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» Application Story «

VME in Industrial Automation



Proven Technology from a Proven Vendor

Kontron VME technology is the first choice for safety critical systems in nuclear power stations



Safety systems in nuclear power stations require proven, reliable technology that provides the highest level of system availability. That is why AECL (Atomic Energy of Canada Limited) decided to implement a safety system based on the long established VME technology. The system is working faultlessly in power stations around the world.

The world's first nuclear power plant to generate electricity for a power grid began operation at Obninsk, USSR in 1954. The reactor produced five megawatts of energy, enough to power 2,000 homes. Today, there are 435 nuclear power reactors operating in 31 different countries around the world. Together, they provide about 17% of the world's electricity.

In order to operate safely, nuclear power stations require high availability safety systems. One company at the forefront of research into nuclear safety is AECL. Established in 1952, AECL is the designer and builder of the CANDU® (Canada Deuterium Uranium) technology including the CANDU 6® reactor, one of the world's top performing nuclear power plants. The reactor's safety features include two highly reliable Safety Shutdown Systems (SDS1 and SDS2), designed to shutdown the reactor on detection of abnormal conditions. For SDS2 AECL has chosen a system based on the long-standing and proven VME technology.



Figure 1: The Safety Shutdown System 2 (SDS 2), based on proven VME technology, monitors safety critical parameters at the Qinshan Phase III Nuclear Power Station in China..

The safety shutdown system (SDS)

Nuclear power stations use nuclear fission to set up a controlled chain reaction that produces heat to boil water, produce steam and drive a turbine for the generation of electricity.

If the rate of the chain reaction speeds up, heat within the reactor could approach a dangerous level. Should this occur, the reactor would shut down immediately and safely. This procedure is handled by the reactor's two safety shut down systems, SDS 1 and SDS 2. These systems, which are independent of each other, continuously monitor safety critical values within the reactor. Each system consists of three independent safety channels (triple logic circuit) arranged in a 2-out-of-3 voting system. If the values in any two channels of one system are outside pre-determined envelopes, an emergency shutdown (reactor trip) is initiated.

Reliable technology for safety critical applications

Safety critical applications like the Safety Shutdown System need a robust, reliable and proven technology that is guaranteed to function under all conceivable circumstances, for example, in the event of an earth quake or extreme temperature fluctuations. In addition, the systems need to have electromagnetic compatibility with other electronic devices and stand the test of time (AECL requires that all technology involved pass a 40 year aging test). The safety shutdown systems must have the highest standards of manufacturing, reliability and safety comparable with those used in aeroplanes, military applications and the medical sector. The systems must be based on proven technology and pass rigorous seismic, EMC, temperature, shock, vibration and lifetime tests.

For optimal safety, different vendors were chosen to supply each SDS system. This guarantees single failure tolerance so that an unpredictable fault in one of the SDS systems is not duplicated in the second system. AECL required competent partners that could deliver a system robust enough to meet seismic, EMC, temperature, shock and vibration requirements. The chosen companies would also have to provide the necessary expertise and support, both for the initial fine tuning of the equipment and in the long term. After evaluating the products and services of different vendors the partner of choice for SDS 2 was Kontron, who worked closely with AECL to develop a system based on VME technology. Since VME is a well-established, proven technology that is designed for high-availability, 99.9999% applications, it is ideal for this kind of safety critical project.

Kontron supplied the Programmable Digital Comparators (PDC) for the SDS 2 system. The SDS 2 system consists of six PDCs in total - two PDCs for each of its three functionally identical channels. Two PDCs are necessary in order to monitor and process all of the safety-critical parameters such as steam generator level, heat transport system pressure, feed water line pressure, etc. Each PDC consists of a VM30 CPU board together with 3 analogue I/O boards, 6 digital I/O boards, 10 boards for signal conditioning, 8 over-voltage protection boards and 12 isolation modules as well as power supply units and cables. All of the components were supplied by Kontron and mounted in a 19" inch chassis. The chassis themselves are housed in a seismic cabinet. Information on the reactor status is obtained from sensors within the reactor and sent to the PDCs via the analogue and digital I/Os. Software routines written by AECL in Modula-2, a derivative of Pascal, compare the current status of the reactor with set point values. If current values are outside the safety envelope, the PDC sends a signal to initiate a reactor trip. The reactor trip is only carried through, however, if a PDC in two of the three channels indicates a problem. The "2 out of 3" voting logic is handled by independent relays and safeguards against spurious reactor trips caused by a fault in one of the SDS 2 channels.

Since the software runs on the VM30 without the need for an operating system, it provides a further safety feature by ruling out the possibility of operating system failures. Optimal safety requires adequate processing power as well as reliability. This is provided by Motorola's RISC based processor platform that enables reactor values to be sampled and processed every 40 ms to ensure that the reactor can be shut down safely at the first indication of a problem. An extra safety feature is the hardware watchdog timer, also supplied by Kontron, designed to monitor the PDC operation and to initiate a channel trip should the PDCs themselves operate abnormally. In addition, all of the values sampled and processed by the PDC are also sent via the digital and analog outputs to displays in the control center, enabling operators to monitor the safety parameters.

Rigorous testing and diagnostics

Before the system could be handed over to AECL, independent specialists were commissioned to carry out the rigorous seismic, EMC, temperature, shock and vibration tests on all of the Kontron boards used in the PDCs. This "proof of concept" procedure ensures that every component will continue to operate under possible adverse conditions. In addition, Kontron carried out full Factory Acceptance Tests (FAT) at its Kaufbeuren location in Germany in the presence of AECL staff to ensure the functionality of every board and component. Before the system could be handed over to AECL, independent specialists were commissioned to carry out the rigorous seismic, EMC, temperature, shock and vibration tests on all of the Kontron boards used in the PDCs. This "proof of concept" procedure ensures that every component will continue to operate under possible adverse conditions. In addition, Kontron carried out full Factory Acceptance Tests (FAT) at its Kaufbeuren location in Germany in the presence of AECL staff to ensure the functionality of every board and component.

After handing over the SDS 2, AECL also needed to be able to test the functionality of all components on site before the system could go live. And once in operation, regular maintenance is obligatory for confirming the ongoing functionality of the installed components. This is why AECL also asked Kontron to develop and supply a Maintenance and Diagnostic system. Operators can use the Maintenance and Diagnostic system at any time to ensure the functionality of newly delivered boards and to check the functionality of the boards in any of the PDCs. The boards to be checked are placed in the Maintenance and Diagnostic system's 19" rack. Specially developed diagnostic software, written and supplied by Kontron, runs on the system's VM30 board under OS-9 RTOS. A user interface is provided by the robust Kontron VL203 server with Intel processor together with a TFT graphic terminal and keyboard. Emulation software running on the VL203 under Windows OS guides AECL operators through the diagnostic procedures. By selecting the relevant menu options, operators are able to check the functionality of all SDS 2 components. For example the Kontron VME processor boards, including the VM30 real-time clock and timer as well as dynamic RAM, static RAM and the contents of VM30 EPROM. Operators can also check the functionality of all the digital and analog I/O boards as well as the watchdog.



Figure 2: One of the rugged Kontron PDCs for monitoring safety critical values in the CANDU reactor.

Documentation and training

As part of the project, Kontron also supplied over 3000 pages of detailed system documentation, including a detailed operating and maintenance manual with circuit diagrams. Extensive documentation consisting of a test plan and report describing the procedures and results of the independent seismic, EMC and other tests that the system successfully passed was also handed over to AECL along with full documentation of the Factory Acceptance Tests. In addition, AECL staff received an intensive one month training course on the SDS 2 system.

All around the world

SDS 2 systems are up and running in CANDU power plants around the world, including Wolsong (South Korea), Qinshan III (China) and Cernavoda (Romania) to name just a few. To date they have all been running faultlessly, ensuring the level of protection and safety required in modern nuclear power stations. Safety critical applications demonstrate the continued need for VME based equipment and experienced vendors with the expertise to design and implement systems that adhere to the strictest safety standards. Impressed by

the quality and reliability of the VME technology as well as the level of cooperation and support, AECL is already looking towards implementing future projects with Kontron: Kontron offers the wide range of industrial control products required for AECL's different applications. They also provide customization for special requirements and ongoing support.



Figure 3: The Maintenance and Diagnostic system enables operators to check the functionality of all SDS 2 components.

The VME bus system

VME bus technology is a robust, modular 19" computer architecture based on the Eurocard 3U and 6U physical design. It is the leading bus technology in embedded applications and a globally recognized standard - ANSI/ IEEE 1014-1987 for 32-bit VME and ANSI/VITA 1-1994 for the 64-bit version. Actively supported by VITA (VMEbus International Trade Association), VME is an open technology that offers a choice of thousands of products from hundreds of vendors. It is processor independent and can be used, for example, with Motorola's CISC CPU's as well as Intel, Freescale and SPARC processors. VME technology is thus highly flexible and can be easily customized to suit the requirements of individual applications. Its high scalability enables genuine multiprocessor performance from 1 to 21 processors and makes it ideal for real-time applications in the fields of industrial automation, process control and robotics as well as aerospace, telecommunication and other applications that require high availability and performance under harsh environmental and mechanical conditions.

VMP3 CPU board from Kontron

The latest addition to Kontron's family of 3U and 6U VME processor boards is the VMP3 3U VME CPU board with the Freescale PowerQUICC III RISC processor MPC8541. The PowerPC board with a maximum clock-rate of 660 MHz is distinguished by outstanding performance (1520 MIPS at 660 MHz according to Dhrystone 2.1) with reduced energy consumption (10W at 660 MHz), and also offers two integrated Gigabit Ethernet ports. The integrated Hardware Security Engine supports encryption in accordance with IPSec, DES, 3Des and AES. This feature, along with the very fast DDR-SDRAM, makes the VMP3 a universal processor card for computing-intensive real-time applications in, for example, automation, transportation and military technology. The 100 x 160 mm board has up to 256 MB of directly soldered DDR-SDRAM, 16 MB Flash, 1MB buffered SRAM, and E²Prom for user and configuration data. A slot for Compact Flash memory cards is optional. The two Gigabit Ethernet ports are supplemented by a Fast Ethernet interface and a serial port. A JTAG/BDM interface is provided for debugging and on-board programming. Additional features are Watchdog, real-time clock, and a temperature sensor. The VMP3 is designed for a temperature range from 0°C to 60°C, and optionally available for the extended range from -40°C to +85°C.

Available software support includes an operating systemindependent bootloader with network support, as well as a Linux and VxWorks board support package



About AECL

AECL is a full-service nuclear technology company providing services to nuclear utilities around the world. Established in 1952, AECL is the designer and builder of CANDU technology. AECL specializes in a range of advanced nuclear-energy products and services that are an important component of clean-air energy programs on four continents. AECL provides research and development, support, design and engineering, construction management, specialized technology, refurbishment, waste management and decommissioning in support of CANDU reactor products. More information on AECL, CANDU Services and CANDU technology can be found at www.aecl.ca.

About Kontron

Kontron is a global leader in embedded computing technology. With more than 40% of its employees in research and development, Kontron creates many of the standards that drive the world's embedded computing platforms. Kontron's product longevity, local engineering and support, and value-added services, helps create a sustainable and viable embedded solution for OEMs and system integrators.

Kontron works closely with its customers on their embedded application-ready platforms and custom solutions, enabling them to focus on their core competencies. The result is an accelerated time-to-market, reduced total-cost-of-ownership and an improved overall application with leading-edge, highly-reliable embedded technology.

Kontron is listed on the German TecDAX stock exchanges under the symbol "KBC". For more information, please visit: **www.kontron.com**

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