UFC 3-410-02
DRAFT 19 JUNE 2003

# UNIFIED FACILITIES CRITERIA (UFC)

# DIRECT DIGITAL CONTROLS FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS

**DRAFT FOR REVIEW ONLY**

**CONTENTS**

# CHAPTER 1

# INTRODUCTION

## 1-1 PURPOSE

This document describes an open-systems approach for the design direct digital controls (DDC) for building-level systems, subsystems, and equipment and is intended to be used with UFGS-15951. A building-level DDC system can be used to provide local control for heating, ventilating, and air-conditioning systems, chillers, and boilers. DDC can also be used to support monitoring and control of water and sanitary sewer systems, process equipment, electrical systems, lighting, and other utility systems and equipment. The DDC system can function as a stand-alone system but is intended to be capable of openly interoperating with a Utility Monitoring and Control System (UMCS) in accordance with the UMCS guidance (UFC 3-400-02 and UFGS-13801).

Designers, installers, and operation and maintenance (O&M) staff have struggled with the complexities and incompatibilities of multi-vendor building automation and control systems (often referred to as Direct Digital Control (DDC) systems) almost since they were introduced in the 1980's. DDC systems are routinely designed and procured on a building-by-building or sub-system by sub-system basis. Inconsistency and incompatibilities between new and existing DDC systems results, at best, in inefficiencies and at worst in complex and non-functioning systems. This is due in large part to the inability of different vendors' DDC systems to interoperate with each other. This inability to interoperate is a result of closed systems due to vendor-specific proprietary elements.

In contrast, open DDC systems are now available. An open DDC system is characterized by the ability for any qualified entity to readily modify, operate, upgrade, and perform retrofits on the DDC system. An open system:

- Permits multiple devices from multiple vendors to readily exchange information.
- Provides the capability to easily replace any device with another device procured from multiple sources.
- May have proprietary components within devices, but these proprietary components must be a small percentage of the overall device.
- May have fees associated with use of certain components.

The open systems approach described in this document is based on ANSI/EIA standard 709.1 communications protocol (sometimes referred to as LonTalk®) and on LONWORKS® Network Services (LNS™) network operating system. The standard protocol supports open communications while LNS supports open network management. Both of these are described in greater detail in this chapter and throughout this document.

## 1-2 SCOPE

This document provides criteria and guidance for the design of heating, ventilating and air conditioning (HVAC) control systems and other building-level systems, sub-systems and equipment. It describes frequently encountered control system loops, provides examples of how these loops are used, and provides guidance and criteria for the design of standard HVAC control systems capable of being interconnected with a Utility Monitoring and Control System (UMCS) for the purpose of remote monitoring and control. The guidance in this document describes an open system approach using LonWorks® Network Services (LNS™) in support of interoperable multi-vendor direct digital control systems compatible with UMCS. This criteria pertains to new construction, addition, renovation, and retrofit projects. This document does not provide guidance on selecting HVAC systems and does not prohibit selection of system types not included herein.

## 1-3 REFERENCES

The following documents form a part of this criteria as referenced:

- Government Publication TM-5-785 Engineering Weather Data.
- Government Publication UFC 3-400-02 ‘Utility Monitoring and Control Systems’.
- May need to add the ‘HVAC’ UFC and possibly others. Will decide later.

## 1-4 POLICY

### 1-4.1 Adherence to the standards.

At the discretion of and with approval from the assigning government agency (such as the responsible Corps District), the design of the control systems may deviate from the standards defined in this criteria document. As is the case with all communication protocol standards, LONWORKS® technology has certain limitations as described in the ‘LONWORKS® Technology Features’ section below. In recognition of this, the UFC guidance is not mandatory. With approval from the assigning government agency, designers may use alternate communication protocol(s) should they decide that LonWorks® is not suitable for the application(s). Systems based on an open protocol are recommended. Proprietary procurement of single-vendor systems is discouraged. Refer to the section entitled ‘PROCUREMENT OPTIONS’.

### 1-4.2 Control system designer responsibilities.

The control system designer will be responsible for designing each control system required for the project systems, and will incorporate the control loops, and control system sequences of operation, using the symbols, abbreviations, and acronyms designated in this guidance. This design responsibility requires producing a design package that includes a specification, and a set of drawings for each control system. The designer will not depend on any control system vendor for the design of the control systems.

### 1-4.3 Control system vendor compliance.

The specification will require the control system contractor to produce shop drawings, schedules, instructions, test plans, test procedures, testing procedures, and other documents showing the application of products to implement the control system design. The specification will require the contractor to define the building-level ‘open-protocol’ communications network in a manner that is consistent with performance requirements defined in the specifications. The specification will further require that the contractor perform calibration, adjustments, and testing of the control system and document the testing to show that the control system functions as designed.

## 1-5 CONTROL SYSTEM DESIGNER GUIDANCE.

### 1-5.1 HVAC control system loops and control logic.

This document includes descriptions of loops for controlling temperature, humidity, airflow, duct system static pressure, and piping system pressure. These descriptions include control sequences of operation with life safety and special interlocks (such as for freeze protection of equipment).

### 1-5.2 Building-level monitoring and control.

This document includes descriptions of processes not typically associated with HVAC control that may be instrumented, monitored, and controlled for energy or utility systems management purposes.

### 1-5.3 Control system architecture.

This document describes network communications architecture and cabling in support of open communications (using a standard protocol) between multiple-vendor building-level DDC systems. While the control system contractor will be required to define the cabling network, the designer must select data exchange parameters. This document describes the methodology for designer selection and specification of building-level data exchange parameters.

### 1-5.4 UMCS interface.

This document is intended to be used in coordination with ‘Utility Monitoring and Control Systems’ UFC 3-400-02 and UFGS-13801 to provide for remote or base-wide interface between the building-level control systems and the UMCS. This document describes the methodology for designer selection and specification of data exchange parameters including (albeit minimal) requirements for building preparation for this interface.

### 1-5.5 Types of equipment covered.

HVAC equipment including: primary (air and water) built-up systems, terminal units, packaged equipment, boilers, and chillers. Other building-level systems including: equipment, sensors and instrumentation that can be interconnected with a base-wide or remote Utility Monitoring and Control System.

## 1-6 DESIGN CONCEPT.

The design concept described in this document provides definitive guidance intended to streamline DDC system design and installation leading to maintainable, interoperable, extensible, and non-proprietary control systems based on LonWorks® Network Services (LNS™) and the ANSI 709.1 standard communications protocol.

## 1-7 CONTROL SYSTEM STANDARDS.

### 1-7.1 Instrumentation signals.

Instrumentation signals such as pressure, flow, and humidity, connected to primary equipment controllers, will be 4-20 mA. Temperature sensor instrumentation signals can be either 4-20 mA or direct-wired to controllers. To facilitate third-party vendor replacement of temperature sensors, standard 18-gage sensor cabling will be required. Primary equipment controller output signals will be 4-20 mA. Primary equipment actuators can be electric or pneumatic. VAV box terminal units will require shaft mount controllers with pneumatic actuators as a design variation. No other sensor and instrumentation standards will be required for terminal unit controllers.

## 1-8 COMMUNICATION PROTOCOL STANDARDS.

### 1-8.1 Standard protocol needs and benefits.

Government procurement rules, which require competitive bidding, make it extremely difficult to procure new DDC systems compatible with existing ones. In the absence of sole-source procurement, the government is faced with inefficient and ineffective operations that result from incompatible systems. Open communications and data sharing between multi-vendor systems is necessary to achieve effective system operation. Some of the benefits and capabilities of multi-vendor DDC systems that openly communicate include:

- Competitive procurement, most notably at the building and sub-system level.
- An operator workstation/user interface that provides for the same look and feel for monitoring and control regardless of which vendor's DDC system or sub-system an operator is viewing. As a result, system operators need only become proficient with one user interface.
- An operator workstation/user interface (software) that provides for management of base-wide system operations such as; remote alarm reporting; remote scheduling (on/off control), remote set point override, data logging and reports, energy management including load shedding, utilities monitoring/measurement for the purpose of monitoring energy performance contracts, and initial diagnosis of service calls. As a result, through a single user interface, system operators and managers are afforded the means to efficiently and effectively manage base-wide operations.
- Whole-building approach to systems integration. This includes the efficient inter-connection of HVAC control sub-systems. For example, terminal unit equipment, such as VAV boxes can be readily interfaced to the servicing air handler to provide a call for cooling. In addition, the whole-building approach provides the capability for integrating non-HVAC sub-systems such as fire and security
- Lays the groundwork for establishment of a non-proprietary and openly accessible 'point-database' in support of communications-network management requirements. The open database approach further insulates the government from the possibility of vendor lock-in and resulting proprietary procurement.

### 1-8.2 LonWorks® selection.

Any of several standard communications protocols could feasibly meet the government's needs for obtaining interoperable multi-vendor DDC systems. At the onset of the criteria development effort (and as of the date of this writing) LonWorks® technology was deemed to be technically on par with any other available technology and it met the government's requirements better than any other available open solution largely because LONWORKS provides a complete solution, not just a protocol. In summary, and as further described in the 'LONWORKS® Technology Features' section below, the single most important reason for selecting LonWorks® was its capability to support the design and specification of a system that could be implemented in an open and consistent manner, due to:

- LonWorks® is a technology, not just a protocol, due to the open network services management capability available with LONWORKS®.
- Certification testing by the LonMark® Interoperability Association (which is comprised of an array of industry partners).
- Availability of numerous LonMark® certified devices from multiple DDC vendors.
- The underlying ANSI/EIA 709.1 protocol has a reference implementation which, in practice, is fixed in firmware thus not open to interpretation. This provides consistency in the implementation of the standard helping to ensure openness and avoid proprietary systems.

## 1-9 LONWORKS® TECHNOLOGY FEATURES.

### 1-9.1 Standard protocol.

LONWORKS technology is based on ANSI standard protocol, ANSI/EIA 709-A-1999. The protocol is not subject to interpretation which helps to ensure compatibility between different manufacturers' devices. The protocol can be openly implemented by a microprocessor of choice by using the downloadable reference implementation of the protocol. In practice though, due to it's low cost, most control manufacturers use the Neuron® chip which is patented by a private corporation. The protocol can be (and has been) implemented on third-party microprocessors.

### 1-9.2 Network services.

Requirements for an open system include more than a standard communication protocol. One other key requirement is the ability to configure and manage the network. A software tool is used to manage network services. While network services are not necessary for day-to-day intercommunication of devices, they are the focal point for system expansions or modifications. An open network service, such as LonWorks® Network Service (LNS™), allows third-party contractors to access, expand, and manipulate all devices on the network. Closed network services are available but should be avoided.

### 1-9.3 Network architecture.

LonWorks® supports system architecture and networking requirements for the various campus-like applications encountered in government applications. At the building level this consists of a standard flat ANSI 709.1 network with logical segmentation accomplished using routers to segment the network and to manage communications and bandwidth. In large buildings a high speed TP/XF-1250 backbone can be used with

TP/FT-10 segmenting. This arrangement remains logically flat. In UMCS applications Internet Protocol (IP) is used as a high-speed backbone. An ANSI/EIA 709.1 and EIA-852 compliant 709.1-to-IP router is used to interface the building-level network to the high-speed base-wide Utility Monitoring and Control System (UMCS) network.

This approach essentially defines a 'flat' base-wide architecture and was chosen to help ensure openness. In support of the flat and open architecture, all system-wide communications are required to be 'implicit' ANSI/EIA 709.1 Standard Network Variable Types (SNVTs). The SNVT approach in a flat network eliminates the need for proprietary gateways, except in the case of legacy system support. The open architecture in turn dictates that supervisory functions such as scheduling, trending, alarming, demand limiting, etc. be accomplished in a specific manner as explained elsewhere in this UFC and/or UFC 3-400-02.

### 1-9.4 **Legacy system support.**

A variety of options are available for interfacing to legacy (existing) DDC systems. In general, this requires the use of a gateway, sometimes referred to as a protocol translator or communications bridge. Interface options and considerations are described in UFC 3-400-02.

### 1-9.5 **Device certification, availability, and adherence to standards.**

LonWorks devices are available for a wide variety of applications, down to the sensor level, supporting a wide variety of applications extending beyond HVAC control. The LonMark® Interoperability Association provides device certification. Certified devices must adhere to a 'Functional Profile' which basically defines its network input/output communications data and capabilities. An up-to-date listing of certified devices can be found on the LonMark Website (http://www.lonmark.org/products/lmprod.htm). Some device categories contain only one or two certified devices (although suitable uncertified devices may be available for some of these categories). The UFC and UFGS provides guidance on overcoming this limitation and industry momentum shows that new devices are being certified on a regular basis. Some common HVAC control systems, such as a return fan VAV system, are not covered by a device category. These systems will require the use of a non-certified device. Use of a non-certified device can complicate the process of ensuring that the device is open and LonWorks® compatible therefore requirements are defined in the 'HVAC and Other Local Building Control Systems' UFC and UFGS guidance.

## 1-10 **PROCUREMENT OPTIONS.**

### 1-10.1 **Non-proprietary procurement.**

This approach is preferred and includes the use of LNS-based LonWorks® compatible with UMCS.

### 1-10.2 **Proprietary procurement.**

Approaches other than LNS-based LonWorks® as described in this document may require proprietary procurement which is discouraged. Possible proprietary procurement options include:

- Develop a five-year requirements contract.

- Develop contract documents for an open system, but indicate in the contract that in lieu of an open system the contractor may provide a proprietary DDC system compatible with the existing base-wide system. This requires two designs and two specifications.
- Develop a contract specification for a control system that is strictly "local" with no need to interface to a supervisory system.

# CHAPTER 2

# CONTROL SYSTEM ARCHITECTURE

## 2-1 INTRODUCTION

This chapter describes the building-level open-communications control system architecture and control devices for HVAC and other building-level monitoring and control applications. The communications network and devices are based on LonWorks® technology and ANSI-709.1 communications protocol. Control device function, sizing, and selection are also described.

Design of an open-communications building-level control system does not require an extensive familiarity with the ANSI-709.1 protocol. Pertinent information in regard to control system design is presented in this document. System architecture, device functionality and data sharing capabilities are also described in this chapter.

## 2-2 ARCHITECTURE

Figure 2-1 shows a sample architecture for a basewide system consisting of multiple building level controls networks (installed per UFGS-15951 and this UFC) connected to a Utility Monitoring and Control System (UMCS). Each building performs all necessary control functionality independent of the basewide UMCS, but the UMCS provides a common monitoring and control platform for the entire installation.

### 2-2.1 Building Level Network Architecture

#### 2-2.1.1 Communication Protocol

The building level control network will use the ANSI-709.1 communications protocol (ANSI/EIA 709-A-1999). As discussed elsewhere in this UFC, this protocol provides a standard for open and interoperable communication between devices.

#### 2-2.1.2 Communications Media

In most applications the devices that make up the building-level control network (the ‘nodes’) will communicate via a 78kbps twisted-pair network (TP/FT-10) as shown in Figure 2-1. In some cases a higher speed 1.25 Mbps backbone may be used with multiple lower speed 78 Kbps segments connected to this backbone. Routers (R) are used to sub-divide the network, bridge the two media types and, to a lesser degree, manage bandwidth. This produces a logically flat network in the building where each node can communicate directly with any other node without the intervention of a third device. Some possible variations to this basic architecture are:

- Multiple buildings can share a common building-level network. For example, two or more adjacent buildings can be physically linked by a common 78 Kbps network cable as long as network restrictions such as cable length and the total number of nodes as described elsewhere in this document and in UFGS-15951 are adhered to. If connecting the building to a UMCS in this case a single BPOC can be used to connect these buildings to the UMCS.

- A large building can have multiple 78 Kbps building-level ANSI-709.1 networks. In this case, the building-level contractor(s) will install multiple independent building-level ANSI-709.1 networks. If connecting the building to a UMCS in this case the UMCS contractor will install a separate BPOC for each network.

### 2-2.2 Connection to a UMCS

As previously discussed, the building-level control network will perform all necessary control functionality in a stand-alone mode but does not provide an operator interface for monitoring and control of the network. If the building is to be operated in a stand-alone mode for an extended period and monitoring and control functionality are required, the designer should utilize the required portions of UFGS-13801 to obtain a local monitoring and control system. If the building is to be connected to the UMCS, the UMCS contractor will be responsible for installation and configuration of the BPOC and integration of the building system into the UMCS. See Chapter 6: Project Implementation for more information.

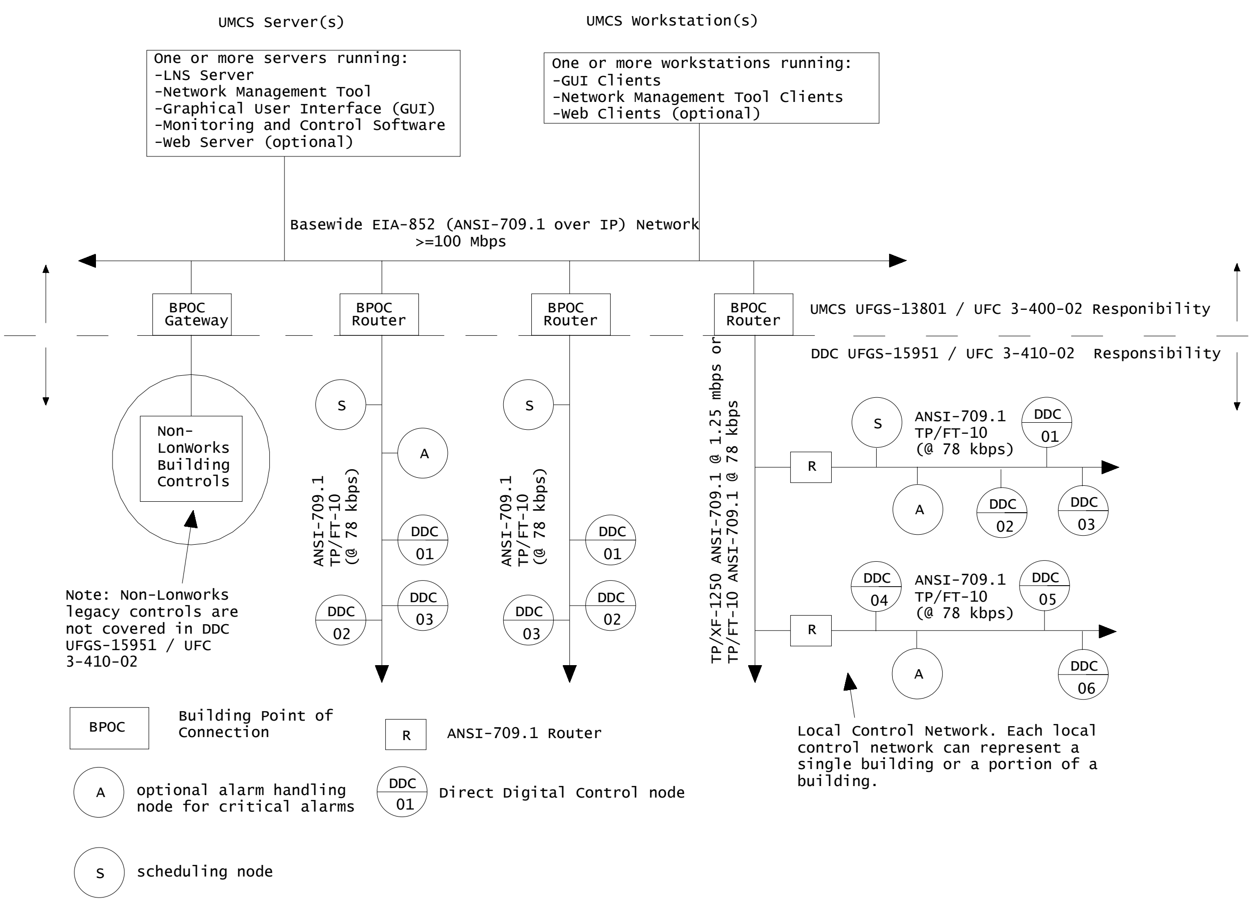



**Figure 2-1. UMCS Basic Architecture**

### 2-2.3 Network design and layout

Network layout is left largely to the building-level controls contractor as specified in UFGS-15951. Designer layout selections and considerations are described in the Project Implementation chapter.

# CHAPTER 3

# DIRECT DIGITAL CONTROL HARDWARE AND CONTROL DEVICES

## 3-1 BUILDING-LEVEL CONTROLLERS AND DEVICES

Intro verbiage.

### 3-1.1 Unique Identifiers

A unique identifier/bubble scheme is used for device identification. The objective is to make identification of control drawing devices as simple and self-evident as possible. For example, as shown in Figure 3-1, DDC-01 represents direct digital controller number 01, where the controller number is shown in the bottom half of the bubble. The bisecting line indicates that this is a node, where a node is a device that is physically connected to and communicates on the building-level network. Each node is numbered sequentially where the intent is to easily count the number of nodes residing on the building level network. Control devices that are not directly connected to the network are shown as non-bisected bubbles, and are not numbered. For example, a mixed air temperature (MA-T) sensor that is hardwired to a DDC controller is not numbered, unless there are multiple sensors with identical unique identifiers. The unique identifier convention for sensors shows ‘device location’ and ‘device type’. In some cases the ‘signal ‘type’ is also shown. For example, MA-T represents a mixed air temperature sensor. MA-T-LL represents a mixed air temperature low limit device (freeze stat). A complete list of unique identifiers and acronyms is shown in the Glossary.

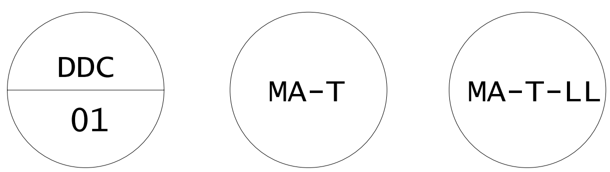



**Figure 3-1. Sample Identifiers**

### 3-1.2 SNVTs

During inter-communication, nodes share data and information by transmitting and receiving Standard Network Variable Types (SNVTs). SNVTs are messages that are exchanged between devices. In general a SNVT is a command, a status, or a variable (such as temperature, pressure, humidity, etc.), but a SNVT can contain other types of information.

### 3-1.3 Functional profile

The LonMark® Association defines functional profiles for LonWorks devices or nodes. A functional profile describes standard node communications. The LonMark® Association is working on the development of *Functional Profiles* for scheduling, trending, and alarming devices. Release of the scheduling functional profile is imminent (within 2 weeks), with alarming and trending soon to follow and will be incorporated in these design guidelines. Guidance contained in this UFC defines functional profile equivalents for the HVAC systems covered in this UFC.

### 3-1.4 **LonWorks node**

A LonWorks node is any device that resides on the LonWorks network and communicates via the ANSI-709.1 protocol. This can feasibly include sensors, actuators, and controllers, along with a variety of other microprocessor-based devices. Discuss LonMark certification. Node spray versus GPC approach?

### 3-1.5 **Building Management Interface node (BMI)**

A small scale building-level network might also include a building management interface (BMI) node. The BMI should only be used in the absence of a UMCS. The BMI provides web services and can also perform scheduling, logging (trending), alarming, and other supervisory interface functions. A disadvantage of the BMI is that, while it is an open protocol device at the building level, it does not support open standard communications over the base wide network. Specifically, the BMI does not perform  routing functions.

### 3-1.6 **Scheduler node (SCHD)**

A scheduler node will be used to perform scheduling and calendar related functions such as turning equipment on and off. A dedicated node will be specified to perform scheduling, although the same functional profile functionality can also be accomplished using a DDC controller. The node approach is preferred as it is less likely to be proprietary and is more likely to be end-user friendly and simpler. A user interface must be provided. Ideally a UMCS will serve as a remote operator interface to the scheduler node, although a building-level (i-Lon1000) web server is a low cost alternative

### 3-1.7 **Alarm node  (ALRM)**

An alarm node is used to generate and manage building-level critical alarms. A critical alarm is defined as an alarm that must receive immediate attention. A dedicated node will be specified to manage critical alarms, although the same functional profile functionality can also be accomplished using a DDC controller. The node approach is preferred as it is less likely to be proprietary and is more likely to be end-user friendly and simpler.

Non-critical alarms do not require an alarm node and are simply transmitted over the IP network to the UMCS. In the absence of a UMCS, non-critical alarms can be transmitted using a web-server.

# CHAPTER 4

# STANDARD CONTROL LOOPS

# CHAPTER 5

# TYPICAL CONTROL DRAWINGS

## 5-1 HVAC CONTROL SYSTEM DRAWING DESCRIPTION.

### A-1.1 Drawings Overview

For each drawing, describe how to read/use it. The drawings must be edited to be project specific based on standard control system drawings in Chapter 6. What to edit/change will be in ‘Project Implementation’ Chapter 5.

### A-1.2 Control system schematic.

Describe/elaborate connection to other control systems, etc.

### A-1.3 Ladder diagram.

Describe/elaborate HVAC starters, hardwired interlocks, and safeties.

### A-1.4 Points Schedule

Hardware I/O, device ranges and settings, LONWORKS SNVTs (local & UMCS).

### A-1.5 Sequences of Operation.

Will be short/abbreviated. (accompanies Logic Diagram).

### A-1.6 Logic Diagram.

Provides details not in written sequence.

### A-1.7 Thermostat and VAV Box Schedule.

### A-1.8 Valve and Damper Schedule

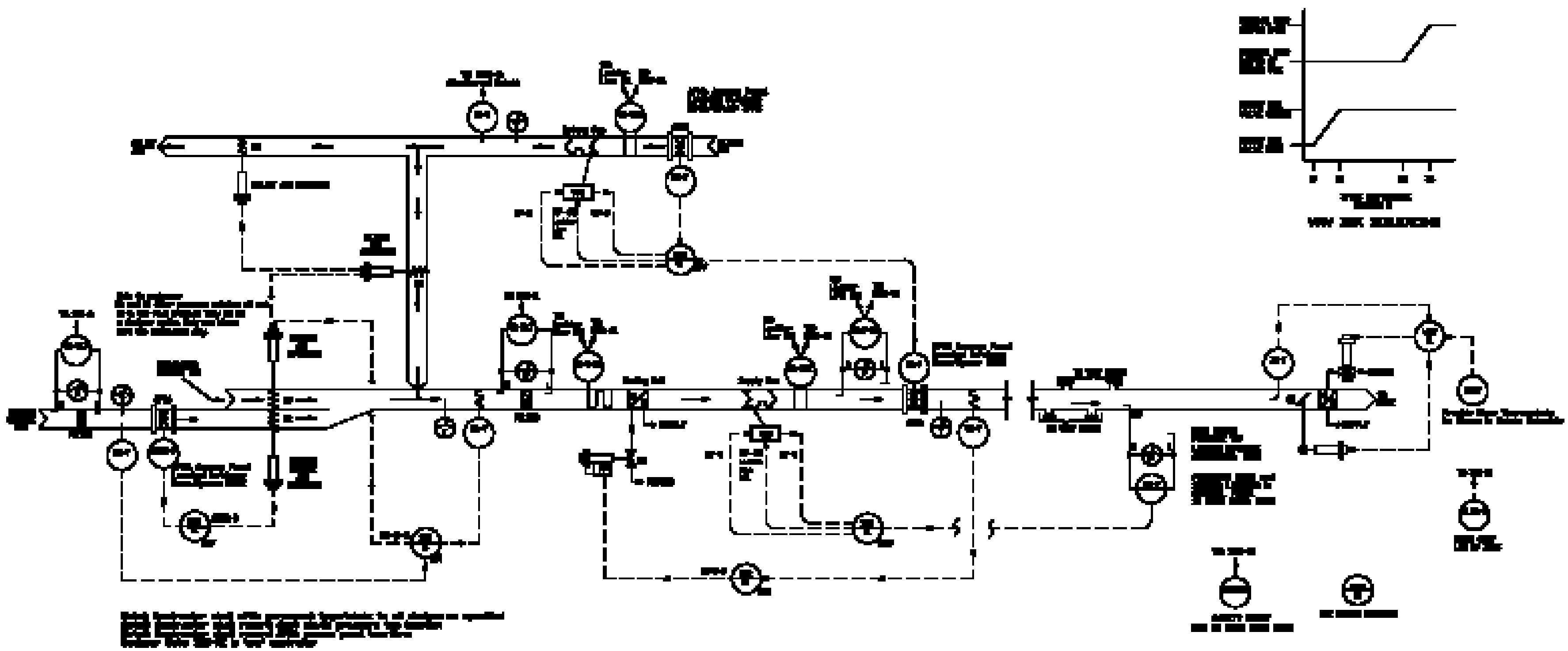
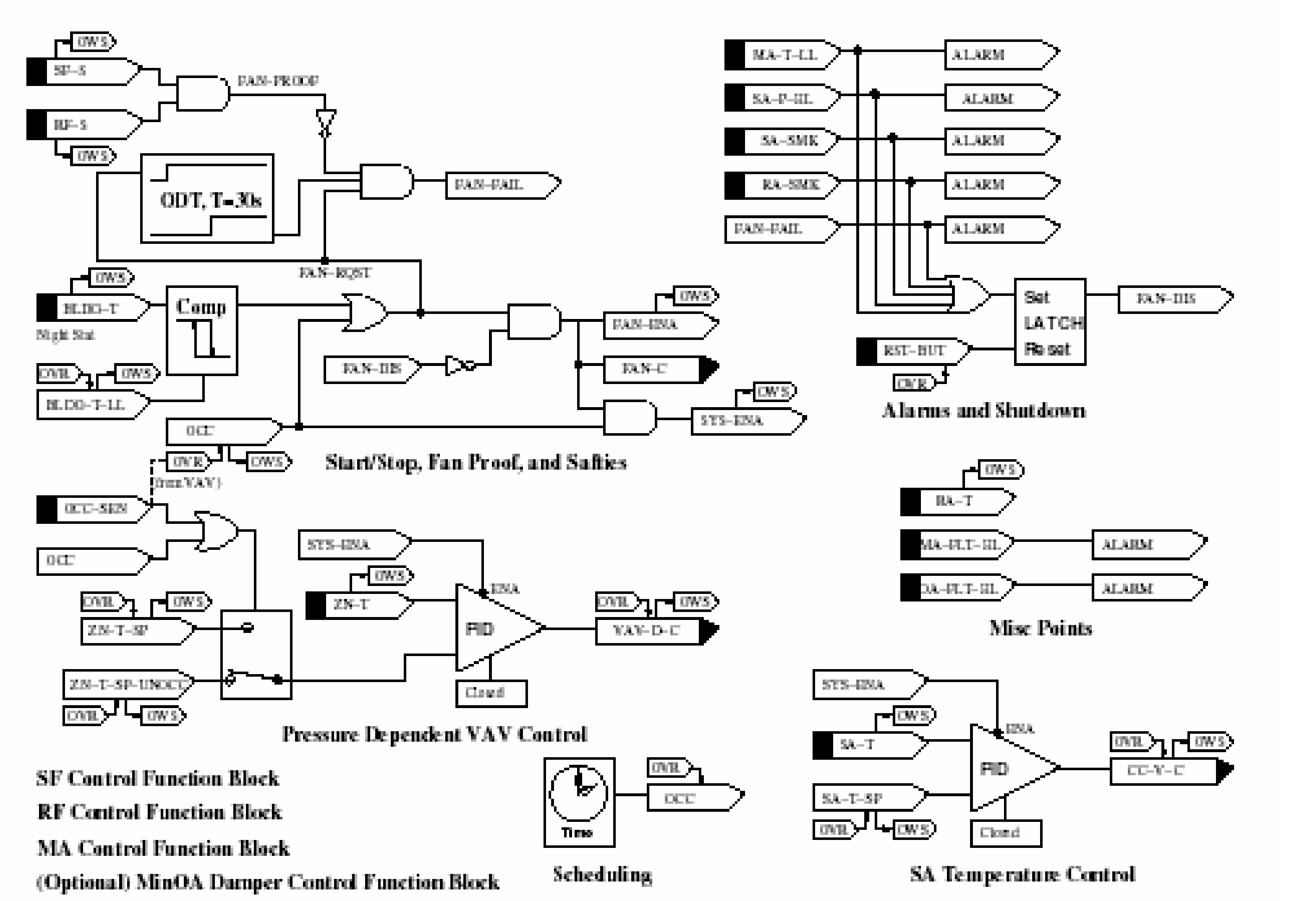


FIG 9 - VAV WITH RETURN FAN AND MINIMUM OA CONTROL


SF-S
RF-S
FAN-PROOF
ODT, T=30s
FAN-FAIL
FAN-RQST
BLDG-T
Night Stat
Comp
BLDG-T-LL
FAN-DIS
FAN-ENA
FAN-C
SYS-ENA
OCC
OVR
OWS
(from VAV)
Start/Stop, Fan Proof, and Safties
MA-T-LL
SA-P-HL
SA-SMK
RA-SMK
ALARM
Set
LATCH
Reset
RST-BUT
Alarms and Shutdown
RA-T
MA-FLT-HL
OA-FLT-HL
Misc Points
OCC-SEN
ZN-T-SP
ZN-T-SP-UNOCC
ZN-T
ENA
PID
Cload
VAV-D-C
Pressure Dependent VAV Control
SF Control Function Block
RF Control Function Block
MA Control Function Block
(Optional) MinOA Damper Control Function Block
Time
Scheduling
SA-T
SA-T-SP
CC-V-C
SA Temperature Control

**NODE:** DDC-01
Node Address:
Neuron ID:

| Function | Name | Description | Setting | Unit | Range | Cfg | AI | AO | BI | BO | SNVTs: SNVT Name (Note 1) | SNVT_ Type | NVI/NVO Local | OWS / Server Points: GUI Display | M&C Trend | M&C OVR | OVR SNVT Name | Alarms: Condition | Priority | Routing Group | SNVT Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Safeties | SA-SMK | Supply Air Smoke | - | True/False | - | - | | | X | | | alarm | | | | | | TRUE | | | |
| | RA-SMK | Return Air Smoke | - | True/False | - | - | | | X | | | alarm | | | | | | TRUE | | | |
| | MA-T-LL | Mixed Air Temperature Low Limit Switch | 4 | Deg C | - | HW | | | X | | | alarm | | | | | | TRUE | | | |
| | SA-P-HL | Supply Air Pressure High Limit Switch | TBD | Pa | 0 - 1200 Pa | HW | | | X | | | alarm | | | | | | TRUE | | | |
| | RST-BUT | System Reset Button (for safeties) | - | True/False | - | - | | | X | | | | | | | X | | | | | |
| Filters | MA-FLT-HL | Mixed Air Filter Pressure High Limit Switch | ____ | Pa | - | HW | | | X | | | alarm | | | | | | TRUE | | | |
| | OA-FLT-HL | Outside Air Filter Pressure High Limit Switch | ____ | Pa | - | HW | | | X | | | alarm | | | | | | TRUE | | | |
| Start/Stop | SF-S | Supply Fan Status | - | On/Off | - | - | | | X | | | switch | | X | | | | | | | |
| | RF-S | Return Fan Status | - | On/Off | - | - | | | X | | | switch | | X | | | | | | | |
| | BLDG-T | Building Temperature (Night Stat) | - | Deg C | - | - | X | | | | | temp_p | | X | | | | (BLDG-T < BLDG-T-LL) | | | |
| | BLDG-T-LL | Building Temperature Low Limit | 13 | Deg C | - | CPT | | | | | | switch | | X | | X | | | | | |
| | OCC | Occupied Mode (Input from Scheduler) | - | | - | - | | | | | | switch | Input | X | | Note 3 | | | | | |
| | SYS-ENA | System Enable | - | On/Off | - | - | | | | | | | Output | X | | | | | | | |
| | FAN-C | Fan Command | - | On/Off | - | - | | | | X | | switch | | | | | | | | | |
| | FAN-FAIL | Fan Proof Failed | - | True/False | - | - | | | | | | alarm | | | | | | TRUE | | | |
| | FAN-ENA | Fan Enable | - | On/Off | - | - | | | | | | | | X | | | | | | | |
| Supply Air Temperature | SA-T | Supply Air Temperature | - | Deg C | - | - | X | | | | | temp_p | | X | X | | | ( [SA-T] – [SA-T-SP] > 3 degC ) and SYS-ENA | | | |
| | SA-T-SP | Supply Air Temperature Setpoint | 13 | Deg C | - | CPT | | | | | | temp_p | | X | | X | | | | | |
| | CC-V-C | Cooling Coil Valve Command | - | Percent | - | - | | X | | | | lev_percent | | X | | X | | | | | |
| Minimum Outside Air | MinOA-F | Min OA Flow | - | LPS | 0 - _____ LPS | - | X | | | | | flow | | X | X | | | | | | |
| | MinOA-F-SP | Min OA Flow Setpoint | TBD | LPS | - | CPT | | | | | | flow | | X | | X | | | | | |
| | MinOA-D-C | Min OA Damper Command | - | Percent | - | - | | X | | | | lev_percent | | X | | X | | | | | |
| Duct Static Pressure | SA-P | Supply Air Duct Static Pressure | - | Pa | 0 - 625 Pa | - | X | | | | | press_p | | X | X | | | | | | |
| | SA-P-SP | Supply Air Duct Static Pressure Setpoint | 250 | Pa | - | CPT | | | | | | press_p | | X | | X | | | | | |
| | SF-SPD-C | Supply Fan Speed Command | - | Percent | - | - | | X | | | | lev_percent | | X | | X | | | | | |
| Return Air Flow | SA-F | Supply Air Flow | - | LPS | 0 - _____ LPS | - | X | | | | | flow | | X | X | | | | | | |
| | RA-F | Return Air Flow | - | LPS | 0 - _____ LPS | - | X | | | | | flow | | X | X | | | | | | |
| | F-DIFF-SP | Flow Differential Setpoint | TBD | LPS | - | CPT | | | | | | flow | | X | | X | | | | | |
| | RF-SPD-C | Return Fan Speed Command | - | Percent | - | - | | X | | | | lev_percent | | X | | X | | | | | |
| Mixed Air Temperature and Economizer | OA-T | Outside Air Temperature | | | | | X | | | | | temp_p | | X | X | | | | | | |
| | ECO-EN-SP | Economizer Switchover Setpoint | 17 | Deg C | - | CPT | | | | | | | | X | | X | | | | | |
| | MA-T | Mixed Air Temperature | - | Deg C | - | - | X | | | | | temp_p | | X | X | | | MA-T < 4.5 degC | | | |
| | MA-T-SP | Mixed Air Temperature Setpoint | 12 | Deg C | - | CPT | | | | | | temp_p | | X | | X | | | | | |
| | ECO-EN | Economizer Enable | - | On/Off | - | - | | | | | | switch | | X | X | X | | | | | |
| | OA-D-C | Outside Air Damper Command | - | Percent | - | - | | X | | | | lev_percent | | X | | X | | | | | |
| | | **HARDWARE I/O POINT TOTAL** | | | | | 8 | 5 | 9 | 1 | | | | | | | | | | | |
| | | | | | | | **23** | | | | | | | | | | | | | | |

**NODE:** SCHD-01
Node Address: __________
Neuron ID: __________

| Function | Name | Description | Setting | Unit | Range | Cfg | AI | AO | BI | BO | SNVT Name | SNVT_ Type | NVI/NVO Local | GUI Display | M&C Trend | M&C OVR | OVR SNVT Name | Condition | Priority | Routing Group | SNVT Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scheduling** | OCC | Building Occupied Output | Table 1 | Enumeration | - | - | | | | | | switch | Output | | | X | | | | | |

**DEVICE/Location:** VAV-01 / Room: XXXX
Node Address: __________
Neuron ID: __________

| Function | Name | Description | Setting | Unit | Range | Cfg | AI | AO | BI | BO | SNVT Name | SNVT_ Type | NVI/NVO Local | GUI Display | M&C Trend | M&C OVR | OVR SNVT Name | Condition | Priority | Routing Group | SNVT Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pressure Independent VAV Box | ZN-T | Zone Temp from hardware sensor | - | Deg C | - | | X | | | | | | | X | X | | | | | | |
| | ZN-T-SP | ZN-T Setpoint | User adj. | Deg C | 20 - 25 degC | CPT | | | | | | | | X | | X | | | | | |
| | ZN-T-SP-UNOCC | ZN-T Setpoint for Unoccupied Mode | See 'Range' | Deg C | 20 heat / 25 cool | CPT | | | | | | | | X | | X | | | | | |
| | OCC | Occupied Mode Input from Scheduler | - | On/Off | - | | | | | | | | Input | X | | | | | | | |
| | OCC-SEN | Hardware Occupancy Override Sensor | - | On/Off | push button | | | | X | | | | Output (Note 4) | X | | | | | | | |
| | SYS-ENA | System Enable from AHU | - | On/Off | - | | | | | | | | Input | X | | | | | | | |
| | VAV-D-C | VAV Damper Command | - | Percent | - | | | X | | | | | | X | X | X | | | | | |
| | | **HARDWARE I/O POINT TOTAL** | | | | | 1 | 1 | 1 | 0 | | | | | | | | | | | |
| | | | | | | | **3** | | | | | | | | | | | | | | |

**DEVICE/Location:** VAV-XX / Room: YYYY
Node Address: __________
Neuron ID: __________

| Function | Name | Description | Setting | Unit | Range | Cfg | AI | AO | BI | BO | SNVT Name | SNVT_ Type | NVI/NVO Local | GUI Display | M&C Trend | M&C OVR | OVR SNVT Name | Condition | Priority | Routing Group | SNVT Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pressure Independent VAV Box | ZN-T | Zone Temp from hardware sensor | - | Deg C | - | | X | | | | | | | X | X | | | | | | |
| | ZN-T-SP | ZN-T Setpoint | User adj. | Deg C | 20 - 25 degC | CPT | | | | | | | | X | | X | | | | | |
| | ZN-T-SP-UNOCC | ZN-T Setpoint for Unoccupied Mode | See 'Range' | Deg C | 20 heat / 25 cool | CPT | | | | | | | | X | | X | | | | | |
| | OCC | Occupied Mode Input from Scheduler | - | On/Off | - | | | | | | | | Input | Note 2 | | | | | | | |
| | OCC-SEN | Hardware Occupancy Override Sensor | - | On/Off | push button | | | | X | | | | Output (Note 4) | X | | | | | | | |
| | SYS-ENA | System Enable from AHU | - | On/Off | - | | | | | | | | Input | Note 2 | | | | | | | |
| | VAV-D-C | VAV Damper Command | - | Percent | - | | | X | | | | | | X | X | X | | | | | |
| | | **HARDWARE I/O POINT TOTAL** | | | | | 1 | 1 | 1 | 0 | | | | | | | | | | | |
| | | | | | | | **3** | | | | | | | | | | | | | | |

**NOTES:**

General:
a) 15951 contractor shall define and configure all SNVTs as shown, including GUI OVR (Overrides)
b) 15951 is not responsible for OWS work, but shall provide SNVTs in support of OWS Server points interface as shown.
c) Contractor shall enter OA and MA filter pressure high limit switch loaded filter setpoint(s)
d) Contractor shall enter DEVICE identifier, node address, and Neuron ID.
e) Contractor shall organize the points schedule to show each node as a separate table

Note 1: 15951 contractor shall provide all SNVT Names as specified (for existing/future UMCS system integration)
Note 2: This SNVT is to be displayed at the OWS, but can be obtained from a device other than that shown.
Note 3: At AHU, the OCC override signal is from the individual VAV boxes and is used to command the AHU 'ON'
Note 4: This SNVT is to be bound to the OVR SNVT which overides the Occupied Mode

Reviewer Note: May need SNVT overide value column

**Legend:**
cfg: Configured via HW adjustment/setting or CPT
HW: Hardware
CPT: Controller configuration property/setting
OVR: Override (from OWS)
NVI: Network variable input
NVO: Network variable output
TBD: To be determined by designer

**Conversions:**
DegF = ( 9/5 x ____DegC ) + 32
iwc = ____Pa / 248.6
cfm = ____LPS / 0.47195
LPS = 1000 x ____m/s x ____metric duct cross sectional area = 1000 x ____m/s x ____m^2

# POINTS SCHEDULE

VAV WITH RETURN FAN AND MIN OA

16-Apr-03

# CHAPTER 6

# PROJECT IMPLEMETATION

## 6-1 COORDINATION

### 6-1.1 Coordination With Mechanical Designer.

- Air flow measurement requirements for VAV systems
- Indicate locations for control panels on M-plates
- Indicate thermostat/room sensor locations on M-plates
- Indicate locations for outdoor air temp sensor, static pressure sensor, etc. on M-plates
- Indicate location for air compressor and dryer on M-plates

### 6-1.2 Coordination With Electrical Designer.

- Provide power where required
    - Terminal units
    - Control panels
    - Air Compressor/Dryer

## 6-2 CONTRACT DOCUMENTS

1) RFP
2) Award contract
3) Contractor meeting
4) Design Review
5) Final design acceptance

## 6-3 NEW PROJECTS

### 6-3.1 Impact Of Other Design Disciplines On Control System Design.

Design of control systems is largely driven by decisions on the overall building mechanical and electrical design. Therefore, design of the control system must be incorporated into the overall design process to insure adequate consideration of the space requirements for the control system's mechanical and electrical support services. Early involvement of the control system designer in the project can help prevent unfortunate system design choices that could result in marginally controllable systems. The control system designer's involvement should start with the development of the design concept and continue throughout the design process. The control parameter criteria (temperature, humidity, pressurization, occupancy schedules, etc.) must be defined for all systems. These criteria are the starting point for the control system design. The controller setpoints are shown on the control system contract drawings and are based on the system design criteria. The setpoints are guidance for maintenance of the control system.

### 6-3.2 **Edit Standard Schematics To Make Project Specific.**

The standard control drawings, including the Control System Schematic, Points Schedule, and device schedules (such as for valves and dampers) require editing to reflect project specifics. Designations used should be coordinated with the Points Schedule. The intention of and description of each heading in the Points Schedule are located in Appendix B of this document. All elements of the Points Schedule need to be edited for the specific building systems. Some of the more significant items to be edited:

- Hardware (sensor and controller) designations
- Setpoints and Settings
- Device Ranges
- Standard Network Variable Type (SNVT) names
- Actuator symbol and signal line (pnuematic or electric)
- Addition or deletion of added or deleted sensors, actuators, controllers
- System name

### 6-3.3 **Add Delete Loops As Required.**

The standard schematics may not have all control loops required for project specific applications. Control loops required that are not on the standard schematic need to be added. Points need to be added to the Points Schedule to reflect these additions.

### 6-3.4 **Incorporate System Variations As Required.**

System variations also require changing sequence of operations.

### 6-3.5 **Umcs Interface.**

The building controls design will require details of interfacing to the UMCS. The hardware which facilitates communication between building controls and the UMCS network is the Building Point of Connection (BPOC) which is a ANSI-709.1 to IP based router as specified per UFGS-13801. All Standard Network Variable Types (SNVTS) which communicate with the UMCS for purposes other than ANSI-709.1and trending have to be identified and documented on the Points Schedule as SNVTs. The systems integrator uses the Point Schedules to bind various variables between building devices and UMCS devices (Binding refers to setting up the implicit communications relationships among various SNVTS).

### 6-3.6 **Device Location, Clearance And Access.**

The designer needs to show the locations of wall-mounted instruments, control panels and outside air sensors, transmitters, and sunshields on floor plan drawings. The designer must show the location of sensing elements and primary measuring devices on the system drawings. The control system designer must coordinate with the mechanical designer to show the sensing location of the duct static pressure sensor on the HVAC ductwork drawing for a VAV system. This requirement is intended to insure that design consideration is given to these details so that the sensing will be proper and accurate, and to provide for clearance and access for maintenance of the control system. The locations of thermometers and pressure gauges should be selected for normal visual access by personnel required to read them.

#### 6-3.6.1 **Control device clearance and access.**

Control system elements must not intrude upon the space required for mechanical and electrical system maintenance access. The control system design must be coordinated with the system design to provide ductwork access to install and service sensing elements and transmitters including access doors for permanently mounted devices such as air flow measurement stations and in-line fan inlet guide vanes.

#### 6-3.6.2 **Location of permanent instrumentation.**

The location of the permanent instrumentation thermometers, spare wells, and valved outlets for gauges in piping systems must be coordinated with the system design and must be shown on the system contract drawings. Sufficient access space must be provided in the ductwork downstream of each air flow measurement sensor and array, to allow for a traverse with a portable instrument for calibration purposes.

### 6-3.7 **Sequence Of Operation.**

Typical sequence of operations are contained in UFGS-15951. These have to be edited to conform to project specific requirements. They are then placed on the appropriate system schematic drawings.

### 6-3.8 **Testing Procedures.**

Commissioning is to be coordinated with UFGS-15995. These procedures have to address/include project specific commissioning requirements. Project specific Performance Verification Test Procedures and testing requirements should be added to the specification, particularly for special purpose and problematic controls based on designer and user experience. In addition to the traditional testing for functional perfomance, tests are required to ensure openess of the system. Understanding the need for many of these tests requires at least a basic understanding of the LonWorks technology. Some of the most important tests to be performed to confirm an open LonWorks system are:

- Use of SNVTs for variable communication
- The use of explicit messages allowed only on an exception basis
- Use of a LNS based network management tool for network configuration
- Availability to the UMCS of SNVTs for access to system variables

### 6-3.9 **Stand Alone Buildings.**

Buildings in which the intent is to operate independently of the UMCS require special considerations. The designer needs to decide what devices and tools to include which are normally part of the UMCS design. These include:

- LonWorks Network Configuration Tool

- Monitoring and Control Software
- Computer Workstations and Servers

## 6-4 RETROFIT PROJECTS

### 6-4.1 General Considerations.

When determining whether to retain or replace existing control systems (in whole or in part) in the retrofit of existing systems, the designer must evaluate the applicability of the design guidance provided in this manual. The reason for this evaluation is that deviation from this guidance may be necessary in certain circumstances to prevent adverse impacts on the operation and performance of the retrofitted systems.

### 6-4.2 Reuse Of Existing Control Devices.

Renovation and addition projects require extra engineering work in the form of a detailed field survey of existing control systems to determine if existing control devices can be reused for the project, and, if so, the extent to which they require modification. Devices that use standard 4-20 milliampere or 21-103 kPa (3-15 psig) signals are among those which possibly may be reused. Existing control system components which do not meet the current specification requirements might be of questionable quality and/or reliability. The contract drawings must show control devices that will be reused, replaced, modified, or removed.
Examples of control system situations that require such evaluation are as follows:

- Reuse of existing valves, where their sizes may affect the existing or new hydronic systems and their pump sizing.
- Reuse of existing dampers, where their sizes may affect the existing or new air handling systems and their fan sizing.
- Replacing three-way valves with two-way valves and vice versa and its effect on hydronic systems and their pump sizing.
- Partial retrofit, where only the final elements such as dampers, valves, and operators may be left in place.
- Retrofits involving economizer control loops.
- systems that may not match the systems shown or their variations

### 6-4.3 Conversion To An Open Systems Protocol.

When converting to an open systems protocol refer to UFC 811-12 for guidance.

# CHAPTER 7

# STANDARD HVAC CONTROL SYSTEMS

# APPENDIX A

# GLOSSARY

## 7-1 DEVICE ABBREVIATIONS

| Abbreviation | Description | Abbreviation | Description |
|---|---|---|---|
| CC-T | Cooling Coil Temperature | HX-V-C | Heat Exchanger Valve Command |
| CC-T-SP | Cooling Coil Setpoint | MA-P | Mixed Air (Static) Pressure |
| CC-V-C | Cooling Valve Command | MA-T | Mixed Air Temperature |
| CD-T | Cold Deck Temperature | MA-T-SP | Mixed Air Setpoint |
| CD-T-SP | Cold Deck Temperature Setpoint | MA-T-LL | Mixed air tempetature low limit (freeze stat) |
| CD-V-C | Cold Deck Valve Command | MA-T-LL-SP | Mixed air tempetature low limit (freeze stat) setpoint |
| CHW-P-C | Chilled Water Pump Speed Command | MA-T-LL-S | Mixed air tempetature low limit (freeze stat) status |
| CHW-P-S | Chilled Water Pump Status | MinOA-D-C | Minimum Outside Air Damper Command |
| CHW-P-SS | Chilled Water Pump Start/Stop | MINOA-F | Minimum Outside Air Flow |
| CWR-T | Condenser Water Return Temperature | MINOA-F-SP | Minimum Outside Air Flow Setpoint |
| CWS-T | Condenser Water Supply Temperature | OA-CO2 | Outdoor Air CO2 |
| DX-EN | DX Unit Enable | OA-D-C | Outdoor Air Damper Command |
| EA-D-C | Exhaust Air Damper Command | OA-D-S | Outdoor Air Damper Status |
| EA-D-S | Exhaust Air Damper Status | OA-F | Outside Air Flow |
| EA-F | Exhaust Air Flow | OAPH-T | Outdoor Air Preheat Temperature |
| ECO-EN | Economizer Enable | OAPH-T-SP | Outdoor Air Preheat Temp. Setpoint |
| ECO-EN | Economizer Enable | OAPH-V-C | Outdoor Air Preheat Valve Command |
| ECO-EN-SP | Economizer Enable Setpoint | OA-RH | Outdoor Air Relative Humidity |
| EF-S | Exhaust Fan Status | OA-T | Outdoor Air Temperature |
| EF-SS | Exhaust Fan Start/Stop | OA-T-SP | Outdoor Air Temp. Setpoint |
| GAS-V | Gas Valve Command | OA-T-WB | Outdoor Air Wet Bulb Temperature |
| HC-T | Heating Coil Temperature | OC-MODE | Occupied/Unoccupied Mode (= OCC, UNOC, NS) |
| HC-T-SP | Heating Coil Setpoint | PC-T | PreCooling Coil Temperature |
| HC-V-C | Heating Coil Valve Command | PC-T-SP | PreCooling Coil Setpoint |
| HD-T | Hot Deck Temperature | PC-V-C | PreCooling Coil Valve Command |
| HD-T-SP | Hot Deck Temperature Setpoint | PH-P-C | Preheat Pump Speed Command |
| HD-V | Hot Deck Valve Command | PH-P-S | Preheat Pump Status |
| HUM-EN | Humidifier Enable (or Isolation Valve) | PH-P-SS | Preheat Pump Stop/Start |
| HUM-SS | Humidfier Start/Stop (2-position valve) | PH-T | Preheat Coil Temperature |
| HUM-V-C | Humidifier Valve/Output Command | PH-T-SP | Preheat Coil Setpoint |
| HW-P-C | Hot Water Pump Speed Command | PH-V-C | Preheat Coil Valve Command |

| Abbreviation | Description | Abbreviation | Description |
|---|---|---|---|
| HW-P-S | Hot Water Pump Status | PHW-P-C | Primary Hot Water Pump Speed Command |
| PHW-P-S | Primary Hot Water Pump Status | SA-RH-SP | Supply Air RH Setpoint |
| PHW-P-SS | Primary Hot Water Pump Start/Stop | SA-P | Supply Air (Static) Pressure |
| RA-CO2 | Return Air CO2 | SA-P-SP | Supply Air (Static) Pressure Setpoint |
| RA-CO2-SP | Return Air CO2 Setpoint | SA-T | Supply Air Temperature |
| RA-D-C | Return Air Damper Command | SA-T-SP | Supply Air Temp Setpoint |
| RA-F | Return Air Flow | SD-C | Smoke Damper Command |
| RA-RH | Return Air Relative Humidity | SD-S | Smoke Damper Status |
| RA-RH-SP | Return Air Relative Humidity Setpoint | SF-C | Supply Fan Speed Command |
| RA-T | Return Air Temperature | SF-S | Supply Fan Status |
| RF-C | Return Fan Speed Command | SF-SS | Supply Fan Stop/Start |
| RF-S | Return Fan Status | SHW-P-C | Secondary Hot Water Pump Speed Command |
| RF-SS | Return Fan Start/Stop Command | SHW-P-S | Secondary Hot Water Pump Status |
| RH-T | Reheat Coil Temperature | SHW-P-SS | Secondary Hot Water Pump Start/Stop |
| RH-T-SP | Reheat Coil Setpoint | SYS-ENA | System Enable |
| RH-V-C | Reheat Coil Valve Command | SYS-FLOW | System Flow |
| RL-D-C | Relief Air Damper Command | VFD | Variable Frequency Drive |
| RL-D-S | Relief Air Damper Status | ZN-CO2 | Zone CO2 |
| RL-F | Relief Air Flow | ZN-CO2-SP | Zone CO2 Setpoint |
| SA-CO2 | Supply Air CO2 | ZN-RH | Zone Relative Humidity |
| SA-D-C | Supply Air Damper Command | ZN-RH-SP | Zone Relative Humidity Setpoint |
| SA-F | Supply Air Flow | ZN-T | Zone Temperature |
| SA-P-HL | Supply Air Pressure High Limit | ZN-T-SP | Zone Temp Setpoint |
| SA-RH | Supply Air Relative Humidity | | |

## 7-2 TERMS AND DEFINITIONS.

**10Base-T, 100Base-T, 100Base-FX** Ethernet media and communication speeds. The 10 or 100 refers to 10 Mbps or 100 Mbps, respectively. "T" is twisted pair wire, while FX is fiber optic cable. See IP networking chapter.

**ADC** Analog-to-digital converters transform analog values into digital signals that a microprocessor can use. DDC controllers with AIs have built-in ADCs to perform this conversion. ADC resolution is measured in bits, with an 8, 12, or 16 bit ADC being a low, middle, and high-end ADC, respectively.

**Architecture** A design referring to either hardware or software, or to a combination of both hardware and software.

**ASC** Application Specific Controller. A controller which has a built-in, fixed program to execute a sequence for a specific hardware system, e.g. a VAV box controller. ASC controllers cannot be used for different applications, but can be configured for the specific application. For example, a VAV box controller would have different configurations depending on whether the VAV box had a fan, reheat, a velocity pressure sensor, etc. ASC controllers have a fixed program ID.

**Closed** The opposite of Open. A standard/protocol/specification where important details of it's implementation are not available to all interested parties. Closed standards are closely controlled by the developing party and implementation of devices based on them is generally limited to a small number of vendors.

**Control network** A group of nodes that communicate to implement a "sense and control", control, or monitoring application.

**Device** A piece of hardware. See also 'Node'.

**DAC** Digital to Analog Converters transform digital signals from a microprocessor into analog values. DDC controllers with AIs have built-in DACs to perform this conversion.

**DDC** Direct Digital Control, defined as control consisting of microprocessor-based controls with the control logic performed by software

**DDE** Dynamic Data Exchange, an interprocess communication (IPC) system built into the Macintosh, Windows, and OS/2 operating systems. DDE enables two running applications to share the same data.

**DHCP** Dynamic Host Configuration Protocol is a protocol for automatically assigning IP configuration information to clients from a central server. See IP networking chapter.

**FMMP** Facility Management Master Plan: Details options to standardize the integration of control systems in all buildings. Provides road-map for future building designs and aids in the development of a migration plan for existing buildings (networks)

**FTP** File Transfer Protocol is a common protocol used on the Internet for sending files. See IT Networking chapter

**Gateway** A device (usually a combination of software and hardware) that connects networks using different communication protocols so that information can be passed from devices on one network to the other. Gateways perform protocol conversion to translate this information from one protocol to another.
See IT Networking chapter.

**GPPC** General Purpose Programmable Controller. A controller which can be programmed to run any (within hardware limits) sequence and can be set up as a controller for different hardware systems. Changes to the program result in a different Program ID.

**GUI** Graphical User Interface. A program interface that takes advantage of the computer's graphics capabilities to make the program easier to use. A true GUI includes formats for representing text and graphics.

**HMI** Human-Machine Interface: The means by which an operator interacts with an automation system, often a GUI.

**HTTP** HyperText Transfer Protocol, which is the underlying protocol used by the World Wide Web. HTTP defines how messages are formatted and transmitted, and what actions Web servers and browsers should take in response to various commands.

**Interoperability** The ability to integrate products from multiple vendors into flexible, functional systems without the need to develop custom hardware, software, or tools.

**Interoperable** This is closely related to open standards and refers to the level of difficulty of integrating components (or systems) from multiple vendors into a single system. Interoperability needs to be considered from the perspective of hardware installation (will the parts physically fit and interconnect), configuration and programming (is the same software tool used for different vendor components), maintainability (do the components have similar maintenance procedures and requirements), and operation (do the components have similar functionality/sequences and utilize the same operator interface). Open standards enhances/encourages interoperability because it allows multiple vendors to utilize a common standard. A caveat: In many (if not all cases), when vendors use the term interoperable, they do not mean *interchangeable* (in the sense of swapping out a VAV box for an identical VAV box).

**IP** Internet Protocol. IP is a key protocol on the Internet and is concerned with addressing and routing of data packets from their origin to the destination. Many other protocols are used in the Internet (TCP, HTTP, etc), but IP is the key protocol the others run on top of.
See IT networking chapter.

**LAN** Local Area Network, which is a network for transferring data between computers or other digital devices.
See IT networking chapter.

**LNS** LonWorks Network Service, which is the database architecture that resides on the computer attached to the LonWorks Network that is used to install and manage the Network. LNS is a 32-bit database that can be accessed by any LNS-based Network Manager and by multiple users simultaneously.

| | |
|---|---|
| **LON** | Local Operating Network |
| **LonTalk** | A networking protocol developed by Echelon Corporation and recognized by ANSI as ANSI-709.1-A. LonTalk implements layers 1-6 of the OSI reference model. See IP networking chapter. |
| **LonWorks** | A networking platform (created by Echelon Corporation) that provides solutions to numerous problems of designing, building, installing, and maintaining control networks. |
| **LonWorks Router** | A piece of equipment which allows ANSI/EIA-709.1-A communication and routing of network variables over a ANSI/EIA-709.1-A network. See "Router" |
| **LonWorks LON to IP Router** | A piece of equipment which allows ANSI-709.1 communication and routing of network variables over IP. Also known as an EIA 852 router. See "Router" |
| **Network** | A group of devices (computers, controllers, or other digital units) that are connected by communication facilities, such as twisted-pair cabling, coaxial cable, fiber-optic cable, or wireless means. See IP network chapter. |
| **Neuron C** | A derivative of the C programming language specifically designed for developing applications for the Neuron chip |
| **Neuron chip** | A chip which implements the ANSI-709.1 protocol. This chip is used by most LonWorks devices for communication on the network. Many LonWorks devices also use this chip for control functionality. |
| **Node** | A device (such as a computer or a controller) on a network that is capable of communicating with other network devices via a networking protocol such as ANSI-709.1. |
| **Open** | 'Openess' is a measure of how easily available is the standard/protocol/specification. . The specifications are readily available and can be used without charge by all parties. An example of a truly open standard is the Apache webserver. Open standards allow for multiple vendors to develop solutions based on these standards, which is a necessary condition for interoperability. Gray areas arise when licensing agreements or royalty payments are required, when the standard is based partially on proprietary information, or when the implementation of the standard is controlled by a limited number of vendors. |
| **Open system** | A system with characteristics that comply with specified, open, readily available standards and that therefore can be connected to other systems that comply with these same standards. |

| | |
|---|---|
| **OWS** | Operator Work Station, a type of computer-based GUI. An OWS is designed for use by an operator (a technician or maintenance worker might have a different computer and GUI with a different "look and feel"). |
| **Peer-to-Peer** | A type of network in which each node has equivalent capabilities and responsibilities. See IT networking chapter. |
| **Plug-in** | If the software used to configure an ASC can be run from within a network management tool (typically LonMaker for Windows) the software is known as a plug-in. There is also a standard XXX-860 for plug-ins |
| **POT** | Portable Operator Terminal. Governmentese for a laptop computer. |
| **Program ID** | All DDC controllers have a firmware-based program inside them that allows them to execute their function. For LON controllers, this program has a Program ID that is unique to that particular program. Changing the program results in a different Program ID. Program IDs may be used to ensure that 2 controllers have the same program. |
| **Proprietary** | Privately owned and controlled. Proprietary is the opposite of public domain. |
| **Proprietary – Government procurement** | In Government procurement regulations, a proprietary product is one that cannot be purchased from three different vendors. |
| **Router** | A device that connects two or more LANs. Routers are devices that provide network-independent packet filtering and forwarding. They may also include bridge functionality. See IT networking chapter. |
| **SCADA** | Supervisory, Control and Data Acquisition, a computer system for gathering and analyzing real-time data. |
| **SNMP** | Simple Network Management Protocol See IT networking chapter. |
| **SNVT** | Standard Network Variable Type, a LON standard for network variable declaration. Using SNVT variables helps ensure that the program is capable of communicating with other LON devices |

**SOAP** Simple Object Access Protocol: A lightweight protocol for exchange of information in a decentralized, distributed environment. It is an XML based protocol that consists of three parts: an envelope that defines a framework for describing what is in a message and how to process it, a set of encoding rules for expressing instances of application-defined datatypes, and a convention for representing remote procedure calls and responses.

**SQL** Structured query language, defined as a standardized query language for requesting information from a database. There is an ANSI standard for SQL.

**Standard, De-Facto** De-Facto standards are ‘standards of fact’, that is, standards that have been adopted by an industry or a market. An example of a de-facto standard is Microsoft Word. While it has not been adopted by a recognized standards organization, it's market dominance makes it the de-facto standard for word processing. Gray areas arise here over market share and industry recognition

**Standard, De-Jurie** De-Jurie standards (literally, ‘standards of law’) are those that have been adopted and approved by some recognized standards organization, such as ASHRAE, IEEE, ASTM, ISO, etc. ANSI-709.1is an example of a de-jurie standard. Gray areas can arise here over what constitutes a standards body.

**Standard, Proprietary** Proprietary standards are those that are owned and controlled by an organization not generally recognized as a 'legitimate' standards body (they are often owned by a for-profit organization). They frequently are considered to be, or to contain, intellectual property of value to the owning body. Proprietary standards may be open, closed, or somewhere in between, though they tend to be more closed. The Microsoft Word document format (.doc files) is an example of a closed proprietary standard.

**Transceiver** A device that enables hardware to communicate on the network. See IP networking chapter.

**WAN** Wide Area Network. A geographically widespread network, usually comprising of one or more LANs. WANs are often connected through public networks, leased lines, satellite, or microwave communications.

# APPENDIX B

## POINT SCHEDULE DESCRIPTION

### B-1 GENERAL

The Points Schedule will serve as a contract drawing with the initial entries (as described below) made by the designer. The UFGS-15951 contractor makes the bulk of the entries and submits it as a design drawing for government approval, then finalizes it as an as-built submittal. The as-built then is used as a contract drawing for use by the UFGS-13801 contractor. Schedule columns and entries are described below.

### B-2 FIELD DESCRIPTIONS

- **Device**: Designation for control hardware as shown on the system control diagram.
- **Node Address:** The Lon Network address of the node, which consists of three addresses: domain, subnet, and node ID. The UMCS contractor (using UFGS-13801) will provide (for each building) a domain address and range of subnet addresses. The node ID number will be assigned by the building-level (UFGS-15951) contractor.
- **Neuron ID:** A unique 48-bit ID permanently stored on the neuron chip.
- **Function:** Basic description of the function performed by this group of points.
- **Name:** Point name to be used at OWS for graphics, alarms, etc.
- **Description:** Summary description of the point.
- **Setting:** Shows designer selected setpoints and contractor-entered settings (such as loaded filter setpoints). Typical values are shown. The designer must select the TBD (To Be Determined) entries, based on the application. The 15951 contractor must show the loaded filter setpoints.
- **Unit:** Units of the Setting and Range. A range of Enum stands for Enumerated; which is a small set of possible values. For example, a status variable of type Enum might have one of the following values: ON, OFF, STANDBY, OCC, or UNOCC.
- **Range:** For sensors, the required range of the sensor (to meet the expected sensing range of the application). The designer edits this as required.
- **Cfg:** Configuration (Cfg) method for the point:
    - HW – Hardware adjustment / setting (such as a freezestat set point)

  - CPT – Configuration property / setting inside a controller or node. Ordinarily these will not change or be edited.

- **AI / AO / BI / BO:** Point type - Analog Input, Analog Output, Binary Input, Binary Output. These are all hardware points.

- **SNVT Name:** Name of the standard network variable type (SNVT) as assigned by the building level (UFGS-15951) contractor, for use by the UMCS (UFGS-13801) contractor.

- **SNVT Type:** SNVT type to be used per the LonMark standard.

- **NVI/NVO Local:** Building (15951) contractor shall bind these points on the local building network.

  - Input - Point will be bound on the network as a SNVT from another node

  - Output – Point will be bound on the network as a SNVT for use by another node.

- **GUI Display:** Point shall be an output SNVT from the node for use by the UMCS contractor. The building contractor must provide **SNVT Name** for the point. The UMCS contractor must set up polling of this point from the OWS using **SNVT Name** provided by the building contractor. The UMCS contractor must display this point on a system graphic. The graphic must use the **Name**, as shown, for the point.

- **M&C Trend:** Point shall be an output SNVT from the node for use by the UMCS contractor. The UMCS contractor must set-up the trend for this SNVT point.

- **M&C OVR:** The building contractor must define this SNVT point so as to provide the capability for the UMCS contractor to override this point via SNVT. UMCS contractor must provide override capability at OWS via point-and-click on UMCS system graphic display. Note: This column may also be used to show overrides affecting this SNVT which originate elsewhere in the system (example: an AHU OCC being overridden to ON by a VAV served by the AHU). This will be noted on the table.

- **OVR SNVT Name:** The SNVT name for **GUI OVR,** to be provided by building contractor to the UMCS contractor to implement override capability.

- **Alarm Condition:** This defines the condition(s) under which the point is in alarm. The building contractor must set up the local building controls to generate an alarm SNVT if the given condition(s) are true. This alarm SNVT must be named and made available to the UMCS contractor for an alarm report at the OWS. At the designer’s discretion, instead of generating an alarm at the building, the UMCS contractor may be required to generate an alarm based on the value of a SNVT being monitored at the OWS. This requires binding of this point to the OWS.

- **Alarm SNVT Name.:** This is the SNVT name assigned by the building contractor to the alarm SNVT. The building contractor provides this information so that the UMCS contractor can bind it to the OWS alarm handling and reporting software.

- **Alarm Priority**: This is the priority of the alarm, to be used in some unspecified manner.

- **Alarm Routing Group**: This is the routing group used for this alarm and describes where the alarm should be sent to, as defined in the Alarm Routing Group Table drawing.

## APPENDIX C

## CONTROL LOGIC DIAGRAM (CLD) DESCRIPTION

### C-1 INTRODUCTION

The control logic diagram is a graphical unambiguous description of the sequence of operation of the system. It is focused on the logic of the sequence, not on a particular hardware implementation.

For example, a typical sequence calls for a ‘fan status’ input (to be used in a fan-proof logic block). The actual hardware could be implemented in a variety of ways, -- a current-sensing-relay on the fan motor, a DP switch across the fan, or an airvane switch. Which piece of hardware is used is irrelevant to the CLD. All of these possible pieces of hardware are show as a simple binary input to the sequence. Controller hardware implementation is likewise not shown; while a given functional block is probably implemented in one controller, a build-up system (such as a RF VAV system with MA Economizer and Ventilation Demand control) may be in one or more controllers – the CLD does not make that distinction.

### C-2 FUNCTIONAL BLOCKS USED IN CONTROL LOGIC DIAGRAMS

In the following descriptions, logical values are always referred to as TRUE or FALSE. Synonyms for these names include ON and OFF, as well as 1 and 0.

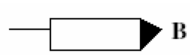
#### C-2.1 Analog Signal

This thick line represents an analog signal path within the logic. This line will be used on other blocks to show analog inputs and/or outputs

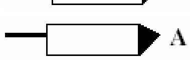
#### C-2.2 Binary Signal

This thin line represents a binary signal path within the logic. This line will be used on other blocks to show binary inputs and/or outputs.

#### C-2.3 Actuator Output



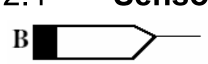
2-Position Actuator Output



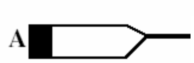
Modulating Actuator Output

This block represent a physical output from the system, an actuator or valve. It takes a binary or analog input and drives a piece of hardware. Since the CLD shows the control logic without reference to the hardware implementation, the actual hardware is unspecified.

#### C-2.4 Sensor Input



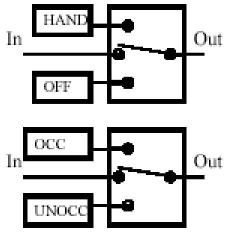
Binary Sensor Input



Analog Sensor Input

This block represents a hardware sensor input to the system. It may provide either an analog or binary signal. Again, the exact hardware type is unspecified.

C-2.5 **Hand-Off-Auto (H-O-A) Switch**




H-O-A Switch

This represents a HAND-OFF-AUTO switch. Sometimes, a H-O-A switch will be shown differently; for example where the position of the H-O-A switch would select some input to control logic. This block is generally used when the output of a control block is selected. The top block shows a normal H-O-A switch, the bottom shows a variant where the manually selected values are OCCUPIED or UNOCCUPIED.

C-2.6 **Constant Value**

 Binary Constant Value

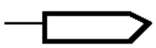
 Analog Constant Value

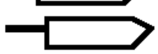
This logic block represents a constant value, either analog or binary

C-2.7 **Signal I/O**

 Binary Signal Input

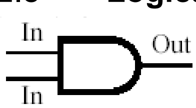
 Analog Signal Input

 Binary Signal Output

 Analog Signal Output

This block represents a named signal path within the logic. This is functionally identical to the **Analog Signal** or **Binary Signal** symbols described earlier, except that this signal is given a name, which allows it to be defined or used elsewhere in the logic.

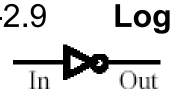
C-2.8 **Logical AND**




Logical AND Function

This logic block represents the logical AND function. It takes two or more binary inputs and produces a binary output. Its output is TRUE if and only if all of its inputs are TRUE. If any of its inputs are FALSE, then its output is FALSE.

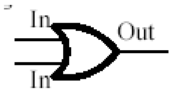
C-2.9 **Logical NOT**




Logical NOT Function

This logic block represents the logical NOT function. It has one binary input and one binary output. Its output is TRUE if and only if its input is FALSE. If its input is TRUE, its output is FALSE.

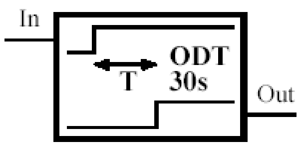
C-2.10 **Logical OR**




Logical OR Function

This logic block represents the logical OR function. It has two or more binary inputs and one binary output. Its output is TRUE if and only if any of the inputs are true. If all the inputs are FALSE, the output is FALSE.

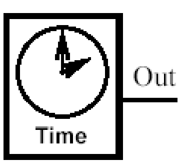
C-2.11 **On Delay Timer**




On Delay Timer

This logic block represents an On Delay Timer. It has one binary input and one binary output. In addition it has one parameter, a time (T) value. The output is always equal to the input, except when the input changes value from FALSE to TRUE. In this case, the transisition of the output from FALSE to TRUE is delayed by the value of the time parameter. This time value has no effect on the transistion from TRUE to FALSE, it only affects the output when the input becomes TRUE.

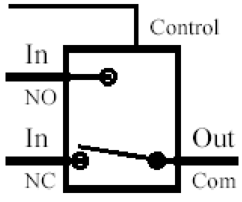
C-2.12 **Sequencer**




Sequencer

This block represents a sequencer, such as a scheduler or time clock. It provides one or more outputs. The outputs are typically binary values; however they may be enumerated values (sometimes incorrectly referred to as digital outputs), where the output may assume multiple discrete integer values (i.e. 0, 1, 2, 3, …, but not floating point values like 2.5). The output will not be an analog value.

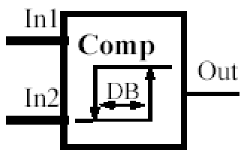
### C-2.13 **Switch**




Switch

This block represents an analog switch with 2 analog inputs, one analog output, and a binary control input. When the control input is false, the output is the value of the analog signal at the Normally Closed (NC) input. When the control input is true, the output is the value of the analog signal at the NO (Normally Open) input. Note that this convention for NC and NO follows the electrical switch convention; it is opposite from that used for pneumatic switches.

### C-2.14 **Comparator with Deadband**




Comparator with Deadband

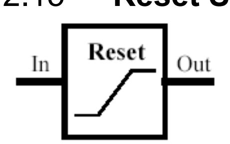
This logic block represents a comparator function with hysteresis. It takes two analog inputs and produces a binary output. It also has one parameter, deadband (DB). As shown in Table C-1 the output value only changes if the difference between the inputs exceeds half the deadband, if the difference in inputs is less than half the deadband, the output remains at its present value.

**Table C-1. Comparator Input and Corresponding Output**

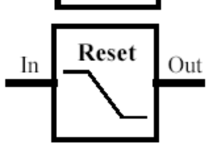
| Input Conditions | Output Value |
|---|---|
| (*In1–In2*) < -*deadband*/2 | FALSE |
| -*deadband*/2 ≤ (*In1–In2*) ≤ *deadband*/2 | Output does not change; remains fixed |
| (*In1–In2*) > -*deadband*/2 | TRUE |

For example, if *In1*=75, *In2*=68 and the *deadband*=4, the output would be TRUE. As *In1* fell, the output would remain TRUE until *In1* went below 66 (68–66=4/2). Essentially, the output of this block is TRUE if the top value is greater than the bottom value and FALSE if the bottom value is greater than the top value (neglecting the deadband).

### C-2.15 **Reset Schedule**



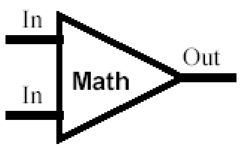

Reset Schedule
(output increases as input increases)




Reset Schedule
(output decreases as input increases)

This block represents a reset schedule. It has one analog input, one analog output, and 4 parameters: InputMin, InputMax, OutputMin, and OutputMax. For the first reset schedule shown, the output increases as the input increases; as the input ranges from InputMin to InputMax, the output varies linearly from OutputMin to OutputMax. Inputs below InputMin or above InputMax result in the output going to OutputMin or OutputMax, respectively. For the second reset schedule shown, the output decreases as the input increases. The reset schedule block can be thought of as a graph, with the input variable on the X-axis and the output variable on the Y-axis.

### C-2.16 **Math Function**



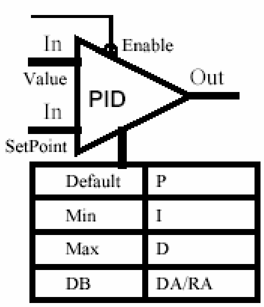

Math Function

This logic block represents a variety of mathematical functions. It takes two or more analog inputs and produces an analog output. Some common functions for this block are shown in Table C-2.

**Table C-2. Common Math Block Functions**

| Name | Function |
|---|---|
| Minus | Subtraction |
| Minimum | Select the minimum value from the input values |
| Maximum | Select the maximum value from the input values |

### C-2.17 **PID Loop with Enable**




PID Loop with Enable and Default Output

This function block represents a PID loop with an Enable input. It has 2 analog inputs (a value and a setpoint), an analog output, a binary ENABLE input, and several parameters as described in

**Table C-3. PID Block Parameters**

| Parameter | Description |
|---|---|
| Default | Value of output when Enable = FALSE |
| Min | Minimum value of output (generally 0%) |

| | |
|---|---|
| Max | Maximum value of output (generally 100%) |
| DB | Deadband that input must change by to affect output |
| P | Proportional Constant |
| I | Integral Constant |
| D | Derivative Constant |
| DA/RA | Direct Acting or Reverse Acting |

Astute readers will notice that we could also specify a RA loop by specifying a negative value for P. Instead, we will always make P > 0 and explicitly specify DA or RA. When ENABLE is FALSE, the PID loop will no long implement the PID algorithm and its output will assume its Default value. When ENABLE becomes TRUE, the PID loop will re-initialize the loop and resume control.

## C-2.18 **Override.**


Override Input

This block represents the ability to Override a signal value. This has the effect of assigning a different value to the signal for the duration of the override. After the override is released, the signal should return to its value as determined by the normal source of the signal. For example, a temperature sensor input (currently reading 68 degrees) may be overridden to 75 degrees. Any logic dependent on this signal would utilize the value of 75 degrees. When the override is released, the signal would assume the current temperature as sensed by the temperature sensor (which may no longer be 68 degrees). While this is typically done from the Operator WorkStation (OWS), it may be overridden from elsewhere; in that case the source of the override must be specified.

## C-2.19 **OWS Display:**

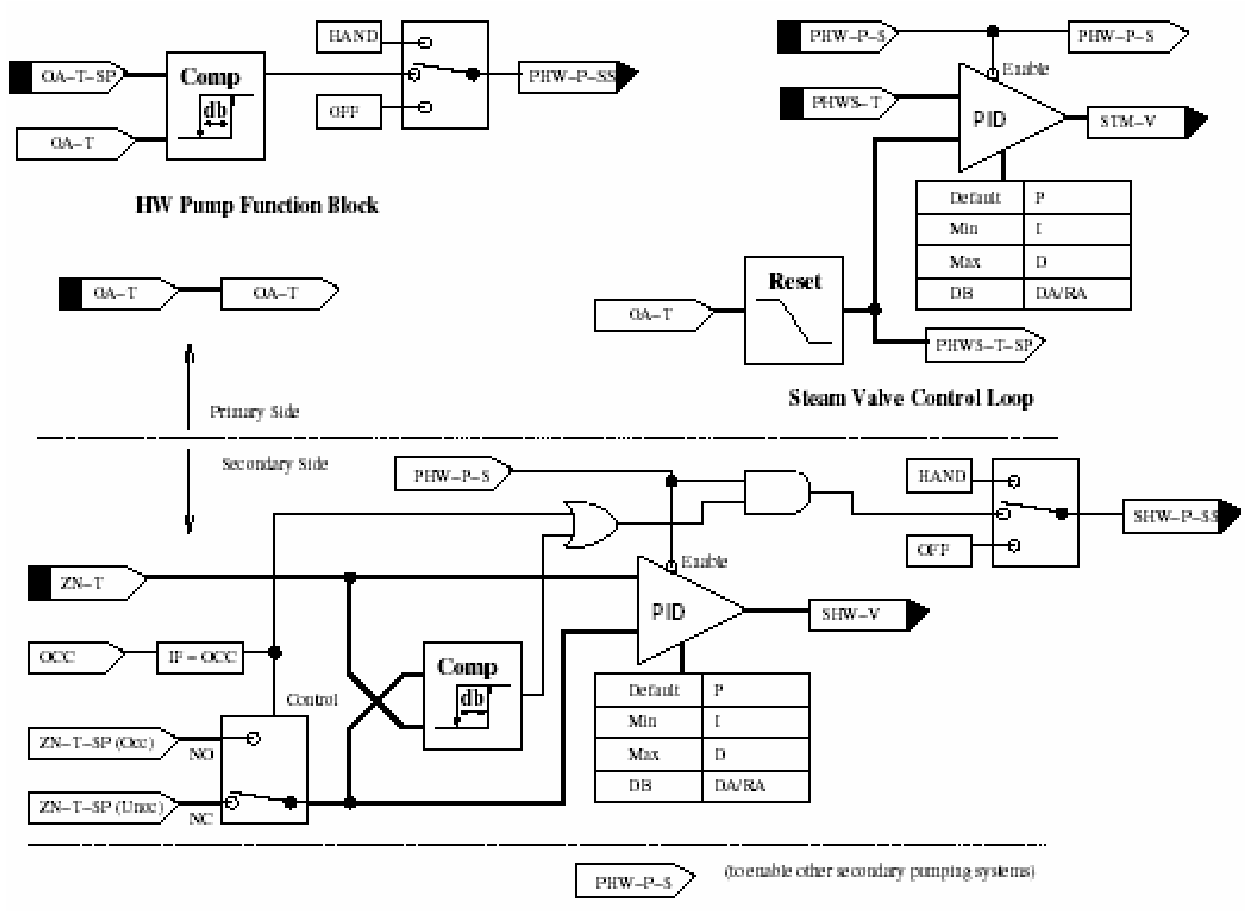

OWS Display

This block represents the ability to display a signal value at the Operator WorkStation (OWS).

## C-3 **EXAMPLE CONTROL LOGIC DIAGRAM**

To better illustrate the interpretation and use of control logic diagrams, this section explains a sample control logic diagram for Central Plant Hydronic with Steam/HW Converter shown in

**Figure C-2. Control Logic Diagram for Central Plant Hydronic with Steam/HW Converter**




Examining the logic diagram we see that there are 3 main functional blocks, a hot water (HW) pump function block and a steam valve control loop on the primary side and a secondary control system functional block.

## C-3.1 HW Pump Function Block

This block has one physical output, a Start/Stop signal to the Primary Hot Water Pump (PHW-P-SS). There may be other outputs from this block, signals that are available to other systems on the network. In addition, this block has 3 inputs:

- OA-T-SP: A hardware input; a Temperature SetPoint
- OA-T: A network input; Outdoor Air Temperature. OA-T is shown as a network input to the block. However, just below the block is a fragment which shows a hardware OA-T sensor which makes OA-T available on the network. This shows that the primary system must in fact have an OA-T sensor. This sensor could have been shown connecting directly to the this function block (see PHW-P-S in the steam valve control loop).
- A H-O-A switch on the output going to the PHW-P-SS

The OA-T and OA-T-SP signals feed a comparator with deadband. Assume that the deadband is set at 4 degrees and OA-T-SP = 64. Then, upon a drop in OA-T below 62 degrees the output of the comparator will be true. Upon a rise of OA-T above 66 degrees, the output of the comparator will be false. For OA-T between 62 and 66 degrees, the comparator will hold its current value.

The output of the comparator (ON when OA-T < 62, OFF when OA-T > 66) feeds the H-O-A switch. Note that there may be some hardware (a relay, for example) to interface the controller output to the H-O-A switch, since the H-O-A switch probably operates at 120 VAC. The output of the H-O-A switch controls the Primary Hot Water Pump.

### C-3.2 **Steam Valve Control Loop**

This block has three outputs:

- STM-V: A hardware signal; a modulating control signal to the STeaM Valve
- PHW-P-S: A network output; Status of the Primary Hot Water Pump
- PHWS-T-SP: The SetPoint for Primary Hot Water Supply Temperature

This block also has 3 inputs:

- PHW-P-S: A hardware input; a Status signal from the Primary Hot Water Pump
- PHWS-T: A hardware input; the Temperature of the Primary Hot Water Supply
- OA-T: A network input; the Outside Air Temperature.

The OA-T signal feeds a reset schedule for the Primary Hot Water Supply Temperature SetPoint (PHWS-T-SP). This setpoint decreases as OA-T increases. PHWS-T-SP and PHWS-T feed a PID loop, which modulates the STeaM Valve (STM-V) to maintain PHWS-T at PHWS-T-SP. If the Primary Hot Water Pump (PHW-P) is off, the Status (PHW-P-S) will be false and the PID loop will assume its default value, which should result in STM-V being closed.

### C-3.3 **Secondary Control System**

This control system has two outputs:

- SHW-V; a modulating hardware output to the Secondary Hot Water Valve
- SHW-P-SS; a hardware output; the Start/Stop signal to the Secondary Hot Water Pump (SHW-P)

In addition, there are 5 inputs:

- PHW-P-S; a network input indicating the Status of the Primary Hot Water Pump
- ZN-T; a hardware input from a ZoNe Temperature sensor
- OCC; a network input indicating OCCupancy status

- ZN-T-SP (Occ); a network input giving the ZoNe Temperature SetPoint for when the system mode is OCCupied

- ZN-T-SP (Unoc); a network input giving the ZoNe Temperature SetPoint for when the system mode is UNOCcupied

If the Primary Hot Water Pump is off, PHW-P-S will be false and SHW-V will be closed and SHW-P-SS will be off (unless overridden ON by the H-O-A switch). The Secondary Hot Water Pump (SHW-P) will be controlled by an H-O-A switch. The AUTO position will be ON if: PHWP-S is true and either the system is in OCCupied mode or the ZN-T is below ZN-T-SP (Unoc) (with a deadband)

The Secondary Hot Water Valve (SHW-V) is a modulating valve controlled by a PID loop which is enabled whenever PHW-P-S is true. When enabled, the PID loop will control SHW-V to maintain the ZoNe Temperature (ZN-T) at either the ZoNe Temperature OCCupied SetPoint (ZN-T-SP (Occ)) or the ZoNe Temperature UNOCcupied SetPoint (ZN-T-SP (Unoc)), depending on the value of the OCCupancy network input.

There may be additional secondary control systems, if so, the PHW-P-S signal will be available on the network for those systems.