

Logic One Sample Specification

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SECTION 17100 DIRECT DIGITAL CONTROL SYSTEM

PART 1 GENERAL

1.1 SCOPE

- A. Furnish and install a complete Direct Digital Control (DDC) Temperature Control System to automatically control the operation of the entire Heating, Ventilating and Air Conditioning System as indicated by contract drawings, specifications and I/O points list. Failure to mention any specific item or device does not relieve the Contractor of the responsibility for furnishing and installing such items or devices in order to comply with the intent of the Drawings and/or this Specification. DDC system shall be as listed in this specification Section 1.1.C.1.a.
- A. Provide and install a direct extension of the existing direct digital control (DDC) system. All existing DDC panels are to remain installed and functional, except as noted in other specification sections and/or on contract drawings. Additional devices as indicated on the I/O points list, shall be interconnected directly to existing and/or new DDC panels. All additional devices shall interconnect with existing communication networks. DDC system shall be as listed in this specification Section 1.1.C.1.a.
- B. Provide DDC system, including all peripherals of types, ratings, and performance with adequate capacity for processing the number of points as defined in the I/O points list. Comply with manufacturer's standard design, materials, and components. Construct in accordance with published product information, as required for complete installation, and as herein specified. Existing DDC equipment shall remain functional during integration period; disruption to building operation for a period of more than two hours is unacceptable.
- D. General Product Description:
 - 1. The DDC system (DDCS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.
 - 2. The building automation system shall consist of the following:
 - a. Stand-alone peer-to-peer Executive Modules
 - b. Stand-alone Universal Input/Output Controllers
 - c. Stand-alone Application Specific Controllers (ASC's)
 - d. Operator workstation(s)
 - 3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Executive Modules, Universal Input/Output Controllers, Application Specific Controllers and operator devices.
 - 4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each Executive Module shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The

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failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

5. Executive Modules shall be able to access any data from, or send alarm reports directly to, any other Executive Module or combination of modules on the network without dependence upon a central processing device. Executive Modules shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

PART 2 PRODUCTS

2.1 NETWORKING COMMUNICATIONS.

- A. The design of the DDC network shall provide for integration of operator workstations and stand-alone Executive Modules on a peer-to-peer communications network, and other devices on other networks. The network architecture shall consist of the following four levels:
 1. Wide Area Ethernet communications network based on TCP/IP protocol
 2. An auto-dial/auto-answer telecommunications network
 3. A building-wide peer-to-peer (Novar LAN) communications network between Executive Modules
 4. Many local area networks extended from appropriate Executive Modules to associated Universal Input/Output Controllers and associated Application Specific Controllers.
- B. Access to system data shall not be restricted by the hardware configuration of the building automation system. The hardware configuration of the DDC network shall be totally transparent to the user when accessing data or developing control programs.
- C. Ethernet Communications Network:
 1. Each Executive Module shall have an internal, integral interface to 10/100 BT Ethernet provided by the DDC manufacturer, to remotely monitor, control, alarm, and program sequences of any and all building-wide points over the Ethernet network. Note: No external Ethernet devices shall be acceptable.
 2. Executive Modules shall automatically report alarms or other significant events to work stations.
 - a. An operator shall be able to access remote buildings by selection of any facility by its logical name. The workstation dial-up program shall store the phone numbers of each remote site, so the user shall not be required to remember or manually dial telephone numbers.
 - b. A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial Executive Modules or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity, nor shall network activity keep the workstation from handling incoming calls.
- D. Auto-dial/Auto-answer Telecommunication Network:
 1. Communications shall make use of Hayes compatible modems and voice-grade telephone lines. Provide modems rated at 56k baud with auto ranging. System access shall be provided through phone lines to the existing Front End Computer. Cost and coordination of any phone line installation is the responsibility of the owner.
 2. Auto-dial/auto-answer communications shall be provided to allow Executive Modules to communicate with remote operator stations and/or remote terminals on an intermittent basis via telephone lines, as indicated in the sequence of operations. This will be accomplished via

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built-in 56K auto baud modem provided by the DDC manufacturer. No external devices shall be acceptable.

3. Auto-dial Executive Modules shall automatically place calls to workstations to report alarms or other significant events.
 - a. Executive Modules shall be able to store a minimum of 24 phone numbers of at least 20 digits. Retry a single primary number at a fixed interval until successful.
 - b. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers.
4. Operators at dial-up workstations shall be able to perform all control functions, all report functions and all database generation and modification functions as described for workstations connected via the network. Routines shall be provided to automatically answer calls from remote Executive Modules. The fact that communications are taking place with remote Executive Modules over telephone lines shall be completely transparent to an operator.
 - a. A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial Executive Modules or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity, nor shall network activity keep the workstation from handling incoming calls.

E. Building-wide Peer-to-Peer Communications Network:

1. Operator workstations and Executive Modules shall directly reside on a network such that communications may be executed directly between Executive Modules and workstations on a peer-to-peer basis, without requirement for any device to operate or manage the network. A portion of the network management is built into each of the 'peer-to-peer' members. 'Peer-to-peer' refers to controllers that (when interconnected) will act independently as equals, without a network manager, and will communicate in a token passing protocol with each other to pass data packet information for the purpose of building-wide monitoring and control. Any peer-to-peer device on this network can request data from, or send data to, any other device on the network.
2. All operator devices either resident on the peer-to-peer network, or connected via dial-up modems shall have the ability to access all point status and application report data via the peer-to-peer network. Access to data shall be based upon logical identification of building equipment.
3. Network design shall include the following provisions:
 - a. System performance shall insure that an alarm occurring at any DDC Controller is displayed at local and remote workstations and/or alarm printers within 5 minutes.
 - b. Support of any combination of Executive Modules and operator workstations directly connected to the peer-to-peer network. A minimum of 256 devices shall be supported on a single network.
 - c. Message and alarm buffering to prevent information from being lost.
 - d. Error detection, correction and retransmission shall be included to guarantee data integrity.
 - e. Synchronization of real-time clocks, to include automatic daylight savings time updating between all Executive Modules shall be provided.

F. Controller Local Area Network:

1. This communications network shall be limited to Universal Input/Output Controllers and Application Specific Controllers, and shall communicate bi-directionally with the Executive Module. Executive Modules shall support up to 4 separate Controller LAN's.
2. Universal Input/Output Controllers and Application Specific Controllers shall be arranged on the LAN's in a functional relationship to the corresponding Executive Modules. For example, a VAV Application Specific Controller serving a VAV terminal box shall be connected on a LAN from the Executive Module that is controlling the corresponding air handling unit.
3. A maximum of 32 Universal Input/Output Controllers and Application Specific Controllers may be configured on any individual LAN from any Executive Module to insure adequate global data and alarm response times.

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2.2 EXECUTIVE MODULE

- A. Executive Modules shall have a minimum 80486 microprocessor or equivalent. They shall be multi-tasking, multi-user, real-time digital control processors. Controller size shall be sufficient to fully meet the requirements of this specification. Executive Modules shall be capable of operating in environmental conditions of 32' to 140°F (0' to 60°C) at a relative humidity of 0-95% non-condensing. They shall be of two-piece design to allow wiring of terminals without the electronics being present. This design shall also allow replacement of the operational electronics without the need to unwire any connection on the controller. Products which require rewiring for electronic replacement will not be considered.
- B. Each Executive Module shall have a minimum of 16 megabyte RAM and 8 megabyte flash RAM. Memory shall be upgradeable as required to support its own operating system and databases, including:
1. Control processes
 2. Energy management applications
 3. Alarm management applications for each point in the system.
 4. Historical/trend data for points specified
 5. Maintenance support applications
 6. Custom processes
 7. Operator I/O.
 8. Dial-up communications
 9. Manual override monitoring
- C. Executive Modules shall provide the minimum of the following integral communications options, provided by the DDC manufacturer, without the need for external devices. The connection of external third party devices will not be acceptable.
1. One RS-232C serial data communication port for operation of operator I/O devices such as laptop portable operator's terminals. Executive Modules shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
 2. A standard or optional RJ-11 jack for connection to the optional internal 56K auto baud modem to be used as a dial-up access port for monitoring, program changes, automatic transfer of alarms and historical data. It shall also be used for automatic dial out of alarms to remote workstations.
 3. One RJ-45 Ethernet port to be connected to the peer-to-peer Ethernet network.
 4. Up to four RS-485 ports to be used as a LAN to Universal Input/Output Controllers and Application Specific Controllers. Each communication port shall support up to 32 of these controllers.
 5. The Executive Module shall have an optional internal touch screen which will allow the operator to query, troubleshoot and modify set points and schedules within the system without using one of the before mentioned communications ports. Other similar remote touch screens shall be connected to the Ethernet LAN as required on the drawings as convenient query stations.
- D. Each Executive Module shall support up to 128 Universal Input/Output Controllers, Application Specific Controllers, 128 inputs or 128 outputs.
- E. Each Executive Module shall be capable of providing connection for inputs and outputs, which are global information used by all controllers on its LAN, and these shall not count toward the maximum allowable inputs and outputs on the system. These include:
1. Outside Air Temperature
 2. Outside Light Level
 3. Electrical Demand Pulse Input
 4. Phase Loss Input

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5. Emergency Status Input
 6. System Fault Output
- F. Each Executive Module shall continuously perform self-diagnostics, communication diagnostics and diagnostics of all connected Universal Input/Output Controllers and Application Specific Controllers. The Executive Module shall provide both local and remote annunciation of any detected problems.
- G. In the event of the loss of normal power, there shall be an orderly shutdown of all Executive Modules to prevent the loss of database or operating system software. Programs shall be protected by storage in Flash RAM. There shall also be a backup power source sufficient capacity to call out and report the power loss situation to the assigned operator workstations.
1. Upon restoration of normal power, the Executive Module shall automatically resume full operation without manual intervention. Controllers which require manual intervention to resume normal control shall not be acceptable.
 2. Should Executive Module memory be lost for any reason, the user shall have the capability of reloading the Executive Module via the local RS-232C port, via telephone line dial-in or from an ethernet network workstation PC.
- H. All points associated with a given mechanical system (i.e., an air handling unit) will be controlled from a single Executive Module. No points from a given mechanical system may be distributed among Executive Modules.
- I. Approved products for Executive Modules on peer-to-peer networks are as follows:
1. Novar Controls Corporation, Lingo
 2. Novar Controls Corporation, Savvy
 3. Novar Controls Envoi

2.3 EXECUTIVE MODULE SOFTWARE FEATURES

- A. General:
1. All necessary software to form a complete operating system as described in this specification shall be provided. Normal software programming shall be English language, menu driven without requirement to learn any type of programming language.
 2. The software program database specified in this section shall be provided as an integral part of Executive Modules and shall not be dependent upon any higher level computer for execution.
 3. The system shall provide protection against excessive demand situations during start-up periods by introducing time delays between successive start commands to heavy electrical loads.
 4. Upon the resumption of normal power, each Executive Module shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.
 5. Point naming convention shall be as referenced in Appendix A.
- B. Control Software Description:

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1. The Executive Module, along with its group of distributed direct digital control modules shall have the ability to perform any or all of the following pre-tested closed loop control algorithms by selecting it from a menu. Systems that require algorithms to be built by the user are not acceptable.
 - a. On/Off Control: two-position control in which the device is either on or off with no intermediate operating positions.
 - b. Proportional (P) Control: control method in which the final control element moves to a position proportional to the deviation of the value of the controlled variable from the setpoint.
 - c. Proportional-integral (PI) Control: control method that combines proportional response and integral (reset) response, to correct for the offset resulting from proportional control.
 - d. Proportional-integral-derivative (PID) Control: control method that enhances PI control by adding a component that is proportional to the rate of change (derivative) of the deviation of the controlled variable. Compensates for system dynamics and allows faster control response.
 - e. Floating (Tri-state) Control: control method comprising a SPDT controller with a center-off position. On a change in the controlled variable, one contact closes driving the controlled device to an intermediate position, then opens the circuit causing the device to remain in this position until a further change. One contact closes driving the controlled device in one direction and reverses the controlled device action when the other contact closes.
 - f. Reset Control: control method of adjusting the control point of a given controller to compensate for changes in a second measured variable.
- C. All programs shall be executed automatically without the need for operator intervention. Programs shall be applied to building equipment as described in the Sequence of Operations. Executive Modules and their family of distributed direct digital control modules shall have the ability to perform any or all of the following supervisory energy management routines:
 1. Equipment Scheduling:
 - a. Scheduling of up to 48 discrete schedules with definable calendar dates and the capability of shifting to alternate calendar periods automatically.
 - b. Scheduling shall be activated by time of day/day of week, input or output state, or other scheduled states.
 - c. Scheduling for time of day/day of week schedules shall have multiple on/off time pairs, include 7 days per week, and temporary schedule for Today/Tomorrow time pairs which will automatically revert to original schedule upon expiration.
 - d. Scheduling shall allow for definable timed override periods of up to 4 consecutive hours.
 - e. Shifted Schedules: As opposed to entering the discrete time of day for schedule entries, the user shall have the option of entering a "shift" value in hours and/or minutes. The shift shall be with respect to a "master" schedule. This will allow the ability to change the master schedule only, and all shifted schedules will automatically shift their on/off times according to the new master schedule.

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2. Holiday Scheduling:
 - a. Scheduling shall allow for up to 16 definable holiday periods.
 - b. Holidays shall be programmable for up to 99 consecutive days and allow for automatic repetition of holidays that occur on the same calendar date from year to year.
3. Start/Stop Optimization:
 - a. OSS shall be capable of learning building thermal characteristics and respond to variable conditions.
 - b. OSS shall start controlled equipment as late as possible prior to occupied time and as early as possible prior to unoccupied time.
 - c. OSS shall be calculated based on outdoor temperature, zone temperature, and control setpoint/setback parameters. OSS calculations shall be updated daily and shall support calculations for 48 discrete time of day/day of week schedules.
4. Setpoint/Setback Optimization:
 - a. Setpoint/setback control shall modify zone temperature setpoints during unoccupied hours, reducing the heating/cooling load.
 - b. Timed override for each setpoint control shall permit unoccupied hours adjustments without operator involvement.
5. Enthalpy Optimization:
 - a. Enthalpy optimization shall be accomplished by measuring the temperature and humidity of two individual air streams then calculating and comparing the total heat content of the air from each source.
 - b. Enthalpy optimization control parameters shall be definable including inputs, sequences, limits, schedules and control differentials. The calculations shall be converted to BTU/LB.
6. Demand Limit Control:
 - a. Demand limit control shall monitor up to 4 individual demand meters or watt transducers with different KWH/pulse multipliers and integrate load shedding based upon energy usage over a 15 minute or 30 minute sliding demand window.
 - b. Demand peaks shall be limited by switching loads on/off or by adjusting control setpoints in order to prevent exceeding the on-peak and off-peak setpoint limit. Control shall be based upon 30-second integration of demand, rate of increase or decrease, and historic effects of load shedding.
 - c. Demand peaks shall have definable targets and dates for each individual month. Demand targets shall have time of day adjustments for off-peak times.

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- d. Load shedding and restoration shall be programmable of up to 128 steps in sequential "first off/first on" order.
7. Duty Cycle Control:
 - a. Duty cycle control shall cycle applicable equipment by shedding and restoring loads on a cyclic basis in order to reduce total run time. Cycle on/off intervals shall be definable.
 - b. Duty cycle control shall integrate demand limit programming in order for equipment operating under a duty cycle to be restored following a demand initiated shed period to the beginning of its on cycle to stage start cycle patterns.
 8. Temperature Reset Control:
 - a. Control setpoints shall be capable of automatic setpoint calculations with definable linear proportional reset functions.
 - b. Control variable inputs shall be from a single or multiple input and the calculated variable shall be definable as highest, lowest, or average for the inputs.
 - c. Reset schedule shall be capable of being shifted automatically for occupied or unoccupied time periods.
 9. Lead/Lag Control:
 - a. Lead/Lag control shall automatically determine the sequence of operation for up to 4 primary equipment loads.
 - b. Lead/Lag sequence shall be determined by accumulated run hours based on definable intervals.
 10. Sequence Events:
 - a. Sequence events shall be any digital data points, actual data variable, or analog limit, which can initiate a sequence of events, based on definable occurrences.
 - b. Sequence events shall be capable of resetting a value or change variable as conditions change.
 11. Zero Energy Band:
 - a. Zero Energy Band shall be implemented allowing temperatures to float between selected settings, preventing the consumption of heating or cooling energy while the temperature is within this range.
- D. In addition to all of the above functions, Executive Modules shall also be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
1. It shall be possible to use any of the following in a custom process:
 - a. Any system measured point data or status
 - b. Any calculated data

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- c. Any results from other processes
 - d. User-defined constants
 - e. Arithmetic functions (+, -, *, /, square root, absolute values, etc.)
 - f. Boolean logic operators (and, or, not, etc.)
 - g. Basic program parameters (if, then, else, etc.)
2. Custom processes may be triggered based on any combination of the following:
 - a. Time interval
 - b. Time-of-day
 - c. Date
 - d. Other processes
 - e. Events (e.g., point alarms).
 3. A single process shall be able to incorporate measured or calculated data from any and all other Executive Modules on the network. In addition, a single process shall be able to issue commands to points in any and all other Executive Modules on the network.
 4. The custom control programming feature shall be documented via English language descriptors. These descriptors (comment lines) shall be viewable from local operator workstation devices to facilitate troubleshooting.
- E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Executive Module shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the Executive Modules ability to report alarms be affected by either operator activity at a PC workstation, local I/O device or communications with other panels on the network.
1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of ten priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, Executive Module, pager, etc.) to provide full flexibility in defining the handling of system alarms.
 3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs.
 4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

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- a. Alarms shall have ability to be acknowledged from the local operator I/O device, and once the problem is resolved, automatically clear from the alarm buffer.
- F. Historical Data Logs: A variety of historical data collection utilities shall be provided to manually or automatically sample, store, display and transfer system data for points as specified in the I/O summary.
- 1. Executive Modules shall store point history data for selected analog and digital inputs and outputs:
 - a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Executive Modules point group. Sample intervals of six seconds to twenty-four hours shall be provided. Each Executive Module shall have the capability of having a minimum of 48 different trend logs, each with up to 8 different definable data points, and a minimum of 256 samples per point. Each Executive Module shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 98,000 data samples.
 - b. Trend data shall be stored at the Executive Modules and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, or manual command. All trend data shall be available for use in standard 3rd party personal computer applications such as Excel, Access or SQL. File format type to be comma delineated ascii, or SQL.
- G. Executive Modules shall automatically accumulate and store run-time hours for digital output points as specified in the point I/O summary.
- 1. The totalization routine shall have a sampling resolution of hours, and tenths of an hour.
 - 2. The user shall have the ability to define a limit for run-time totalization. When the limit is reached, a maintenance notification alarm will be generated. The maintenance alarm shall have the ability to have a 256 character maintenance instruction printed automatically.

2.4 UNIVERSAL INPUT/OUTPUT CONTROLLERS:

- A. General:
- 1. Each Universal Input/Output Controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. Each Universal Input/Output Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Failure of Executive Modules, DDC modules or operator's workstation shall not interrupt the operation of module local control functions. Module shall utilize distributed processing communications network. Executive Modules shall automatically download module local control programs without operator involvement.
 - 2. Universal Input/Output Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden.
 - 3. All programs shall be field-customized to meet the user's exact control strategy requirements.

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- B. Design:
1. Module microprocessor and memory:
 - a. 80188 Control processor; 128Kb RAM, 128Kb ROM
 2. EEPROM programming and real time clock battery backup:
 - a. Each Universal Input/Output Controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event that communication with its Executive Module is lost and to insure protection during power outages. Memory shall be maintained for a minimum of 90 days
 - b. Universal Input/Output Controllers that lose control due to loss of communication with Executive Modules are not acceptable.
 3. Operating environment:
 - a. 32 to 140 °F (0 to 60 °C), 0 to 95 %RH, non-condensing
 4. Two-part construction:
 - a. Removable electronics
 - b. Separate backplate that contains wiring termination points.
 5. Module Network communications:
 - a. EIA Standard RS-485 9600bps, serial, two-wire differential, low parity bus using cyclic redundancy checking (CRC) for error detection.
 - b. RS-485 Local expansion network capable of adding up to 24 additional inputs or outputs for on/off control or monitoring inputs.
 6. Input/Output points:
 - a. Module shall contain integral surge suppression for all inputs and outputs to prevent transient voltage introduction.
 - b. 8 input and outputs, definable as analog or digital:
 1. Digital Inputs - 24VDC 30mA dry contact closure
 2. Analog Inputs - 24VDC 4-20mA, loop powered
 3. Digital Outputs - 24VAC 2A, pilot duty, N.O. or N.C.
 4. Analog Outputs – a variety of analog outputs can be provided via output transducers that convert the output pulse variation 0.59 sec. to 2.93 sec. Into a variety of output signals including 4-20 milliamp, 0-10 volt, 2-10 volt, tri-state, pneumatic, and more.
 5. Each output shall contain an integral ON/OFF/AUTO switch.

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- c. A total of 32 additional inputs and/or outputs may be added per Universal Input/Output Controller via expansion modules on its separate submodule network.
- 7. Peripherals:
 - a. Integral Keypad/Display:
 - 1. Lighted LCD 20 character x 2 line
 - 2. Displays input/output status reading, including local expansion network data.
- 8. Approved products for Universal Input/Output Controllers are:
 - a. Novar Controls Corporation (IOM/2)

2.5 APPLICATION SPECIFIC CONTROLLERS (ASC's)

- A. General:
 - 1. Each Application Specific Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Application Specific Controller shall be a microprocessor-based, multi-tasking, digital control processor. Module shall utilize distributed processing communications network. Provide the following minimum types of Application Specific Controller:
 - a. VAV and VVT Terminal Box Controllers
 - b. Fan Coil Unit Controllers
 - c. Unit Ventilator Controllers
 - d. DX HVAC Unit Controllers
 - e. Heat Pump Controllers
 - 2. Modules shall be fault tolerant and capable of stand-alone operation of local control functions. Failure of the Executive DDC Panel, DDC modules or operator's workstation shall not interrupt the operation of control module's local control functions. Analog outputs shall be industry standard signals such as 24V floating control, 0-10VDC or 4-20mA allowing for interface to a variety of modulating actuators. Module shall contain integral surge suppression for all inputs and outputs to prevent transient voltage introduction.
 - 3. Executive DDC panel shall automatically download module local control parameters without operator involvement. After the initial download, each controller shall perform its primary control function independent of Executive Module LAN communication. The controller shall receive its real-time data from the Executive Module time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) values for all applications. Application Specific Controllers shall incorporate self-tuning control loops to learn the thermal characteristics, and adjust operation to improve control. Application Specific Controllers without this capability will not be considered.

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4. Application Specific Controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.

B VAV and VVT Terminal Box Controllers:

1. A single Terminal Box Controller product model shall be software selectable as to provide for control of each piece of building HVAC equipment, including, but not limited to, the following pressure independent applications:
 - a. Variable Air Volume (VAV) terminal boxes
 1. VAV, cooling only
 2. VAV, with hot water reheat
 3. VAV, with electric reheat
 4. VAV, fan-powered
 5. VAV, fan-powered, with hot water reheat
 6. VAV, fan-powered, with electric reheat
 - b. Constant Air Volume (CAV) terminal boxes
 1. CAV, cooling only
 2. CAV, with hot water reheat
 3. CAV, with electric reheat
 - c. Dual Duct (DD) terminal boxes
 1. DD - Constant Volume - Cold Duct & Hot Duct Outlets.
 2. DD - Variable Air Volume - Cold Duct & Hot Duct Outlets.
 - d. Variable Volume and Temperature (VVT) terminal boxes
2. Design:
 - a. Two-part construction:
 1. Integral electronics and mounting plate
 2. Removable wiring terminals
 - b. Network communications:
 1. EIA Standard RS-485 9600bps, serial, two-wire differential, low parity bus using cyclic redundancy checking (CRC) for error detection.
 2. Network communication maximum cable lengths of 8,000 feet.
 - c. Module microprocessor and memory:

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1. 80C51 microprocessor; 2Kb RAM, 32Kb ROM
2. Fail safe program setpoint stored in non-volatile PROM
- d. Operating environment 32 to 158 °F (0 to 70 °C), 0 to 99 %RH, non-condensing
- e. Inputs:
 1. Space Temperature
 2. Supply Air Temperature
 3. Override Input
 4. Setpoint Adjust
- f. Outputs:
 1. Fan
 2. Cooling Damper
 3. Heating Damper, Heating Valve or Staged Reheat
3. The Terminal Box Controller shall be powered from a 24 VAC source. The DDC Contractor shall provide a separate isolation transformer for each controller or group of Terminal Box Controllers. Each controller shall be manufactured with an integral cover to protect the intelligence board assembly.
4. The Terminal Box Controller shall include an integral differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the velocity pressure in the duct. The controller shall convert this value to actual airflow in cfm. The cfm setpoints shall have a range of 1-7905 CFM and measurement accuracy of $\pm 5\%$.
5. The Terminal Box Controller shall include provisions for calibration using a standard airflow hood by the Independent Test and Balance Contractor.
6. The Terminal Box Controller shall interface to a matching room temperature sensor. The controller shall function to maintain space temperature to within $\pm 0.5^\circ\text{F}$ ($.3^\circ\text{C}$) of setpoint at the room sensor location.
7. The Terminal Box Controller performing space heating control shall be software selectable, allowing for modulation of a hot water reheat valve, or cycling up to two (2) stages of electric reheat, as required to satisfy space heating requirements.
8. The Terminal Box Controller shall as a minimum incorporate on its menu of software settings and setpoints the following to maximize flexibility, and minimize energy consumption. Systems that require knowledge of any type of programming language are not acceptable:
 - a. Separate heating and cooling temperature setpoints for both occupied and unoccupied periods.
 - b. Separate heating and cooling maximum and minimum CFM setpoints for both occupied and unoccupied periods.

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- c. Capability on fan-powered boxes to select whether to operate the fan continuously, or on a call for heat.
- d. The ability to limit or disable the occupant setpoint adjustment at the sensor.
- e. A morning warmup mode to force the terminal box damper to a user specified position during transition from unoccupied to occupied to reduce the run-time of the main air handling unit. This mode shall also have a user defined Warmup Timeout feature which will allow each terminal box controller to operate in this mode for a specified period of time.
- f. During an electrical demand situation, the Terminal Box Controller shall incorporate separate control algorithms for heating and cooling which will allow it to modify the operation of the terminal box such that it can respond in the following manner:
 - 1. Do nothing if energy cannot be conserved because of control mode.
 - 2. Automatically adjust the temperature setpoint to a user-defined range of 0-9°F
- g. Optimum start/stop shall be a standard feature which will allow the Terminal Box Controller to decide when to go to occupied mode based on zone thermal characteristics and historical recovery statistics.

C. Unit Ventilator Controllers:

- 1. As a minimum, shall support the following types of applications for terminal control:
 - 1. Fan Coil units
 - 2. Unit Ventilator units
- 2. As a minimum, shall support the following types of fan coil and/ or unit ventilator units:
 - 1. 2-pipe, heating or cooling
 - 2. 4-pipe, heating or cooling
 - 3. Digital cooling, analog heating, analog outside air damper, digital relief damper
 - 4. Analog cooling, analog heating, analog damper and digital relief damper
 - 5. Digital cooling, digital heating, and digital relief damper
 - 6. Analog heating/cooling and digital outside air damper
 - 7. Analog heating/cooling and analog outside air damper
 - 8. Analog cooling, digital heating and analog outside air damper
- 3. Design:
 - a. Two-part construction:

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1. Integral electronics and mounting plate
2. Removable wiring terminals
- b. Network communications:
 1. EIA Standard RS-485 9600bps, serial, two-wire differential, low parity bus using cyclic redundancy checking (CRC) for error detection.
 2. Network communication maximum cable lengths of 8,000 feet.
- c. Module microprocessor and memory:
 1. 80C51 microprocessor; 2Kb RAM, 32Kb ROM
 2. Fail safe program setpoint stored in non-volatile PROM
- d. Operating environment maximum 100 °F (30 °C), 0 to 99 %RH, non-condensing
- e. Inputs:
 1. Space Temperature
 2. Supply Air Temperature
 3. Override Input
 4. Setpoint Adjust
 5. Supply Fan Status
 6. Filter Status
4. The Unit Ventilator Controller shall be powered from a 24 VAC source. The DDC Contractor shall provide a separate isolation transformer for each controller or group of Unit Ventilator Controllers. Each controller shall be manufactured with an integral cover to protect the intelligence board assembly.
5. The Unit Ventilator Controller shall interface to a matching room temperature sensor. The controller shall function to maintain space temperature to within $\pm 0.5^{\circ}\text{F}$ ($.3^{\circ}\text{C}$) of setpoint at the room sensor location.
6. The Unit Ventilator Controller shall as a minimum incorporate on its menu of software settings and setpoints the following to maximize flexibility, minimize energy consumption, and protect the unitary equipment. Systems that require knowledge of any type of programming language are not acceptable:
 - a. Separate heating and cooling temperature setpoints for both occupied and unoccupied periods.
 - b. Operator definable minimum discharge air temperature setpoints for both heating and cooling modes.
 - c. Definable outside air temperature lockout setpoints for heating, cooling and outside air dampers.

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- d. The ability to limit or disable the occupant setpoint adjustment at the sensor.
 - e. A morning warmup mode shall be incorporated to force the outside air damper closed during transition from unoccupied to occupied eliminate conditioning outside air during this period. This mode shall also have a user defined Warmup Timeout feature which will allow each Unit Ventilator Controller to operate in this mode for a specified period of time, or terminate by Morning Warmup utilizing a temperature deviation from setpoint by a user-defined amount of 0-7°F
 - f. During an electrical demand situation, the Unit Ventilator Controller shall incorporate separate control algorithms for heating and cooling which will allow it to modify the operation of the unit ventilator such that it can respond in the following manner:
 - 1. Do nothing if energy cannot be conserved because of control mode.
 - 2. Automatically adjust the temperature setpoint to a user-defined range of 0-9°F
 - 3. Operate the fan in a continuous mode to circulate air without conditioning it to reduce warm or cool areas during the setpoint adjust time.
 - g. Optimum start/stop shall be a standard feature which will allow the Unit Ventilator Controller to decide when to go to occupied mode based on zone thermal characteristics and historical recovery statistics.
 - h. Forcing of outputs to operator defined states should a system emergency occur. (i.e. smoke alarm)
 - i. Ability to define whether heating and cooling outputs operate in a direct acting or reverse acting manner.
 - j. Activate emergency shutdown of three-phase units during a phase loss situation.
 - k. Should the Unit Ventilator Controller sense the zone sensor has failed, allow the user to define a control mode (off, heat, cool) and force any modulating outputs to a specific position.
 - l. Incorporate a fail safe mode should the fan proving switch open during operation to protect compressors and other sensitive parts of the unitary system.
 - m. A user-definable timed override period of 0-4 hours shall be incorporated to limit the amount of override time an occupant can force the unitary equipment during unoccupied hours.
 - n. A selection shall be available to limit the discharge temperature to a maximum user-defined setpoint during heat operation to eliminate overheating of space.
 - o. Utilization of ASHRAE Cycle 2 to keep the outside air damper closed during unoccupied times to eliminate conditioning of outside air when the zone is unoccupied.
- D. DX HVAC Unit Controllers:
- 1. As a minimum, shall support the following types of applications for DX HVAC Unit control:

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- a. Staged Heating and Cooling
 - b. Staged Heating and Cooling with ventilation air
 - c. Staged Heating and Cooling with dehumidification
2. Design:
- a. Two-part construction:
 1. Integral electronics and mounting plate
 2. Removable wiring terminals
 - b. Network communications:
 1. EIA Standard RS-485 9600bps, serial, two-wire differential, low parity bus using cyclic redundancy checking (CRC) for error detection.
 2. Network communication maximum cable lengths of 8,000 feet.
 - c. Module microprocessor and memory:
 1. 80C51 microprocessor; 2Kb RAM, 32Kb ROM
 2. Fail safe program setpoint stored in non-volatile PROM
 - d. Operating environment -40° to 158°F (-40° to 70°C) and 0% to 99%RH (non-condensing)
 - e. Possible Inputs:
 1. Space Temperature
 2. Supply Air Temperature
 3. Override Input
 4. Setpoint Adjust
 5. Supply Fan Status
 6. Outside Air Position
 7. Filter Status
 8. Space Humidity
3. The DX HVAC Unit controllers shall be powered from a 24 VAC. The DDC Contractor shall provide a separate isolation transformer for each controller. Each controller shall be manufactured with an integral cover to protect the electronic board assembly.
4. The DX HVAC Unit controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within $\pm 5^{\circ}\text{F}$ ($\pm 3^{\circ}\text{C}$) of setpoint at the room sensor location.

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5. The DX HVAC Unit Controller shall as a minimum incorporate on its menu of software settings and setpoints the following to maximize flexibility, minimize energy consumption, and protect the unitary equipment. Systems that require knowledge of any type of programming language are not acceptable:
 - a. Separate heating and cooling temperature setpoints for both occupied and unoccupied periods.
 - b. Operator adjustable time and temperature differentials between stages of heating and cooling.
 - c. Operator definable minimum discharge air temperature setpoints for both heating and cooling modes.
 - d. Definable outside air temperature lockout setpoints for heating, cooling and outside air dampers.
 - e. The ability to limit or disable the occupant setpoint adjustment at the sensor.
 - f. A morning warmup mode to shall be incorporated to force the outside air damper closed during transition from unoccupied to occupied eliminate conditioning outside air during this period. This mode shall also have a user defined Warmup Timeout feature which will allow each DX HVAC Unit Controller to operate in this mode for a specified period of time, or terminate Morning Warmup utilizing a temperature deviation from setpoint by a user-defined amount of 0-7°F
 - g. During an electrical demand situation, the DX HVAC Controller shall incorporate separate control algorithms for heating and cooling which will allow it to modify the operation of the HVAC Unit such that it can respond in the following manner:
 1. Do nothing if energy cannot be conserved because of control mode.
 2. Automatically adjust the temperature setpoint to a user-defined range of 0-9°F
 3. Operate the fan in a continuous mode to circulate air without conditioning it to reduce warm or cool areas during the setpoint adjust time.
 - h. Optimum start/stop shall be a standard feature which will allow the DX HVAC Unit Controller to decide when to go to occupied mode based on zone thermal characteristics and historical recovery statistics.
 - i. Forcing of outputs to emergency states should a system emergency occur.
 - j. Utilization of ASHRAE Cycle 2 to keep the outside air damper closed during unoccupied times to eliminate conditioning of outside air when the zone is unoccupied.
 - k. Activate emergency shutdown of three-phase units during a phase loss situation.
 - l. Should the DX HVAC Unit Controller sense the zone sensor has failed, allow the user to define a control mode (off, heat, cool) and force any modulating outputs to a specific position.

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- m. Incorporate a fail safe mode should the fan proving switch open during operation to protect compressors and other sensitive parts of the unitary system.
- n. A user-definable timed override period of 0-4 hours shall be incorporated to limit the amount of override time an occupant can force the unitary equipment during unoccupied hours.
- o. A selection shall be available to limit the discharge temperature to a maximum user-defined setpoint during heat operation to eliminate overheating of space.
- p. Should the application require, the user shall have the ability to define a dehumidification setpoint to operate both heating and cooling to maintain humidity at a defined setpoint.

E. Heat Pump Controllers:

1. As a minimum, shall support the following types of applications for heat pump unit control:
 - a. Heat Pump, water source
 - b. Heat Pump, air-to-air source
 - c. Heat Pump with ventilation air
 - d. Heat Pump with auxiliary heat
2. All Heat Pump control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of heat pump units to perform the specified sequences of control.
3. Design:
 - a. Two-part construction:
 1. Integral electronics and mounting plate
 2. Removable wiring terminals
 - b. Network communications:
 1. EIA Standard RS-485 9600bps, serial, two-wire differential, low parity bus using cyclic redundancy checking (CRC) for error detection.
 2. Network communication maximum cable lengths of 8,000 feet.
 - c. Module microprocessor and memory:
 1. 80C51 microprocessor; 2Kb RAM, 32Kb ROM
 2. Fail safe program setpoint stored in non-volatile PROM
 - d. Operating environment -40° to 158°F (-40° to 70°C) and 0% to 99%RH (non-condensing)
 - e. Inputs:

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1. Space Temperature
 2. Supply Air Temperature
 3. Override Input
 4. Setpoint Adjust
 5. Supply Fan Status
 6. General Heat Pump Fault
 7. Compressor Status
4. The Heat Pump controllers shall be powered from a 24 VAC. The DDC Contractor shall provide a separate isolation transformer for each controller. Each controller shall be manufactured with an integral cover to protect the intelligence board assembly.
 5. The Heat Pump controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within $\pm 5^{\circ}\text{F}$ ($\pm 3^{\circ}\text{C}$) of setpoint at the room sensor location.
 6. The Heat Pump controller shall directly switch the reversing valves on a call for heat or cool, whichever is appropriate.
 7. The Heat Pump Controller shall as a minimum incorporate on its menu of software settings and setpoints the following to maximize flexibility, minimize energy consumption, and protect the unitary equipment. Systems that require knowledge of any type of programming language are not acceptable:
 - a. Separate heating and cooling temperature setpoints for both occupied and unoccupied periods.
 - b. Operator definable minimum discharge air temperature setpoints for both heating and cooling modes.
 - c. Definable outside air temperature lockout setpoints for heating, cooling and outside air dampers.
 - d. The ability to limit or disable the occupant setpoint adjustment at the sensor.
 - e. A morning warmup mode to shall be incorporated to force the outside air damper closed during transition from unoccupied to occupied eliminate conditioning outside air during this period. This mode shall also have a user defined Warmup Timeout feature which will allow each Heat Pump Controller to operate in this mode for a specified period of time, or terminate Morning Warmup utilizing a temperature deviation from setpoint by a user-defined amount of 0-7°F
 - f. During an electrical demand situation, the Heat Pump Controller shall incorporate separate control algorithms for heating and cooling which will allow it to modify the operation of the heat pump such that it can respond in the following manner:
 1. Do nothing if energy cannot be conserved because of control mode.
 2. Shift the temperature setpoint a user-defined range of 0-9°F

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3. Operate the fan in a continuous mode to circulate air without conditioning it to reduce warm or cool areas during the setpoint adjust time.
4. Turn the heat pump off for a specified period of time.
- g. Optimum start/stop shall be a standard feature which will allow the Heat Pump Controller to decide when to go to occupied mode based on zone thermal characteristics and historical recovery statistics.
- h. Forcing of outputs to emergency states should a system emergency occur. (i.e. smoke alarm)
- i. Ability to define whether heating and cooling outputs operate in a direct acting or reverse acting manner.
- j. Activate emergency shutdown of three-phase units during a phase loss situation.
- k. Should the Heat Pump Controller sense the zone sensor has failed, allow the user to define a control mode (off, heat, cool) and force any modulating outputs to a specific position.
- l. Incorporate a fail safe mode should the fan proving switch open during operation to protect compressors and other sensitive parts of the unitary system.
- m. A user-definable timed override period of 0-4 hours shall be incorporated to limit the amount of override time an occupant can force the unitary equipment during unoccupied hours.
- n. A selection shall be available to limit the discharge temperature to a maximum user-defined setpoint during heat operation to eliminate overheating of space.
- o. Utilization of ASHRAE Cycle 2 to keep the outside air damper closed during unoccupied times to eliminate conditioning of outside air when the zone is unoccupied.

2.5 BUILT-UP AIR HANDLING UNIT APPLICATION SPECIFIC CONTROLLERS

A. General:

1. The Built-Up Air Handling Unit Controller shall be a microprocessor-based standalone controller. Failure of the Executive DDC Panel, DDC modules or operator's workstation shall not interrupt the operation of control module's local control functions. Except for associated zone data, it shall have the capability to operate in a standalone capacity without the requirement for additional inputs and outputs to accomplish any combination of the following application algorithms. Unused inputs and outputs shall have the capability to be renamed, and used for other control processes.
2. Modules shall be fault tolerant and contain integral surge suppression for all inputs and outputs to prevent transient voltage introduction.
3. Executive DDC panel shall automatically download module local control parameters without operator involvement. After the initial download, each controller shall perform its primary control function independent of Executive Controller LAN communication. The controller shall receive real-time data from the Executive Controller time clock to insure

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LAN continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) values for all analog applications.

4. The software shall be English language, menu-based, without the requirement to learn any programming language to accomplish any of these control algorithms. Systems requiring multiple controllers or programming language to meet these applications are not acceptable.
5. If required for associated zone data, the Built-Up Air Handling Unit Controller shall have the capability to use as its control inputs, its local inputs, inputs from an Executive Controller, inputs that reside in a Universal Input/Output Controller, or inputs from Application Specific Controllers.
6. When conflicting zone requirements exist, the Built-Up Air Handling Unit Controller shall be able to prioritize whether to start in the heating or cooling mode based on user preference. It shall have the option to prioritize in heating, cooling, whichever is first running, or no priority.
7. Capability shall be incorporated for special control sequences based on the local smoke alarm state, or on smoke alarms which may occur in adjacent Built-up Air Handling Unit Controllers. Control algorithms shall allow for a variety of smoke purge and smoke evacuation scenarios based on adjacent zones.
8. The space occupant shall have the ability to press a momentary override button provided in the space during unoccupied hours to initiate an override of the built-up air handling unit system. The user shall have the capability to define an override period from 1 minute to 4 hours and 13 minutes which will allow the entire system to operate in the occupied mode for the specified time period. The user shall also have the capability to initiate a continuous override until the next scheduled unoccupied time.
9. The Built-up Air Handling Unit Controller shall have a digital airflow input which, when signaling airflow loss, can allow the user to define what action the controller should initiate:
 - a. Fans are unaffected
 - b. Fans are forced off
 - c. Fans are on, heating and cooling are inhibited
10. The Built-up Air Handling Unit Controller shall incorporate control algorithms which will protect three phase air handling units on a phase loss condition.
11. The Built-up Air Handling Unit Controller shall contain a freeze protection input which will initiate a variety of user-defined control algorithms for the fans, heating and cooling outputs to protect against damage from exposure to sub-freezing temperatures.
 - a. Fans
 1. Forced off
 2. Forced on
 - b. Heating
 1. Unaffected
 2. On or maximum output
 3. Off or minimum output

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- c. Cooling
 - 1. Unaffected
 - 2. On or maximum output
 - 3. Off or minimum output
 - 12. During an electrical demand situation, the Built-up Air Handling Unit Controller shall incorporate separate control algorithms for heating and cooling which will allow it to modify the operation of the heat pump such that it can respond in the following manner:
 - a. Shift the temperature setpoint a user-defined range of 0-9°F
 - b. Turn the air handling unit off for a specified time period of 0-60 minutes.
 - c. Operate the fans continuously to circulate air only.
 - 13. The Built-up Air Handling Unit Controller shall monitor its integral CO2 input, and if it reaches its user-defined alarm setpoint, will generate an alarm to its Executive Controller.
 - 14. The Built-up Air Handling Unit Controller shall have the option of using the outside air temperature input being globally distributed by the Executive Controller network, or its own integral outside air temperature input.
 - 15. The user shall have the capability of forcing any input or output to a specified value for testing and commissioning purposes. After the commissioning process is complete, the user shall then place the controller back in automatic mode.
 - 16. The Built-up Air Handling Unit Controller shall be powered from a 24 VAC. The DDC Contractor shall provide a separate isolation transformer for each controller. Each controller shall be manufactured with an integral cover to protect the intelligence board assembly.
- B. Supply Fan:
- 1. The user shall have the option to cycle the fans on a call for heating or cooling, or operate the fans continuously. The user shall be able to operate differently in the occupied and unoccupied modes. The supply air fan shall be able to control by any of the following methods, using either direct acting or reverse acting control algorithms:
 - a. Constant Speed
 - b. Variable Speed Direct Acting
 - 1. Variable speed operation shall allow the user to define the acceptable operating range from 0-100% to protect the fan motor from overheating.
 - 2. The user shall have the ability to define whether the control algorithms use P, PI or PI&D for control.
 - 2. During a smoke alarm situation the area served by the Built-up Air Handling Unit Controller, the user shall be able to define how the supply fan shall react.
 - a. Inactive-not affected
 - b. Off –turn the fan Off
 - c. On-Force the fan On

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1. Define a fan speed setpoint from 0-100%
 3. During a smoke alarm situation in an area served by another Built-up Air Handling Unit, the user shall be able to define how the supply fan shall react.
 - a. Inactive-not affected
 - b. Off –turn the fan Off
 - c. On-Force the fan On
 - i. Define a fan speed setpoint from 0-100%
 4. Should the Built-up Air Handling Unit sense its integral control input for the supply fan has failed, the user shall be able to define an output from 0-100% to which the fan speed output shall operate. An alarm shall be generated that a failure has occurred.
 5. The user shall be able to define a separate minimum on and minimum off time for the supply fan from 1 second to 127 minutes.
- C. Return Fan:
1. The Built-up Air Handler Controller shall have a user defined delay after the supply fan starts before it shall send the start signal to the return fan. It shall be able to control the return fan by any of the following methods, using either direct or reverse acting control algorithms:
 - a. No Return Fan
 - b. Constant Speed
 - c. Variable Speed as a Percentage of Supply Fan Output
 - d. Variable Speed Controlling to Building Static Pressure
 - e. Variable Speed Controlling to Mixed Air Plenum Pressure
 - f. Variable Speed Tracking as a percentage of Supply Fan CFM
 - g. Variable Speed Tracking Supply Fan CFM Minus Differential
 2. The user shall be able to define whether the return fan uses P, PI or PI&D in its control algorithms. In a variable speed application, the user shall be able to define and limit the control range anywhere between 0 and 100% to protect the motor from overheating.
 3. During a smoke alarm situation area served by the Built-up Air Handling Unit Controller, the user shall be able to define how the return fan shall react.
 - a. Inactive-not affected
 - b. Off –turn the fan Off
 - c. On-Force the fan On
 - i. Define a speed from 0-100%
 4. During a smoke alarm situation in an area served by another Built-up Air Handling Unit, the user shall be able to define how the return fan shall react.
 - a. Inactive-not affected
 - b. Off –turn the fan Off
 - c. On-Force the fan On
 - i. Define a speed from 0-100%
 4. Should the Built-up Air Handling Unit sense its control input for the return fan has failed, the user shall be able to define an output from 0-100% to which the fan speed output shall operate. An alarm shall be generated that a failure has occurred.

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5. The user shall be able to define a separate minimum on and minimum off time for the return fan from 1 second to 127 minutes.

D. Heating

1. Heating shall be accomplished by any of the following control methods, using either direct or reverse acting control algorithms:
 - a. Digital only
 - b. Analog only
 - c. Analog and digital
 - d. Staged – Up to seven stages
2. Heating control setpoint shall be user defined as a straight setpoint or a setpoint that is reset by some other variable such as outside air temperature, return air temperature, associated zone temperatures, or some other user defined variable.
3. The Built-up Air Handling Unit Controller shall contain a self-learning schedule optimization algorithm for heating which will allow the user to define the maximum allowable time that heating starts before its schedule occupied time. The user shall also be able to define a separate optimization target heating setpoint to eliminate overheating of the zones served by the air handling unit.
4. The Built-up Air Handling Unit Controller shall contain a separate schedule for heating to allow the user to define allowable times for heat to operate, such as during a morning warmup period only.
5. The user shall have the capability to define outside air temperatures to keep heat from operating above, below, outside, or between a range of temperatures. The user shall be able to define similar values to force heat to operate.

E. Cooling

1. Cooling outputs can be defined to be any of the following types:
 - a. Digital only
 - b. Analog only
 - c. Analog and digital
 - d. Staged – Up to seven stages
2. Cooling control setpoint shall be user defined as a straight setpoint or a setpoint that is reset by some other variable such as outside air temperature, return air temperature, associated zone temperatures, or some other user defined variable.
3. The Built-up Air Handling Unit Controller shall contain a self-learning schedule optimization algorithm for cooling which will allow the user to define the maximum allowable time that cooling starts before its schedule occupied time. The user shall also be able to define a separate optimization target cooling setpoint to eliminate overcooling of the zones served by the air handling unit.
5. The user shall have the capability to define outside air temperatures to keep cooling from operating above, below, outside, or between a range of temperatures. The user shall be able to define similar values to force cooling to operate.
6. The user shall have the capability to define a humidity setpoint above which the cooling shall operate for dehumidification purposes.

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F. Outside Air Dampers and Economizer

1. The Built-up Air Handling Unit Controller shall be capable of controlling the outside air damper setpoint using any the following integral inputs:
 - a. Mixed air temperature
 - b. CO2 level
 - c. Return air temperature
 - d. Space temperature
 - e. Outside air CFM
 - f. Supply air temperature
2. Reset of the control setpoint for any of the above outside air damper control types shall also be possible based on the following integral controller inputs:
 - a. Local or system outside air temperature
 - b. High, low or average of the space temperatures of associated zones
 - c. Mixed air temperature
 - d. CO2
 - e. Supply air CFM
 - f. Local space temperature
 - g. Outside air CFM
3. Minimum position of the outside air damper shall be user defined between 0 and 100%. The minimum position shall have the capability to reset the minimum outside air setpoint based on the following integral controller inputs:
 - a. CO2
 - b. Supply air temperature
 - c. Return air temperature
 - d. Local space temperature
 - e. Supply or return air CFM
4. The Built-up Air Handling Unit Controller shall incorporate control algorithms to force the outside air damper to a position setpoint in the event of a smoke condition in either its local smoke detection input, or one in an adjacent zone. The user shall define separate setpoints for each type of occurrence to achieve smoke purge or smoke evacuation.
5. The Built-up Air Handling Unit Controller shall incorporate control algorithms to initiate a purge cycle based on a separate schedule, which will allow the user to precool the building using outside air, if proper conditions exist, before normal occupancy time.

G. Humidification Control:

1. The Built-up Air Handling Unit Controller shall incorporate control algorithms required to control an analog humidification system as part of its integral processes. Control systems that require a separate device will not be acceptable. Humidity control shall be achieved by modulating the analog humidity output based on a return air humidity setpoint. The Controller shall also be able to reset the humidity setpoint based on other integral inputs such as outside air temperature. There shall also be a supplementary lockout of humidification based on an integral input, such as supply humidity.

H. Design:

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1. Module microprocessor and memory:
 - a. 80C188 microprocessor; 128Kb RAM, 256Kb ROM
 - b. Program shall be maintained in Flash memory
 - c. Real-time clock chip for local control
2. Operating environment -40° to 158°F (-40° to 70°C) and 0% to 95%RH (non-condensing)
3. Minimum Integral Analog Inputs-24 VDC, 4-20 mA
 - a. Supply static pressure
 - b. Mixed air temperature
 - c. Return air humidity
 - d. CO2
 - e. Building static pressure
 - f. Supply fan velocity pressure
 - g. Return fan velocity pressure
 - h. Local outside air temperature
 - i. Supply air temperature
 - j. Return air temperature
 - k. Local space temperature
 - l. Calculated supply air CFM
 - m. Calculated return air CFM
4. Minimum Integral Digital Inputs-5 VDC, contact closure only
 - a. Supply fan status
 - b. Return fan status
 - c. Filter status
 - d. Smoke detector
 - e. Timed override
 - f. Freeze stat
 - g. Auxiliary confirmation input
 - h. Auxiliary digital input
5. Minimum Integral Analog Outputs-0-10 VDC, 1 mA maximum
 - a. Supply fan speed or vane control
 - b. Return fan speed or vane control
 - c. Analog cooling
 - d. Analog heating
 - e. Humidifier
 - f. Outside air dampers
6. Minimum Integral Digital Outputs-24 V, 2 amp, Class 2
 - a. Supply fan start/stop
 - b. Return fan start/stop
 - c. Auxiliary digital output
 - d. Cool 1
 - e. Cool 2 or Heat 7
 - f. Cool 3 or Heat 6
 - g. Cool 4 or Heat 5
 - h. Cool 5 or Heat 4

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- i. Cool 6 or Heat 3
 - j. Cool 7 or Heat 2
 - k. Heat 1
7. Communications ports
- a. 9600 baud RS -485 module communications
 - b. 9600 baud RS -232 standalone DB-9 serial port
 - I. Connection shall be made to this port while the Controller is part of the Executive Controller network to monitor and make some parameter changes.
 - II. Connection shall be made to this port while in standalone mode to monitor or change setpoints and schedules

2.6 PERSONAL COMPUTER OPERATOR WORKSTATIONS

- A. Personal computer operator workstations shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.
1. GENERAL:
- a. Operator's workstation shall not be required to be in continuous communication with the DDC control panels or any of the network modules for proper operation of the DDC system.
 - b. Operator's workstation shall receive alarm/data logs automatically without operator involvement; the information shall be stored on the workstations fixed disk for future summary analysis.
 - c. Operators workstation shall have simultaneous, peer to peer, access to a single DDC database, multiple database programs shall not be acceptable.
 - d. Provide operator workstations at the following locations:
 - I. Location
 - II. Location
 - III. Location
 - e. Personal computer minimum requirements:
 - I. 300MHz. Pentium microprocessor or equivalent
 - II. 128 Megabytes of RAM
 - III. 40 Gigabyte Fixed Disk Drive
 - IV. CD R/W Drive
 - V. Integral 10/100 Ethernet Network Interface
 - VI. Color Display Monitor

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VII. Mouse