Communicating Control Sequences Through the Use of Logic Diagrams

The old saying is true: 'The devil is in the details'

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Design engineers typically rely on the written word to describe the desired operation of control systems. Often, their descriptions are generic and overly simplistic, which can lead to unintended results.

This column presents an alternative approach to communicating desired control sequences.

AN ANALOGY

Let's say I e-mailed the following message to my travel agent: "I want to travel from Washington, D.C., to New York City on Thursday morning and return Friday evening." This statement does not adequately communicate my intent and could lead to a variety of outcomes, including my being booked on a train when I wanted to fly.

The following is a more-specific set of instructions: "I would like to travel by air on a non-stop flight from BWI to New York LaGuardia on a major airline on Thursday morning, arriving before 10, and returning Friday evening, leaving after 5."

Even these more-detailed instructions leave out important considerations such as airline and fare class, as well as how early or late I am willing to fly. If my travel agent does not know my preferences, he has to make assumptions, assumptions that may result in a trip different from the one I intended to take.

The point of this analogy is that, as the saying goes, "The devil is in the details" of control sequences. In this regard, an engineer cannot be too specific. Far too often, though, details are not included in written sequences, leaving important decisions to be made by controls contractors during the construction process. A more-thorough approach during design would help to eliminate this problem.

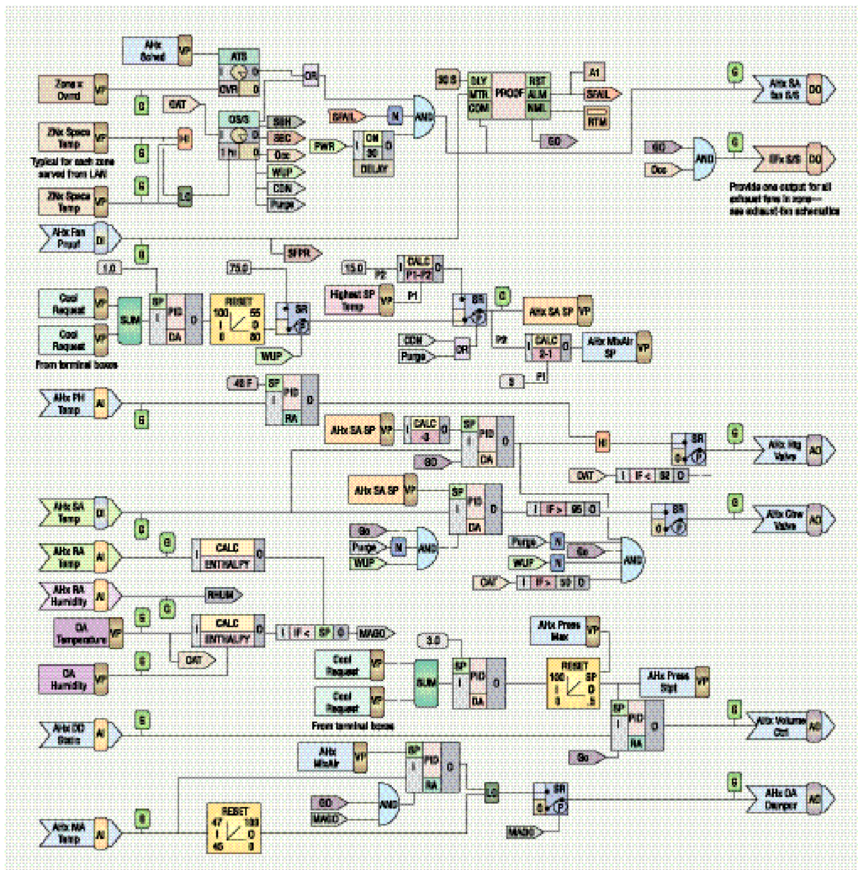

FIGURE 1. A typical control-logic diagram.

CONTROL-LOGIC DIAGRAMS

The development of a control-logic diagram forces the system designer to make critical decisions regarding the intended operation of the system. Figure 1 is an example of such a diagram.

Control-logic diagrams are not new. The process-control industry uses process-and-instrument diagrams, while many direct-digital-control manufacturers use graphical-programming interfaces (Figure 2).

Figure 3 is an example of a mixed-air control-loop logic diagram used in teaching mixed-air-subsystem control logic. Simply writing, "The mixed-air dampers shall open on a demand for cooling before the cooling coil opens and maintains minimum ventilation air, except when outside air is too warm for

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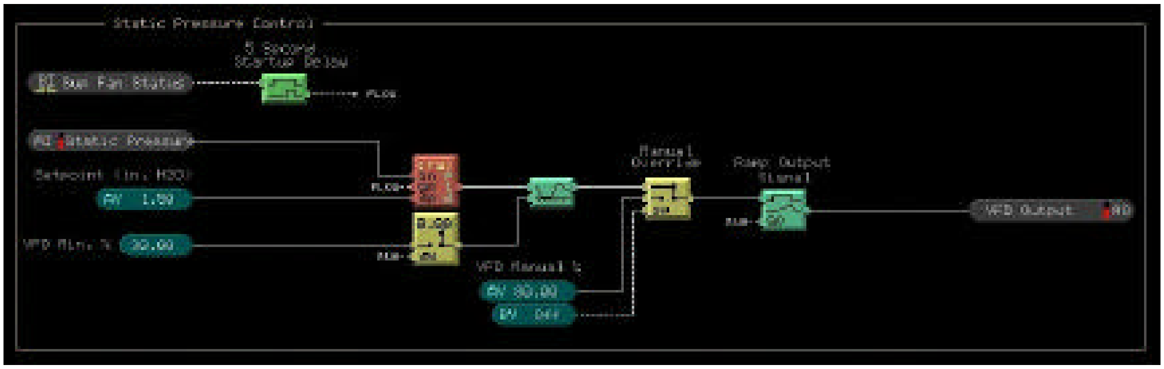

FIGURE 2. An example of a graphical-programming interface. Image courtesy of Automated Logic Corp.

free cooling," is not adequate. There are many other considerations:

• The control-loop response (proportional, proportional plus integral [PI], or proportional plus integral plus derivative). In Figure 3, PI control is called for.

• How the mixed-air setpoint (MASP) is determined (is it fixed or reset, and, if it is reset, on what is it based?). In Figure 3, the MASP is reset based on the discharge-air setpoint (DASP) minus 2 F.

• What determines that it is too warm for free cooling. In Figure 3, the high limit is initiated when the outside-air temperature (OAT) exceeds the return-air temperature (RAT) or when the outside-air (OA) enthalpy exceeds 28 Btu per lb.

• What happens if the fan runs in an unoccupied mode. For the logic shown in Figure 3, the minimum OA requirement is interrupted if the unit runs when the space, according to a time schedule, is unoccupied.

• How the minimum OA requirement is handled. In Figure 3, a fixed 25-percent signal is generated to ensure ventilation air when the space is occupied, and the fan is running.

• What happens if the fan is off. The logic in Figure 3 shows a supply-fan current switch sending the outside-, return-, and exhaust-air dampers to their normal positions.

ADVANTAGES

The primary advantage of control-logic diagrams is that control-sequence requirements are detailed during the design phase. This allows flaws to be detected and sequences to be rewritten.

If control sequences are adequately detailed during design, there should be a savings in the cost of the controls contractor, who otherwise would have to devote a significant amount of time to controls design. This savings should more than offset the increase in design cost.

The documentation of control logic can serve as an excellent commissioning tool. Without specific sequences, commissioning engineers must weigh the design engineer's intent against the controls contractor's interpretation.

Finally, logic diagrams make excellent training aids for instructing operations-and-maintenance personnel.

OBSTACLES

Why don't we see more detail during the design phase? First, there are no adequate standard symbols for control logic geared toward HVAC. Also, with the consulting community moving to less control detail in its documents, the required expertise is not as prevalent as it once was.

A more-significant impediment to design-phase control logic is liability—the more detailed a control sequence is, the more liable the designer will be if something goes wrong. However, it is in the best interest of owners that an engineer design the details of control logic, given that the engineer has the experience to do so.

CONCLUSION

As the design engineer, ask yourself if your verbal performance specification adequately covers the details of the installed system. Could you write detailed functional-performance tests based on this sequence to test all of the modes of operation? If not, how could the sequence be improved? Consider developing a more-detailed approach to communicating the intended operation. Control-logic diagrams are an excellent tool for developing, communicating, and documenting control-system logic.

Send comments and questions to controlfreaks@penton.com.

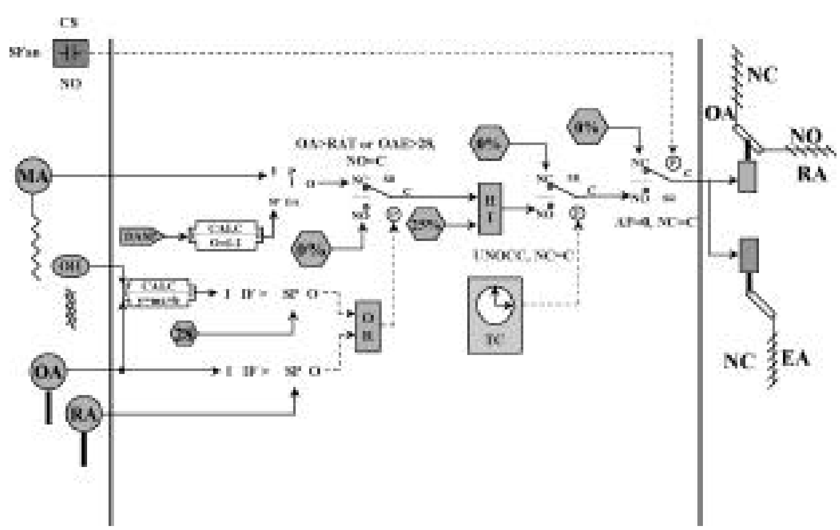

FIGURE 3. An example of a mixed-air control-loop logic diagram.