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LU-10M LINAC SYNCHRONIZATION SYSTEM

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The synchronization system is based on STM32F407VG and DP83848. The system generates pulses with a frequency of 1 to 600 Hz, a length of up to 2500 ns to synchronize the operation of the klystron modulator, master oscillator, source modulator, control equipment of LINAC. The setting of the delay of the synchronization pulses is adjustable from 0.01 to 20 μs. Synchronization system control is implemented via USB or Ethernet network via TCP/IP protocol. Implemented a set of applications for the organization of system management and monitoring of LINAC, compatible with Windows XP/7/10.

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INTRODUCTION

The task was to develop a new synchronizer to ensure the operation of the new LU-10M LINAC. As a result of the development, the following hardware and software complex was created that meets the assigned tasks.

1. SOFTWARE

1.1. SERVER APPLICATION

The server application (Fig. 1) is engaged in storing and transmitting information and is an intermediary between the controller and client applications. The server stores information about the synchronizer settings and about incoming locks for transmission to all requesting clients. It has no settings, only a field for outputting debug information and a warning. The application can be conveniently minimized to the tray, takes up only ~ 10 MB of RAM and does not load the PC too much [1].

Fig. 1. Server application

1.2. CLIENT APPLICATION

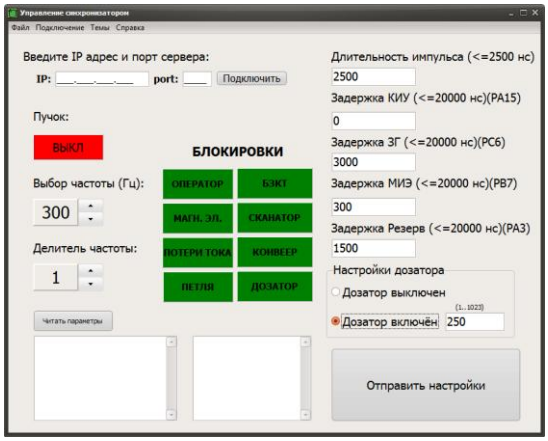

Fig. 2. Client application

A client application (Fig. 2) for the operator was developed to work with the Ethernet network and modified to retain the ability to work both via USB connection and via TCP connection. In the first case, alas, without the dissemination of data to observers. Day and night themes of the application have been added for more convenience. The application requests information about blocking from the server every 100 ms.

1.3. OBSERVER APPLICATION

On the basis of the operator's application developed earlier, an application for the observers (Fig. 3) was developed that allows you to receive current information about the state of the synchronizer: the settings transferred to it and the received locks. The server also requests information every 100 ms. The observer does not have the ability to make any corrections to the synchronizer settings.

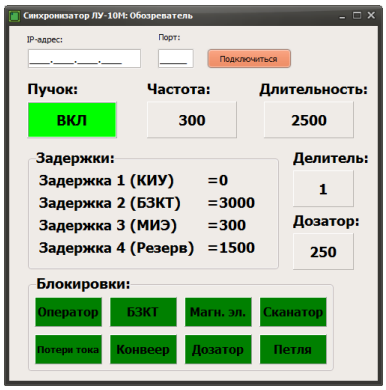

Fig. 3. Observer application

1.4. MCU APPLICATION

Using the HAL and LwIP libraries, the TCP/IP stack was implemented, a packet exchange protocol with guaranteed delivery, since in cases of transferring settings and / or data about locks, data corruption is unacceptable. The microcontroller requests settings from the server every 50 ms, and sends information about incoming locks as soon as the data transmission channel is released. In order to preserve equipment and the safety of people, the beam is disconnected in the event of a blockage being triggered even before the message is sent to the server and the operator or observers receive information about it. In order to increase the stability of the connection, as well as isolate the microcontroller from garbage network traffic and unauthorized access, it was decided to separate it into a

isolated network connected only with the server node, which, in turn, will be located simultaneously both in an isolated network and in a common one, allowing keep lots of connections (Fig. 4).

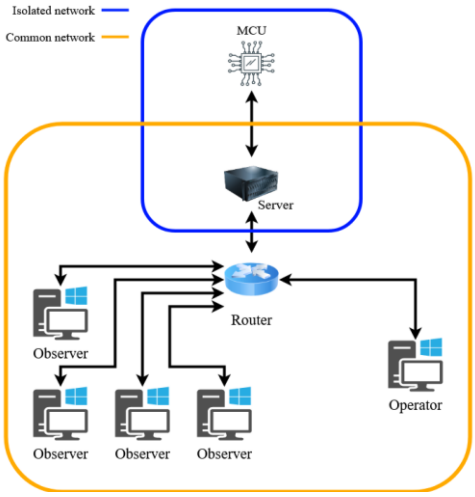

Fig. 4. Network schematic

In the launch channel of the source modulator the function of "shutdown of a beam" at operation of protective locks is provided. During the adjustment of the accelerator, the operating delays for the start pulses of the instrument control unit are set; SMTU; master oscillator. The beam is disconnected: from the UBS system, the process control system for irradiation programs and other systems. At the same time the light indication of the place from where the beam is disconnected works. After removing the locks, the restoration of the operating mode is performed by the operator from the computer or from the front panel of the synchronizer. The choice of frequency of parcels and delays on channels, and also on/off of a beam is made from the computer.

2. HARDWARE

The synchronizer is developed on the basis of the STM32F407-Discovery module (Fig. 5), with the following characteristics: Clock frequency 168 MHz, RAM 192 KB, flash memory 1 MB [2].

To implement the TCP/IP connection, the DP83848 module was used (Fig. 6), which provides microcircuits with the ability to communicate at the data link level to a physical transmission medium, for example, to fiber or twisted pair. Typical interfaces for data exchange between devices and PHY modules are MII (Media Independent Interface) and RMII (Reduced MII), MII requires 8 pins directly for data transfer and clocking from 25 MHz in 100 Mbps mode or 2.5 MHz in 10 Mbps mode. RMII, in turn, requires only 4 pins for data transmission, but clocking is required from 50 MHz in 100 Mbps mode and 5 MHz in 10 Mbps mode, respectively.

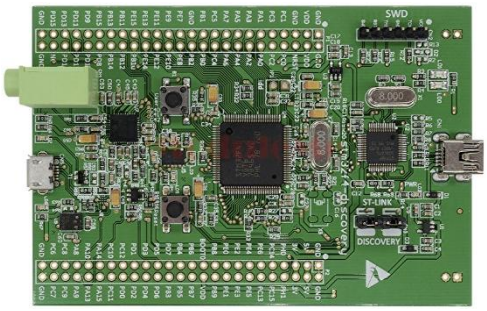

Fig. 5. STM32F407-Discovery module

Fig. 6. DP83848 Module

CONCLUSIONS

The synchronization system is based on the Discovery STM32F407VG module. The system generates pulses with a frequency from 1 to 594 Hz to synchronize the operation of the klystron modulator, the master oscillator, the source modulator and the control equipment of the linear electron accelerator. The setting of the delay pulses of the synchronization pulses is adjustable from 0.012 to 20 μs. The synchronization system is designed for the hourly operation program of the accelerator LU-10M and ready to use.

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СИСТЕМА СИНХРОНІЗАЦІЇ ПРИСКОРЮВАЧА ЕЛЕКТРОНІВ ЛУ-10М

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Система синхронізації розроблена на основі STM32F407VG та DP83848. Система формує імпульси частотою від 1 до 600 Гц, довжиною до 2500 нс для синхронізації роботи модулятора клістрона, задающого генератора, модулятора джерела, контрольної апаратури ЛПЕ. Установка затримки імпульсів синхронізації регулюється від 0,01 до 20 мкс. Керування системою синхронізації реалізовано за допомогою USB або Ethernet-мережі за протоколом TCP/IP. Реалізований комплекс додатків для організації керування системою та спостереження за роботою ЛПЕ, сумісний з ОС Windows XP/7/10.

СИСТЕМА СИНХРОНИЗАЦИИ УСКОРИТЕЛЯ ЭЛЕКТРОНОВ ЛУ-10М

В.Н. Борискин, В.А. Момот, В.В. Чуриков, В.И. Солодовников, Е.И. Зайцев

Система синхронизации разработана на основе STM32F407VG и DP83848. Система формирует импульсы частотой от 1 до 600 Гц, длиной до 2500 нс для синхронизации работы модулятора клистрона, задающего генератора, модулятора источника, контрольной аппаратуры ЛУЭ. Установка задержки импульсов синхронизации регулируется от 0,01 до 20 мкс. Управление системой синхронизации реализовано с помощью USB или Ethernet-сети по протоколу TCP/IP. Реализован комплекс приложений для организации управления системой и наблюдения за работой ЛУЭ, совместимый с ОС Windows XP/7/10.