6. A Concept of Integrated Control for Nuclear Power Plants, *R. M. Edwards, A. Ray, M. A. Schultz, E. S. Kenney (Penn State)*

INTRODUCTION

This paper presents a novel concept of integrated control of the diverse functions and spatially distributed system components in nuclear power plants. The goal is to develop an integrated system as a safe, economic, reliable, and flexible means for nuclear power generation by utilizing recent advances in microcomputer technology. This research builds upon the earlier work on control and protection systems in Canadian reactors[1] and the ultra-safe plant concept within a distributed microprocessor environment.[2,3]

DESCRIPTION

An advanced light water reactor design concept is currently under development at Pennsylvania State University.[2] The design concept is based on a reconfigured pressurized water reactor in which the conventional pressurizer is replaced by a modified injection letdown system. The design also accommodates station blackout by including emergency power generation from shutdown steam turbine generators until natural circulation in the rearranged plant is alone sufficient for long-term cooling. A salient feature of the ultra-safe[2] research is to examine implementation of the nuclear power plant control system in a microcomputer-based control environment.

Keiper and Shidner[4] traced the evolution of process control from the early days of steam electric power generation to the current state of the modern digital control environment. Most of today's operating nuclear power plants use an early 1970s split architecture employing analog safety and control systems functioning in conjunction with a digital data acquisition system (DAS). The DAS manages incoming data and performs certain computational functions but does not execute any control action. A goal of the ultra-safe plant control research was to use the modern distributed control environment to design a simple-appearing control room for one operator using three televisionlike monitors and a computer keyboard similar to currently available commercial operator interfaces to distributed control systems. A higher level goal was to take the design one step further and limit the use of the computer keyboard to calling up different displays of plant status and include eight pushbuttons as the only means for the supervisory operator to direct operation of the plant. The eight pushbuttons direct *startup, shutdown, power increase, power decrease, cutback, scram*, *enter*, and *cancel* operations. They also provide verification or cancellation of other pushbutton requests in the sense of conventional computer usage. The implication of this arrangement for the ultra-safe plant is that the distributed digital control system is capable of executing all the necessary control functions required to not only execute standard operations but also respond to all off-normal and upset conditions in such a manner as to avoid activation of the usual independent plant safety systems.

To accomplish the autonomy of the ultra-safe plant concept, the functions of a conventional nuclear plant control system were modified and cast into a distributed control environment, part of which is shown in Fig. 1. The control system is distributed in standard microprocessors that execute individual control function(s). The modules are functionally arranged in a hierarchical manner, but they are physically connected on a single high-speed data highway as suggested by Ray.[5] This concept allows structural flexibility in the sense that the control system can be reconfigured with software modifications only. The supervisory control module coordinates the activities of the rod drive system, reactor coolant system, makeup and cleanup system, steam generator controls, turbine generator system, main condenser system, reactor building controls, and major auxiliary systems modules. Each of these modules communicates with lower level modules in the hierarchy. (This is not shown in Fig. 1.)

There are many research areas associated with the ultra-safe control concept: diagnostics, communications, and control in a distributed computer environment. The first step toward implementing the ultra-safe control system was to conduct simulation experiments. The real-time simulation facility[6,7] has been used to develop and test an expert system for installation at the Experimental Breeder Reactor II (Ref. 8).

CONCLUSION

A distributed control configuration can yield substantial improvements in the operation of future nuclear power plants. Such an integrated control system would have the potential to enhance maintainability, reliability, efficiency, and public acceptability and substantially alleviate the complexity of plant operations. Development of sophisticated applications soft-

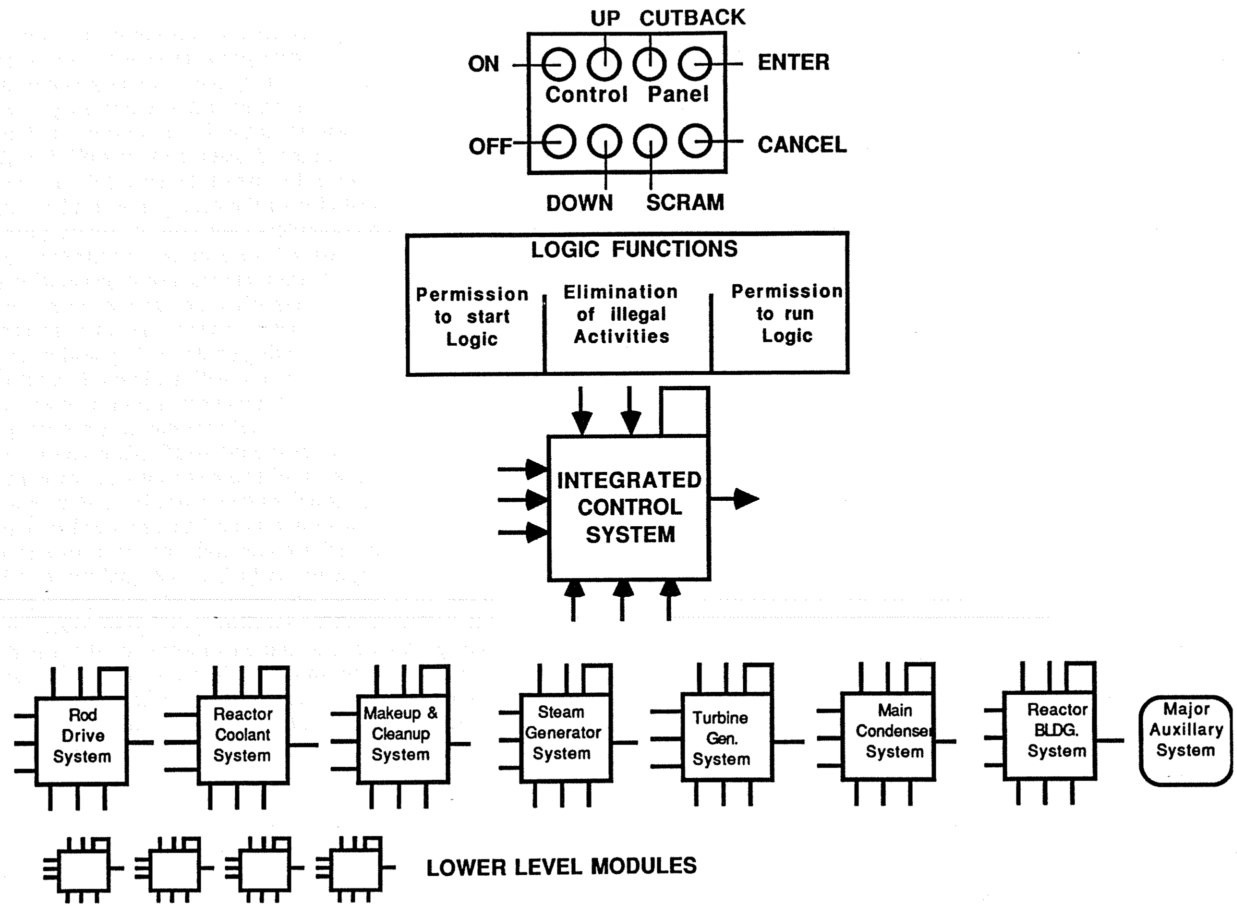

Fig. 1. Ultra-safe distributed control system.

ware for powerful microprocessor-based controllers will facilitate the development of an integrated fault-tolerant control system.

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7. PECo Computer Replacement Lessons Learned at Peach Bottom, *James M. Clark (Impell Corp, Melville), John O'Hara (PECo)*

INTRODUCTION

The current regulatory climate continues to prod today's nuclear utilities toward safer and more reliable operation of their plants. U.S. Nuclear Regulatory Commission guides NUREG-0660, NUREG-0696, and Supplement I to NUREG-0737 have all set forth increased requirements for plant monitoring. In response, the industry has looked at their existing plant computer systems as targets for enhancement or upgrade. This external pressure is nearly matched by the increasing demands made on existing computer systems by utility engineering and operations departments.