

Fundamentals of DDC



Specifying Your System



Presented by:
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Major Sections

- m **230900 - General System Descriptions**
- m **230901 - Basic Materials, Interface Devices, Sensors**
- m **230903 - EMS/DDC Hardware**
- m **230905 - EMS/DDC Software**
- m **230993 - Sequence of Operation**
- m **230801 - System Commissioning**



General System Descriptions

- m **Description of System Installation**

- q Overall scope of project

- m **Interface to existing system**

- q Network, communication issues

- q Information sharing

- q Setup of workstations

- m **Procurement issues**

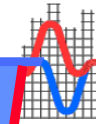
- q Qualified Bidders

- q Reference any agreements in place

- q Prequalification

- q Minimum requirements of potential bidders

General System Descriptions

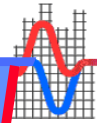


m Quality Control

- q Product Line Demonstrated History**
- q Installer Qualifications**
- q Experience with proposed line**
- q Personnel Experience**
- q Response time/proximity to project**

m Codes & Standards

- q Electronics Industries Alliance (EIA)**
- q UL & UUKL**
- q NEMA (enclosures)**
- q NFPA**
- q IEEE**
- q ASHRAE 135 (BACnet)**



General System Descriptions

- **Definitions**

- **EMS/DDC/BAS/FMS/FAS/EMCS**
- **Control units (Primary/Secondary/Interface devices)**
- **Operator workstation, portable terminal, hand-held**

- **Submittals**

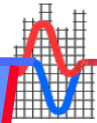
- **Product component data**
- **Shop drawings**
 - **System Architecture & System Layout**
 - **One per AHU/system**
 - **Paper and CADD**
 - **Schematic system flow diagrams**
 - **Point Naming, descriptors – Point summary table**
 - **Point Labeling to include ranges, settings, adjustable range**
 - **Verbal Sequence of Operation**
 - **Valve and Damper Schedules**

General System Descriptions



- ▣ **Submittals (cont.)**
 - ▣ **Shop drawings (cont.)**
 - ▣ **Graphic Screens**
 - ▣ **Wiring Diagrams**
 - ▣ **Panel terminations on separate drawing**
 - ▣ **Differentiate between existing, factory, and field installed**
 - ▣ **Control panel details**
 - ▣ **Labeling**
 - ▣ **Wiring**
 - ▣ **Wire tabulation list**
 - ▣ **ID number**
 - ▣ **“to” & “from”**
 - ▣ **wire color**
 - ▣ **Material List**
 - ▣ **Formatting**
 - ▣ **Memory allocation projections**
 - ▣ **Calculated and guaranteed maximum system response times**

General System Descriptions



m Submittals (cont.)

q Field mounted control drawings

- | Size
- | Location
- | Letter size

q Control Logic Diagrams

- | Symbology
- | Details
- | Program flow

q Commissioning Software

- | For remote use
- | Support for set-up
- | Set of manuals/documentation early

q Pre-commissioning test report



General System Descriptions

m Submittals (cont.)

q O&M Materials

- | User guides**
- | Programming manuals**
- | Maintenance Instructions**
- | Spare parts list**

q Conformance certificates

q Warranty certificates

q Wiring/Networking Guidelines

m Record Documents

q Reflecting installed condition

q Updated logic diagrams, installation, wiring drawings

q Electronic copies of graphics software

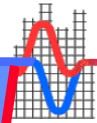


General System Descriptions

m Maintenance during Warranty Period

- q Warranty period (2 years)**
- q Maintenance services required**
- q Emergency services**
 - | Response times**
 - | Remedies**
 - | Phone numbers**
- q Normal services**
- q Telephone support and services**
- q Technical support**
- q Preventative maintenance**

Basic Materials, Interface Devices, Sensors



- m **Control & Instrument Air**

- q **Specialties**
- q **Tubing & Piping**

- m **Wiring**

- q **Reference Code and Manufacturer requirements**
- q **Communication wiring**
 - l **Shielding issues**
 - l **Local Labeling Requirements**
- q **Data communication to peripherals**
- q **Signal wiring**
- q **Low voltage wiring**

Basic Materials, Interface Devices, Sensors



m **Control Panels**

- q **NEMA rating**

- q **Location**

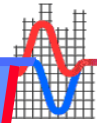
 - | **Locate on Drawings**

 - | **Height**

- q **Wiring/Labeling**

- q **Wire way with excess capacity**

Basic Materials, Interface Devices, Sensors



- m **Control Valves and Actuators**

- q Valve sizing by engineer
- q Describe by type
- q Close off pressures
- q Approved Manufacturers

- m **Control Dampers and Actuators**

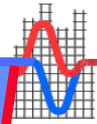
- m **Temperature Sensors**

- q Accuracy by application
- q Resolution by application

- m **Humidity Sensors**

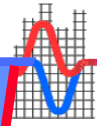
- q Accuracy by application

Basic Materials, Interface Devices, Sensors



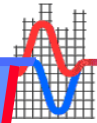
- m **Differential Pressure Sensor, Pressure Sensors, Differential Pressure Switches**
 - q **Outdoor air SP tip (wind effects)**
- m **Flow Meter**
 - q **Water**
 - q **Steam**
 - q **Location**
- m **Air Flow Measuring Stations**
- m **CO₂ Sensor**

Basic Materials, Interface Devices, Sensors



- m **Pneumatic Control Components (Gauges, switches, relays, etc.)**
- m **Electric Control Components (Switches, EP valves, thermostats, relays, smoke detectors, etc.)**
- m **Transducers**
- m **Current Switches**
- m **Refrigerant Monitors**
- m **Nameplates**
- m **Testing Equipment**
 - q **Specify accuracy of testing equipment**

Basic Materials, Interface Devices, Sensors



m **Installation**

q **Wiring/tubing details**

- | **Support**
- | **Location**
- | **Conduit**

q **Freeze stats**

- | **1 square foot coil area/foot of capillary**

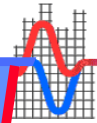
q **Averaging sensors**

- | **2-3 square feet per linear foot of sensor**

q **Flow Measurement**

- | **Engineer Responsibility to locate**

EMS/DDC Hardware



m System Architecture

q Digital Control Stations

- | Limitations, Locations
- | One per Major Equipment
- | No mixing
- | UPS?

q Maximum configurations

q Communications speeds and system response times

- | Elapsed time between alarm occurrence and enunciation at operator workstations for different alarm levels
- | Elapsed time for change of SP to update
- | Elapsed time for start/stop command to initiate
- | Elapsed time for a change of value or state to update on workstation
- | Elapsed time for graphic painting of screen and updating ten points

EMS/DDC Hardware



- **Server (IT impact)**
- **Operator workstation**
 - **Software**
 - **Large HD**
 - **8+ GB RAM**
 - **Large Monitor (24+”)**
 - **Network card**
 - **Back-up capabilities**
- **Portable operator workstation (notebook)**
 - **Software, CD, Network Card**
- **Hand held operator interfaces (tablet)**
- **Printers**

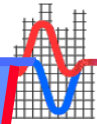
EMS/DDC Hardware



m **Primary Control Units.**

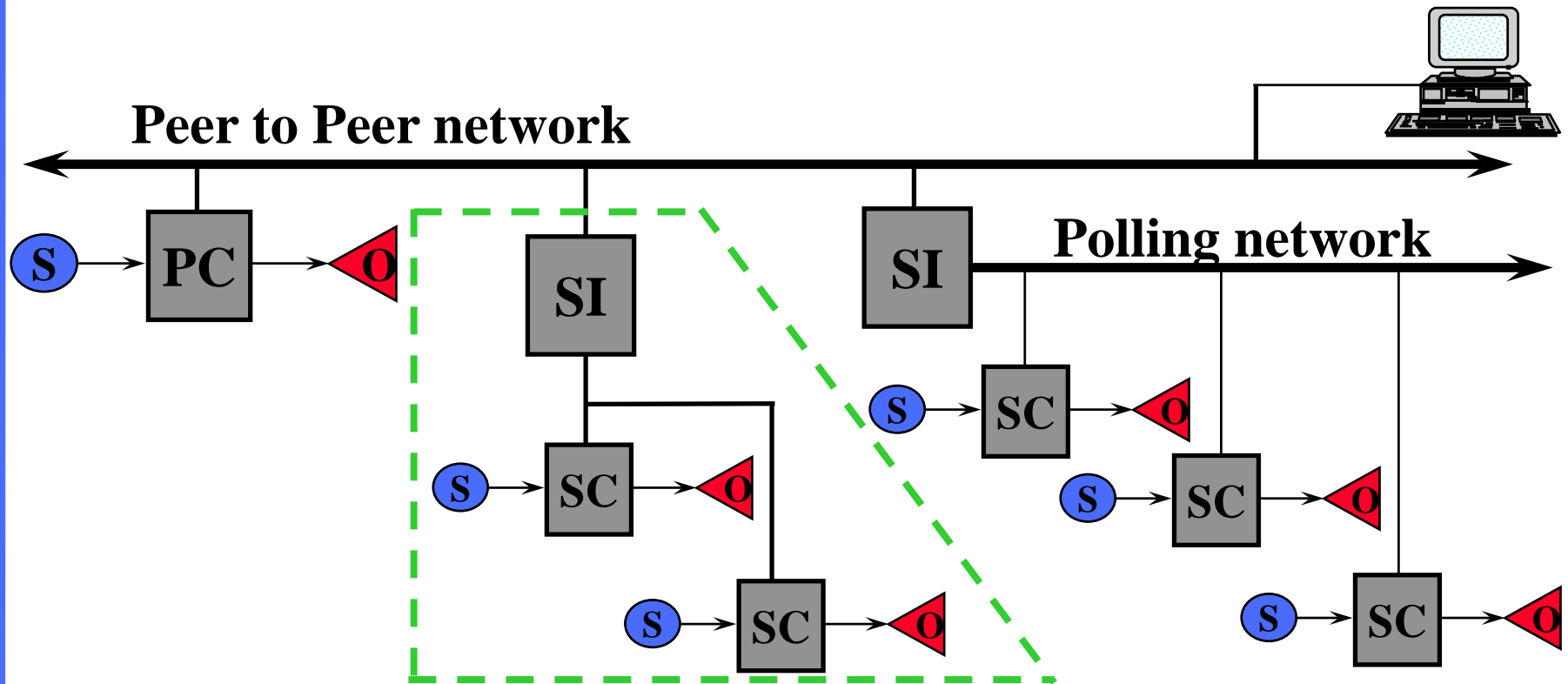
- q **Live on primary LAN (Peer to Peer)**
- q **More sophisticated**
- q **Capable of storing 144 trend values of every I/O point**
- q **Totally programmable**
- q **Stand-alone capable**
- q **Minimum 10 bit A/D converter**
- q **Minimum 8 bit D/A converter**
- q **Slope/Intercept selectable on a point by point basis**
- q **Password levels**
- q **Battery back-up capabilities**
- q **Expansion Boards included (define)**

EMS/DDC Hardware



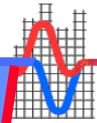
- ▣ **Built-up Primary Controllers**
- ▣ **Secondary Control Units**
 - ▣ **Application Specific Controllers (ASC' s)**
 - ▣ **Terminal Equipment Controllers (TEC' s)**
 - ▣ **Unitary Controllers (UC' s)**
 - ▣ **A/D resolutions 8 or 10 bit depending on application**
- ▣ **Operator Workstations/Portable Units/Hand-held Set-up**

Controllers Types



- PC – Primary Controllers
- SC – Secondary Controllers
- SI – Supervisory Interface

EMS/DDC Hardware



m **Application Requirements of Control Units**

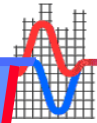
- q **Application category 1 (Application specific)**
 - | **Terminal Units**
 - | **Small Unitary Equipment**
- q **Application category 2 (General purpose SCU)**
 - | **Pump Start/Stop**
 - | **Exhaust Fan Start/Stop**
 - | **Unitary equipment < 15 tons**
 - | **Miscellaneous monitoring**

EMS/DDC Hardware



- q **Application category 3 (Primary controller or allow built-up primary controller)**
 - | 100% OA make-up AHU serving areas served by fan coil units
 - | Unitary equipment > 15 tons
- q **Application category 4 (Primary controller)**
 - | Multizone Air Handling Units
 - | Dual Duct Air Handling Units
 - | VAV Air Handling Units
 - | Local Chiller Control (unit specific)
 - | Local Cooling Tower Control
 - | Local Free Cooling Heat Exchanger Control
 - | Chilled Water System Control
 - | Heating Water System Control
 - | 100% Outside Air (Laboratory) Air Handling Units
 - | Any applications not listed in categories 1, 2, or 3.

EMS/DDC Software



m System Software

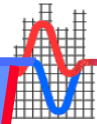
q Licensing Issues

- | System software
- | Third party providers
- | Software Keys

q Describe task that you expect to perform with your system - Provide all necessary software

- | Monitor and supervise control of all points.
- | Add new points and edit the system database.
- | Change control set point, timing parameters, and loop-tuning constants in all control units.
- | Enter programmed start/stop time schedules.
- | View alarms and messages.
- | Modify existing control programs in all control units
- | Upload/Download programs, database, etc. as specified

EMS/DDC Software



- m **Primary Control Unit Software**
- m **Secondary Control Unit Software**
- m **Programming Description**
 - q **Specific type**
 - q **Off-line simulation capabilities**

EMS/DDC Software



- m **Control Algorithms**

- q **Function blocks available**

- m **Energy Management Applications**

- q **Scheduling**

- q **Optimal Start/Optimal Stop-based on**

- q **Night Setback and Morning Recovery Control with ventilation only during occupancy.**

- q **Peak Demand Limiting**

EMS/DDC Software



- m **Password Protection**

- q **Levels of password**
- q **Auto sign off**
- q **Number of users**

- m **Alarm Reporting**

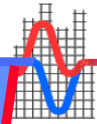
- q **Prioritization**
- q **Routing**
- q **Auto notification**
- q **Graphic Links**
- q **Trending Links**
- q **Alarm Acknowledgment**

EMS/DDC Software



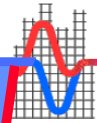
- **Trending**
 - **Tabular and graphical formats**
 - **Any point, hardware or software (virtual)**
 - **Simultaneous display of values**
 - **User adjustable ranges and scaling**
 - **High resolution capable sampling on PID control loops**
 - **Archiving and storage issues**
- **Operator's Graphical Interface Software**
 - **Operating System**
 - **Multi-tasking capability**
 - **Graphical importing capabilities**

EMS/DDC Software



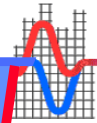
- **Operator's Graphical Interface Software (cont.)**
 - **Screen Penetration/Graphic page linking**
 - **Dynamic update**
 - **Point Override features**
 - **Dynamic Symbol updating**
 - **Graphics Package**
 - **Symbol Library**
 - **Standard Pictures**

EMS/DDC Software



- m **Management Reporting**
 - q **Linking with third party programs**
 - q **Reports required**
 - q **Flexibility**
 - | **Sorting**
 - | **Wildcards**

System Setup



m Passwords

- q Set up levels
- q Program users
- q **Do not enable high end passwords until job complete**

m Points

q Analog Inputs

- | Name and Address
- | Scanning frequency
- | Engineering units and scaling factors
- | High and low alarm values and alarm differentials
- | High and low value reporting limits (reasonableness values).
- | Default value to be used when the actual measured value is not reporting.

System Setup



m Points

q Analog Outputs

- | **Output Range**

q Digital Inputs

- | **Message and alarm reporting as specified.**
- | **Reporting of each change of state, and memory storage of the time of the last change of state.**
- | **Totalization of on time (for all motorized equipment status points), and accumulated number of off-to-on transitions.**

q Digital Outputs

- | **Minimum on/off time**
- | **Status association with a DI and failure alarming (as applicable)**
- | **Default value to be used when the normal controlling value is not reporting.**

System Setup



m Alarms

q Reporting locations

- | **Level 1: fire and security office monitor**
- | **Level 2: central control station monitor and alarm logging printer**
- | **Level 3: controls maintenance shop monitor**
- | **Level 4: energy conservation engineer monitor**
- | **Level 5: filter changing crew alarm logging printer**

q Alarm criteria for different applications

- | **Low alarm**
- | **Low return to normal**
- | **High alarm**
- | **High return to normal**

q Proof Alarms

q Maintenance run time alarms

System Setup



- m **Trending**

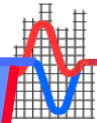
- q **Site specific**
- q **For commissioning**

- m **Schedules**

- m **Graphic Screens**

- q **Floor Plans with Links to Mechanical Room and Terminal Equipment**
- q **Mechanical Room Floor Plans with Links to HVAC equipment**
- q **Key plans with Links to Floor Plans**
- q **Site plans with Links to Buildings**

System Setup



- m **Graphic Screens (cont.)**

- q **Equipment screens linked to related equipment**
- q **Alarms showing on screens**
- q **Adjustable set points**
- q **Tabular summary pages**

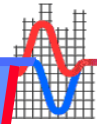
- m **Management Reports**

- q **Current conditions**
- q **Energy**
- q **Run time**

- m **Data handling routine**

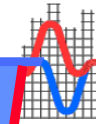
- m **Set up Back up routine**

Sequences



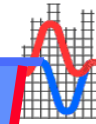
- m **Detailed**
- m **By control loop or subsystem**
- m **Logic Diagrams**
- m **Standardize**

System Commissioning



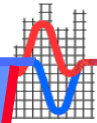
- m **Define responsibilities and roles**
- m **Vendor to provide control technician**
- m **Compensation for excessive commissioning failures**
- m **Pre-commissioning requirements**
 - q **Verify proper pneumatic pressures and conditions**
 - q **Verify proper electrical voltages and amperages, and verify all circuits are free from grounds or faults**
 - q **Verify integrity/safety of all electrical [and pneumatic] connections.**
 - q **Verify proper interface with fire alarm system**

System Commissioning



- m **Pre-commissioning requirements (cont.)**
 - q **Coordinate with TAB subcontractor** to obtain control settings that are determined from balancing procedures
 - | Optimum VAV duct pressure set points
 - | VAV fan VFD minimum and maximum speed settings
 - | VAV Return fan volume tracking settings
 - | Minimum outside air damper settings for air handling units.
 - | VAV box minimum and maximum volume settings.
 - | Optimum differential pressure set points for variable speed pumping systems.
 - | Variable volume pump VFD minimum and maximum speed settings
 - q **Test, calibrate, and set all digital and analog sensing, and actuating devices**
 - q **Check and set zero and span adjustments for all actuating devices**

System Commissioning



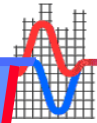
m Pre-commissioning requirements (cont.)

- q Check each digital control point**
- q Verify proper sequences**
- q Tune all control loops (establish criteria)**

m Demonstration

- q Software installed**
- q Graphic commands**
- q Calibration (establish criteria)**
- q Remote communication capability**
- q Sequences**
- q Power failure start-up**

System Commissioning



- m **Demonstration (cont.)**

- q **Stand alone operation**

- m **Acceptance period**

- q **2-4 weeks**

- q **Commissioning Agent Performance Testing**

- q **Maintain alarm logs**

- q **Produce punch list**

- q **Control Technician support**

- l **qualifications**

System Commissioning



- m Trend Logs**

- q Use during pre-commissioning**
 - q Use during Acceptance period**
 - q Specify time interval**

- m Opposite season testing**

- q During warranty period**

- m Training**

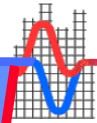
- q Levels of training**
 - q Length**
 - q Detail subject matter**

Principle 1



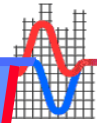
- **The control system must first and foremost provide effective and reliable control, commensurate with the systems it is controlling.**
 - All controllers aren't created equal
 - One size does NOT fit all
 - Application Categories
 - Stand-alone
 - Network is the controller?

Principle 2



- m The manufacturer and installer must be highly qualified with extensive experience and must be committed/bound to a thorough Commissioning of the system**
 - q Qualifications of installer equally important as the product**
 - q Committed to commissioning process**
 - q Research into the products and local capabilities of installer is necessary**

Principle 3



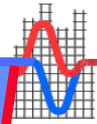
- m The control installation must be fully documented as consistently as practical with nothing required to fully operate and maintain the system withheld from the owner**
 - q Specifications must cover these issues**
 - q Details like graphics, point naming conventions, programming logic, network configuration, documentation**
 - q Owner has all software tools and owns their own sequences**

Principle 4

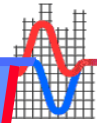


- m **The system must be interoperable to the appropriate level**
 - q **Level 5 - Enterprise Historical Data**
 - | Historical data
 - q **Level 4 - Enterprise Real-Time Data**
 - | Real time data, alarming, supervisory EMS
 - q **Level 3 - Control Inter-Network Communication**
 - | Separate control networks, gateways, control
 - q **Level 2 - Control Intra-Network Communication**
 - | Same LAN, interchangeable, same configuration tool
 - q **Level 1 - Point Level Interoperability**
 - | Same programming tool

Principle 5



- **The sequence of operation must be clearly and completely communicated for each system.**
 - **Performance specifications – punting**
 - **Generic sequences are subject to interpretation**
 - **FPT' s are challenging to write for gray sequences**
 - **Consider logic diagrams**
 - **Clarify sequences as soon as possible in the process**



The Future

- **Web/Intranet-based DDC**
- **Cx becoming commonplace**
- **Fault Diagnostic Software**
- **Resource Limitations (people) getting worse**
- **True Open Protocol – eventually.....maybe**

- **Other Websites**
 - <http://maps.unc.edu/guidelinespdf/Control%20Standard.pdf>
 - <https://av8rdas.wordpress.com>