Software Architecture for Next Generation Beam Position Monitors at Fermilab

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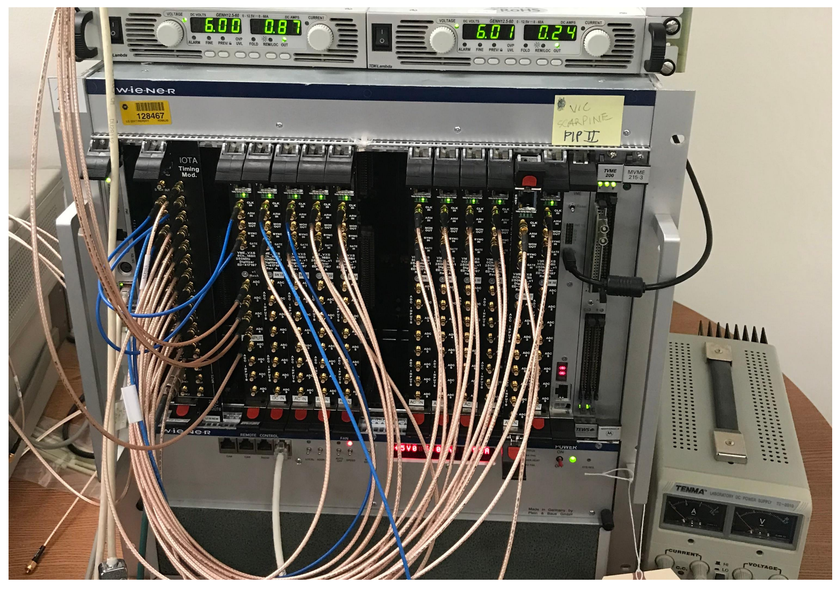
Abstract

The Fermilab Accelerator Division / Instrumentation Department develops Beam Position Monitor (BPM) systems in-house to support its sprawling accelerator complex. Two new BPM systems have been deployed over the last two years – one upgrade and one new. These systems are based on a combination of VME and Gigabit Ethernet connected hardware and a common Linux-based embedded software platform with modular components. The architecture of this software platform and the considerations for adapting to future machines or upgrade projects will be described.

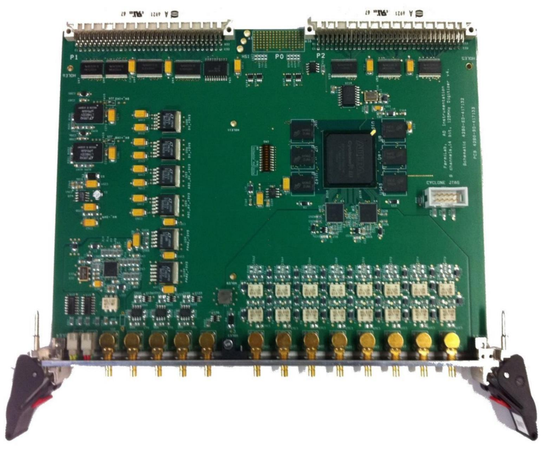


IOTA BPM Test Stand Crate contents, from left:

Concurrent 405x SBC

IOTA Timing Module

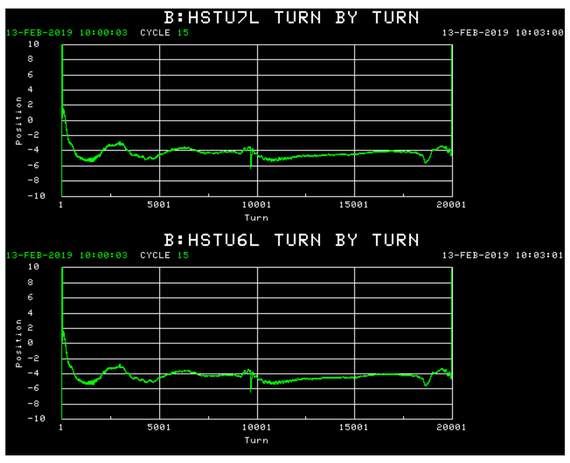
IOTA BPM Digitizer Modules (x11)



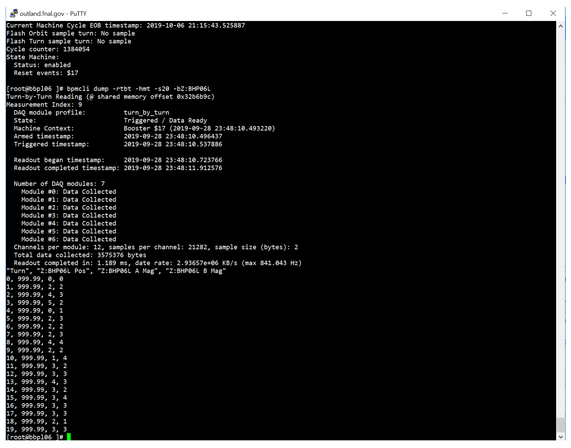
Accelerator Division / Instrumentation Department FPGA-based VME Digitizer Module

Hardware & Firmware

BPM Digitizer Modules, Timing Signal Generator and Clock Decoder and Analog Transition Modules were all developed in-house with customer firmware and software. Artesyn MVME-8100 and Concurrent Technologies 405x Single Board Computers are utilized for crate controller and front end processing.



Turn-by-turn position measurement ACNET console display from Fermilab Booster



Turn-by-turn position measurement dump using the command line tool

User Interfaces

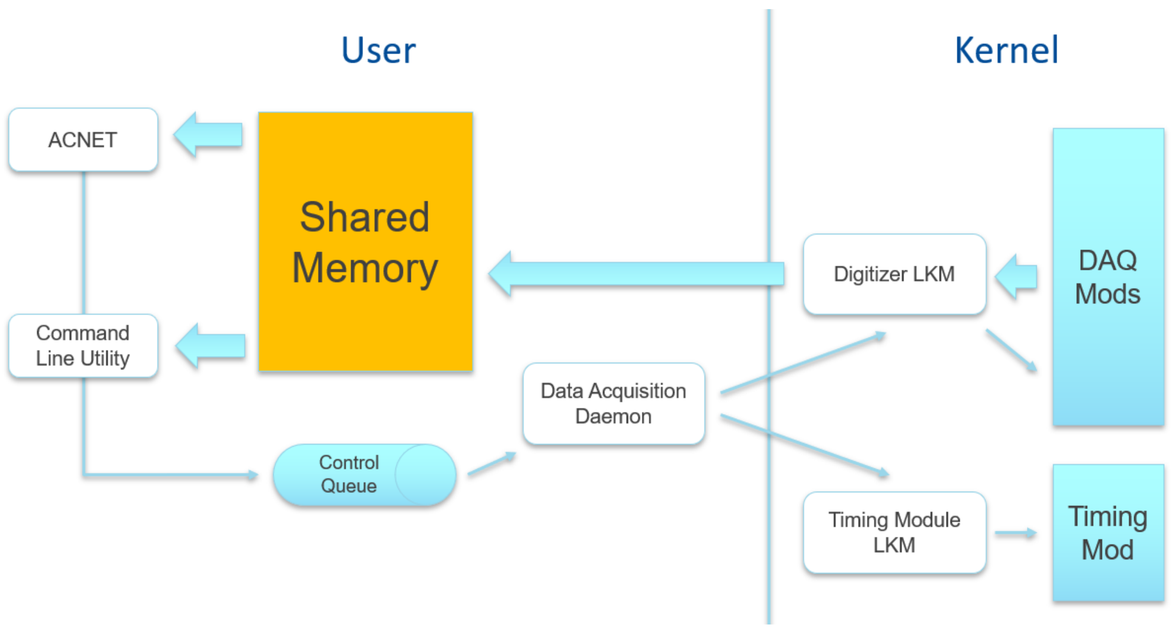
Measurement and configuration data is available to user interfaces through a shared memory region accessed with a C++ client API. Interfaces to the Fermilab accelerator controls system (ACNET) for Booster and IOTA were developed to work with existing console / client software. An universal command line tool was developed to assist experts in diagnosing the BPM system and performing advanced functions.

Embedded Linux Stack

Linux kernel, root file system and cross-compile toolchains were built using Buildroot, an open-source embedded Linux build system. Targets include a MVME-8100 (QorIQ architecture) and a Concurrent 405x (x86 architecture)

Linux Kernel Modules (LKMs)

- Linux Kernel Modules utilize the mainline Linux VME driver (3.x kernels) to interact with in-house developed timing and digitizer modules.
- Support for both major VME bridge chips was utilized - Universe-II (IOTA BPMs) and TSI-148 (Booster BPMs)
- Linux Character Device, Sysfs and Generic Netlink interfaces are used to communicate between user-space and hardware
- DMA and VME BLT transfers used to efficiently move measurement data to shared memory region



Beam Position Monitor / Data Acquisition Software process model

Data Acquisition Daemon

- Coordinates beam position measurements for all BPM represented by this Front End
- Configured via human-readable configuration file
- Synchronizes with accelerator events via TCLK
- Prepares digitizer modules to make position measurements
- Receives commands from user interfaces via a control message queue
- Directs digitizer modules to DMA measurement data into shared memory region