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DEVICE FOR SYNCHRONIZATION ELECTRON ACCELERATOR

I.O. Chertishchev, V.O. Mats, V.O. Momot, S.K. Romanovsky, Yu.O. Titarenko, V.Yu. Tytov
National Science Center "Kharkiv Institute of Physics and Technology", Kharkiv, Ukraine
E-mail: titarenko@kipt.kharkov.ua

A device designed for continuous management and control of the parameters of elements and nodes of an electronic accelerator has been developed. The created device makes it possible to control the modes of the accelerator taking into account the state of electrical blockages and counting the necessary time exposures.

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INTRODUCTION

Synchronization and adjustment of nodes and blocks of the electronic accelerator is necessary for the stability and reliability of its operation.

The devices that were in operation were developed in the 80s of the last century and were made on discrete digital elements of that time.

They had many disadvantages: the complexity of the design, the large number of elements used, the difficulty of adjusting and displaying the parameters of the device itself and the state of the controlled equipment, the impossibility of changing the developed logic or parameters. These shortcomings made it difficult to maintain and repair them, to use them when changing the composition of the controlled equipment, and to reproduce them in the conditions of a difficult modern personnel and economic situation.

It was not possible to eliminate these shortcomings within the limits of the circuit and technical solutions used.

WORKING PRINCIPLE

The new device was created using existing modules based on STM32 microcontrollers [1, 2]. The modules consist of a board with an STM32407VE6 microcontroller and a 3.2-inch display board with a resolution of 320x240 dots (Fig. 1). This microcontroller contains 14 timers with a clock frequency of up to 168 MHz and the possibility of mutual internal and external synchronization (Table).

STM32F4 microcontroller timers

Timer type	Timer	Counter resolution	Counter type	Prescaler factor	DMA request generation	Capture/ compare channels	Complementary output
Advanced-control	TIM1, TIM8	16-bit	Up, Down, Up/down	Any integer between 1 and 65536	Yes	4	Yes
General purpose	TIM2, TIM5	32-bit	Up, Down, Up/down	Any integer between 1 and 65536	Yes	4	No
	TIM3, TIM4	16-bit	Up, Down, Up/down	Any integer between 1 and 65536	Yes	4	No
	TIM9	16-bit	Up	Any integer between 1 and 65536	No	2	No
	TIM10, TIM11	16-bit	Up	Any integer between 1 and 65536	No	1	No
	TIM12	16-bit	Up	Any integer between 1 and 65536	No	2	No
	TIM13, TIM14	16-bit	Up	Any integer between 1 and 65536	No	1	No
Basic	TIM6, TIM7	16-bit	Up	Any integer between 1 and 65536	Yes	0	No

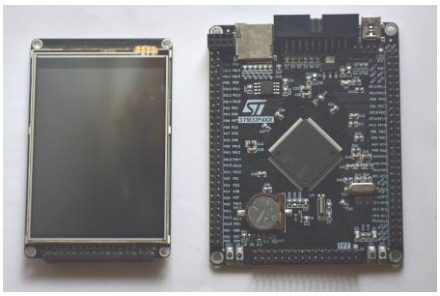

Fig. 1. Appearance of the STM32 module

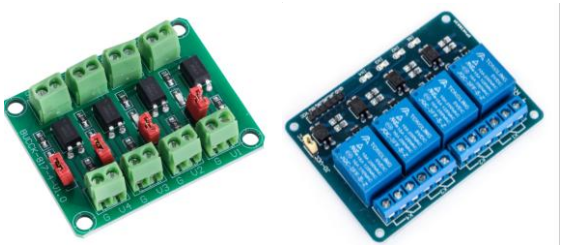

Fig. 2. Appearance of PC817 opt coupler modules

To coordinate the STM32 microcontroller with the power and high-voltage elements of the modulator, ready-made boards on the widespread RS817 optocoupler modules were used (Fig. 2). Thanks to this, it was necessary to independently manufacture only a simple printed circuit board with output optodrivers.

The software for the STM32 microcontroller is developed in the SI programming language in the CubeIDE software environment [3]. The microcontroller forms one reference and four delayed relative to it synchronous pulses with the following parameters:

1. Reference pulse repetition frequency from 6 to 300 Hz.
2. The duration of the shift of each sync pulse relative to the reference is from 0 to 10 μs with an adjustment step from 10 to 100 ns.
3. Synchronization of the reference pulse can be in three modes: from the 220 V network, internal and external.
4. The possibility of turning off or changing the shift duration of individual synchro pulses in the event of an emergency in the equipment.
5. Regulated periodic change in the duration of the sync pulse shift.

6. The duration of the synchronous pulse is chosen to be 2.5 μs, the leading and falling times are 40 ns, the amplitude is +15 V.

Device operation modes are controlled using encoder and button switches. It is also possible to quickly switch the “START” and “STOP” modes, in which the parameters of the synchronized pulses necessary for the controlled equipment are changed.

The device has the ability to track up to 15 individual blocking channels in case of emergencies in the controlled equipment with memory and display of the status of the error channel. There is also an adjustable trigger delay from part of the error channels to eliminate the influence of random interference.

The display shows all settings and operating modes of the device, existing or memorized errors of blocking channels (Figs. 3, 4). All the settings made are saved in the memory of the microcontroller when the device is powered off.

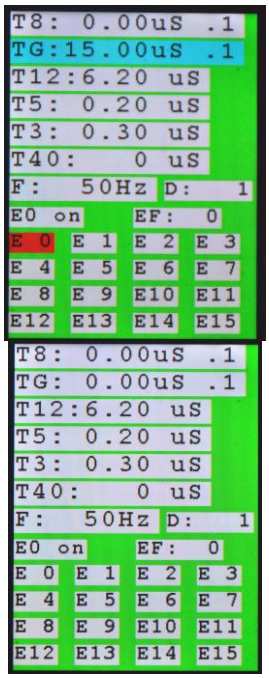

Fig. 3. Examples of displaying operating modes on the device display

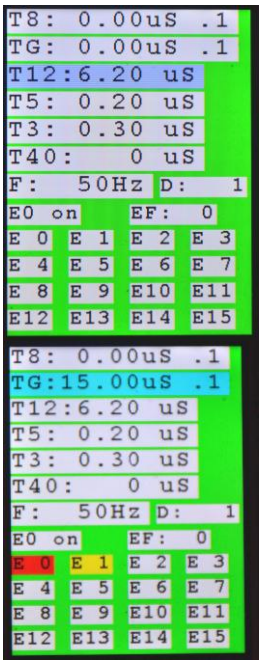

Fig. 4. Examples of displaying operating modes on the device displa

The listed operating parameters of the device are selected taking into account the needs of operating the existing equipment and, if necessary, can be changed by changing the software code. The STM32F407VE series microcontroller used has a sufficient number of internal timers and speed to solve the existing need to manage existing equipment.

There are also possibilities for further modernization of the system, for example, tracking and processing of analog parameters at specified time intervals. Software processing of input signals and formation of synchronization pulses significantly simplified the hardware part of the device, making the necessary changes in the logic of operation and its manufacture. In the case of the need for a significant improvement or development of the device for use with a different purpose, it is possible to use microcontrollers with better performance parameters.

CONCLUSIONS

High-quality synchronization and control of the systems and blocks of the electron accelerator is necessary to ensure the specified radiation characteristics. The use of modern microcontrollers and the corresponding software product made it possible to create a high-quality and at the same time simple hardware control system. The necessary stability of the accelerator's operation and the possibility of operational display of its parameters, introduction of some operational changes in the control logic were achieved.

The possibility of making appropriate changes to the software code makes it possible to adapt the logic of the device for conducting various scientific studies. Thanks to the use of inexpensive ready-made electrical modules, there was no need for the development and manufacture of printed circuit boards and large material costs when creating the device, which is important considering the difficult current economic situation in the country.

The relatively simple hardware part, low cost and the possibility of changing the logic of the device's operation simplify its replication and allow its use with other nodes and systems of research equipment.

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ПРИСТРІЙ ДЛЯ СІНХРОНІЗАЦІЇ ПРИСКОРЮВАЧА ЕЛЕКТРОНІВ

І.О. Чертіщев, В.О. Мац, В.О. Момот, С.К. Романовський, Ю.О. Тітаренко, В.Ю. Титов

Розроблено пристрій, призначений для безперервного керування та контролю параметрів елементів та вузлів електронного прискорювача. Створений пристрій дає можливість керування режимами прискорювача з урахуванням стану електричних блокувань та відліком необхідних часових витримок.