DIGITAL CONTROL OF RTM LINAC RF SYSTEM WITH DSP.

Chepurnov A.S., Gudkov K.A., Shumakov A.V.,
Institute of Nuclear Physics, Moscow State University
119899, Moscow, Russia, tel.(095) 939 5659
chas@compnet.msu.su

Abstract.

The high quality of the beam, which is one of the main advantage of the continuous-wave racetrack microtron (RTM), depends on the reliability and accuracy of the RF control system operation. RF control system forms local level of the accelerator computer control system (CCS). Modern architecture, based on digital signal processor (DSP) application, and fieldbus structure ensure using of complicated control algorithms for direct digital control of RF channel and stabilising the main RF parameters: amplitude, phase shift and self frequency of an accelerating section. The application of the DSP system will decrease loading of the bottom level of CCS and increase reliability and accuracy of RTM operation. The systems based on DSP will replace analogue systems, operating today. The prototype of the local control system has been designed on the base of DSP. A local level of computer control system of RTM is described.

INTRODUCTION.

The high operational characteristics of RF power supply system of RTM accelerating sections are a necessary condition for the high quality of the output electron beam. Control system of power feeding serves the triple function: safe and emergency control, switching different RF devices in a definite order in different operational modes and stabilising of the RF parameters. At the same time, provision should be made for realisation of dual role of control system: reliable control and ability of research works. Therefore, it is necessary to choose architectural solution with the optimal relation between functionality, complexity and intellectual ability.

Today we are faced the problem to provide a computer control for the following research works:

- nuclear fluorescence physics experiments with 6 MeV electron injector of RTM [1],
- construction of 175 MeV RTM in collaboration with the Institute of Nuclear Research (Moscow, Russian Academy of Sciences),
- experiments with two sections linac for industrial application [2].

The components of RF power supply system of the accelerator installations are very similar. But conditions of operation and technical demands are differ strongly.

We have started, approximately a year ago, a design work to create reliable and adaptable device for intellectual control of RF power supply system for application in various hardware schemes of RF devices. This controller should operate in the computer control system for RTM and as stand alone device for industrial applications.

MIL-1553-B FIELDBUS AND DSP IN COMPUTER CONTROL SYSTEMS.

Application of MIL-1553-B fieldbus standard in many modern CCS of accelerators makes possible to believe in our choice of optimal architectural solution for a local control [3].

This fieldbus standard is used in LEP Control and Alarm systems [4,5], one of the alternative standard for equipment control in Fermilab Linac Control System [6], as base standard for low level VME subsystem connection in ELETTRA and power supply control [7,8] for interconnection of VME subsystems and connection with top level of computer control system in Pohang Light Source [9]. This standard is widely used in Protection system of SLAC [10].

One can see that application of DSP and DSP technique, mentioned in accelerator Conference Proceedings, are playing a great role in architecture of accelerators CCS. There are a few main points of DSP application in CCS: beam positioning and suppressing of longitudinal multibunch instabilities [11,12], dumping coupled bunch synchrotron oscillations [13], electron optics power supply control [14], etc.

SPECIAL MIL-1553-B TERMINAL WITH DSP.

Special module for local control of RF power supply system consists of three main parts: DSP core, input/output block with ADC and DAC multi-channel converters and data conditioners and MIL-1553-B interface (Fig.1).

DSP core.

Microprocessor core consists of two fixed point processors TMS320C50 for direct digital control and MIL-1553-B interface support. The third generation of fixed point processors has a very good performance and characteristics: 35-50 ns single-cycle instruction execution time, 8.5K words on-chip data or program RAM, 2K words boot ROM, JTAG scan path, serial port, etc.[15].

Support of real time fieldbus interface and direct digital control algorithms offer the ability of parallel operation, which is possible due to multy-processor mode of DSP and common block of RAM. The blocks of external data and program memory serve for loading program codes from CCS and transmitting data blocks from the bottom local level to the top level, data base and operator console.

Prototype of the system has been designed with the help of PC-based instrumental tools. The tools consist of special PC card with TMS320C25 fixed point DSP and external RAM and special original software. External user devices could be connected through local bus, which is buferized pins of DSP

microprocessor.

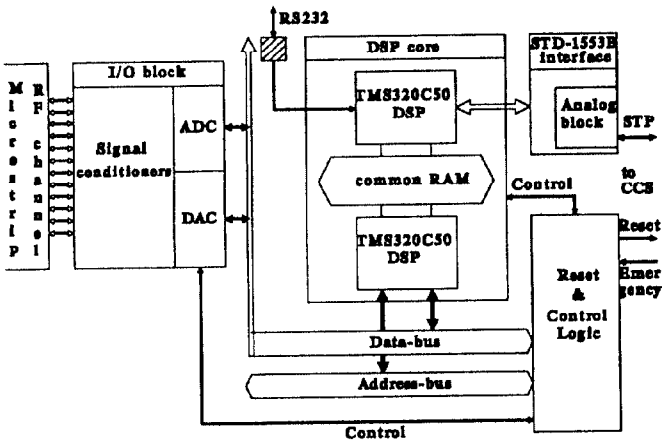

Fig. 1. Internal structure of DSP based MIL-1553-B Remote Terminal for local control of RF power supply system.

I/O interface.

The main function of the DSP module to process analogue data from low frequency outputs of RF devices and to generate control analog and bit actions. Special I/O module has been designed for these purposes. It consists of input and output signal conditioners and digital to analog and analog to digital converters. For direct digital control of phase and amplitude we are using two 12-bit fast ADC and single chip two channels 12-bit fast DAC. For data acquisition of non critical parameters 8-channel 8-bit ADC chip with FIFO memory has been used. Fast ADC and DAC ensure maximum 500 ksamples/sec rate for direct digital control algorithms. Real bandwidth of stabilisation depends on complexity (number of DSP program cycles) of control algorithms and performance of DSP and not stands out above 0.1 MHz. It is not enough from the stand point of technical demands (1.5 MHz), but quite enough from the stand point of real existing disturbances in the system [16].

To suppress possible disturbances with frequency higher than bandwidth of direct digital controller fast analog proportional feedback loop has been added to the system. The loop is closed on a command from DSP core.

MIL-1553-B interface.

MIL-1553-B interface executes full set of functions of Remote Terminal. Fieldbus interface consists of processor core, word-message block, and analog interface to standard shielded twisted pair. All fieldbus specific parts are realised on the base of a special chip set. Existence of Russian original version of MIL-1553-B chip sets offers a cost effective solution.

Structure of fieldbus branch.

Local RF system controller will be placed near a microstrip channel for each accelerating section. Twisted pair monochannel will connect Remote Terminals to Branch Controller with Q-bus interface. Q-bus crate with LSI-11 compatible minicomputer and MIL-1553-B Branch Controller belongs to the "Station" level of CCS. Q-bus station will be replaced by VME subsystem in future [17,18].

Local controller will control dynamic parameters of RF power supply system such as amplitude and phase of RF field and self frequency of the cavity. At the same time the controller will realize true order of RF devices switching in different mode operation and safe locking. RF power supply system, microstrip channel and algorithms of operation are described in details in [19].

The controller will support MIL-1553-B Remote Terminal functions thus, true real time operation with short time of response will be ensured. A possibility of the control program loading to the DSP core via fieldbus interface or standard RS-232 yields universal application of the module.

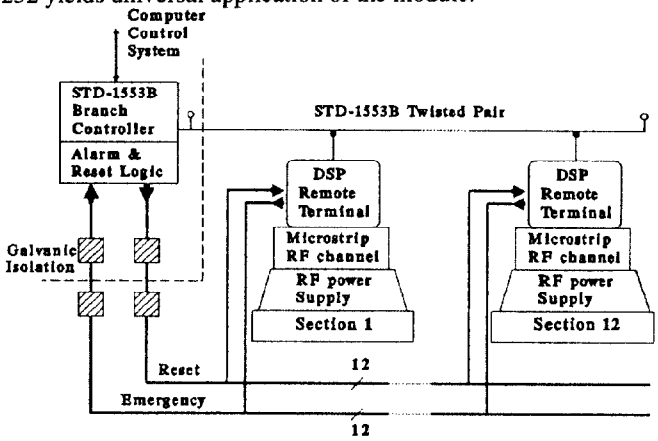

Fig. 2. MIL 1553-B fieldbus brunch for local control of RF power supplies of accelerating sections.

The controller exists in the form of principal schemes and really operating prototypes.

DIRECT DIGITAL CONTROL ALGORITHMS.

The application of DSP technique makes possible to use a number of control algorithms. Analog local control systems, which stabilise RF parameters now, are operating under commonly used PID (Proportional-Integral-Derivative) control algorithm [19]. Therefore, digital version of PID algorithm, specially designed and approved for fixed-point TMS320XX family of DSP, is used on the first stage of the system upgrading[20].

Non-steady and non-linear properties of RF elements and unremovable sources of disturbances require more complex control algorithms. To improve a quality of the beam, other modern control algorithms are tested.

CONCLUSIONS.

The elaboration of universal DSP based MIL-1553-B Remote Terminal will ensure to improve quality of the RTM output beam and increase reliability of the accelerator. This controller will be suitable and useful hardware decision for accelerator control applications.

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