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UPGRADE OF QUENCH RECORDING SYSTEM FOR MULTIPOLE SUPERCONDUCTING WIGGLERS AT BINP

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Abstract

Magnetic poles of superconducting wigglers (SCWs) are passed through "training" phase during fabrication of SCWs at Budker INP. In "training" procedure magnetic field is increased until superconducting coils enter the resistive state. Quench Recording System (QRS) is used for registration of waveforms in each coils to determine fault initiator coil. The total number monitored coils reach 312. Outdated QRS is based on modules in CAMAC standard and requires modernization. The basis of the new system is VME64-BINP crate with multichannel digitizer ADCx32 and RIO-module for safe signal receiving in high-voltage common-mode environment. The structure and details of the new system, as well as the experience of using the old one are given in the report.

INTRODUCTION

Superconducting multipole wiggler (SCMW) is a series of magnets with sign-alternating polarity. SCMW creates lateral periodical deflection ('wiggle') of electron beam passing through. These deflections generate radiation with properties of Synchrotron Radiation (SR) depending on SCMW parameters: number of poles, period, magnetic field. The Budker Institute has manufactured wigglers, which are successfully used as insertion devices for such centres of synchrotron radiations as CLS (Canada), DLS (England), LNLS (Brazil), ELETTRA (Italy), BESSY (Germany), CAMD (USA), Siberia (Russia), ASHo (Australia), ALBA-CELLS (Spain), KIT (Germany) [1].

Each pole of the wiggler consists of a core of soft magnetic material, which is divided into two halves: lower half and upper one with four superconducting coils wound on each of them. All coils are connected in series in such a way that the magnetic field changes its sign from pole to pole.

"Training" is an important phase of SCMW manufacturing process. During the "training" procedure the magnetic field is increased until superconducting coils enter the resistive state. The voltage is monitored in each coil by Quench Recording System (QRS) to determine the fault initiator. Repeating this process several times helps to increase the acceptable magnetic field in coils until reaching the target value. The defective coils that are not able to withstand the necessary magnetic field can be also detected and replaced.

QRS based on modules in CAMAC standard has been used for this purpose over several decades. The first automated system for quench recording at BINP was created at 2001 for 49 poles wiggler for ELETTRA storage ring (Italy) [2]. Despite the high reliability of the existing system, its upgrade is required. CAMAC platform is becoming obsolete, and support of outdated modules, repair of the faulty ones or fabrication of the new batch, seems impossible due to the discontinuation of production of a significant part of used electronic components. In addition, the necessity of QRS expanding and increasing the number of channels is present.

CAMAC BASED QRS

Stand, which is currently in use for quench recording, is based on three pairs of modules in CAMAC standard: digitizer ADC–333 [3] and multiplexer MUX16->1x4. ADC-333 (Fig. 1) is a four-channel multiplexed digitizer with 12-bit resolution and 3 MSPS sampling rate. MUX16->1x4 (Fig. 2) is a carrier board with four embedded MUX-cards (Fig. 3), on each of which analog multiplexer 16 to 1 and 16-channel preamp are installed. The total number of measured coils reaches 192 channels (64 channels per modules pair). Pair of modules block diagram is shown in Fig. 4.

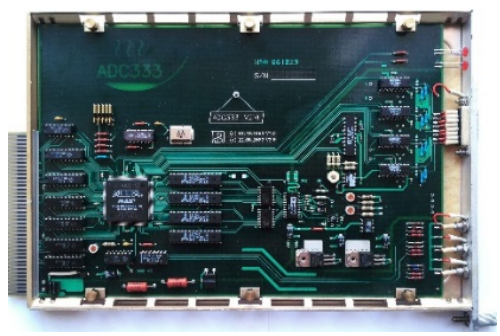

Figure 1: Digitizer ADC-333.

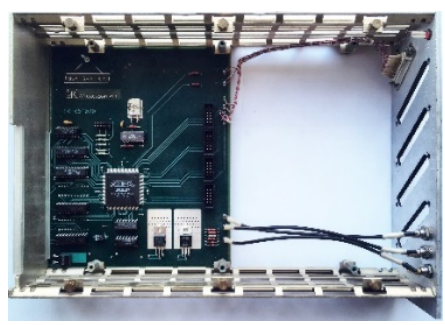

Figure 2: MUX16->1x4.

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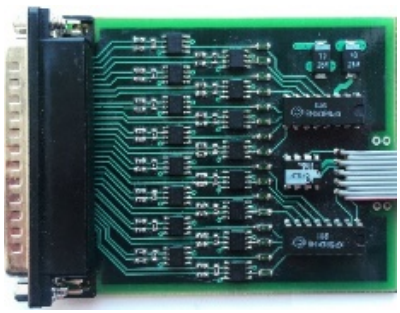

Figure 3: MUX-card.

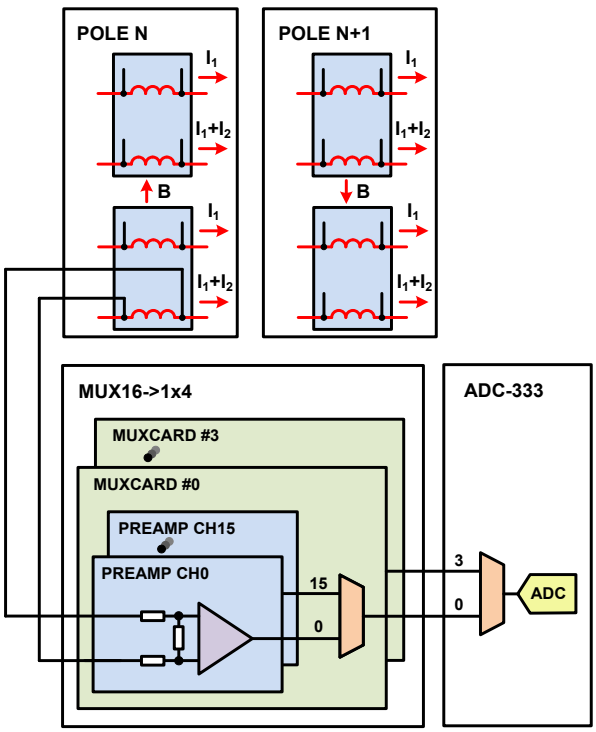

Figure 4: ADC-333 and MUX16->1x4 block diagram and QRS connection.

Recorded waveforms of voltage on coils are shown in Fig. 5. They demonstrate the appearance of the resistive state in pole 39 and the process of its expansion on poles 38, 37, 36 and etc.

VME64-BINP BASED QRS

New system for quench recording is based on VME64-BINP standard crate [4] and ADCx32 digitizer [5]. ADCx32 is 32-channel digitizer with sample rate 125 kHz per channel and 12 bit resolution, which consists of four 8-channel multiplexed ADC chips (Fig. 6). VME64-BINP crate contains 21 positions for 6U modules. The first position is designated for VME-controller, remaining general-purpose positions can be used for ADCx32 modules, and thus the total number of monitored coils in QRS based on VME-64 BINP can reach 640 channels.

The digitizer is designed in such a way that monitored signals can be applied to the module inputs through front panel as well as through backplane via RIO-lines (Fig. 7).

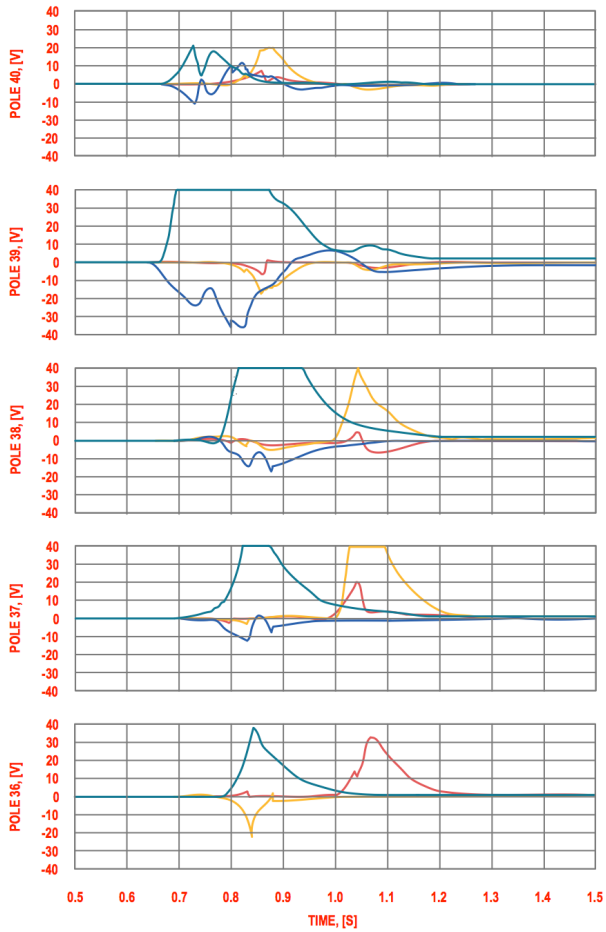

Figure 5: Waveforms of voltage on coils.

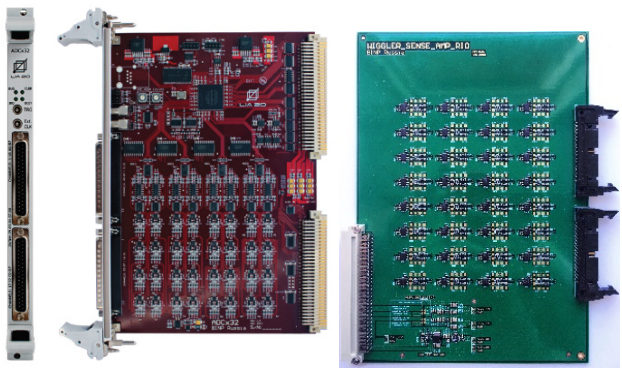

Figure 6: ADCx32 and RIO-module.

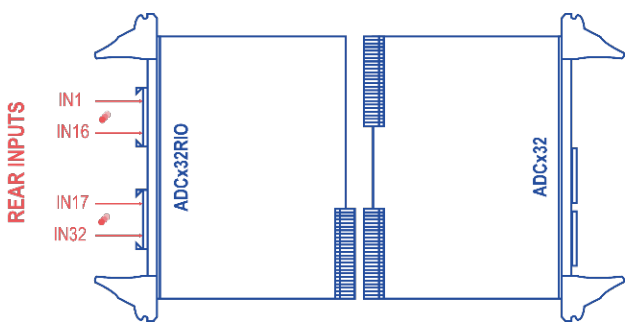

Figure 7: Rear inputs.

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Wiggler coils are connected in series, which creates very high common-mode voltage up to ±2500V. To provide the safe signal receiving in high-voltage common-mode environment a RIO-module with the protecting preamplifiers for each channel was developed (Fig. 6). Also using the RIO-module in this multi-channel waveform monitoring system allows to route the monitored signals through backplane and prevent cluttering of front panels by signal cables.

RECORDER MODE

The superconducting coils enter the resistive state unpredictable in time. Recording of randomly occurring processes is based on so-called "Recorder" mode of ADCx32 digitizer.

The basic idea of the "Recorder" mode is continuously writing the digitized signal in a cyclic buffer in memory. This process is performed until a stop event is triggered by backplane / front panel, exceeding of preconfigured level of input signal or software command. This stop event is issued by quench detection unit. As a result, the data will be stored in the module memory after stopping, which corresponds to the event prehistory, event and system behavior after the event. The "Recorder mode" in multichannel monitoring system allows to create system for recording, analyzing emergency processes and detecting the cause of its occurrence.

SOFTWARE

ADCx32 module is provided with software based on TANGO Control System [6]. ADCx32 software includes libraries, client program, utility for firmware update, and TANGO integration kit. This set of software significantly simplifies the development new QRS software. We plan to use HDF5 format for storage of collected data.

COMPARISON OF QR SYSTEMS

Main parameters of outdated QRS and new one are shown in Table 1. Main advantages of QRS based on VME64 BINP are modern hardware standard and supported software. Max. sample rate per channel is significantly increased from 4.5 KSPS to 125 KSPS by system architecture. Maximum number of monitored channels amount is 640 in comparison with 192 channels in CAMAC based QRS. Common voltage range is extended by modification of protection preamp circuit from ±1000 V to ±1375 V.

CONCLUSION

Concept for a new quench recording system for multipole superconducting wigglers fabrication at BINP is based on VME64 standard and ADCx32 digitizer.

Currently the first batch of ADCx32 with required QRS RIO-modules is fabricated, tested and is ready to be installed on QRS stand. Also the equipment for cable commutation is developed as well as a cabling structure is designed. At the moment the software for new QRS is under development.

Table 1. Comparison of New and Outdated QRS Parameters

	Outdated QRS	**Updated QRS**
Standard	CAMAC	VME64 BINP
Digitizer	ADC-333	ADCx32
Number of channels	192	640
Common voltage range	±1000V	±1375V
Input protection	±2500V	±2500V
Max. sample rate / CH	4.5 KSPS	125 KSPS
Resolution	12 bit	12 bit
Error	$\pm 5 \cdot 10^{-4}$ FS	$\pm 3 \cdot 10^{-4}$ FS
Built-in calibration	-	+
"Recorder" mode	+	+
Software support	-	SDK Device Server Firmware update function

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