J.A. Moore
S.M. Herb

Understanding DISTRIBUTED PROCESS CONTROL

IRP *Instructional Resource Package*

STUDENT TEXT

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INSTRUMENT SOCIETY OF AMERICA

UNDERSTANDING DISTRIBUTED PROCESS CONTROL

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Developed by
THE EDUCATION DEPARTMENT
Instrument Society of America

Acknowledgments

The genesis of the short course "Understanding Distributed Process Control" was material put together by Sam Herb to supplement another short course he had developed and was teaching, "Understanding Process Control: an Overview". Sam offered me the opportunity to teach several sessions of the distributed control course, which he had also developed and was teaching, and it quickly became evident to both of us that the auditors deserved something more permanent than copies of the visual aids and whatever notes they were able to take. When ISA agreed to sponsor a text, we had the chance to see if we could convert what had been a conceptual presentation into a coherent document. We hope that has been accomplished.

The structure is Sam's, while the words are mine. Some of my own prejudice has inevitably been included in the text, so the onus for any statements that may be taken issue with is also mine. The material has come from many sources. One has been research of articles published in trade journals, and there is an abundance of them. Another has been discussions with suppliers and users at trade shows and symposia. Most particularly, we have been fortunate in working with very knowledgeable co-workers, who have been patient and thorough with their explanations. In particular, we are grateful to Jim Fahnstock, Larry Heine, and Paul Taylor for their help.

We also want to express our thanks for literature and photographs sent in reply to our requests for material. Responses from Anatek, Allen Bradley, Bailey Controls Company, Beckman Instruments, Inc., Fischer and Porter, The Foxboro Company, Leeds and Northrup, Moore Products, Powell Industries, Inc., Toshiba International Corporation, and the Combustion Controls Division of Westinghouse Electric Corporation are gratefully acknowledged. Not all the photographic material sent to us could be used but we have included as much as was appropriate.

Manufacturers of commercially available distributed control systems are invited to send complete and thorough descriptions of their products to be used in conjunction with Appendix B of this Student Text. In this manner, students of this course will be able to keep abreast of developments in this field and the material will be kept current.

The text was written using the Wordstar® word processing program on an IBM PC® computer. I think it is sufficient to say that without Wordstar, the task would never have been accomplished. Take it from a convinced hunt-and-peck artist, one does not have to be a typist to use it.

J.A. Moore

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SECTION 1 INTRODUCTION TO THE STUDENT

This *Instructional Resource Package*, Understanding Distributed Process Control, is written in the context of industrial process control. Distributed control is a new way of implementing control functions that are not new, but rather are well established and proven by satisfying results. To make intelligent application of innovations to existing practices there must be understanding of the new techniques, the new devices, and the new technologies employed to support the basis for change. To generate such an understanding is the purpose of the course and of this text.

1-1 WHO IS INTERESTED IN UNDERSTANDING DISTRIBUTED CONTROL?

From teaching experiences, the authors know that some of the course participants are instrumentation engineers who are interested in applying distributed control but have not had an opportunity to learn about it by working with it. Others are engineers concerned with selection of equipment who want to know what is available and how to evaluate it. Others who will be managing projects employing distributed control equipment are more interested in understanding what has to be done to achieve a functioning system than in learning the details of instrumentation. Still others will be familiar with one supplier's distributed control equipment but want to be brought up to date about developments in this rapidly changing field and to broaden their experience. In summary, everyone reading this text will do so because they want to know why distributed control deserves a place under the instrumentation sun, how it is structured, and what has promoted its rapid acceptance.

1-2 COURSE CONTENT

The format of the text, like the lecture periods, is divided into six general groups of information. The first establishes the relationship of distributed control to other control forms in the current technology of instrumentation and control. The second concentrates on hardware, the third on communications, and the fourth on software. The fifth is specific to the design of representative present-day systems. The sixth concerns itself with criteria for selection of distributed control equipment and how to specify needs that are specific to individual requirements.

1-3 HOW AND WHY HAS DISTRIBUTED CONTROL EVOLVED?

To begin to answer this question, a brief review of instrumentation is presented that is designed to provide a setting in which distributed control can be related to more familiar types of control. Reasons for the interest shown by management, engineers, and operators are given in the next section. Distributed control has definite appearance and structure that are different from those of previously favored forms of instrumentation. This structure is treated in the next two sections. In the last section of this group the questions of safety and reliability, matters of great concern to all users, are discussed.

In a more general sense, these five sections are used to establish an identity for distributed control systems. It is difficult to find a definition for distributed control that satisfies everyone. Is it distributed geographically, or functionally, or by the tasks that are performed by its microprocessors? Is the equipment distributed, or the intelligence? An objective has been to provide enough explanation of fundamental design so that the reader can create a definition that is meaningful in the context of his particular needs.

1-4 WHAT HARDWARE IS USED IN DISTRIBUTED CONTROL SYSTEMS?

A worthwhile precept is that change must start with what exists and works. The communication and the digital domains, both existing and proven, have been exploited to produce innovations in control technology. Neither of these disciplines has previously been used extensively for industrial process control application, but both exist and perform well in other operating systems. Computers have been performing process control since the '60s, although there is no physical comparison with the computers used for distributed control. The designs used had one big mainframe, usually kept in an antiseptic room behind locked doors and ministered to by programmers who were not part of the instrument group. Computers were used most commonly by the industrial giants and were sold as turnkey digital systems, somehow separate from the areas of expertise that speak familiarly of 3 to 15 psi or 4 to 20 milliampere ranges. Now, although there are sometimes jurisdictional decisions to be made as to whether distributed control is part of the realm of the instrument department or of the computer department, in most cases instrument technicians are going to have to keep the distributed control equipment operating; operators must learn how to visualize the process they are controlling from the display on a CRT screen; and designers are grappling with the representation of software on piping and instrument flow diagrams.

Today the engineers designing the distributed control equipment for the suppliers are digitally oriented. They use the techniques that have been developed for computers and information communication. However, their products are now part of the industrial process control domain. This means that the users of automatic control equipment must become familiar with a new jargon, a new way of expressing ideas and of describing situations. Ideas are always better understood when the terms in which they are expressed have meaning.

One of the objectives of the text is to express new terms in context, so that when they are encountered in advertising literature or written specification, the content of the information they are expressing can be better understood and evaluated.

Parenthetically, it seems that in order to be successful in the digital world, one must be able to speak in acronyms. Some combinations of initials have become familiar and as well accepted as the words Xerox (for a reproduction machine) or Kleenex (for sanitary tissues). Combinations like CRT (for cathode ray tube), LED (for light-emitting diode), or RAM (for random access memory) are generally used without any question. Writers of literature for suppliers have a regrettable habit, however, of spelling out a combination of words that are peculiar to their product, following the definition with the initials between parentheses, and from that point on using the initials. Every time the initials are encountered the writer has to find the original definition to know what the text is saying. Admittedly, there is something to be said in favor of ASCII instead of "American Standard Code for Information Interchange." However, the authors have tried to use words for unfamiliar expressions and to employ only the most familiar acronyms.

At first glance, all distributed control systems seem to have a similar appearance. They all use CRTs, they all have remote electronics, and somewhere there is, or will be soon, a data highway. Closer investigation, however, begins to uncover differences. Keyboards may have movable keys or touch pads; the arrangement of keys differs greatly from one supplier to the next. Some CRTs are black and white but most are colored; some are smaller than others. Some offer graphic picture displays; there are a number of ways that displays can be constructed. The number of characters available for tag names and service descriptions varies. Procedures for recognizing and storing alarm information vary significantly; a single keystroke is all that is required in some cases to display the information the operator needs when an alarm occurs. Other systems require several keystrokes to achieve the same result. There are different techniques for moving information around. The list goes on and on.

Another objective, then, has been to discuss the characteristics by which the hardware common to most systems can be evaluated. This is done so that the differences in available products are recognized. If the options are understood, readers will be better able to compare competitive offerings. Accordingly, a section of the text speaks to the characteristics of the remotely located electronics that are common to most suppliers' equipment. Another addresses the equipment used at central locations to provide the operator interface with the process and the remote hardware. Still another is concerned with the peripherals, considering the relative properties of these devices.

The text is not intended to teach the reader how to design or troubleshoot equipment. Nevertheless, a section about troubleshooting has been included. The primary reason for doing so is to emphasize the similarities and differences between analog equipment and digital equipment. The readers will, in most cases, be familiar with the former. The latter is designed differently and requires unfamiliar tools and servicing methods. Everyone tends to think in terms of the surroundings and equipment he is accustomed to, not instinctively appreciating that new techniques and procedures have to be learned when using new types of equipment. Opportunities should be found to emphasize this point, and the section about troubleshooting has been included in order to implement such an opportunity.

1-5 COMMUNICATION LINKS IN DISTRIBUTED CONTROL

Probably the biggest difference between distributed control and conventional instrumentation is the means by which information is communicated between devices. The data highway is one of the entirely new concepts, and the technology associated with it is more familiar to someone who deals with telephone networks than with pneumatic and electronic instrumentation. A complication is that few standards exist; for the foreseeable future there will be a number of different ways to accomplish the end result. Two sections of the text have been assigned to this subject, one discussing highways and the other communication theory. These are in no way tutorial, trying rather to clarify the definitions of the many confusing terms and to relate them to each other so that descriptions of communications systems, equipment, and techniques can be read with some degree of understanding. In this business, you can't tell the players without a program.

1-6 CONFIGURATION AND SOFTWIRING, THE ANTITHESIS OF HARDWIRING

For those interested in the uses to which distributed control is put, two sections are included describing configuration procedures and algorithms (the preprogrammed functions that are used to implement process control). Much of the material in these sections could have been shortened and presented in the form of lists and tables, but it was felt that more detail was better than too little for those who might want to explore solutions to particular problems of application.These sections are preceded by a section summarizing the principles of control, explained in a very elementary way. The explanation is included so that a reader not familiar with instrumentation and control can appreciate the reasons for controlling process variables and can more satisfactorily understand the discussion of algorithm usage.

1-7 DIFFERENT SUPPLIERS HAVE DIFFERENT DESIGNS

The differences between the various suppliers' systems are more than superficial. This soon becomes apparent when comparisons are made. Not only the traditional companies supplying extensive lines of instrumentation — Bailey, Fisher, Foxboro, Honeywell, and Taylor, to name a few — but suppliers whose principal activities are not immediately associated with industrial process control — EMC Controls, Forney Engineering, Anaconda Copper, and Powell Industries — are in the market, along with many more. The authors have tried to compare a few of these, in some detail, choosing offerings that, between them, use most of the techniques discussed in foregoing sections. This is risky business. First of all, somebody's favorite supplier is going to be left out. Secondly, designs are changing so rapidly that some of the specifics are going to be out of date by the time the material is read. In fact, during the editing of the first draft of the text it was found that a number of predictions of trends and new products had become realities. In one case the predicted design was already obsolescent. Certainly, anyone interested in a particular supplier's equipment must make an independent investigation and get his information up to date and complete from the supplier's representatives.

The authors have tried to be completely impartial in presenting this material. In fact, it would be doing a disservice to make recommendations, because every person reading the text will be doing so to satisfy particular and individual needs. Throughout the preparation of the text the most significant objective has been to present a picture sufficiently broad and complete that these needs can be satisfied by knowing what questions to ask and how to relate the answers to the problems.

1-8 CRITERIA FOR SELECTION

Many class attendees unacquainted with distributed control are concerned with the requirements for selecting a supplier. All the differences in equipment and design that the authors feel have significance in making a selection have been combined in the final section. To some extent this is a review of the entire subject. More importantly it can serve as a checklist for the many pieces of information that must be considered by a prospective user so that he may end up with a system that meets all of his needs. If one potential problem that might have been overlooked is prevented from occurring by using the material in this section as a guide, the careful study of it will be well rewarded.

The importance of preparing a comprehensive specification is emphasized. Many users interested in learning about distributed control have not been involved in this type of systems activity. Their instrument acquisitions have been piecemeal, characterized by small additions to existing installations. They are accustomed to buying products, and expect that they can buy and install distributed control equipment as they have other instruments in the past. A reminder to these people: distributed control must be treated as a system, and organized planning is necessary to assure satisfactory installations.

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STUDENT SUMMARY NOTES and QUESTIONS FOR INSTRUCTOR