AN EMBEDDED IOC for 100-MeV CYCLOTRON RF CONTROL

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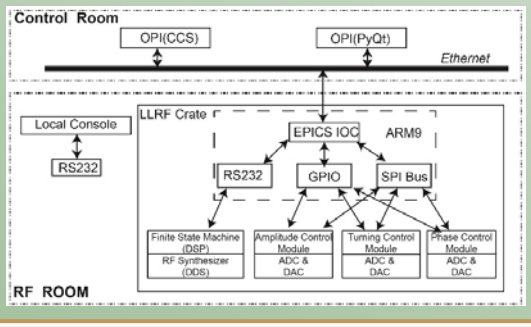
ABSTRACT

An ARM9 based embedded controller for 100MeV cyclotron RF control has been successfully developed and tested with EPICS control software. The controller is implemented as a 3U VME long card, located in the first slot of the LLRF control crate, as a supervise module that continuously monitors the status of the RF system through a costume designed backplane and related ADCs located on other boards in the crate. For high components density and signal integrate considerations, the PCB layout adopts a 6 layers design. The Debian GNU/ Linux distribution for the ARM architecture has been selected as an operating system for both robustness and convenience. EPICS device support, as well as Linux driver routings, has been written and tested to interface database records to the onboard 12 multichannel 16bits ADCs and DACs. In the meantime, a chip selecting encoding-decoding strategy has been implemented from both soft-ware and hardware aspects to extend the SPI bus of the AT91SAM9g20 processor. The detailed software, as well as hardware designed, will be reported in this paper.

Hardware Design of the embedded Controller

ARM9 series processors combine the advantages of high computational power with a small footprint. It also provides advantages such as high reliability and low power consumption. These features make it ideal for embedded controller design. In recent years, IOC based on ARM9 processor has been widely adopted for the control of many large scientific devices around the world. For the hardware designs of the IOC described in this paper, an AT91SAM9g20 processor has been selected as the central processing unit. Besides, the hardware design also includes 64MB SDRAM as memory, selects NAND FLASH and SD card to store OS and data. Other related hardware resources are one USB bus, two serial ports, two SPI interfaces, one Ethernet, 40 GPIO, etc.



SPI device driver

The hardware design of 100MeV IOC system modified the Chip Selection of SPI bus, the Linux kernel driver should be adjusted accordingly to enable system-level functionality.

The standard version implementation doesn't include the feature of chip select extending, therefore line by line read and modification of the code has to be done. The first step is to add an atmel_spi_data structure to describe which GPIO they use as CS line and as well to enable or not the use of the CS decode feature. Secondly, the at91_add_device_spi() has been revamped, it is now used to add an SPI *controller* device only. The boards need to register their SPI devices with spi_register_board_info(). The third step is to modify the relevant code in the atmel_spi.c file under the Linux-2.6.38/drivers/spi/ folder, to add decoding support for the driver. Lastly, it is needed to modify the board support level definition file board-sam9g20ek.c under the Linux-2.6.38/arch/arm/match-at91/ folder, register the extended SPI device to the Linux device tree and initialize the 16 devices in the board level.

The OPI

In the early stage, especially in the system development phase, this OPI interface was developed using Pyepics and PyQt frameworks. In the new OPI, we use the LED animation to display the switch status and use the text control to display the RF system information such as the Dee voltage, Driven amplitude, and phase, etc.

Conclusion

This embedded IOC is developed in late 2013 and goes online in early 2014. Together with the cyclotron LLRF control, it has been put into continuous operation for 24/7 after the commissioning of the cyclotron on May 4, 2014. Operational experience shows the design is stable and reliable. The embedded IOC was specially developed for the LLRF system of CYCIAE-100 cyclotron, yet the technology involved can be valuable for similar control systems.