DDC MADE EASY

THE PRINCIPLES BEHIND DIRECT DIGITAL CONTROL

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WHAT IS DDC?

Even though direct digital control (DDC) is a major part of the HVAC industry, it remains surrounded by a cloud of mystery. Engineers, service technicians, sales people - we all talk about DDC every day, but what exactly is it?

The answer to the question is not as complicated as you may think. Understanding DDC will help you talk to your customers about Carrier controls as effortlessly as you talk about equipment. And help you specify the proper control systems easily and quickly.

THE POINT IS ...

When specifying an HVAC system, we often hear the term “point.” This air handler has 10 points. That controller has 64 points. If we go to an energy management guide, we’ll find that a point is defined as “any input or output device used to control the overall or specific performance of equipment or output devices related to equipment.”

This is a long way of saying that DDC is made up of two types of points – inputs, or sensors, and outputs, or actions. These inputs and outputs are the fundamental building blocks of direct digital control.

Inputs and outputs are further categorized as analog or digital. We can also refer to digital points as discreet inputs, the terms mean the same. So in reality, there are four different points:

- An analog input is a sensor that monitors physical data, such as temperature, flow or pressure. An example is a wall-mounted temperature sensor. It’s analog because it’s a proportional signal – it varies within a range of extremes.
- A discreet input is a sensor that monitors status. In the case of an air handler, an airflow switch could provide the status on or off, or in a pump, a water flow switch. This positive/negative status relates to binary code, and is why discreet inputs are also referred to as “digital” inputs.
- An analog output is the interface between a command generated by the processor and the controlled equipment. In other words, it’s the physical action of a proportional device – like an actuator opening an air damper from 20% to 50%.
- A discreet output switches a device from one status to another, or maintains a status. If the control system is programmed to turn an air handler on at 8 a.m. and off at 5 p.m., the discreet output is the action of turning the switch on and keeping it on until the stop time.

Now that we know what points are, let’s talk about their role in the direct digital control process.

THE MICROPROCESSOR

In DDC, the inputs and outputs – in the form of input/output (I/O) modules – send information to and from a microprocessor to control the operation of HVAC system equipment.

The microprocessor could be programmed to adjust an air handler mixed air damper based on the relative humidity level in the zone as compared to the relative humidity outside. Each humidity sensor would act as a separate analog input, measuring the percentage of relative humidity in the air and transmitting the information to the processor.

Let’s say it’s a warm, damp day, and the outside air relative humidity sensor tells the processor that the relative humidity level of outside air is too high. The processor then tells the air handler’s mixed air dampers to modulate to a lower percentage of outside air. This action is performed by an analog output.

What if we program the air handler fan to come on when the zone’s air temperature reaches 75°? The temperature reading would still be an analog input, but the action of turning the fan on is a discreet output. When an airflow sensor in the air handler confirms that the fan is indeed on, this is a discreet input.

Once the input-output-input cycle is complete, it begins again. The temperature sensor measures the air temperature and sends the data to the processor. The processor sees that it’s still 75°, and instructs the fan to stay on. The fan switch reports back to the processor that the fan is still operating.

This cycle, which repeats continuously to keep the zone at the desired temperature, is called closed loop control.

CLOSED LOOP CONTROL

In closed loop control, the control signal is sent from the processor to the controlled device (output) while the controlled device sends constant feedback (input) to the processor. Let’s look at how the processor accomplishes its tasks.

Joe, the building manager, wants all the lights in his building to come on at 8 a.m.. So he programs the building control system to carry out this instruction. At 8 a.m. the next morning, the control system processor sends a signal to the circuit panel telling the lights to turn on, and a sensor in the circuit panel sends a message to the processor confirming the action.

This input/output process is the closed loop. Within the processor, closed loop control signals are determined by:

- Control algorithms
- Configuration values
- Time schedule data
- Setpoint schedule data
Control algorithms are mathematical calculations performed by the DDC processor – formulas that actually compute the control signals and maintain closed loop control. Because one control unit handles multiple inputs and outputs, the algorithms require configuration values, which are numbers that represent the various points found in an HVAC system.

Carrier's Comfort Controller 6400, for example, can control up to 64 hardwired points. It's the configuration values' job to help the Comfort Controller unit identify them. Point 8, for example, could be a cooling coil valve - an analog output.

The algorithms also require time schedule and setpoint schedule data, such as the times specific equipment should turn on and turn off, temperatures at which valves and dampers should reset, and so on. Using this data, a processor can be programmed to perform a wide range of control algorithms. Some of the most typical are:

- Heating/cooling coil control
- Humidification/dehumidification
- Mixed air damper optimization
- VAV fan control
- VAV supply and return fan tracking
- Indoor air quality
- Control point reset
- Time of day scheduling
- Discrete interlock
- Discrete staging
- Primary/secondary pump control
- Night free cooling
- Permissive interlock

PROPORTIONAL-INTEGRAL CONTROL

Another name for closed loop control is Proportional-Integral-Derivative Control, or PID Control. To explain the principles behind the name, let's first look at Proportional Control.

Proportional Control (P-Control), is much like cruise control in the '70s. Back then, setting the cruise at 55 mph meant the car would go 55 on a flat road. But when the car started up a hill, it would slow to 50, or maybe 60. Then when the car traveled down the hill, it would increase to 60 or 65. Overall, the car's speed fluctuated within a wide range.

If we use the same example, but change the miles per hour to degrees, we can see that even though the setpoint is 55°, the temperature doesn't stay constant. It rises and falls, wasting energy and mechanical cooling, and causing uncomfortable temperature swings.

Proportional-Integral-Derivative (PID Control) is cruise control today. Now when you set your cruise at 55 mph, it feeds more gas to the engine to help maintain that speed when the car travels up a hill. When the car goes down the hill, the cruise control brakes the car. Consequently, the car's speed stays as close to 55 as possible.

As a result, the system uses the minimum amount of mechanical cooling or heating to maintain zone temperature.
THE CONTROL NETWORK

Sizable HVAC systems may have any number of controllers. These are networked together through a communication bus, the same way computers are networked together to form a Local Area Network (LAN). The bus allows the user to see all the system's inputs and outputs – analog and discreet – and monitor their operation via a computer software program.

HOW DO WE APPLY THIS KNOWLEDGE?

Now that we've learned about points (inputs and outputs) and control loops, let's put our knowledge to use by building an air handler.

Starting with a basic air handling unit with no controls, the first thing we want to be able to do is turn it on and off – a discreet output. So we add an input/output module to control the fan starter, and program the control processor to turn the unit on at 8 a.m. and off at 5 p.m.

Since we want to be sure the unit actually comes on, we need a report of the unit's status back to the processor – a discreet input. Attaching an airflow switch will provide us with confirmation that the fan is operating. We now have a basic air handler unit with direct digital control of start/stop scheduling.

For the air handler to function properly – to supply air, exhaust air and bring in outdoor air – we add mixed air dampers. The dampers will modulate open and closed based on the air temperature in the duct, which can vary substantially.

A return air temperature sensor – an analog input – is then placed in the return air duct to send temperature data to the processor. The processor plugs the data into an algorithm to calculate the damper position required to maintain the setpoint, then sends a signal to the damper actuator to modulate a percentage open or closed – an analog output.

Another sensor is placed to the right of the damper to measure the reaction from the change in damper position and report back to the processor. The processor again uses the control algorithm to determine whether the damper needs further adjustment. This is direct digital control of start/stop and damper control.

We can continue adding components to the air handler – a cooling coil valve, inlet guide vanes, variable frequency drives, enthalpy control – and their associated input/output sensors and devices until we have full direct digital control of all the air handler components.

WHY CARRIER?

Who better to design, specify, install and service direct digital controls than Carrier – the company that invented air conditioning equipment. Helping your customers choose a Carrier Comfort control system provides them a number of benefits:

- **A single source of responsibility.** In the event of a question or a problem, the customer need only make one phone call – to Carrier.
- **Confidence in the system.** The superior knowledge of our sales teams helps the customer make the right system choices, whether the project calls for a new system or a retrofit.
- **Reduced installation time and costs.** Carrier controls are pre-installed on the equipment, avoiding delays and high labor costs.
- **Reliability.** Carrier's legendary reputation for quality materials, precise manufacturing and equipment durability is well deserved.
- **Faster repairs.** Service technicians can diagnose problems and make repairs more easily and quickly.
- **Shorter learning curve.** In-house maintenance staff need to learn and operate only one simple system.
- **Equipment designed with controls to meet all systems applications.** Whatever your customers’ systems requirements might be, Carrier has the means to control them.

Satisfying your customers starts when you help them analyze their HVAC needs and choose the system, equipment and control solutions right for them. With a basic understanding of DDC and the direct digital control process, you’ll be able to not only meet their expectations, but exceed them.

For valuable assistance and information about direct digital control applications, please refer to the source listed below.

**SOURCE**

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