THE COMPUTER CONTROL SYSTEMS OF H^+ AND H^- INJECTORS OF THE MOSCOW MESON FACTORY LINAC

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Technical solutions for the computer control systems which was designed for the proton and H^- injectors of the MMF linac are considered. The base of systems is the LabVIEW software. The National Instruments Corp input/output modules are used. Proton injector operator workstation provides the control (up to 73 channels) of the 400 kV pulse generator, which can operate with repetition rate up to 100 Hz. The control of the ion source which is under high potential (45 channels for H^+ and 104 for H^-) is carried out with the help of the fiber line. The analog channels transmission band is up to 1.6 MHz.
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The concept of a computer control system (CCS) is developed within the framework of the H^- injector design [1]. There are two modular groups in the injector structure: the high-voltage pulse generator (HVPG) and ion source (IS) with auxiliary technological systems. The CCS structure is also parted into two independent parts. The H^- injector HVPG is identical to the H^+ injector HVPG. The H^- IS is more complex than the H^+ one. The list of CCS signals of H^-/H^+ injectors is given in Table 1.

The CCS is created on the basis of the LabVIEW software package in Windows medium. It allows easily to compose from separate devices more composite virtual devices and gradually to increase structure complex control opportunities. The modifications and development of structural connections between program blocks are facilitated. The graphic language "G" from the package gives doubtless conveniences to the developers. It is accessible for mastering even by operating staff which is not having the programming skills. The example of the signal transmission and processing program module for the HVPG divider, stabilization system and current measuring device unit are given in Fig. 2.

Let's consider a design feature and details of the CCS hardware complex.

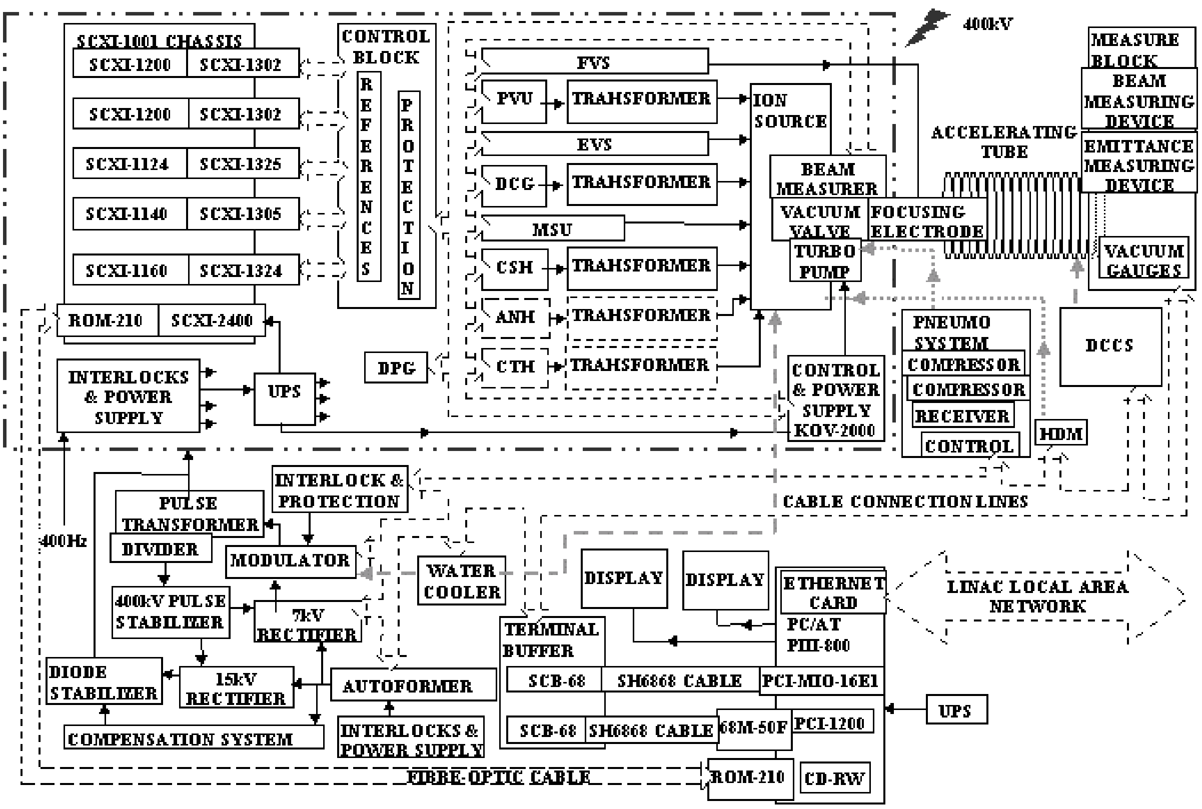

Fig. 1. The H^- injector flowchart.

Table 1. The H^-/H^+ injectors information signals array.

Block / subsystem	measuring channels				control channels		
	Analogue		Discrete	counter	Analogue	discrete	timer
	Video	DC					
Magnet **P**ower **S**upply **U**nit		1/1	1/1		1/1		
H_2 leak-in pulsed valve **PSU**		1/-	1/-		1/-		2/-
Hydrogen leak-in unit		-/1			-/1		
Caesium heater block		1/-	1/-		1/-		
Focusing voltage source	1/1	1/1	5/5		1/1	2/2	
Discharge current generator	1/1	2/2	5/5		1/1	2/2	2/2
Extracting voltage source		3/3	5/5		1/1	2/2	
50/400Hz current transducer			1/1				
400/50Hz current transducer			1/1				
SCXI chassis			1/1				
Delay pulse generator			1/-				6/2
Interlocks			2/2			2/2	
Pumping-out complex			14/-	2/-		4/-	
24V power supply			1/1				
Beam profile measuring device	10/10						1/1
Beam current measuring device	1/1						
Emittance measuring device	20/20					4/4	3/3
Anode heater		1/-	1/-		1/-		
Cathode heater		1/1	1/1		1/1		
Air cooling			2/2				
HVPG	3/3		22/22	1/1	4/4	6/6	4/4
Vacuum system		2/1	4/2			2/-	
Water cooling		1/1	1/1			1/1	
Pneumosystem		1/-	2/-			2/-	
TOTAL	36/36	15/11	73/53	3/1	12/10	27/19	18/12

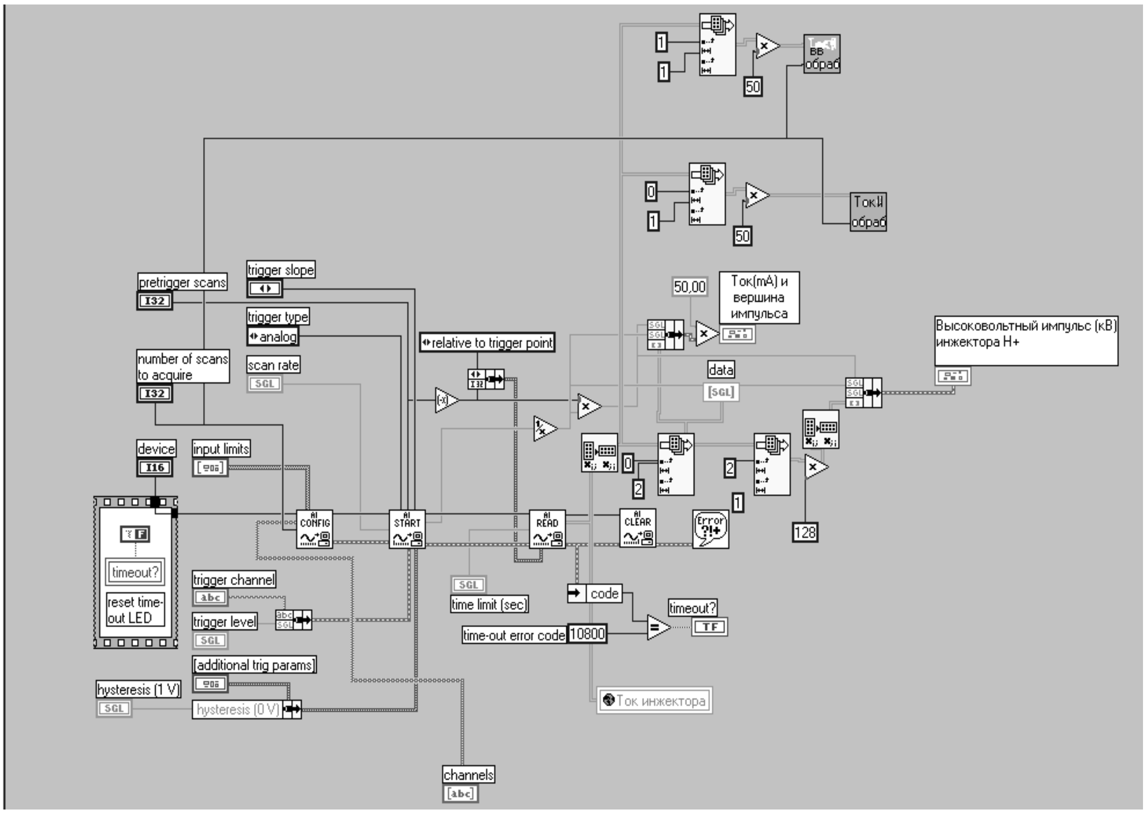

Fig. 2. The block-diagram of the beam current and a high-voltage pulse signals transmission and processing program module.

The central console - the operator workstation - is based on the P-III/800 processor and has a data exchange opportunity to the Ethernet protocol with other control linac posts by a local network with throughput 100 Mb/s. Built-in in the workstation system block the PCI-1200 and PCI-MIO-16E1 multifunctional input/output devices [2] provide the HVPG and auxiliary systems control by means of cable communication links. 28 12-bit analogue channels with a programmed coefficient of amplification (0.01÷10V + 0.025%) and transmission band up to 1.6 MHz (24 ADC, 4 DAC), 40 TTL-input/output channels, 5 counter/timer channels (with precision 10 ns) in total are accessible. The controlled devices of the HVPG and auxiliary systems are as follows: - 15 kV and 7 kV rectifiers; the thyratrons discharge rack; compensation and stabilization systems; interlock and protection devices; auxiliary systems, units and blocks, including power supply systems, cooling and ventilation, vacuum, compressed air delivery system and differential evacuation complex for vacuum tube, hydrogen delivery pipe-line (HDM), an accelerating tube divider circulation and cooling system (DCCS), beam diagnostics block etc.

Through a RS232 port the workstation is interlinked to the IS which is taking place under potential 400 kV, with the help of the fiber link. Length of a line – 100 meters. As modems the ROM-210 transformers are applied [3].

The controlled IS devices are: discharge current generator (DCG); focusing (FVS) and extracting (EVS) voltage power supply; magnet power supply units (MSU) and pulsed valve unit (PVU); 6-channel generator of delayed pulses (DPG); caesium, cathode and anode heaters (CSH, CTH, ANH); a differential evacuation vacuum complex; auxiliary units and measuring blocks. Allocated inside the shield of the IS the subsystem of control is based on the SCXI-1001 microprocessor chassis. The modules, built-in in the chassis, ADC SCXI-1124, DAC SCXI-1140, relay SCXI-1160, and multifunctional SCXI-1200 [4] provide 34 analogue channels, 48 discrete; 6 counter/timer channels. Besides there are up to 16 relay channels for load control with currents of switching up to 2 A at a voltages up to 250 Vrms. It is possible to insert into the chassis basket additional modules (up to 12). The part of channels is reserved.

The system SCXI with the help of sampling-storage buffer device stores the information during an injector pulse (200 μs) and dumps it on the operator workstation by a fiber line during 10 ms before the beginning of the next pulse. The information goes in both directions through the multiplexer and the SCXI-2400 connection module [5] RS232 port.

The workstation system block RAM (256 Mb) stores a previous injector operation history for the subsequent analysis. In order to prevent RAM overflow the difference information between the ion current sequential pulses is inserted to the storage buffer only and the injector subsystems status changes are fixed. System is dumping the accumulated information in archive periodically.

System noise stability and protection are provided at different levels with a particular circuit and constructive solutions set. Among them, except for the mentioned above fiber optics, it is possible to mark buffer devices, in function of which the signals normalization and coordination, channels protection against overloads and noises filtration enter. The input/output modules maintain input overloads up to 42 V, and if equipped by terminal blocks - up to 250 V. The selection of modules with the inlet optical insulation is possible also.

The SCXI chassis is in unfavorable operating conditions: near IS powerful high-voltage pulsed devices, at a boosted ionizing radiation. The chassis exterior shielding is used in addition.

The linac sessions duration can take some weeks. The uninterruptible power supplies (UPS) are applied for system viability maintenance in long-lived operation sessions.

In Fig. 3 the result of transmission and processing in real time for the 3 information channel signals is given. Program module of this CCS fragment is mentioned above in Fig. 2. The H^- injector CCS has about 180 local transmission channels, plus the linac local network area channel, and disposes of a further expansion opportunity. Large volume of the output information requires the adequate screen space.

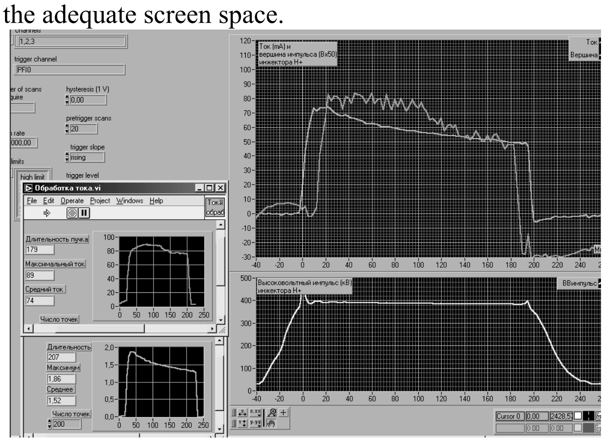

Fig. 3. Workstation monitor data display of the beam current and H^+ injector high-voltage pulse top signal transmission and processing results.

The DualHead videocard separates and outputs HVPG and IS information massifs on two different monitors. Usage in the workstation of two synchronized system blocks enables the information streams additional separation, and also duplication and control functions interception by other computer if one of them will be in failure. Such solution is well conformed and with the corporations-manufacturers guidelines to un-overload the computer system bus with a plenty of additional devices. It can become the reason of interruption system (IRQ) conflicts and programs "hovering".

The CCS can make unit deletions without assistance in critical situations.

The CCS gives new qualities and implements technologies unavailable earlier. Using CCS it is possible to solve extreme regulation problems, to build new beam energy stabilization systems, to robotize optimization of parameters.

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