# MicroTCA.4 based data acquisition system for KSTAR Tokamak

Woong-ryol Lee, Taegu Lee, Kihyun Kim, Peter Milne, Giil Kwon, Jaesic Hong

***Abstract*– For the systematic standardization of the real time control at Korea Superconducting Tokamak Advanced Research (KSTAR) facility, we developed a new functional digital controller based on the MTCA.4 Standard. The KSTAR Multifunction Control Unit (KMCU, K-Z35) is realized using Xilinx System-On-Chip (SOC) architecture. The KMCU is matched with a dedicated Rear Transition Module (RTM) with sites for two FMC-like analog Data Acquisition (DAQ) modules. The first DAQ system to be implemented is the Motional Stark Effect (MSE) diagnostic. We also implement a two way steaming data transmission function for the real time plasma control.**

**We present the complete data acquisition system and operation results which is configured with MTCA.4 standards.**

## I. Introduction

THE KSTAR control system comprises various heterogeneous hardware platforms [1]. This diversity of platforms raises a maintenance issue. In addition, limited data throughput rate and the need for higher quality data drives us to find the next generation control platform.

Physics community has been contributing to the enhancement of standard system platforms. Recently, they have announced the extension of MTCA as known MTCA.4. To take advantage of the modular structure with high-speed links and the flexible reconfiguration capability of the MTCA.4, we initiate systematic standardization for the real time control system and diagnostics. After surveying of new products in the market, we decided to develop a SOC based MTCA.4 board for specific diagnostics.

## II. Motivation and Approach

A running plasma control system at KSTAR uses dedicated analogue interface devices with well defined internal software architecture [2]. The internal processing code pickup raw data from diagnostics sensors and executes the plasma equilibrium-reconstruction using EFIT (Equilibrium Fitting) code in real time. A plasma diagnostics system share sensor to the PCS and executes post analysis to measure plasma characteristic and states. Each control and diagnostics system have configured with DAQ devices in conventionally. To keep a functional compatibility, the KMCU considered providing a simultaneous two way streaming data transmission function for current plasma control system.

A stand-alone operation capability also considered for a small size diagnostics. It plans to use not only for DAQ, but also for an actuator controller.

## III. Design and Development

The architecture of the overall system is illustrated in Fig. 1.

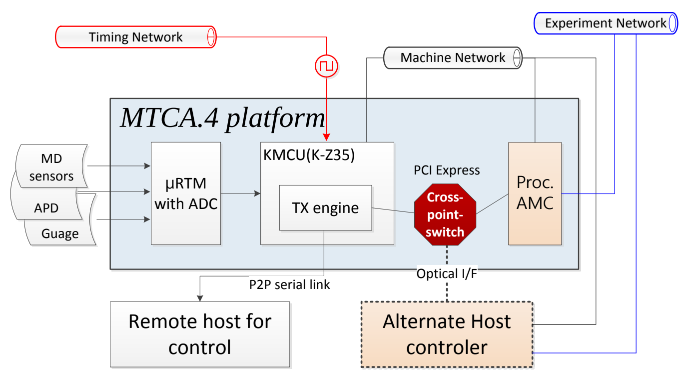


Fig. 1. Basic concept and architecture of the DAQ system

### A. Hardware design

The KMCU features a Xilinx ZYNQ7000 SOC with ARM processor, FPGA fabric with multi-gigabit transceivers, 1GB DDR-3 memory, as well as a single VITA-57 FMC site reserved for future functional expansion. KMCU is matched with a dedicated Rear Transition Module (RTM) with sites for two FMC-like analog Data Acquisition (DAQ) modules. The RTM pin out is compatible with the DESY standard Zone-3 interface, D1.0. The schematic diagram and manufactured device are depicted in Fig. 2.

### B. Software design

Basic software application divided into target and host. The host side application is implemented using KSTAR standard software framework (SFW) [3]. Over 20 numbers of DAQ and control systems are implemented based on the SFW in currently. Storage saving logic and absolute time based operation scheme are implemented recently. The target application, meanwhile, is developed based on the EPICS and Xilinx cross compile toolchain.

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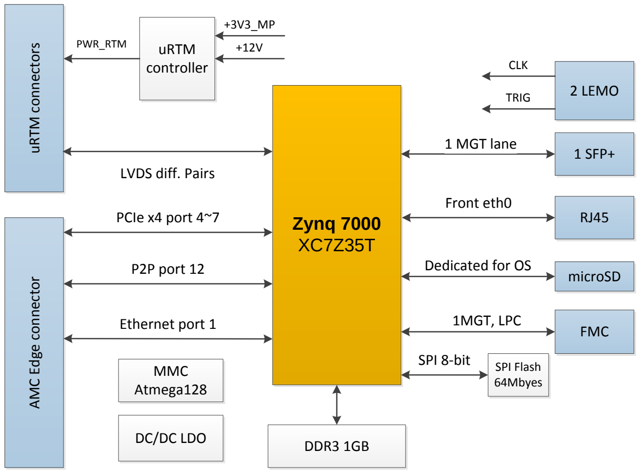


A. Block diagram of KSTAR multifunction control unit.

B. Manufactured KMCU-Z35.

Fig. 2. Block diagram of KSTAR multifunction control unit and appearance.

### *C. Application architecture*

Target application has non-blocking software architecture based on the EPICS device/driver support routine [4]. All control commands are dispached to an execute thread through the message queue. The stream input raw data temporarily stored in an elastic buffer which has a RAM disk interface. A DAQ and Ring buffer control thread takes a raw data and archiving them into the local file system using ring buffer interface. The basic working procedure is illustrated in Fig. 3.

## IV. System Implementation

The first implemented target DAQ system is a Motional Stark Effect (MSE) diagnostics. The MSE diagnostics is used to measure the radial magnetic pitch angle profile in neutral beam heated plasma. It has two extended FMC modules, each has 16 channels, 2MSPS, and programmable gain function. It will be used for a real time current profile control with digital lock-in amplifier function by FPGA [5]. The second implemented system is a Mirnov Coil (MC) diagnostics. The MC measures magnetic fluctuations (up to 1MHz) at the edge region during plasma discharge in the KSTAR machine [6]. The Magnetic Diagnostics (MD) are essential tools for operation and control of the KSTAR and for understanding the plasma behavior [7], [8]. The MD data acquisition system will be replaced with the MTCA.4 based DAQ system.

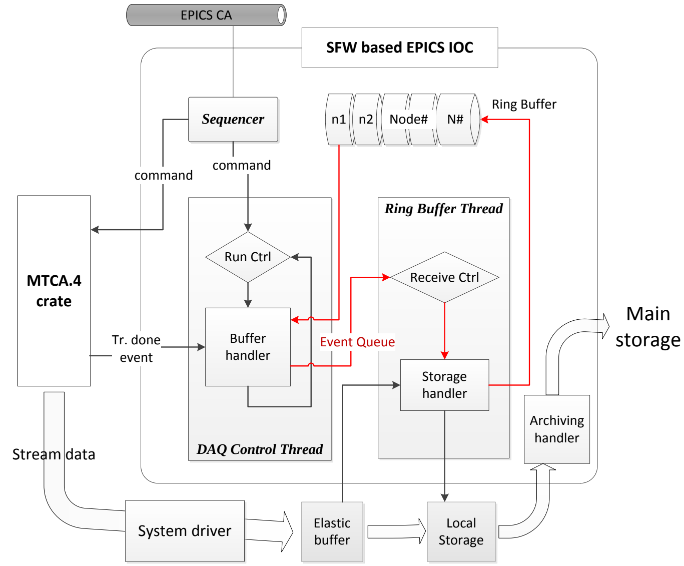


Fig. 3. Conceptual software architecture and data flow.

## V. Conclusions

We have been investigating the next generation control platform and new standards both hardware and software infrastructure. KSTAR adopt the MTCA.4 standard for the systematic standardization of a fast controller and real time diagnostics. Manufactured Xilinx SOC architecture based AMC is a result of successful international collaboration. The KMCU has a new streaming data transfer function for the plasma control system as well as diagnostics. We consider the K-series AMCs for a small size diagnostics and control system by means of standalone operability.

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