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Distributed Control System

Distributed control systems (DCSs) are computer-software packages communicating with control hardware and providing a centralized human–machine interface (HMI) for controlled equipment.

From: Flexible Packaging, 2015

Related terms:

Process Control, Turbine, Actuators, Steam Generator, Subsystems, Control Logic, Electric Potential, Shutdown

Distributed control system

B.R. Mehta, Y.J. Reddy, in Industrial Process Automation Systems, 2015

3.1 Introduction

Automatic control typically involves the transmission of signals or commands/information across the different layers of system, and calculation of control actions as a result of decision-making. The term DCS stands for distributed control system. They used to be referred to as distributed digital control systems (DDCS) earlier, implying that all DCS are digital control systems. They use digital encoding and transmission of process information and commands. DCS are deployed today not only for all advanced control strategies but also for the low-level control loops. The instrumentation used to implement automatic process control has gone through an evolutionary process and is still evolving today. In the beginning, plants used local, large-case pneumatic controllers; these later became miniaturized andcentralized onto control panels and consoles. Their appearance changed very little when analog electronic instruments were introduced. The first applications of process control computers resulted in a mix of the traditional analog and the newer direct digital control (DDC) equipment located in the same control room. This mix of equipment was not only cumbersome but also rather inflexible because the changing of control configurations necessitated changes in the routing of wires. This arrangement gave way in the 1970s to the distributed control system (DCS).

DCS controllers are distributed geographically and functionally across the plant and they communicate among themselves and with operator terminals, supervisor terminals to carry out all necessary control functions for a large plant/process. The scope of control is limited to the part of the plant it is distributed in. DCS is most suited for a plant involving a large number of continuous control loops, special control functions, process variables, and alarms. Most of the DCS architectures are generally similar in the way they are designed and laid out. Operator consoles are connected to controllers housed in control cubicles through a digital, fast, high-integrity communications system. The control is distributed across by the powerful and secure communication system. The process inputs are connected to the controllers directly or through IO bus systems such as Profibus, Foundation FieldBus, and so on. Some systems also use proprietary field bus systems. The DCS offered many advantages over its predecessors. For starters, the DCS distributed major control functions, such as controllers, I/O, operator stations, historians, and configuration stations onto different boxes. The key system functions were designed to be redundant. As such the DCS tended to support redundant data highways, redundant controllers, redundant I/O and I/O networks, and in some cases redundant fault-tolerant workstations. In such configurations, if any part of the DCS fails the plant can continue to operate. Much of this change has been driven by the ever-increasing performance/price ratio of the associated hardware. The evolution of communication technology and of the supporting components has dramatically altered the fundamental structure of the control system. Communication technology such as Ethernet and TCP/UDP/IP combined with standards such as OPC allowed third-party applications to be integrated into the control system. Also, the general acceptance of object-oriented design, software component design, and supporting tools for implementation has facilitated the development of better user interfaces and the implementation of reusable software.

With advancing technologies, DCS have rapidly expanded their capabilities in terms of features, functions, performance and size. The DCSs available today can perform very advanced control functions, along with powerful recording, totalizing, mathematical calculations, and decision-making functions. The DCS can also be tailored to carry out special functions, which can be designed by the user. An essential feature of modern-day DCS is the integration with ERP and IT systems through exchange of various pieces of information.

To understand DCS, it is a good idea to review the evolution of control systems. This includes hardware elements, system implementation philosophies, and the drivers behind this evolution. This will help in understanding how process control, information flow, and decision-making have evolved over the years.

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Dynamic Simulation of Gas Processing Plants

Saeid Mokhatab, William A. Poe, in Handbook of Natural Gas Transmission and Processing, 2012

17.2.1.4 Distributed Control System Checkout

Distributed control system (DCS) checkout alone will not warrant the construction of a dynamic model of a plant. But if a model is available, the modifications needed to be able to run a DCS checkout are relatively small. The purpose of the DCS checkout is to verify that all the cabling connecting the DCS to the plant and the DCS internal TAG allocations are hooked up properly. Obviously, a dynamic model will not be able to help with checking the physical cabling, but the signals from a dynamic model can replace the plant signals. This will help tremendously in verifying the logical connections inside the DCS. If a wrong measurement is routed to a particular controller, this will be seen quite readily, as the dynamic model provides realistic numbers for these. It is much easier to discern an erroneous number among realistic numbers than to match quasirandom numbers.

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Saeid Mokhatab, ... John Y. Mak, in Handbook of Natural Gas Transmission and Processing (Fourth Edition), 2019

19.8.1.1.4 DCS Check-Out

Distributed control system (DCS) check-out alone will not warrant the construction of a dynamic model of a plant. But if a model is available, the modifications required for running a DCS check-out are relatively small. The purpose of the DCS check-out is to verify that all the cabling connecting the DCS to the plant and the DCS internal TAG allocations are hooked up properly. Obviously, a dynamic model will not be able to help with checking the physical cabling, but the signals from a dynamic model can replace the plant signals. This will help tremendously in verifying the logical connections inside the DCS. If a wrong measurement is routed to a controller, this will be seen quite readily as the dynamic model provides realistic numbers for these. It is much easier to discern an erroneous number among realistic numbers than to match quasi-random numbers.

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Process Systems Engineering for Pharmaceutical Manufacturing

Paul Brodbeck, in Computer Aided Chemical Engineering, 2018

4.2.3 Continuous/integrated unit operations—Distributed control system

Distributed control systems (DCS) take SCADA to the next level of automation. DCS systems have the capability of integrating unit operations via device drivers for PLCs and microprocessors and also controlling devices directly through classical IO (Fig. 5). In many CM installations, there will be unit operations that come with PLCs, but there will also be operations such as utilities such as vacuum systems, safety shutdown systems, and refilling operations that are not provided with a controller that need to be integrated with a process control system such as a DCS.

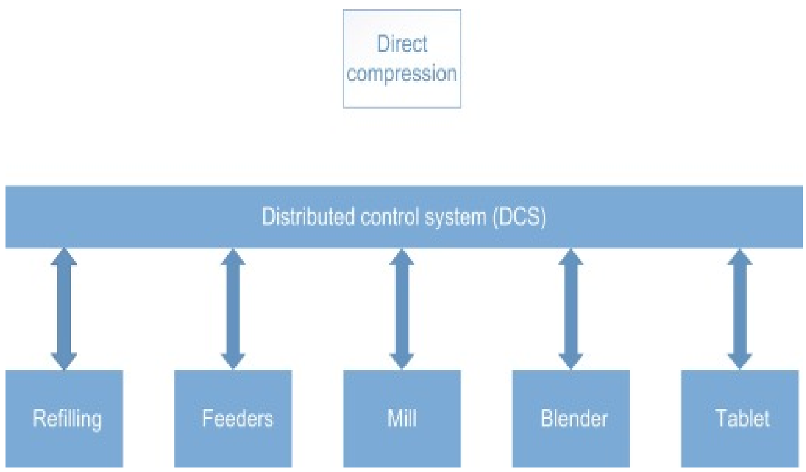

Fig. 5. Distributed control system.

Also, DCSs hold significant amount of the market share for the Pharmaceutical industry where the batch systems are complex and require FDA compliance. Pharmaceutical plants for API and Biologics tend to be large complex batch systems that integrate many unit operations. Compounded with the fact that these systems need to be validated to comply with FDA regulations, they have traditionally relied on DCS systems to control these plants. Fill finish facilities have traditionally not required the sophistication of a DCS as there has not been a requirement to integrate them into one system. When standalone facilities require integration, a simple SCADA system will typically suffice. When fill finish unit operations are linked together for CM, then the complexity is increased and integration with a DCS becomes more necessary.

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Control Systems

William Bolton, in Instrumentation and Control Systems (Second Edition), 2015

13.8.4 Distributed Control Systems

A distributed control system (DCS) is used to control production systems within the same geographic location. It usually involves a computer that communicates with control elements distributed throughout the plant or process, e.g. machine or process controllers and PLCs, through a bus or directly and displays gathered data. DCS systems tend to have a hierarchy of controllers distributed through a plant and connected by a communications network for command and monitoring, whereas SCADAs have central control. SCADA systems often contain DCS components. An example of a DCS system could be an oil refinery where there are a large number of control systems such as flow controllers which are closed-loop controllers by which valves are operated in order to obtain set values.

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Cyber resilience and future of electric power system

Bahman Zohuri, Patrick McDaniel, in Introduction to Energy Essentials, 2021

14.8 Distributed control systems

DCSs are used to control production systems within the same geographic location for industries such as oil refineries, water and wastewater treatment, electric power generation plants, chemical manufacturing plants, and pharmaceutical processing facilities. These systems are usually process control or discrete part control systems. A DCS uses a centralized supervisory control loop to mediate a group of localized controllers that share the overall tasks of carrying out an entire production process [13]. By modularizing the production system, a DCS reduces the impact of a single fault on the overall system. In many modern systems, the DCS is interfaced with the corporate network to give business operations a view of production.

An example implementation showing the components and general configuration of a DCS is depicted in Fig. 14.18. This DCS encompasses an entire facility from the bottom-level production processes up to the corporate or enterprise layer. In this example, a supervisory controller (control server) communicates to its subordinates via a control network. The supervisor sends SPs to and requests data from the distributed field controllers. The distributed controllers control their process actuators based on control server commands and sensor feedback from process sensors.

Fig. 14.18. Distributed control systems (DCS) implementation example.

Fig. 14.18 gives examples of low-level controllers found on a DCS system. The field control devices shown include a PLC, a process controller, a single loop controller, and a machine controller. The single loop controller interfaces sensors and actuators using point-to-point wiring, while the other three field devices incorporate fieldbus networks to interface with process sensors and actuators. Fieldbus networks eliminate the need for point-to-point wiring between a controller and individual field sensors and actuators. Additionally, a fieldbus allows greater functionality beyond control, including field device diagnostics, and can accomplish control algorithms within the fieldbus, thereby avoiding signal routing back to the PLC for every control operation. Standard industrial communication protocols designed by industry groups such as Modbus and Fieldbus [14] are often used on control networks and fieldbus networks.

In addition to the supervisory-level and field-level control loops, intermediate levels of control may also exist. For example, in the case of a DCS controlling a discrete part manufacturing facility, there could be an intermediate-level supervisor for each cell within the plant. This supervisor would encompass a manufacturing cell containing a machine controller that processes a part and a robot controller that handles raw stock and final products. There could be several of these cells that manage field-level controllers under the main DCS supervisory control loop.

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Basics of Control Systems

Thomas Dunn, in Flexible Packaging, 2015

Distributed Control Systems [1]

Distributed control systems (DCSs) are computer-software packages communicating with control hardware and providing a centralized human–machine interface (HMI) for controlled equipment.[1] Programmable logic controllers (PLCs) form the core of DCSs and other computer control systems. These replace hard-wired relay circuits and allow easy programming and reprogramming; easy diagnostics and repair; and communicating with central data collection systems feeding a DCS. The device included a power supply, processor, communication module, and input/output module. They are physically placed close to equipment sensors sending data and devices receiving commands from them. Different functionality can be combined according to the requirements of the system to be controlled (e.g., temperature, tension). The development and implementation of PLCs was the first step toward the highly interconnected DCSs in use today. General information technology systems issues (e.g., security, communication protocols, programming languages, operating systems) make such software a critical part of a company's overall IT policy and a key building block for high-level resource planning systems.[2]

A DCS provides operators and others with a centralized overview of conditions on a piece of equipment. Depending on the process, dozens, even hundreds of machine set points and process variables may be observed through the interface. Observations may lead to a decision that set point changes are necessary or to simple confirmation that the process in fact is operating in control. When the latter is the case, those set points may be recorded and stored as a "recipe" for the next time the product is run. Figure 10.1 presents a DCS screen image from a tandem extrusion line. This indicates tension settings for the three unwinds and one rewind as well as four intermediate nip points. The physical distance from first unwind to rewind can be as much as 100 ft (30 m). The challenge of monitoring numerous process conditions over such large distances underscore the utility of a DCS.

Figure 10.1. DSC screen of tension settings and readings on tandem extrusion laminator/coater.

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Emergency Shutdown

Dennis P. Nolan, in Handbook of Fire and Explosion Protection Engineering Principles for Oil, Gas, Chemical, and Related Facilities (Fourth Edition), 2019

11.6 ESD/DCS Interfaces

Where ESD and distributed control systems (DCSs) are provided, they should be functionally segregated such that a failure of the DCS does not prevent the ESD from shutting down and isolating the facilities. Alternatively, failure of the ESD system should not prevent an operator from using the DCS to shutdown and isolate the facility. There should be no executable commands over the ESD–DCS communication links. Communication links should only be used for bypasses, status information, and the transmission of reports. Confirmation of ESD reset actions can be incorporated into the DCS but actual reset capability should not.

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System hierarchies and components

In Practical E-Manufacturing and Supply Chain Management, 2004

3.5 DCS and SCADA/PLC comparison

Manufacturing industries either have DCS or SCADA/PLC systems. With the advances in technology and the resulting overlapping functionality, these systems became less and less distinct. The following system characteristics give some relevant features of the average systems.

DCS	SCADA/PLC
Expensive hardware but engineering is comparatively cheaper	200% cheaper than DCS Hardware is cheaper but engineering is expensive
Control and monitoring over small areas e.g. a process unit	Over large geographical areas
Data transfer via LAN infrastructure	Use leased telephone lines or radios
Large, extensive applications with many control and data transfer Analog control processing	Small medium-sized applications with majority open/close control
Direct control, output directly to field actuators	Send set points to local controllers
DCS was a single vendor solution	With SCADA the connection with the field is done by third party hardware and software
Focused in process industry	Focused in discrete production industry

DCS	SCADA/PLC
Inter-related continuous complex processes	Batch processing with low level of process interaction
Robust hardware and software are the part of the equipment on the shop floor and are fixed	Operating system software and the processor used in a SCADA PC undergo quick changes due to heavy competition
Process computer on the shop floor and PCs in the control room	PLC platform for process control and a PC platform (SCADA) for display
Data acquisition is event driven, rely on change. The RTUs can typically operate for extended periods of time w/o communications with the 'Host'	Data acquisition via one database with fixed scan cycle for each data point
Application stored on one database	Application data are divided over several databases
Fast with complex control	Fast when used in logical (on/off) application
Predictable, real time	Not completely predictable
Handle many controls	Limited number of controls

The goals of DCS and SCADA are quite different. It is possible for a single system to be capable of performing both DCS and SCADA functions, but few have been designed with this in mind, and therefore they usually fall short somewhere. It has become common for DCS vendors to think they can do SCADA because the system specifications seem so similar, but a few requirements paragraphs about data availability and update processing separate a viable SCADA system from one that would work OK but for the real world getting in the way.

The DCS is process oriented; it looks at the controlled process (the chemical process plant) as the center of focus, and it presents data to operators as part of its job. A DCS operator station is normally intimately connected with its I/O (through local wiring, fieldbus, networks, etc.). When the DCS operator wants to see information, he usually makes a request directly to the field I/O and gets a response. Field events can directly interrupt the system and advise the operator. The DCS is always connected to its data source; so it does not need to maintain a database of 'current values'. Redundancy is usually handled by parallel processing.

The SCADA is data-gathering oriented; the control center and operators are the center of focus. The remote equipment is merely there to collect the data, though it may also do some very complex process control. The SCADA must still operate when field communications have failed. The 'quality' of the data shown to the operator is an important facet of SCADA system operation. The SCADA systems often provide special 'event' processing mechanisms to handle conditions that occur between data acquisition periods. The SCADA needs to get secure data and control over a potentially slow, unreliable communications medium and needs to maintain a database of 'last known good values' for prompt operator display. It frequently needs to do event processing and data quality validation. Redundancy is usually handled in a distributed manner.

These underlying differences prompt a series of design decisions that require a great deal more complexity in a SCADA system database and data-gathering system than is usually found in DCS. The DCS systems typically have correspondingly more complexity in their process-control functionality. The SCADA database architecture is significantly different from the DCS data architecture. The SCADA system is event driven, while DCS is process state driven.

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Instrumentation and Control Systems

John P. King, in Fermentation and Biochemical Engineering Handbook (Third Edition), 2014

20.0 Distributed Control Systems

As the knowledge of the physiology and reaction kinetics of biochemical processes has progressed and the measurement systems for monitoring their activity has improved, the need for sophisticated systems able to execute coordinated control strategies including batch has increased. Fortunately the state of the art of control systems has rapidly evolved to the point where all of the control strategies described above can be embodied in a Distributed Control System (DCS), see Fig. 20.17. This transformation has been facilitated to a great extent by the technology breakthroughs in computer, communications, and software technology.

Figure 20.17. Schematic drawing of Foxboro's Distributed Control System called Intelligent Automation.

(Courtesy of Foxboro, Foxboro, Mass.)

Distributed control systems are organized into five subsystems.

Process interface, which is responsible for the collection of process data from measurement instruments and the issuing of signals to actuating devices such as pumps, motors and valves.

Process control, which is responsible for translating the information collected from the process interface subsystem and determining the signals to be sent to the process interface subsystem based on preprogrammed algorithms and rules set in its memory.

Process operations, which is responsible for communicating with operations personnel at all levels including operator displays, alarms, trends of process variables and activities, summary reports, and operational instructions and guidelines. It also tracks process operations and product batch lots.

Applications engines, which are the repository for all of the programs and packages for the system from control, display and report configuration tools to program language compilers and program libraries to specialized packages such as database managers, spreadsheets and optimization or expert system packages to repositories for archived process information.

Communications subsystems, which enable information flow between the various DCS subsystems as well as to other computerized systems such as laboratory information management systems (LIMS); plant inventory management and scheduling systems such as MRP II; plant maintenance systems and business systems.

The integration of these systems into a cohesive whole has dramatically increased the level of automation possible to improve the quality, productivity and economics of manufacturing.

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