Controls & Computing

Development of Flexible and Logic-Reconfigurable VME Boards

A real-time control system with complex sequences is a key technology for developing equipment for next-generation light sources, various progressive user experiments and accelerator operations. Software on a CPU and simple AI/AOs and DIOs enable us to build control systems with complex sequences, such as slow feedback routines. However, a fast sequence that requires sub-100-microsecond-order timing is currently impossible to achieve using software on a CPU. Hardware in the form of a hard-wired circuit, on the other hand, enables the realization of a fast sequence. However, hardware sometimes has limited flexibility and requires considerable time and cost to modify sequences.

An I/O flexible and logic-reconfigurable VME board was developed to enable both the fast control and modification of sequences [1]. The board has three main features: (i) flexible I/O selection, (ii) real-time and fast control, and (iii) sequence reconfigurability.

(i) Flexible I/O selection: The I/O parts of the board were physically separated from the base board (see Fig. 1). The I/O parts are simple I/O daughter modules such as an AI/AO or DIO module. The users can choose appropriate I/O daughter modules for their own system, put them on the base board and develop the firmware of the sequences to be carried out. The same base board can be used with different I/Os with a small modification of the logic and without any modification of the hardware, such as printed circuit board design. Two I/O parts can be installed on the base board as daughter modules. Three types of the I/O daughter board are developed: AI/AO, DIO and the Camera Link grabber.

(ii) Real-time and fast control: The base board is mounted with field-programmable gate array (FPGA) chips. The user sequences are on one FPGA chip with 1.5 M gates. The FPGA executes user logic at a base clock frequency of 50 MHz. The FPGA enables real-time and fast control with a microsecond-order response, which software on a CPU at present

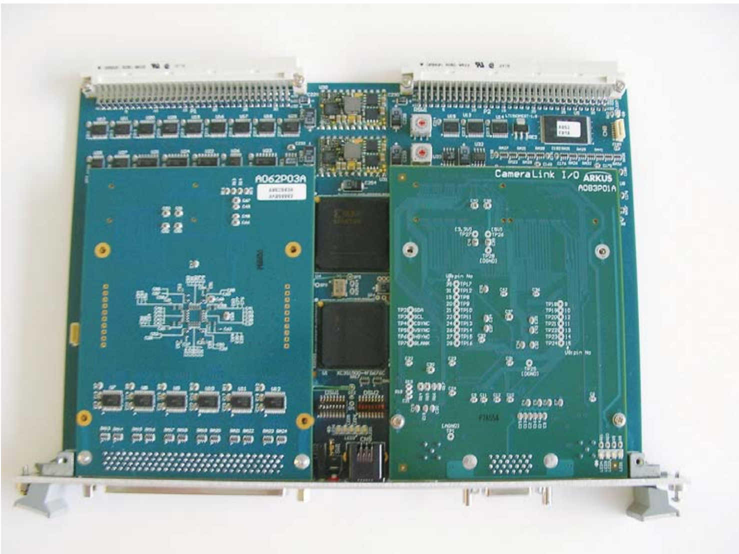

Fig. 1. Photograph of flexible and logic-reconfigurable VME board mounted with DIO (left side) and camera link grabber (right side) daughter boards. The FPGA that execute the users' sequence is mounted in the lower middle part of the base board.

cannot achieve.

(iii) Sequence reconfigurability: An FPGA is reprogrammable. Changing the logic in the FPGA is only the modification of the configuration data of the firmware, which is performed in a few minutes. The feature of reconfigurability enables us to carry out R&D of the sequence because of ease of modification. The users can test several sequences to find the appropriate one for their equipment in a short period of time. This feature is important to facility, such as SPpring-8, where novel measurement systems are developed.

In addition to the above three features, the board has a 256 MB DDR memory as temporal data storage and LEDs for debugging. The block diagram of the board is shown in Fig. 2. The proportional-integral-derivative (PID) feedback system is one of the applications of the board. A base board with the logic for a PID feedback sequence and an AI/AO daughter board function as the feedback system. The board is also applied in many systems, such as the PID system with a pulse width modulation output, a pulse train generator with outputs of a few kHz, screen monitor system with Camera Link camera, a trigger selector that selects a trigger from a 60 Hz pulse and a shutter system that requires an over 80 kHz TTL output.

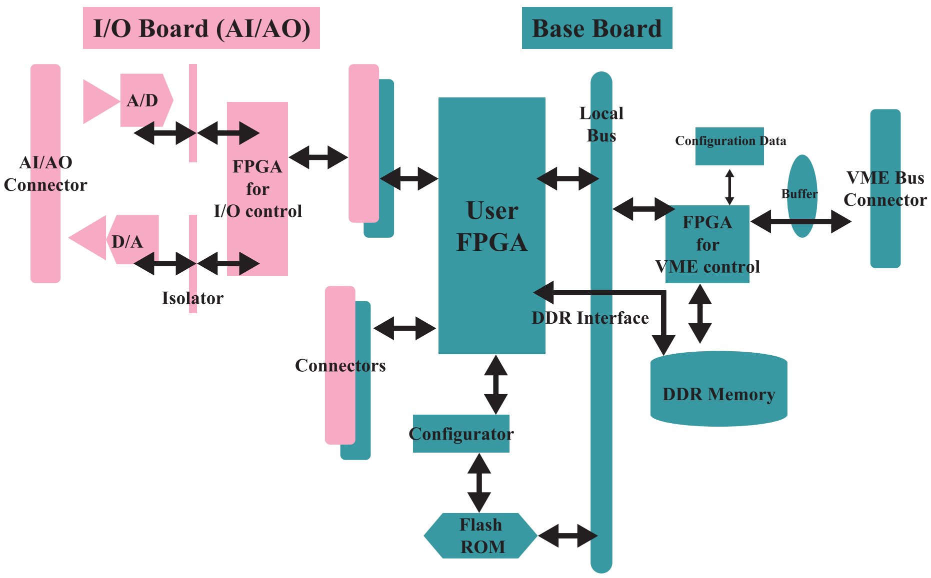

Fig. 2. Block diagram of flexible and logic-reconfigurable VME board. Green blocks are elements on the base board and pink blocks are elements on the I/O daughter board.

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References

[1] T. Hirono *et al.*: Proc. ICALEPCS'07, Knoxville, U.S.A. (2007).