Controls
Level 2: DDC Networking
Technical Development Programs (TDP) are modules of technical training on HVAC theory, system design, equipment selection and application topics. They are targeted at engineers and designers who wish to develop their knowledge in this field to effectively design, specify, sell or apply HVAC equipment in commercial applications.

Although TDP topics have been developed as stand-alone modules, there are logical groupings of topics. The modules within each group begin at an introductory level and progress to advanced levels. The breadth of this offering allows for customization into a complete HVAC curriculum – from a complete HVAC design course at an introductory-level or to an advanced-level design course. Advanced-level modules assume prerequisite knowledge and do not review basic concepts.

The networking of HVAC DDC controls includes the basic concepts of controls interoperability and the benefits of tying HVAC control systems into the greater network of building system controls. This TDP includes a refresher of the elements and building blocks of HVAC controls and presents basic control strategies used to create the desired equipment responses for maintaining space environmental condition set points. This module will explain the workings of control system networks, present four key management methods available through DDC control networks, and show how to specify network configuration and functionality.
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Introduction

This Technical Development Program (TDP) describes the features and functions of a general purpose direct digital controller that is used to control heating, ventilating, and air-conditioning (HVAC) systems. This TDP also discusses how direct digital controllers work in a stand-alone environment and on a network, and how they interact with other building systems (see Figure 1).

This book will be useful to HVAC direct digital control (DDC) system designers, installers, service personnel, and end users. The TDP will refresh your understanding of DDC terminology and concepts, as well as outlining the tasks involved in putting a DDC control system together. If the concepts in this book are mastered, you will be able to identify jobs where a general purpose DDC controller can be used.

In addition, if the reader is already equipped with basic HVAC knowledge, the information presented here will enable the user to specify a general purpose DDC controller for an HVAC system.

This program is not intended as qualification training for control system technicians. Computer literacy or knowledge of microprocessor technology is not a prerequisite. When computer or control terminology is used, it will be defined as necessary.

Traditionally, the HVAC system design process involved load estimating, air and water system design, equipment selection, then consideration of piping and electrical subsystems, followed by design and selection of the controls and control sequences of operation. However, control system design was often treated as an afterthought, since it was usually handled by ATC (automatic temperature control) specialists.

Today, comfort, energy, and building management benefits, along with rapid advances in computer-based technology, have dictated that DDC system aspects be considered much earlier in the design process (see Figure 2). In addition, these system integration trends have demanded that the DDC system be designed at the same time as the rest of the HVAC system. In many cases, the basis of design DDC system features influence the selection of the mechanical system itself. For example, when the...
mechanical designer chooses to provide a variable air volume (VAV) system, the control system can impact the following aspects of the architectural/mechanical design:

- maximum number of zones
- variable frequency drive (VFD) control versus inlet guide vane (IGV) control
- temperature sensors versus temperature/set point displays (thermostats).

What is DDC?

The term **DDC** (direct digital control) has been used (and misused) for many years now. The term originated in the 1970s when newly emerging computer technology was first applied to HVAC control systems. Back then, most large building HVAC systems used pneumatic devices for comfort control. When some companies tried to apply computer technology to these systems, the computer systems provided “overlay” control only. The pneumatics still did the basic control, but the computers monitored and, only occasionally, intervened in the pneumatic control processes.

The DDC breakthrough came when a task force at Hamilton Standard (a predecessor of Carrier Corporation’s present Carrier Electronics Division) bypassed pneumatic control devices, such as receiver-controllers, with computer modules and innovative software to provide direct control using digital (microprocessor-based) techniques. See Figure 3.

**Direct Digital Control**

These device types provide direct control using digital (microprocessor based) techniques.

**DDC Controllers**

There are two types of DDC controllers: product-integrated and general purpose (Figure 4). **Product-integrated controls (PICs)** are DDC controllers which are factory-mounted on specific pieces of equipment such as chillers, air handlers, or packaged units. The controllers are designed and programmed to control the inner workings of that particular product. General purpose DDC controllers are field-installed and, therefore, are sometimes called **field-installed devices (FIDs)**.
General purpose controllers are microprocessor-based modules applicable to a wide variety of new construction, replacement, and retrofit HVAC system equipment. This book will focus on general purpose DDC controllers.

**Applications and Characteristics**

A typical application that uses a general purpose DDC controller would be an air handler with a supply fan, dampers, heating and cooling coils, and filter section. Such units require a general purpose DDC controller because of the many combinations of control types and sequences. Other new HVAC system equipment which are candidates for general purpose DDC controller FIDs are certain split or rooftop systems, cooling towers, boilers, pumps, fan coils, fan-powered mixing boxes, and other products shipped to the job site without PICs. See Figure 5.

Another common application for general purpose DDC controllers is the retrofit of HVAC equipment or systems in existing buildings, many of which have obsolete or inefficient pneumatic, electric, or electronic controls that are badly in need of upgrade or replacement.

Most DDC controllers can extend applications beyond the traditional system realm into non-HVAC areas such as lighting and security. Interoperability, where a common protocol is used to provide communication between disparate systems, has made integrating with lighting controllers, card access systems, and other, non-traditional HVAC building systems more and more popular.

Physically, a general purpose DDC controller is a module or “black box” which has a microprocessor (computer chip) inside. The controller includes all the electronics needed to support it and the signal conditioning necessary to interpret sensor readings (inputs) and to drive the actuators (outputs). The controller needs a source of power and usually incorporates communications ports for networking and human interface.

As with any microprocessor-based device, the DDC controller is dependent on its software, or internal programming, for proper operation. The operating system software allows the computer processor to communicate, process data, store information in memory, and maintain an internal clock to provide timing functions. The main concern, however, with the software is how it has an impact in the HVAC world. To this end, general purpose DDC controllers use a family of algorithms, which are control routines or programs specific to HVAC needs. For example, a program designed to modulate a cooling coil valve between open and closed in response to space...
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temperature is called a cooling coil algorithm. The hallmark of well-designed general purpose DDC controllers includes such features as:

- flexibility of the input/output complement
- versatility of the control algorithms to apply to the widest variety of field situations
- custom programming capability for non-standard control applications

Configurations

The simplest arrangement for a general purpose DDC controller is in a standalone configuration. See Figure 6. This occurs when the controller manages a single system, without the use of a communication wiring network connecting it to the controls of another system. The basic configuration for a single zone packaged or applied heating/cooling air handling unit with economizer cycle is shown in Figure 6. The controller communicates with I/O devices in the system through a pair of twisted wires. The controlled devices (damper actuator, coil valve actuators, etc.) receive commands from the controller and respond back with reports of their actions. If a controlled device does not respond to the controller’s command, an error message is displayed.

This section will concentrate on the standalone aspects and capabilities of these controllers, but it should be noted that they are designed to function and communicate in a network with other control modules, systems, and computers which serve as supervisory and monitoring stations. See Figure 7. A network can be defined as a group of communicating devices (standalone or not) that share data, command, and control functions over a defined physical communication infrastructure. The types of infrastructure can include a twisted pair cable, telephone connection, the Internet, and even satellite communication. The system illustrated in Figure 7 is part of a network because it communicates with a personal computer or other stand-alone systems.

Figure 6
Standalone DDC Controller

Figure 7
Networked DDC Controllers