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EPICS DAQ SYSTEM OF BEAM POSITION MONITOR AT THE KOMAC LINAC AND BEAMLINES

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Abstract

The KOMAC facility consists of low-energy component, including a 50-keV ion source, a low energy beam transport (LEBT), a 3-MeV radio-frequency quadrupole (RFQ), and a 20-MeV drift tube linac (DTL), as well as high-energy components, including seven DTL tanks for the 100-MeV proton beam [1]. The KOMAC has been operating 20-MeV and 100-MeV proton beam lines to provide proton beams for various applications. Approximately 20 stripline beam position monitors (BPMs) have been installed in KOMAC linac and beamlines. A data-acquisition (DAQ) system has been developed with various platforms in order to monitor beam position signals from linac and beamlines. This paper describes the hardware and software system and test results.

INTRODUCTION

Ten stripline BPMs and nine stripline BPMs were installed in the 350MHz pulse KOMAC Linac and beamline, respectively. Figure 1 shows the BPM installed in Linac and beamlines.

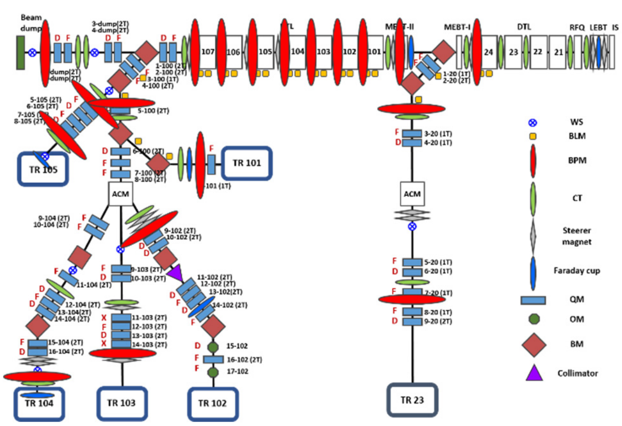

Figure 1: Layout of KOMAC Linac and Beamline.

In addition to the transverse beam position, the BPM is used to measure the beam phase for energy calculation based on flight time measurement. VME-based board was adopted as a major platform for high-performance subsystems. The MVME3100 CPU board has been adopted as a standard control system and is used in beam diagnosis, timing system, and LLRF control systems [2][3].

The DAQ system for BPM measures beam position and phase in pulse mode through IQ-based RF signal measurement. It used a single type of electronic product for all BPMs so that the design of the front electronic device is applied to all type of single-board computers through minor modifications. Table 1 summarizes the main specification of the Linac BPM and beamline BPM. The fabricated BPMs are shown in Fig. 2.

Table 1: Design Parameters of the BPMs

Type	Linac BPM	Beamline BPM
Electrode aperture	20 mm	100 mm
Electrode thickness	2 mm	2 mm
Electrode angle	60 deg.	456 deg.
Electrode length	25 mm	70 mm
Electrode gap	3.5 mm	15 mm
Feedthrough	SMA	SMA
Signal frequency	350/700 MHz	350 MHz

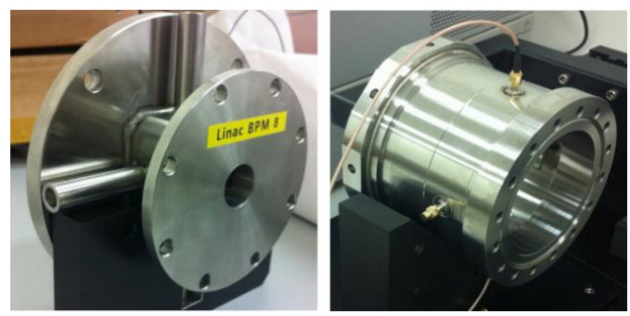

Figure 2: Linac BPM (left) and beamline BPM (right).

The BPM frontend that receives, levels down, and filters BPM signals includes analog parts of some sensitive electrical devices. The signal that has passed the frontend is sampled by the digitizer board and accumulated in memory. The sampled data extracts valid values such as beam position, beam phase, and beam current. KOMAC BPM DAQ has been upgraded to be integrated using EPICS [4] after collecting and processing BPM signals.

SYSTEM CONCEPT

As part of the available electronics platform and electronics standardization strategy, VME has been adopted and used as a major device for KOMAC's high-performance electronics, including BPM, timing and LLRF systems. The main reasons for adopting VME are excellent performance, durability, and cost reduction. In particular, by unifying the platforms of various control system, short development processes and simple maintenance become the biggest advantages.

Figure 3 shows a schematic diagram of the BPM system manufactured by KOMAC for accuracy and calibra-

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tion measurement. The original plan was to measure the beam phase and position using a log ratio BPM electronic device. However, only the beam phase of the BPM is currently being measured. The upgrade plan is to directly measure the four signals of the BPM electrodes and simultaneously generate beam phase, beam position, and beam current from four signals.

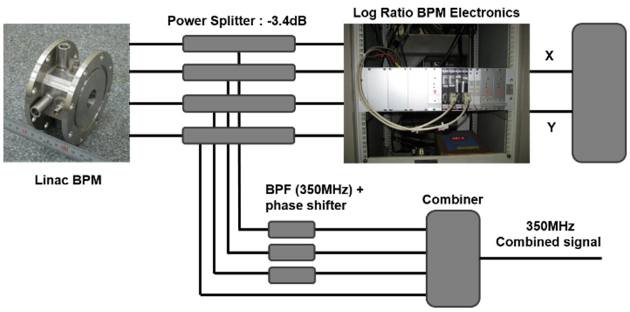

Figure 3: Original plan for beam phase and position.

The induced voltage of the BPM is transmitted to the DAQ system installed in the KOMAC klystron gallery by four coaxial cables. The DAQ contains several electronic modules, such as digitizer board for processing analog signals and VME CPU board with EPICS middleware installed on vxWorks operating system.

The accuracy and calibration of the BPM were performed on the test stand as shown in Fig. 4. After checking the signal processing results of BPM's test stand and DAQ, the calibration value is obtained by measuring the BPM position mapping data using the actual BPM signal line in the tunnel.

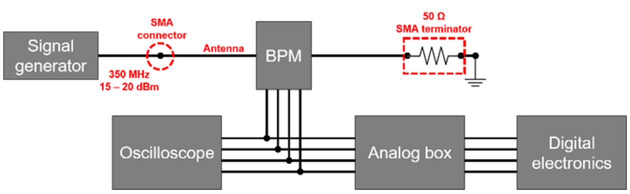

Figure 4: BPM test stand for accuracy and calibration measurement.

A wire containing RF power is passed through the BPM instead of the actual beam. The ADC board measures the X and Y output voltages of the BPM. The X and Y voltages sampled by the ADC are processed in driver support of EPICS IOC and serviced using Channel Access (CA).

BPM DAQ SYSTEM

The data acquisition board consists of a Linac BPM and beamline BPM. The MVME3100 baseboard and PENTEK7142 board for beam signal acquisition have been adopted as Linac BPM as shown in Fig. 5. For beamline BPM, Libera spark HL products have been adopted [5]. PENTEK7142 is a PMC type board with a 14-bit, 125MHz/s/channel sampling function for four independent analog inputs with Xilinx Virtex-4 FPGA. At the KOMAC facility, 10 DAQ boards for Linac BPM and 9 DAQ boards for beamline BPM are installed. Since the BPM DAQ must be synchronized with the beam timing, all DAQ system for beam diagnosis equipment must be synchronized with the KOMAC timing system.

Figure 5: MVME3100 and PENTEK7142 for Linac BPM.

One of the reasons for choosing the MVME3100 board is to match the PCI bus transmission rate with the PENTEK board. Table 2 describes the PCI bus specifications. The PENKEK board supports a PCI bus transmission rate of 64 Bits/66 MHz. The PCI bus of the MVME3100 may select 32bits and 64bits of bus width at 66 MHz.

Table 2: Specifications of PCI Bus

Type	Clock	Bus Width	Data Rate
PCI	33MHz	32bits	132MB/s
		64bits	265MB/s
PCI or PCI-X	66MHz	32bits	264MB/s
		64bits	528MB/s
PCI-X	133MHz	32bits	532MB/s
		64bits	1064MB/s

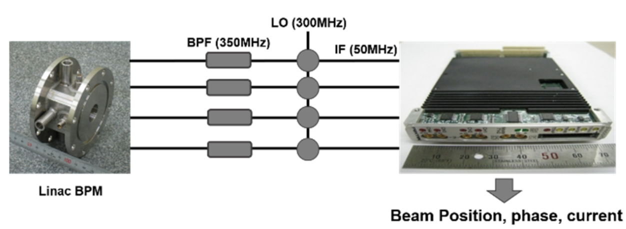

Figure 6: Schematic diagram of BPM DAQ System for measuring beam phase, position, and current.

The analog frontend consists of RF components including a mixer, 4-way splitter, 350MHz band pass filter, low pass filters. The 350MHz beam signal is mixed with the 300MHz LO signal for signal conversion and is down-converted to 50MHz IF signal in the analog frontend. The IF signal is sampled by the PMC ADC board. Figure 6 shows BPM DAQ System for measuring beam phase, position, and current with a 350MHz signal generator and

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a DAQ digitizer board used in the BPM test stand. The DAQ system for the Linac BPM is classified into two parts: MVME3100 baseboard and PMC digitizer board. In PMC, data is sampled using ADC and the sample IQ data is stacked in the FIFO memory. When the stored data reaches a specified memory size, an interrupt is generated and the data is transferred to the baseboard through a PCI bus. The data block transmission between the baseboard and the PMC digitizer board uses the DMA method. DMA uses burst address mode, which repeats read/write indefinitely from start to end. The burst address mode reduces the counter by 1 and proceeds until it reaches zero, and when it is done, it informs the CPU using DMA_INT as shown in Fig. 7.

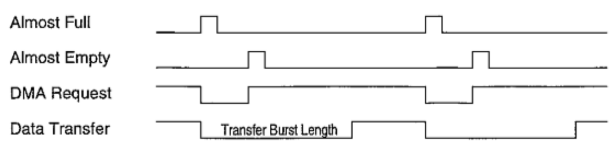

Figure 7: Transfer the data block between two-hardware devices.

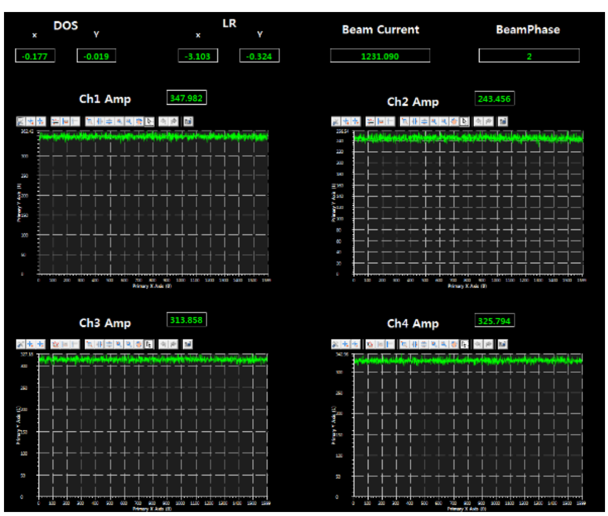

Figure 8: User interface of BPM using CSS.

EPICS Driver Support

The VME baseboard has a built-in EPICS IOC server and generates PV data, and serves it. The ADC data is supplied to the FPGA. The FPGA stacks the data in the FIFO memory in an IQ arrangement and hands over the data to the CPU board after one pulse. The EPICS driver support is implemented to extract the beam position, phase, and current. The beam position is different of sum and log ratio. Position mapping data of BPM is measured to obtain a calibration value, and application to the DAQ system is completed. The beam phase is vector sum of four signals from four electrodes in a beam chamber. The beam current is amplitude sum of four signals from four electrodes. Primary data processing is performed in the driver support area of the EPICS layer. Amplitude and phase are generated from IQ data. The FPGA code must be general and flexible, so it can be used for all BPM types with little modification.

The final value calculated and obtained from the driver support is registered in the EPICS PV. BPM data is monitored in real time through the Control System Studio (CSS) and Channel Access (CA) in shown Fig. 8.

CONCLUSION

The BPM DAQ system for KOMAC Linac and beamline has been developed. The MVME3100 and PENTEK7142 ADC board have been adopted to directly collect signals from the BPM 4 channels and process data. EPICS IOC for MVME3100 has been developed with the PENTEK driver. The BPM data processing is performed by EPICS driver support, and beam position, phase and current values could be checked in real time for each beam pulse. Libera spark HL products have been adopted and installed for beamline BPM. Libera is judged to be a user-friendly system in beam position electronics based on system on chip platform.

The VME baseboard has been adopted and used as a major device for KOMAC's high-performance electronics, including BPM, timing and LLRF systems. By unifying the platforms of various control system, short development processes and simple maintenance become the biggest advantages.

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