fixed in the logbook. If the value reaches the "red" level, the program switches off the beam.

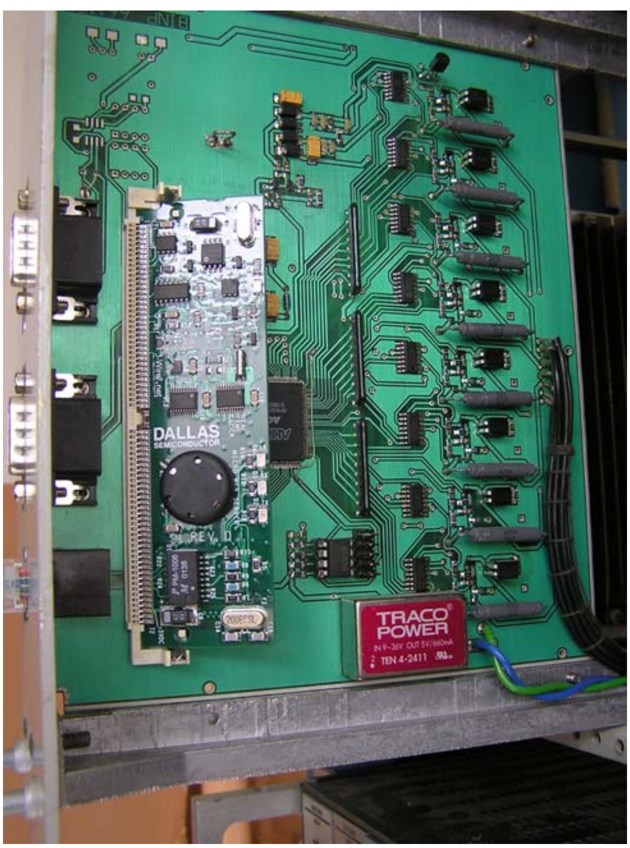

Figure 2: The radiation sensor interface.

Besides, the program "Xray" allows watching the electron beam pass, since insignificant losses of electrons on the walls of the vacuum channel make the dose rate increase. The program «Xray» has three regimes of visualization:

- The first regime reflects instant dose rates in the locations of the ionization chambers.
- The second regime shows the difference of the instant and previous values of the dose rate (the derivative $D_{(t)}$ - $D_{(t\text{-}1sec)}$).
- In the third regime, all readings of radiation sensors at this certain moment are taken for «control points» and then the differences between the instant values of dose rate and «control points» are displayed. For example, a moment when there is no beam in the microtron can be taken as a «control point», and then one can use the «radiation profile» to trace the places of partial losses of the beam.

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