MICROPROCESSOR BASED PULSE SYNCHRONIZATION SYSTEM FOR LINEAR ELECTRON ACCELERATOR

A.Styervoyedov, Ya.Shashel, Kharkiv National University,
4 Svobody sq., Kharkiv 61077, Ukraine

Abstract

The pulse synchonization system is a component of every linear electron accelerator and it provides temporal program forming of accelerator units and nuclear-physical and measuring devices functioning. Elaborated synchronization system represents multi-channel timer with controlled signal delay units for forming start-up pulses of electron gun modulators, klystron HF-modulators and various scientific and applied devices also.

1 INTRODUCTION

Realization of precision physical experiments, researches on nuclear medicine, modern technological operations and solving of other important tasks demand high stability of output parameters of a beam, dynamical control of the accelerator, operative reorganization of current pulses in a wide range of frequencies, values of a pulse and average beam current with the minimal energetic and phase diversity. These parameters mostly depend on a perfection of the pulse synchronization system determining the time sequence of technological equipment operation of the accelerator and experimental and control-measuring devices also.

2 DESCRIPTION OF THE SYNCHRONIZATION SYSTEM

The block diagram of the elaborated according to the algorithm described in [1] accelerator pulse synchronization system is showed on the Fig.1. It consists of following modules: the module that binds synchrosignals to the power supply of the accelerator with a digital phase shifter (MCSS), the module of start up frequencies grid generation (MSDF), modules of wide-range delay circuits of synchrosignals with powerful output shaper (MDL), module of local control and indication (MCI) and distance control module (MDC). The system bus (SB) connects modules to the controlling microcontroller (MC) that on the other hand is connected to the controlling computer by means of a serial interface.

MCSS provides binding of synchropulses to passing through the zero of feeding power (50 Hz, 3-phase) with accuracy $5*10^{-3}$ %. The digital phase shifter included to the module, sets start up phase shift in the range of $0 \div 2\pi$ ($0 \div 20$ms) with step of $6.2*10^{-3}$ rad (20 mks) and stability of ±1 mks It is provided thanking to applying of the Batervart filter of low frequencies of the second order in a combination with the phase compensator. The serial circuit consisted from the active filter of low frequencies of the second order creates constant phase shift in regard to input signals and at the same time cleans electrical supply of the low-threshold comparator from handicaps and external influences.

MSDF provides a number of start up frequencies of the accelerator pulse system, and it varies from unitary start up to 600 Hz with the rigid binding to the 3-phase electrical supply of 50 Hz. From the external generator it is possible to make start up frequencies of 1200 Hz. There is the automatic tuning system of frequency in the tracking range of ±1.5 Hz.

MDL sets a timing sequence of operation of synchronized systems of the accelerator. MDL consists of the general to all modules delay generator, serially connected digital delay circuits (DDL), microseconds range and analogue-digital delay circuit (ADDL) of nanoseconds range. Such combination allows to obtain minimal discretization in the demanding range of delays. To provide the necessary amplitude of the synchrosignals and operation through the long cable there is an output shaper at the output of the system.

The 16-bits digital code of delays time control is transmitted from the AT89C51 microcontroller to the DDL registers, created according to the standard scheme, and to the ADDL registers. Programmable delay generator AD9500 [3] is used as ADDL, and it has such values of C_{ext} and R_{ext} to provide a delay step of accurate adjustment of 1 ns in the range of $0 \div 255$ ns and stability of 50 ps. DDL provides rough adjustment with a step of 200 ns in the range of $0 \div 51$ mks. The analysis of the range and delays step of synchropulses and also its generation algorithm for multi-section accelerator is presented in [1,2].

Synchronizator, that starts-up simultaneously with supplying network frequency, produce a series of shifted pulses for the electron gun modulator (EGM) start-up, modulator of klystron pulse amplifiers (KPAM) and modulator for klystron pulse generator (KPGM). All modulators are operated by corresponding submodulators (MD). Start-up moments of modulators are defined from the relation between time of electron beam flyby, synchronization pulse distribution time and time of functioning of MD, EGM and KPAM. In the performance mode KPGM is started-up first. For other modulators – the last KPA.N, the middle KPA.K and the gun modulator EGM, time delays are defined according to following equations:

$$Tn = \sum (t_{i.0} - t_{i.n}) + t_{b.n} + t_y$$

$$Tk = t_n + \sum (t_{i.0} - t_{i.k}) + (t_{p.n} - t_{p.k})$$

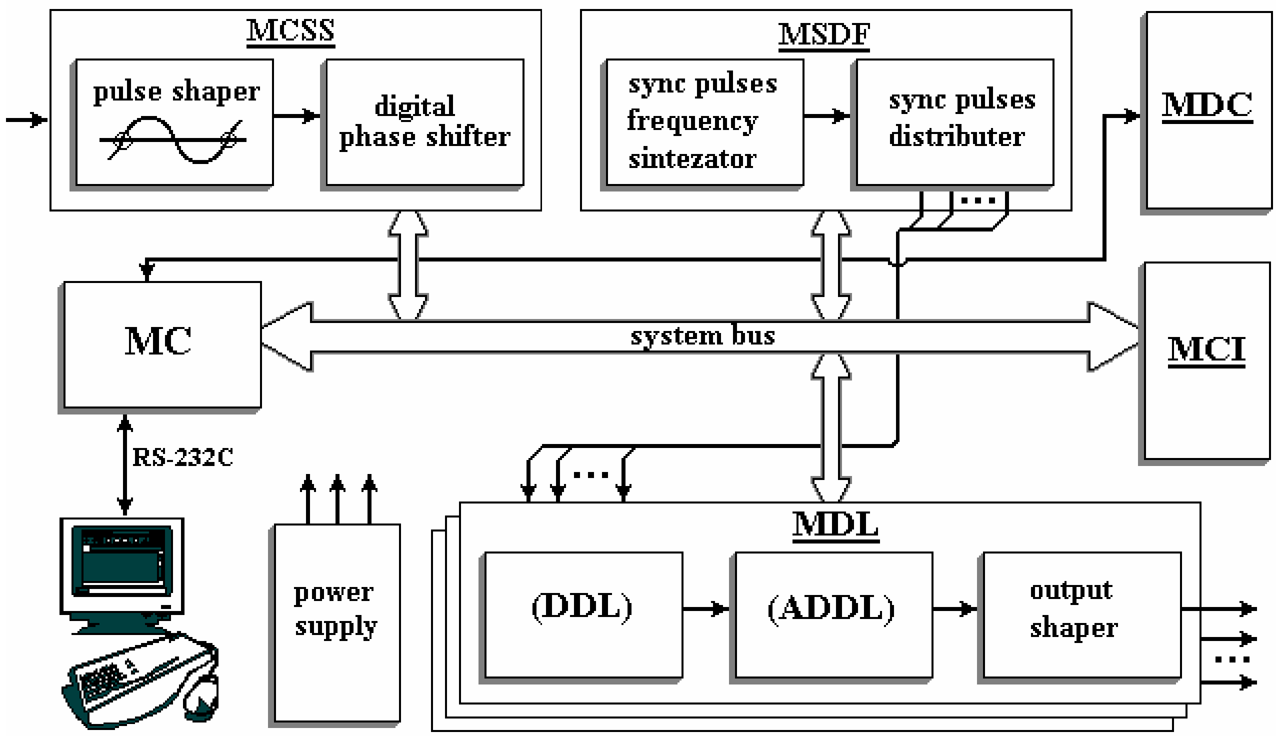

Figure1: Block diagram of the MC based synchronization system.

$$Tg = t_n + \sum (t_{i.n} - t_{i.g}) + t_4 - t_{p.n}$$

We use following designations of delay time:

Tn – start-up moment of the last KPAM;

Tk – start-up moment of the middle KPAM;

Tg – start-up moment of the EGM;

t_1 - distribution time of syncpulse in the cable;

t_2, t_3 - starting-up time of MD and KPAM accordingly;

t_4 - beam delay time with regard to start-up moment of HF supply of a section;

t_y - KPG frequency setup time;

t_b - excitement pulse distribution time from KPG to klystron pulse amplifiers;

t_{gm} - EGM start-up time;

t_p - beam flyby time from the electron gun (EG) to corresponding AS;

Moment 0 – is a KPGM start-up moment.

MCI provides coordinated functioning of all circuits of the equipment, necessary blocking, and local indication of operational modes also.

MDU is necessary to provide adjustment operations.

In addition to its main assignment – to produce the timing program of the accelerator units functioning, the pulse synchronization system can solve tasks unusual for it. For example, by means of the method of time delays, recommended in [4], produce minimization of energetic dispersion of beams of charged particles, by means of method of unsynchronization of electron injections moments and applying HF-supply carry out adjustment of an average current and energy changing of accelerated beam and other unusual for such systems tasks.

3 REFERENCES

[1] A. Styervoyedov. Pulse Synchronisation System for Linear Electron Accelerator. Proc. of the 23rd International Free Electron Laser Conference " FEL 2001", 20 - 24 August, Darmstadt, Germany, 2001, p. 23

[2] N.V.Demidov. Synchronisation System for Linear Electron Accelerator. M. CNIIatominform.- 1984.- 37p.

[3] http://www.analog.com

[4] P.I.Gladkih, A.N.Dovbnya, Ju.D.Tur et al.: Particle Accelerator, Vol. 27, № 3, 1990