RP-1455 and Guideline 36

Control Sequences & Controller Programming

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Since the inception of direct digital control (DDC) systems, control system manufacturers and their customers had to choose between two fundamentally different approaches to control system programming:

- Configurable controllers, where control logic is largely preprogrammed, allowing only a few configuration points and setpoints to be adjusted by the user; and
- Fully programmable controllers, where users can program whatever sequences they want into the controller.

Configurable controllers have several advantages: the control logic and programming are pretested and debugged, reducing installation and commissioning time. These controllers are almost plug-and-play, with only minor configuration work required. But configurable controls developed the reputation of having overly simplistic control logic that sometimes did not meet the requirements of energy and indoor air quality standards.

Unfortunately, using fully programmable controllers presents its own challenges. Even though many HVAC applications are very similar, if not identical, there are no industry standards for control sequences. This results in the following problems and inefficiencies:

- Almost every application is treated uniquely, often with custom logic that must be prepared and debugged over and over again. The result is a waste of resources and, because of the limited time devoted to system programming and commissioning, systems that are never fully debugged and free of operational problems.
- Control sequences are often poorly written or incomplete. Writing precise, concise, and bug-free sequences is difficult given the complexities of modern HVAC systems and few engineers do it well. Installing contractors are often left to complete or correct poorly written sequences often without a complete understanding of the design intent.
- Control sequences mandated by energy efficiency standards such as ASHRAE/IES Standard 90.1-2013, *Energy Standard for New Buildings Except Low-Rise Residential Buildings.* and indoor air quality standards such as ASHRAE Standard 62.1-2013, *Ventilation for Acceptable Indoor Air Quality.* are not always implemented correctly due to lack of familiarity by design engineers and DDC system programmers.

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- The commercial control system market is extremely competitive, often resulting in insufficient time devoted to system programming and commissioning, in part because the custom nature of the programming for each project is so time intensive.
- DDC systems are very powerful, yet their power is not fully used by most engineers. For instance, few systems are programmed with real-time diagnostic algorithms to detect faults, yet almost all systems have the hardware and software capability to do so. These diagnostics could be used to detect system faults that result in energy waste or failure to maintain process or comfort conditions.
- Specified alarm logic varies from generating too few alarms, allowing faults to occur without the knowledge of building operators, to generating too many alarms that quickly become ignored by building operators. Hierarchical fault detection can be used to prevent nuisance alarms as described below.

Ideally, standardized high performance, optimized sequences should be developed that can be preprogrammed into controllers, providing the benefits of configurable controllers while not sacrificing performance.

Research Project 1455

In 2008, Research Project 1455-RP[1] was initiated to develop "best of class" HVAC system control sequences. This first phase included developing optimized control sequences for air distribution and terminal subsystems including single zone VAV AHUs, multiple-zone VAV AHUs, and a variety of VAV terminal units, including single-duct, dual-duct, and fan-powered. These sequences were derived from controls specifications submitted by research partners including engineering consultants, government institutions, and academic researchers. As such, they embody dozens of person-years of design and commissioning experience. A second-phase research project (discussed further below) is being developed to address heating and cooling plants and hydronic distribution systems.

These standardized advanced control sequences for common HVAC applications will provide the following benefits:

- Reduce engineering time for design engineers. Rather than develop sequences themselves, they can adapt standard sequences that have been proven to perform.
- Reduce programming and commissioning time for contractors.
- Reduce energy consumption by making systems less dependent on proper implementation and commissioning of control sequences.
- Reduce energy consumption by ensuring that proven, cost effective strategies, including those required by ASHRAE standards and building codes, are fully implemented.
- Improve indoor air quality by insuring control sequences are in compliance with IAQ standards and codes such as Standard 62.1.
- Reduce energy consumption and reduce system downtime by including diagnostic software to detect and diagnose air handler faults and make operators aware of them before they cause performance problems.

In addition to the written sequences, the RP-1455 deliverables include companion control schematics and points lists for each of the systems. There are application notes in the sequences that clarify the logic behind or application of the written sequences.

As part of RP-1455, functional logic diagrams of the sequences were created and they were programmed into one manufacturer's controllers and bench tested. This both verified that the written sequences could be programmed and that these sequences could be implemented in commonly available commercial HVAC controller hardware. A future research project (discussed further below) will test the sequences in a real facility. However, RP-1455 is based on control sequences that have been proven in the field, so this process is expected to help fine-tune the logic rather than lead to major revisions. This project will also develop functional performance tests to allow manufacturers to test their implementation of the sequences to ensure they were correctly programmed.

Guideline 36

At the conclusion of RP-1455, ASHRAE Guideline 36, "High Performance Sequences of Operation for HVAC Systems" was created to publish and maintain these best of class sequences and future best of class sequences for other systems. The guideline committee will keep the sequences up to date by evaluating and processing recommendations for changes from users to improve performance or fix bugs. The sequences will ultimately be expanded to include sequences for heating and

cooling plant and hydronic systems, dedicated outdoor air systems, radiant heating and cooling systems, etc., whether developed from research projects or recommended by engineers, manufacturers, and contractors. The committee will also maintain functional performance tests used by DDC manufacturers and commissioning agents to verify that sequences have been properly programmed.

The latest version of Guideline 36, as well as news, updates and supporting material can be found at the Guideline Project Committee 36 public website (http://gpc36.savemyenergy.com/).Information on how to join the committee is available for those who wish to become formally involved in the process of developing this Guideline.

Once the Guideline is published, it is expected that design engineers will be able to use them as the basis of control for standard system configurations. For standard systems, it might be possible to simply include in their specifications a table of ASHRAE Guideline 36 sequences with check boxes for the paragraph numbers that are applicable to their project. Having a standardized basis for the sequences will reduce the burden in writing control sequences and improve the operation of those sequences in the field. Controls manufacturers are expected to preprogram the sequences into their controllers and verify the programming is correct with factory performed functional tests. Then control contractors can simply use the programming directly with minimal configuration. Commissioning work could then consist simply of verifying that configuration and setpoints are correct; field functional testing of programming using standardized functional performance tests should be less burdensome.

Status and Future Work

Guideline 36 will be issued for an advisory public review soon and is available for download from the GPC-36 public site. It will include the RP-1455 sequences as issued in the project's final report with slight modifications (primarily clarifications of language, plus a couple of improvements to logic). The comments received from this review will be used to create a publication public review expected to be issued late 2015 or early 2016.

The Guideline committee will also adapt the work of future ASHRAE research projects into the Guideline as the work is completed. The following are active ASHRAE projects expected to be adapted into Guideline 36 sequences in future addenda:

- 1587-RP: "Control Loop Performance Assessment." Creates a metric for determining if control loops are tuned, designed to be programmed into controllers for real-time assessment of loops.
- 1746-TRP: "Validation of RP-1455 Advanced Control Sequences for HVAC Systems – Air Distribution and Terminal Systems." Tests RP-1455 sequences in real building environment using formal functional tests to test stability and performance.
- 1747-TRP: "Implementation of RP-1547 CO_2-based Demand Controlled Ventilation for Multiple Zone HVAC Systems in Direct Digital Systems." Creates workable sequences

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from the RP-1547 results, which is a theoretical approach to Standard 62.1-based CO_2 demand controlled ventilation.

- 1711-WS: "Advanced Sequences of Operation for HVAC Systems – Phase II Central Plants and Hydronic Systems." The second phase of RP-1455 that includes chilled water and hot water plants and distribution systems.

Conclusions

It is expected that most DDC system manufacturers will pre-program the ASHRAE Guideline 36 sequences into their systems so that they can be used directly or easily adapted for most any HVAC system application. Therefore, the plug-and-play benefits of configurable controllers are realized without sacrificing energy performance and occupant comfort.

Guideline 36 is expected to be published in 2015 or early 2016. But that should not prevent the RP-1455 sequences from being used right now. They are currently available by downloading the RP-1455 reports from the ASHRAE website, or by downloading the review draft of Guideline 36 at http://gpc36.savemyenergy.com/. Engineers can duplicate some or all of the sequences in their control specifications. Manufacturers should also start programming the sequences into their systems right now in anticipation of their being specified by engineers and to gain an advantage over their competitors.

References

1. Hydeman et al, Final Report ASHRAE RP-1455 Advanced Control Sequences for HVAC Systems, Phase I, Jan. 14, 2014. ■

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