DOWNLOAD PDF THE PROGRAMMABLE LOGIC CONTROLLER AND ITS APPLICATION IN NUCLEAR REACTOR SYSTEMS

Chapter 1 : PLC Working Principle with Industrial Applications

This document provides recommendations to guide reviewers in the application of Programmable Logic Controllers (PLCs) to the control, monitoring and protection of nuclear reactors. The first topics addressed are system-level design issues, specifically including safety. The document then discusses.

Synchronous drive system High-speed networks To ensure that robots safely weld components for a nuclear reactor requires monitoring and control beyond what typical technologies can offer. Critical requirements for the plant were high welding precision and accuracy coupled with high speed. During the welding process, up to 8, parameters must be transferred in a cycle time under 1 second for each weld point. Welding process detail Rohwedder had to create a welding plant for joining an initially loose construct of longitudinal and lateral bars via laser spot welding to form a rigid steel grid. The plant consists of two welding chambers, each equipped with a laser for the actual welding, a camera system, and a PC for visualization located at the control unit. A Kuka robot handles steel grid components. First, parts are mounted on a workpiece carrier. Then, they are transferred via conveyor belt into the welding chamber and positioned by the robot. Once the workpiece is positioned in the welding cell, the cell is closed and a vacuum is generated. The chamber is then flooded with argon. Welding process specifications also are demanding. Highly dynamic linear-drives are used for moving the laser to the individual contact points. Here, the laser melts the material with high precision, creating the required weld quality. A camera mounted in the cell monitors the complete welding process. The camera system surveys the grid before the welding process and defective welds are immediately identified and automatically re-welded. The plant can process more than 50 steel grids simultaneously, 26 of those can be of differing configurations. Individual grids are asymmetricâ€"some have cut-outs. Regarding data volume, each spacer requires up to 1, welds, each with a cycle time of under 1 second. During this time, the following steps are executed: Positioning, correction via camera, laser welding according to recipe parameters manual, via NC program, or spot welding , and weld point analysis. Due to drive, control technology, and visualization requirements, Rohwedder uses PC-based control technology from Beckhoff running version 2. Exact positioning, fast motion, high data volume, and measuring tasks necessitate the use of a PC-based controller such as this," Blomberg says. All recipe parameters, including NC and laser programs, are handled via Microsoft Excel. Blomberg explains that Rohwedder prefers Excel because "it offers the simplest form of data handling, and no programming knowledge is required for creating the recipes. The document also contains the NC program, the laser and image processing program, and associated parameters. For each component, the PLC creates a data file containing recipe and process parameters, which is also accessed by the higher-level plant management system," Blomberg says. This enables errors to be detected and rectified in advance, optimizing the process. Positioning of the linear axes for standard grids should take less than ms, corresponding to a travel path of 12 mm," Blomberg says. In combination with a SERCOS drive bus, the result is a drive system that can synchronously move several axes to the target. According to Blomberg, the decisive criteria for using the IP67 modules were their compact and robust design and modular expandability through additional modules via the IP-Link system. A coupler box is used for interfacing with the Profibus network. Rohwedder uses its in-house-developed AMS XP product as a plant management system for central monitoring and management of the process. The traceability tool is an increasingly important feature for us," says Blomberg. Any errors or reworking, as well as information on third-party products are stored within the program. In the event of damage, the end-user can obtain information about the cause.

Chapter 2 : Safety instrumented system - Wikipedia

@article{osti_, title = {The Programmable Logic Controller and its application in nuclear reactor systems}, author = {Palomar, J. and Wyman, R.}, abstractNote = {This document provides recommendations to guide reviewers in the application of Programmable Logic Controllers (PLCS) to the control, monitoring and protection of nuclear.

Discrete controllers[edit] Panel mounted controllers with integral displays. The process value PV , and setvalue SV or setpoint are on the same scale for easy comparison. A control loop using a discrete controller. Field signals are flow rate measurement from the sensor, and control output to the valve. A valve positioner ensures correct valve operation. The simplest control systems are based around small discrete controllers with a single control loop each. These are usually panel mounted which allows direct viewing of the front panel and provides means of manual intervention by the operator, either to manually control the process or to change control setpoints. Originally these would be pneumatic controllers, a few of which are still in use, but nearly all are now electronic. Quite complex systems can be created with networks of these controllers communicating using industry standard protocols. Networking allow the use of local or remote SCADA operator interfaces, and enables the cascading and interlocking of controllers. However, as the number of control loops increase for a system design there is a point where the use of a programmable logic controller PLC or distributed control system DCS is more manageable or cost-effective. Distributed control systems[edit] Functional manufacturing control levels. Distributed control system A distributed control system DCS is a digital processor control system for a process or plant, wherein controller functions and field connection modules are distributed throughout the system. As the number of control loops grows, DCS becomes more cost effective than discrete controllers. Additionally a DCS provides supervisory viewing and management over large industrial processes. In a DCS, a hierarchy of controllers is connected by communication networks , allowing centralised control rooms and local on-plant monitoring and control. A DCS enables easy configuration of plant controls such as cascaded loops and interlocks,[further explanation needed] and easy interfacing with other computer systems such as production control. It also enables more sophisticated alarm handling, introduces automatic event logging, removes the need for physical records such as chart recorders and allows the control equipment to be networked and thereby located locally to equipment being controlled to reduce cabling. A DCS typically uses custom-designed processors as controllers, and uses either proprietary interconnections or standard protocols for communication. Input and output modules form the peripheral components of the system. The processors receive information from input modules, process the information and decide control actions to be performed by the output modules. The input modules receive information from sensing instruments in the process or field and the output modules transmit instructions to the final control elements, such as control valves. The field inputs and outputs can either be continuously changing analog signals e. SCADA systems[edit] Supervisory control and data acquisition SCADA is a control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management. The operator interfaces which enable monitoring and the issuing of process commands, such as controller set point changes, are handled through the SCADA supervisory computer system. However, the real-time control logic or controller calculations are performed by networked modules which connect to other peripheral devices such as programmable logic controllers and discrete PID controllers which interface to the process plant or machinery. The SCADA concept was developed as a universal means of remote access to a variety of local control modules, which could be from different manufacturers allowing access through standard automation protocols. In practice, large SCADA systems have grown to become very similar to distributed control systems in function, but using multiple means of interfacing with the plant. They can control large-scale processes that can include multiple sites, and work over large distances. SCADA control functions are usually restricted to basic overriding or supervisory level intervention. For example, a PLC may control the flow of cooling water through part of an industrial process to a set point level, but the

SCADA system software will allow operators to change the set points for the flow. The SCADA also enables alarm conditions, such as loss of flow or high temperature, to be displayed and recorded. Programmable logic controllers[edit] Main article: Programmable logic controller Siemens Simatic S system in a rack, left-to-right: Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. Before the PLC, the control, sequencing, and safety interlock logic for manufacturing automobiles was mainly composed of relays , cam timers , drum sequencers , and dedicated closed-loop controllers. Since these could number in the hundreds or even thousands, the process for updating such facilities for the yearly model change-over was very time consuming and expensive, as electricians needed to individually rewire the relays to change their operational characteristics. When digital computers became available, being general-purpose programmable devices, they were soon applied to control sequential and combinatorial logic in industrial processes. However these early computers required specialist programmers, and stringent operating environmental control for temperature, cleanliness, and power quality. To meet these challenges the PLC was developed with several key attributes. It would tolerate the shop-floor environment, it would support discrete input and output, and it was easily maintained and programmed. Another option is the use of several small embedded controls attached to an industrial computer via a network. History[edit] A pre-DCS era central control room. Whilst the controls are centralised in one place, they are still discrete and not integrated into one system. A DCS control room where plant information and controls are displayed on computer graphics screens. The operators are seated as they can view and control any part of the process from their screens, whilst retaining a plant overview. Process control of large industrial plants has evolved through many stages. Initially, control would be from panels local to the process plant. However this required a large manpower resource to attend to these dispersed panels, and there was no overall view of the process. The next logical development was the transmission of all plant measurements to a permanently-manned central control room. Effectively this was the centralisation of all the localised panels, with the advantages of lower manning levels and easier overview of the process. Often the controllers were behind the control room panels, and all automatic and manual control outputs were individually transmitted back to plant in the form of pneumatic or electrical signals. However, whilst providing a central control focus, this arrangement was inflexible as each control loop had its own controller hardware so system changes required reconfiguration of signals by re-piping or re-wiring. It also required continual operator movement within a large control room in order to monitor the whole process. These could be distributed around the plant and would communicate with the graphic displays in the control room. The concept of "distributed control" was realised. The introduction of distributed control allowed flexible interconnection and re-configuration of plant controls such as cascaded loops and interlocks, and easy interfacing with other production computer systems. It enabled sophisticated alarm handling, introduced automatic event logging, removed the need for physical records such as chart recorders, allowed the control racks to be networked and thereby located locally to plant to reduce cabling runs, and provided high level overviews of plant status and production levels. For large control systems, the general commercial name "Distributed Control System" DCS was coined to refer to proprietary modular systems from many manufacturers which had high speed networking and a full suite of displays and control racks which all seamlessly integrated. Whilst the DCS was tailored to meet the needs of large industrial continuous processes, in industries where combinatoric and sequential logic was the primary requirement, the PLC programmable logic controller evolved out of a need to replace racks of relays and timers used for event-driven control. The old controls were difficult to re-configure and fault-find, and PLC control enabled networking of signals to a central control area with electronic displays. PLC were first developed for the automotive industry on vehicle production lines, where sequential logic was becoming very complex. It was soon adopted in a large number of other event-driven applications as varied as printing presses and water treatment plants. SCADA systems use open-loop control with sites that are widely separated geographically. Most RTU systems always did have some limited capacity to handle local controls while the master station is not available. However, over the years RTU systems have grown more and more capable of handling local controls.

Chapter 3 : PCs Control Welding of Nuclear Fuel Rod Spacers | Control Engineering

This document provides recommendations to guide reviewers in the application of Programmable Logic Controllers (PLCS) to the control, monitoring and protection of nuclear reactors.

Contact Power Control Systems Sartrex has proven design and manufacturing capabilities for the creation of complex control systems and instrumentation. Experienced management and engineers work with clients to ensure the process of turning specifications into technical drawings meet all of their requirements. With over 30 years working in the nuclear industry, Sartrex understands the need for technical designs to be manufactured in a consistent and reliable manner. Contact our team to discuss your technical specifications, design, and manufacturing requirements for projects in any industry. The company has an expert team of software engineers, electronic engineers and mechanical engineers who can design systems requiring the utmost in complexity and reliability. These engineers are capable of designing systems from the ground up, providing turnkey products for your needs. Many of the systems provided include industrial control computers and network switches. Most systems are housed in seismically qualified cabinets will survive the most rigorous operation environments. Its reliability is critical for the safety of the public. The system consists of highly reliable instrumentation cabinets incorporating: Sartrex, in partnership with AECL, designed this complex system and currently manufactures and markets it worldwide. The stringent requirements imposed by such standards as ISO Its flexible software display engine allows for easy customization to different plant configurations. Its modular design also enables customers to select elements of the system for new installations or selective plant upgrades. For example, they may choose to upgrade the large screen display, and software, and use existing operating desks, or any other similar scenario. It senses neutron decay in the heat transport water heavy water leaving the reactor core. During the nominal fission process, the fuel rods retain nuclear fuel, If radioactivity escapes from the rods into the surrounding water, the FFLS will detect the high levels of delayed neutron activity. The process commences by piping the heat transport water from the core to a moderator tank where neutron detectors, suspended in a coil of the piping, can determine the intensity of neutron radiation. These monitor heavy water samples from each reactor channel, individually, to detect a comparatively high level of delayed neutron activity. After circulation through each of the tubes, a header system returns the water to the pump return line. If it detects certain low or high conditions, it trips the corresponding alarm circuitry. The amplifier system consists of four distinct sections: Clare HG3A relay modules. The modules and their chassis are mounted in cabinets in equipment rooms. Each module incorporates an 11 pin octal plug to interface to the mounting chassis. Sartrex selected two C. The coils of the relays are connected in parallel. Three of the available 4 Form D contacts are wired out to the connector pins at the bottom of the module to make it compatible to the original relay module. Post Accident Communication System The Sartrex Post Accident Communication System is an independent voice communication system for performing essential tasks during and after an emergency or accident, until the normal plant communication systems can be restored. The system consists of two parallel small telephone exchanges with ten handsets each, for a total of twelve lines. The exchanges allow individual locations to communicate with each other, as well as a conference call facility amongst any three to twelve locations. The customer has a choice of desktop or wall type mounting handsets. The sensor M series consists of an aluminum strip which is anodized by a special process to provide a porous oxide layer over which a very thin coating of gold is evaporated. The aluminum base and the gold layer form the two electrodes of what is essentially an aluminum oxide capacitor. An integral pump draws a sample of the ventilation stack air through isokinetic sampling nozzles. As the air sample travels through the system, two removable filter elements trap particulate and radioiodine constituent matter. The outlet of the pump returns the sample airstream to the stack. The system operator removes the filter element on a weekly basis and sends it to a laboratory for analysis. Start-up Instrumentation Control Continuous monitoring or neutron flux is required at all times during Approach to Critical ATS , upon successful phase over of neutron power measurement by the plant permanently installed instrumentation used to measure neutron flux. During the initial fuel loading and for the first approach to critical the neutron source is from spontaneous fission only and in-core neutron counters are temporarily installed for monitoring at the initial, low flux levels. After first approach to critical and a period of low power testing, the in-core start-up detectors are removed and a photoneutron source causes the shutdown flux to be or greater. Neutron flux monitoring is achieved for this range using out-of-core start-up detectors 3He and BF3 neutron counters. The hardware Control Circuit Subsystem is responsible for all the inputs and outputs of the System except for Rs communication and audio alarm and is independent of Software Monitoring Circuit Subsystem and can perform its intended safety related functions without software and its related hardware. The main elements in each cabinet consist of Differential Temperature Transmitter Chassis, Single Temperature Transmitter Chassis, an ultraâ€"stable dual DC power supply and associated support hardware. It is related to the instrumentation system for reactors using in-core flux detectors. Trip Test â€" This is a test circuit that when activated, injects a test current parallel to the current injected by the in-core flux detector. Alarm Control â€" This circuit compares the output voltage from the external in-core flux detector amplifier to an adjustable preset voltage reference. When the input voltage from the in-core flux detector amplifier exceeds the reference voltage, it activates the alarm circuit. Buffer Amplifier â€" The Buffer Amplifier section buffers the signals that go into and leave the alarm control section.

Chapter 4 : Power Control Systems

The programmable logic controller and its application in nuclear reactor systems. logic controller and its application in nuclear reactor systems.

Due to its robust construction, exceptional functional features like sequential control, counters and timers, ease of programming, reliable controlling capabilities and ease of hardware usage â€" this PLC is used as more than a special-purpose digital computer in industries as well as in other control-system areas. Principle of Programmable Logic Controller: Programmable Logic Controller s are used for continuously monitoring the input values from sensors and produces the outputs for the operation of actuators based on the program. Every PLC system comprises these three modules: A CPU module consists of central processor and its memory. The processor is responsible for performing all the necessary computations and processing of data by accepting the inputs and producing the appropriate outputs. The 5V DC output drives the computer circuitry. The input and out modules of the programmable logic controller are used to connect the sensors and actuators to the system to sense the various parameters such as temperature, pressure and flow, etc. The program in the CPU of programmable logic controller consists of operating system and user programs. The purpose of the operating system with CPU is to deal with the tasks and operations of the PLC such as starting and stopping operations, storage area and communication management, etc. The Principle of operation of the PLC can be understood with the cyclic scanning also called as scan cycle, which is given in the below figure. The operating system starts cycling and monitoring of time. The CPU starts reading the data from the input module and checks the status of all the inputs. The CPU starts executing the user or application program written in relay-ladder logic or any other PLC-programming language. Next, the CPU performs all the internal diagnosis and communication tasks. According to the program results, it writes the data into the output module so that all outputs are updated. This process continues as long as the PLC is in run mode. To get an idea about the PLC operation,consider the simple mixer process control as shown in the figure below. In addition, a separate manual push button station is used for the operation of the motor. These switches close their respective contacts when conditions reach their preset values. The input field devices like pressure switch, temperature switch and manual push buttons are hardwired to an appropriate input module, and the output device like motor-starter coil is hardwired to an appropriate output module of the PLC. Based on the program done in the PLC, the system continuously scans all the input preset values and correspondingly updates the outputs, i. Applications of Programmable Logic Controller PLC The PLC can be used in industrial departments of all the developed countries in industries like chemical industry, automobile industry, steel industry and electricity industry. Based on the development of all these technologies, functionality and application, the scope of the PLC increases dramatically. Application of PLC in Glass Industry From the year the Programmable-logic controllers are in use in the glass industry, and they are assembled bit by bit. PLCs are used mainly in every procedure and workshop for controlling the material ratio, processing of flat glasses, etc. With the development of PLC and increasing demand in the real world, the control mode of the programmable-logic controller with an intelligent device is applied in the glass industry. In making of a float glass, PLC itself cannot finish some controlling tasks because of the complexity of the control system and processing of huge data. For the production of glass, we make use of bus technology to construct the control mode of a PLC with a distributed-control system. This control system deals with analog controlling and data recording; the PLC is also used for digital quality control and position control. This type of control mode is a big advantage for PLC and DCS for improving reliability and flexibility of the control system. Applications of PLC in Cement Industry Along with the best-quality raw materials, the accurate data regarding process variables, especially during mixing processes within the kiln, ensures that the output provided should be of the best possible quality. Nowadays a DCS with bus technology is used in the production and management industry. This mode comprises PLC and configuration software. The host computer consists of slave and master station. The PLC is used for controlling the ball milling, shaft kiln and Kiln of coal. Thus, this article has covered the principle of operation of programmable logic devices or controller and its applications in various industries like glass industry, steel industry and cement industry. For any help regarding this topic, please contact us by commenting in the comment section given below. He has 8 years of experience in Customer Support, Operations and Administration.

Chapter 5 : Process Control Systems - SCADA, PLC, Energy Monitoring Systems

NUREG/CR UCRL-ID The Programmable Logic Controller and Its Application in Nuclear Reactor Systems Prepared by J. Palomar, R. Wyman Lawrence Livermore National Laboratory.

All the software documents and source codes are managed as software configuration items throughout the software life cycle under the control of a software quality assurance plan and procedure. Automated software tools and a 3rd part review also support the activities for the software qualification. Our experience shows that the software qualification is very efficient for systematically qualifying the safety-critical software of a PLC to be embedded in the safety-critical systems of a NPP, and they can be easily extended to other safety-critical applications such as in the railways, military, medicine, etc. The IDiPS software i. All the systematically to assure a software quality and software shown in Fig. This software qualification approach can be expanded systematically Table 1 Software classification into other safety-critical applicaitons such as in the HW HW SW SW modules components Components Safety Grade railways, military, medicine, and so on. Software test for the life cycle STLC The SC software should be analized for a software consisted of a test plan generation, a test design safety. We developed an SSA process and it was generation, a test case generation, a test procedure applied to the life cycle of the SC software [5]. The generation, and a test execution generation. Table 2 shows an example of the checklists for the SSA. Inconsistency among the SCM items were found to be the date and revision number of software documents. Some of the reported anomalies should be resolved throughout the revision of software documents. The presented software qualificaiton could be applied efficiently and sufficiently to a combined software Fig. It was important to apply a checklist-based and errors are summarized as follows. Especially, the 3rd part review 4. In incorrect, incomplete, and inconsistent specifications. The source extended easily to other safety-critical applications programs were also modified because coding errors such as in the railways, military, medicine, etc. Choi, Development of Unit Testing, Formal Method, Proceedings of the 3rd Annual [18] J. Reliability, Safety and Hazards, Dec.

Chapter 6 : Industrial control system - Wikipedia

The Programmable Logic Controller and its application in nuclear reactor systems Technical Report Palomar, J. ; Wyman, R. This document provides recommendations to guide reviewers in the application of Programmable Logic Controllers (PLCS) to the control, monitoring and protection of nuclear reactors.

Examples[edit] Safety instrumented systems are most often used in process e. High fuel gas pressure initiates action to close the main fuel gas valve. High reactor temperature initiates action to open cooling media valve. High distillation column pressure initiates action to open a pressure vent valve. Examples of critical processes have been common since the beginning of the Industrial Age. One of the more well known critical processes is the operation of a steam boiler. Critical parts of the process would include the lighting of the burners, controlling the level of water in the drum, and controlling the steam pressure. Requirement specification[edit] What a SIS shall do the functional requirements and how well it must perform the safety integrity requirements may be determined from Hazard and operability studies HAZOP , layers of protection analysis LOPA , risk graphs, and so on. During SIS design, construction, installation, and operation, it is necessary to verify that these requirements are met. The functional requirements may be verified by design reviews, such as failure modes, effects, and criticality analysis FMECA and various types of testing, for example factory acceptance testing, site acceptance testing, and regular functional testing. The safety integrity requirements may be verified by reliability analysis. Later on, the initial PFD estimates may be updated with field experience from the specific plant in question. It is not possible to address all factors that affect SIS reliability through reliability calculations. It is therefore also necessary to have adequate measures in place e. Hazard identification[edit] A formal process of hazard identification is performed by the project team engineers and other experts at the completion of the engineering design phase of each section of the process, known as a Unit of Operation. This team performs a systematic, rigorous, procedural review of each point of possible hazard, or "node", in the completed engineering design. System design[edit] A SIS is engineered to perform "specific control functions" to failsafe or maintain safe operation of a process when unacceptable or dangerous conditions occur. Safety Instrumented Systems must be independent from all other control systems that control the same equipment in order to ensure SIS functionality is not compromised. The safe state must be achieved in a timely manner or within the "process safety time". Equipment[edit] The correct operation of an SIS requires a series of equipment to function properly. It must have sensors capable of detecting abnormal operating conditions, such as high flow, low level, or incorrect valve positioning. A logic solver is required to receive the sensor input signal s , make appropriate decisions based on the nature of the signal s , and change its outputs according to user-defined logic. The logic solver may use electrical, electronic or programmable electronic equipment, such as relays , trip amplifiers , or programmable logic controllers. Next, the change of the logic solver output s results in the final element s taking action on the process e. Support systems, such as power, instrument air, and communications, are generally required for SIS operation. The support systems should be designed to provide the required integrity and reliability. International standards[edit] International standard IEC was published in to provide guidance to end-users on the application of Safety Instrumented Systems in the process industries.