Role of DDC Systems in Commissioning

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Synopsis

The Direct Digital Control (DDC) System is one of the most important tools available to the commissioning provider and is the most significant system to be commissioned. This paper will discuss the role of the DDC system in commissioning. It will discuss the remote use of DDC systems along with the use of graphics and trending. The various types of programming interfaces are presented with the influences they have on the commissioning process. It will also bring up practical considerations engineers and commissioning providers need to consider and clarify as part of their role in the design process. Among these are networking and architecture issues that are inherent in various DDC vendor product lines.

As a commissioning provider, there is a unique opportunity as well as a need and expectation to assist in providing better control system installations. This process begins with the better documents. Five principles are presented that are important in designing and specifying DDC systems.

About the Author

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Utilizing DDC Systems for Commissioning

DDC system capabilities have dramatically increased over the past 10 years. Their potential role in the commissioning of HVAC systems has improved as well. For example, the following enhancements have made DDC Systems a much more useful tool to the commissioning provider:

- DDC systems are much more powerful and robust. This allows for more trending, better graphics, and more information available to the commissioning provider.
- Newer systems are accessible via the Internet, which allows for remote access of the system. In addition, with server-based Internet-based systems, software licensing is not as much an issue.
- Operator Interfaces (Workstations, notebook computers, and handheld interfaces) are becoming more powerful and less expensive. Typically, they also can connect at more places in the architecture of a given control system network.
- Graphical programming is becoming more prevalent as a DDC programming tool among vendors, which allows easier off-line simulation of control logic.

With these increased capabilities, has come increased complexity. Over the past 20 years, the controls portion of HVAC systems has undergone the most drastic change of any part of our industry. It has evolved from pneumatic controls to “overlay” energy management systems and first generation Direct Digital Controls (DDC) to current generation distributed DDC. The transition has been rapid and today we find ourselves dealing with control systems that are very different from what was available just a few years ago. The computer industry’s trend of increasing processing power & memory at a lower cost over time is quickly influencing the DDC controllers as well. The advent of open protocols and increased availability and use of site/building/campus networks has increased the complexity of the design, procurement, operations and the *commissioning* of these systems. During this time frame, we moved from a non-proprietary communication protocol (air pressure) to one that has been historically very proprietary. In addition, the control logic that was distributed to single function hardware components (receiver controllers, switching relays, etc) now resides in software. These are significant fundamental changes to a critical subsystem of our HVAC system.

This “subsystem” is vital to the performance and basic operation of the overall HVAC system. It historically gets far too little attention in the design, procurement and installation process. The DDC system is the “brain” of the HVAC system. It dictates the position of every damper and valve in a system. It determines which fans, pumps and chiller run and at what speed or capacity. Yet, proportionally, it receives very little time and attention relative to the rest of the system during the typical design process. Commissioning Providers have both a need and an opportunity to help clarify the DDC systems during the design process so it can be effectively commissioned and become a tool for more efficient and effective commissioning procedures.

Using the DDC System in the Commissioning Process

Programming Types

The DDC System itself obviously must be commissioned. But the control system can be utilized as an effective tool to improve and assist in the commissioning process. There are distinct differences in various DDC systems that affect how one approached control system commissioning. One distinct difference that influences the commissioning process is the type of programming used in the DDC system. The four most common programming types used in today's systems are:

- Line programming;
- Template or database programming
- Configurable or "Canned"; and
- Graphical programming

Of these, graphical programming type systems allow a different approach toward the commissioning of controlled systems. In a line programming system, it is difficult to "simulate" the control logic off-line. Software tools are available to de-bug or trace a line program, but not readily simulate the control logic. Therefore, when commissioning a line code based system, the commissioning engineer must test the control logic in the field after functionally testing the control devices and components. As a result, when field-testing the control logic on a line code system, one is testing for programming errors as well as loop tuning issues or inherent system problems. When a test fails, it is more challenging to diagnose the cause of the problem.

With graphical programming based systems, the opportunity exists to receive and review the control logic before it is running on an actual system. This allows the commissioning engineer to simulate values and "test" the logic off-line before going to the field. In affect, one conducts some of the FPT's virtually. In this process, one can be reasonably confident that once the device and component checks are correct, that most failed tests are due to tuning or some system issue not found earlier.

Remote use of the DDC system

Remote use of the DDC system allows the commissioning provider to assess the overall HVAC and Control system's "readiness" for commissioning. One challenge that exists in commissioning is gauging when a project is sufficiently complete to begin the functional testing portion of the commissioning process. There are many methods and approaches to assist in this assessment, but remote evaluation of the system utilizing the installed DDC System is one of the most efficient. For this to be effective, the commissioning provider must have a copy of the control system software, or some other means of "seeing" system performance data (some sort of terminal emulation software). This remote access capability can also be used during the commissioning process to assess whether changes have been made addressing failed tests. As more control systems move toward web-based software, this ability to remotely access system performance will become easier.

Graphics

The use of the DDC system graphics allow for a "bigger picture" view of the system performance. Overall system graphics for Chilled Water Systems, Air Handlers and Terminal Units can be visualized and check for "reasonableness" at the current conditions. From this graphic, the commissioning provider can check each control loop subsystem performance at the current condition. Also, the graphics can be used to check for coordination of sensors. For example, at the current temperatures and damper positions, does the OA, RA, MA temperatures make sense. The commissioning engineer can typically utilize the DDC system graphic to override conditions and watch for expected results. One option to consider is the overriding of controlled devices such that multiple sensors "see" the same condition and should read approximately the same values. These simple tests can give a good indication of the "readiness" of the overall system for functional testing. Other areas that can be quickly gauged from the graphic include checking point information set-up. One can check if alarms and trends are set up or if there are any calibration or offset values in the point information. Another quick check is to look at the PID blocks to see if the tuning parameters are all the same or if most are still set at the factory default values. These things give a quick indication of how much quality control has been conducted by the installing control contractor.

Trending

Trending features that are inherent in DDC systems are another useful tool to the commissioning engineer. Typically there are multiple types of trends that are useful in the commissioning process:

- Pre-commissioning trends
- Loop-tuning trends
- Acceptance period trends

If these trends are set-up by the contractor, then it is important to specify the details of the time intervals as well as whether that the data is instantaneous. For instance, a loop that is cycling due to a tuning problem will show a fine-looking flat line performance if the values are averaged. As one goes through the process of setting up trends on equipment controlled by the DDC system, there may be practical limitations on how much data can be collected. The trending capacity of a given system will depend on the specific manufacturer and version of system as well as the network architecture of the system. Unfortunately, the system architecture of most systems is dictated by the installing contractor and not designed by the engineer.

DDC System Architecture Issues

Many DDC manufacturers make controllers of two distinct levels. Some make only one. These "levels" refer to where the controller resides within the system architecture on the control network. Knowing the difference between these controllers is important because the appropriate controller is application-dependent. Many specifications do not distinguish between these various types of controllers. This becomes an important issue relative to trending capability as well as fundamental control of the various systems.

Typically, higher end controllers live on a higher-level network and communicate in a peer-to-peer fashion. These "primary controllers" peer-to-peer and can share information to other peer-to-peer devices without going through an intermediary device. These controllers have more memory, more sophisticated CPU's, typically higher resolution A/D converters, more accurate clocks, and can store more complex control strategies as well as trends, schedules and alarms.

Manufacturers also make less sophisticated controllers that typically reside on a lower-level polling network. These controllers have more limited memory and processing capabilities, and must utilize a Supervisory Interface device to communicate with all other devices. Many are designed for typical terminal applications like VAV boxes or Fan Coil Units. Others may be used for air handling systems with simple to moderately complex sequences of operation. Since these controllers have more limited memories, they typically do not store historical information (like trends) and rely on the supervisory interface for this function. The secondary polling networks are configured such that one supervisory interface can monitor a limited number of controllers. This limitation varies by manufacturer. A large number of controllers on a secondary controller network can negatively impact the number of trends that can be practically utilized and the amount of data that can be processed and its speed of transmission over the network. How many is too many on this secondary network? It depends on the manufacturer, the speed of their network and the application in question.

The capabilities of the different vendors' DDC system vary considerably with regards to trending capabilities. Trending features and archiving capabilities have historically been a lower overall priority in the controls industry. It is not uncommon today to find controls technicians that are unfamiliar with their own product's trending capabilities and associated data archiving routines.

Common issues to be considered when designing trends for commissioning purposes include:

- Selection of specific points to be saved/stored by the system;
- Impact of trend activity on control and communication functions;
- Data time interval required; and
- Data format if trends are exported to other software analysis tools.

Principles to *Spec* (controls) by…

In the ever-changing world of DDC, the focus of design engineers in our industry has been on the new technologies in our business like Open Protocol, Web-based control, interoperability and the like. While these are important issues to consider, we should not lose focus on the more basic, more important aspects that make a DDC system work well. As commissioning providers, we have an opportunity, obligation and necessity to improve the quality of control system designs. The following five principles are offered in general order of priority as guidelines to follow for development of improved specifications for our industry:

Principle 1 - The control system must first and foremost provide effective and reliable control, commensurate with the systems it is controlling.

Obviously, not all control products are created equal. Product lines vary greatly with respect to architecture, controller power/quality, networks and the like. It is the design engineers' responsibility to research the various products available and specify the appropriate level of controller, network, I/O devices, etc. for the application. One size does not fit all and therefore judgment must be applied to specify the most cost-effective solution. This is not a trivial task, but it is an essential one. One example of an effective way of dealing with the controller aspect of this is a specification that applies the concept of generic "Application Categories" for controllers where the performance requirements of the controllers (relative to stand alone capability, memory, A/D conversion, communication facilities, etc.) are grouped into categories. The various systems are assigned to the applicable/optimal category. This will dictate for instance whether you accept that the "network is the controller" as is assumed on pure node based LONWorks systems or whether you require critical/complex systems/equipment be on high-powered high-quality, stand alone controllers. Leaving these decisions to the contractor may result in too much or too little relative to the DDC hardware used to control a given application.

Principle 2 – The manufacturer and installer must be highly qualified with extensive experience and must be committed/bound to a thorough Commissioning of the system.

While the control system power/quality is very important, equally or more important is the expertise and commitment of the installing contractor and their collaboration with the design engineer and overall commissioning effort. Specifications should insure that a quality contractor with an extensive proven track record required; and that effective, thorough commissioning of the control systems by that contractor – whether or not a formal Commissioning process is employed - be done. Given that this is crucial, there lies a challenge to the designer to fairly restrict installers to those that can deliver effectively within the context of both the construction and the service/support arenas. To deal with this, the specification should dictate qualifications of both the installer and manufacturers of the systems. This may call for some research into the capabilities of local control contractors on the part of the designer. The specification should require high standard should be set for the Commissioning of the control system.

Principle 3 – The control installation must be fully documented as consistently as practical with nothing required to fully operate and maintain the system withheld from the owner.

Whether proprietary or interoperable, the system must always be put in the context of the inheriting organization and implemented and documented using standard approaches wherever possible. Point naming conventions, programming logic, network configuration, security information, etc. must be strictly adhered to and totally documented. No essential element for the continued operation and maintenance of the control system may be withheld in any way. No part of the installation may be considered confidential or proprietary information. It is unacceptable that operators today do not have the software to see how there systems are programmed. In some cases they may not even "own" the programming to their own sequence of operations. Design documents need to cover these issues. Of course, this is only the first half the battle; they must be enforced as well.

Principle 4: The system must be interoperable to the appropriate level.

Seamless interoperability is a high priority - albeit an illusive - goal. The term "Interoperability" must be considered in the context in which it is used. As one navigates the sea of claims of interoperability, you will find most definitively that the "devil is in the details" because of the multi-dimensional nature of a modern day BAS. There are many levels of "interoperability" that can be specified. A discussion of this issue is beyond the scope of this paper. The designer must determine an appropriate level of interoperability, investigate and validate the requirements necessary and specify these clearly. Blanket statements requiring conformance to an open protocol are meaningless and unenforceable.

Principle 5: The sequence of operation must be clearly and completely communicated for each system.

The sequence of operation must be complete and detailed for each system designed. Performance specifications that are general in nature is "punting" the design responsibility to the contractor. The engineer must figure out how each system is to work in all modes of operation and clearly communicate this in the sequence. Consideration should be given to developing logic diagrams at the design phase. A generic sequence makes programming and commissioning difficult, as there may be many possible interpretations. Which is appropriate for the project? This should be the engineers' decision. Period. Far too often the commissioning engineer must mediate a solution between the engineer's intent, control vendor's interpretation and the owner's desires. It is imperative that the commissioning provider clarify the sequences (the earlier the better). It is challenging if not impossible to write good functional performance tests for a "gray" sequence of operation.

Following these 5 Principles will result in better specifications and sequences of operation. This, of course is easier said than done. Research is required to fulfill these requirements. Design Engineers and commissioning providers must invest the time to climb this learning curve if their intent is to specify better DDC systems.