23 09 00 – Instrumentation and Control for HVAC
Building Management Systems
Design Guidelines and Best Practices

Revision 04/2019

This document is intended to convey RIT's standards for building automation control installation and configuration that are above and beyond the manufacturer's specifications. At all times, the installer is expected to adhere to the manufacturer's specifications and best practices in addition to adhering to local building codes and standards.

This document is a constant work in progress. Contractors and engineers are encouraged to make suggestions as to how this document and our standards can be improved, clarified, or simplified.

Contents

1. **What RIT Expects from its Control Contractors**
   a. All control contractor employees working on RIT projects shall attend a two hour orientation program by RIT as needed.
   b. All problems with mechanical equipment discovered by the controls contractor shall be reported to the project manager in a timely manner.
   c. Control Panels shall be orderly, have permanent labels and shall be completely documented.
   d. Commissioning shall be 100% complete before the project is turned over. See the section on commissioning.
   e. Point checkout shall be complete and accurate.
   f. All documentation shall be complete and accurate.
   g. All panel, floor plan and network drawings shall be complete, accurate and turned over to the owner in both PDF and AutoCAD format when the project is complete.
   h. All Server programming and configuration shall be complete, including (but not limited to):
      i. Equipment Graphic Screens
         1. Every piece (or related group) of equipment shall have its own equipment screen.
         2. All equipment shall be in the proper source trees.
         3. The equipment graphic screens shall contain all source links.
         4. The equipment screens shall have RITs standard override block.
      ii. There shall be a floor plan graphic screen for each area of the project that contains:
         1. Location and status (color) of every piece of controlled equipment
         2. All space sensors
         3. All room numbers
         4. All remote sensors outside of mechanical rooms.
         5. Weather information and link.
         6. HOA switches on all HVAC equipment graphics.

2. **WebCTRL Equipment files naming and use**
   a. All file names will begin with the letters **bldg_** followed by a two-digit building number followed by a description followed by an underscore and finally followed by a two-digit instance number. Use two digits for the building number if possible. Including a leading zero if the building number is 9 or less.
   b. On buildings that have more than three digits use the minimum number possible.
   c. If the file corresponds to a single piece of equipment, then the file name should include the equipment name. AHU, VAV, HP, etc.
   d. If the file corresponds to multiple pieces of associated equipment then the file name should be indicative of the system. HW, CHW, Steam, Radiation, etc.
      i. Examples:
         1. **bldg_01_ahu_02** - serves Building 01 AHU-02 (HC-001-AHU-002)
         2. **bldg_7b_vav** – serves building 7b multiple VAVs (HC-07B-VAV-###)
         3. **bldg_50b_dhw** – serves building 50b domestic hot water
         4. **bldg_400_ahu_10** – serves building 400 AHU-10 (HC-400-AHU-010)
   e. In cases where the program is relevant to multiple buildings the file name will begin with **bldg_00_.**
      i. Examples
         1. **bldg_00_chw_btu_v2** – serves multiple buildings for calculating chilled water energy data
         2. **bldg_00_hw_hx** – serves multiple buildings for hot water heat exchangers
         3. **bldg_00_vav** - serves multiple buildings for multiple VAVs
   f. If possible use one of the template files below. Verify with RIT Building Controls Dept. for current templates. These files begin with **bldg_00_.**
      i. **bldg_00_chw_btu_v2** – Chilled water energy meter program.
      ii. **bldg_00_hw_btu_v2** – Hot water energy meter program.
      iii. **bldg_00_gas_meter_v2** – Gas meter energy program.
      iv. **bldg_00_eleictric_energy_use_v2** – Electrical energy meter program.
      v. **bldg_00_water_meter_v2** – Water use meter program.
      vi. **bldg_00_hw_hx** – Building hot water connect heat exchanger program.
      vii. **bldg_00_irrigation_v2** – Irrigation panel program.

viii. More template programs will be added in the future. Please check with the controls department to see if there is a template program to fit your application.

3. WebCTRL View File Naming and Use.
a. In general, the view file name should match the associated equipment file name. The naming rules are the same. Please refer to the equipment file naming above.
b. In situations where the view is to be customized for a more-generic building-specific equipment file, then the view file name should include the equipment file name with an added instance number.
   i. Example
      1. Equipment file name   :   **bldg_04_vav.equipment**
      2. Matching generic view file   :   **bldg_04_vav.view**
      3. Equipment specific view :   **bldg_04_vav_0305.view**
c. In situations where the equipment file is not building-specific but the view needs to be equipment-specific, then the view is named specific to the equipment as according to the rules above, even though this does not match the equipment file.
   i. Example
      1. Equipment file name   :   **bldg_00_hw_hx.equipment**
      2. Matching generic view file   :   **bldg_00_hw_hx.view**
      3. Equipment specific view :   **bldg_04_hx_02.view**
d. View file location
   i. All view files are to be located in a subdirectory of the W:\webroot\rochester_institute_of_tech\views folder. The subfolder name will generally be named **Bldg-#** where # refers to the building number.
      1. Example all view files for building 1 will be stored in **..\views\Bldg-1**
      2. If the file does not belong to a building then it should be located in one of the other subfolders
         a. ..\views\Campus Summaries
         b. ..\views\Energy (Energy Related, such as BTU metes, etc)
         c. ..\views\HCP (Heating Cooling Plant)
         d. ..\views\graphics
            i. Only as a last resort should items be put in the graphics folder. Please check to see if it belongs in a building folder or one of the other folders instead.

4. WebCTRL Reference Name Nomenclature
a. All geographic reference names are to be absolute names, starting with a **#**.
b. In cases where one new piece of equipment is to be added to existing equipment in the building, then the reference name should match the existing reference name style, even if the existing reference naming does not follow the standard set forth here. Consistency is important.
c. Geographic Reference Names
   i. Geographic Reference name rules follow the rules set for equipment file names, except generally the bldg portion is left off.
      1. Examples
         a. #02-ahu-05   -   Building 02 AHU-05
         b. #75-vav-0312   -   Building 75, AHU-03, VAV-12
         c. #99-rtu-11   -   Building 99 Rooftop unit -11
         d. #81-pump-01-02   -   Building 81 pumps 01 and 02
         e. #400-chw   -   Building 400 CHW System
d. Network Tree Reference Names
   i. LGRs
      1. Display name is to be **Router #?? Bldg #??**.
         a. Example: **Router #38 Building #13**
      2. The reference name is to be the corresponding name from site builder.
         a. Example: **#router__38_bldg_13**
   ii. Arcnet
      1. Main building level: **Bldg#?? Arcnet**
         a. Example **Bldg#75 Arcnet**

2. AAR
   a. Building number – AAR – Instance Number
   b. Example **08-AAR-01** – Building 08 AAR number 01
3. Sub-Arcnet (Arnet on an AAR)
   a. Building number – Arnet – Instance Number
   b. Example **08-Arcnet-01** Building 08 Arcnet Number 01
   iii. Single Equipment Controllers
   1. Building Number – Equipment Type – Instance Number – Module Model
   2. Example:
      a. Display Name: **99-RTU-11-SE6104** – Building 99, RTU-11, Controller SE6104
      b. Reference Name: **#99-rtu-11-se6104** – Building 99, RTU-11, Controller SE6104
   iv. Multiple Equipment Controllers
   1. Building Number – Equipment Description –Instance Number (if Applicable), Module Model
   2. Example:
      a. Display Name: **99-HWPlant-ME812U** – Building 99, Hot Water Plant, Controller ME812U
      b. Reference Name: **#99-hwpant-me812u** – Building 99, Hot Water Plant, Controller ME812U

5. **Network**
   a. Traditional Topology
      i. Each building will have at least one LGR or approved RIT Building Controls Dept. Gateway router.
      ii. AARs (Arcnet Routers)
         1. If the building has more than 30 control modules connected to the LGR, then AARs must be used to create sub-Arcnet segments.
         2. Each AAR will be off the main Arcnet segment for the building
         3. There are only three acceptable locations for the AARs
            a. All of the AARs may be placed in the same panel as the LGR or in a panel next to the LGR. In this way the main Arcnet only has AARs and optionally some other controllers in the same room.
               i. This method is preferred when each AAR will serve one area of the building, such as a building floor.
            b. Each AAR may be placed in the panel of the associated AHU.
               i. In this case the AHU and all of its associated VAVs will be on the secondary side of the AAR. In this situation all of the AHU to VAV communication is all on the secondary side of the AAR.
            c. An AAR may be placed in a dedicated panel in a mechanical area.
               i. For instance if there is one AAR serving each floor of a building, then the AARs may be placed on each corresponding floor. It must be placed in an area accessible by the RIT engineering staff, such as a mechanical room or mechanical area. It may not be placed above the ceiling or in some other hidden location. The panel must be clearly labeled xx-AAR-xx (ex 50A-AAR-02 for building 50A AAR #2).
         4. AARs are not to be placed in difficult to reach or difficult to find places.
         5. AARs are not to be powered off from equipment power. Shutting down an AHU or other piece of equipment should never shut down an AAR. A dedicated circuit for controls is required.

   b. Ethernet Controller Topology
      i. Plant Equipment controllers can be Ethernet controllers such as the ME812u-E.
         1. In this situation these controllers are not using Arcnet, and each controller is located on the campus Ethernet with a dedicated RIT Ethernet jack.
      ii. AHU controllers can be combination Equipment controllers / LGR such as the ME812u-LGR.
         1. The AHU controller is located directly on the RIT campus Ethernet with a dedicated Ethernet jack.

2. All of the associated VAV controllers are located on the Arcnet segment that originates with the AHU controller.

c. Repeaters
   i. No Repeaters are to be used ever.

d. Terminations and Biasing
   i. Locations of all network terminations and/or biasing devices are to be clearly marked on the network riser diagrams and on the network floor plans.
   ii. BT-485s are to be used at the ends of each and every network segment if possible.
   iii. In situations where using a BT-485 is not possible, then Network terminating resistors are to be used at each end of the network segment with a DIAG-485 located roughly in the middle of the network segment.
      1. The DIAG-485 must be in a panel in a mechanical space.
      2. The DIAG-485 must have a dedicated transformer or transformer feed. Turning off the power to any other control device or piece of equipment, must not interrupt power to the DIAG-485. A dedicated circuit is required.

e. Network Variables
   i. Outside Air
      1. All programs that have a network input for outside air Temperature will use **exp:#oa_conditions/temperature** for the primary temperature value. The secondary value will be set to the local building average outside air temperature if one exists or to the nearest valid outside air temperature sensor if a building average does not exist. The intent is to use the campus average if it is available and use a local temperature sensor if the campus average is not available.
      2. Similar to outside air temperature, all programs **exp:#oa_conditions/humidity** for the primary humidity value. The secondary value will be set to the local building average outside air humidity if one exists or to the nearest valid outside air humidity sensor if a building average does not exist.
   ii. Network values on the same control module
      1. If there are multiple programs that are on the same control module and at least one of the programs uses a network input to retrieve the value of one of the other programs then the network input must use the "this" address format. When using "this" format the network input does not use up any network traffic. All communications is retained inside the control module.
         a. Example: Instead of **exp:#bldg_09_chlr_plant/t4_campus_chws** use **bacnet://this/t4_campus_chws_1**. Both of these refer to the same point, but the second does not use or depend upon network traffic.

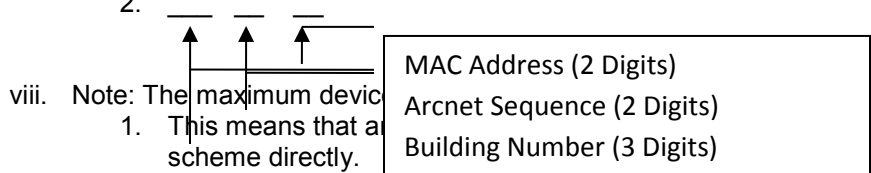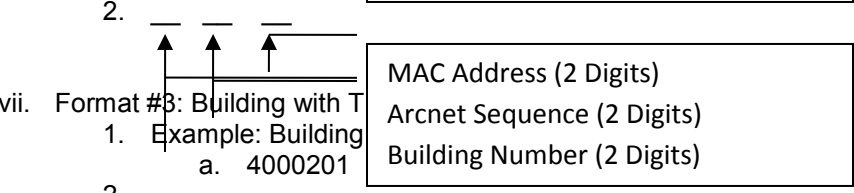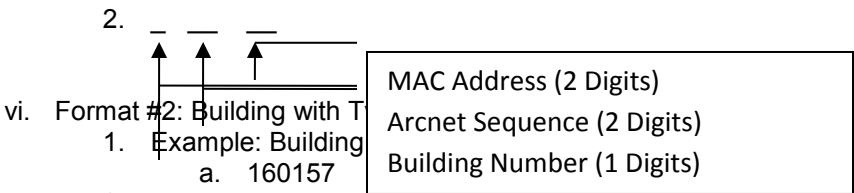6. **Network Numbers and Device Instance Numbers**
   a. Network numbering
      i. Network numbers shall be assigned by building number
      ii. The first network in a building will be the building number followed by 00
         1. In the case where the building has a dedicated LGR the __00 network will be connected to the LGR.
         2. Example: The first network in building 73 will be 7300 this will be the network that is directly connected to the secondary side of the LGR.
      iii. The networks will be numbered sequentially after the first.
         1. Example: The second network in building 73 will be 7301.
      iv. The network numbers will correspond to the AAR numbers
         1. Example: AAR-02 in building 73 will correspond with Arcnet 7302.
      v. Exceptions / Clarifications
         1. Buildings with multiple LGRs
            a. The first LGR will directly host network __00
            b. This first LGR will host AAR numbers 1 to 9 corresponding to networks __01 to __09.
            c. The second LGR will directly host network __10
            d. The second LGR will host AAR numbers 11 to 19 corresponding to networks __11 to __19

        e. There should not be more than 9 AARs on a single LGR
- 2. Multiple buildings on a single LGR
  - a. Do not put multiple buildings on a single LGR.
  - b. Use at least one LGR per building.
- 3. Buildings with letters
  - a. Network numbers cannot have letters.
  - b. Each building with a different letter should have a new LGR.
  - c. If an exception is made and there are multiple buildings with different letters on the same LGR then the rules for "Buildings with multiple LGRs" should be followed
    - i. Example: If building 50A, 50B and 50C are on the same LGR then :
      1. Network 5000 would be the network number from the LGR connecting all of the AARs
      2. Network numbers 5001 to 5009 will be reserved for those networks that are not associated with a particular building letter. For instance if there is a mechanical room AAR that does not belong to a specific building.
      3. 50A would have network numbers 5010 to 5029
      4. 50B would have network numbers 5030 to 5049
      5. 50C would have network numbers 5050 to 5069
    - ii. Example #2 Building 7A and 7B
      1. Networks 0700 – 0749 are reserved for 7A
      2. Networks 0750 – 0799 are reserved for 7B
- b. Device Instance Numbers
  - i. The device instance number should be the network number followed by the MAC address of the controller
  - ii. Examples
    1. Building 81 should have network numbers 8100 to 81__
       - a. The third AAR would have network 8103
       - b. The module with MAC address 25 on the third AAR would have a device instance number 810325
  - iii. In this way it is always possible to determine which building and network a module belongs to simply by decoding the device instance number
  - iv. This will help with coordinating device instance numbers while buildings are under construction before they are connected to the main system.
  - v. Format #1: Building with single digit number
    1. Example: Building 02, AAR 05, MAC 16
       - a. 20516
    2. __ __ __

       MAC Address (2 Digits)

       Arcnet Sequence (2 Digits)

       Building Number (1 Digits)
  - vi. Format #2: Building with T[...]
    1. Example: Building[...]
       - a. 160157
    2. __ __ __

       MAC Address (2 Digits)

       Arcnet Sequence (2 Digits)

       Building Number (2 Digits)
  - vii. Format #3: Building with T[...]
    1. Example: Building[...]
       - a. 4000201
    2. __ __ __

       MAC Address (2 Digits)

       Arcnet Sequence (2 Digits)

       Building Number (3 Digits)
  - viii. Note: The maximum devic[...] will not be able to follow this
    1. This means that a[...] scheme directly.

2. Currently there are no buildings connected to the WebCTRL system with a building number larger than 404.
3. If working on a building with a number larger than 418 contact RIT Controls to determine which instance numbers to use.

7. **Template Programs**
   a. RIT would like to reduce the number of programs in use on our WebCTRL server.
   b. RIT has been developing template programs for certain equipment, contact RIT Building Controls Department personnel for template programs.
   c. If a template program meets the project requirements it shall be used.
   d. If a template program meets most of your project requirements, but not all, contact RIT Building Controls Department personnel to review if the template program can be modified to meet the project requirements while still maintaining compatibility with the existing equipment using the program.
   e. Currently, template programs exist for all types of energy meters.
   f. Other template programs exist for irrigation and HW connects.
   g. As of January 2018, there are about 100 template programs that include VAVs, chilled water connects, hot water connects, coolers, cabinet unit heaters, fan coils, exhaust fans, various meters and various BACNet integration programs.
   h. Template programs for chilled water connects, domestic hot water, heat pumps, RTUs, and chilled beams/inducer are being developed.

8. **Program Substructures**
   a. **Program Edit Order.** Ensure that logic blocks are in the correct section in the logic builder edit order after any program has been modified.
   b. **Logic Latching Software.** Any latch in software shall be resettable without restarting the controller.
   c. **Alarm differential Low Limit.** Modify the standard logic from ALCs equipment builder for alarms that are offset from a setpoint in such a way that there is a minimum offset above and below the setpoint, in addition to the standard percent above and below the setpoint. This is particularly important for processes that have a setpoint near zero such as return duct static pressure control. This applies to all similar logic. See below for example.

RIT's OCL block 1.61 or 1.63 or later

   d. PIDs
      i. All programs are required to have PID that has a deadband.
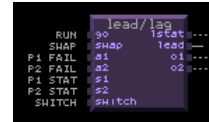   1. This can be
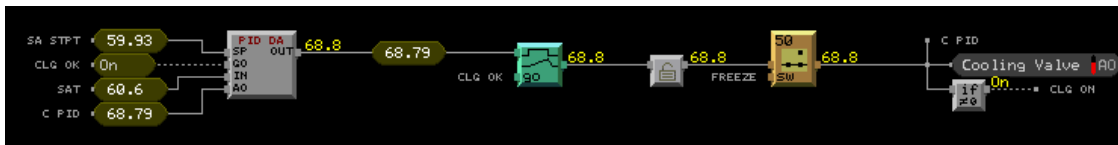
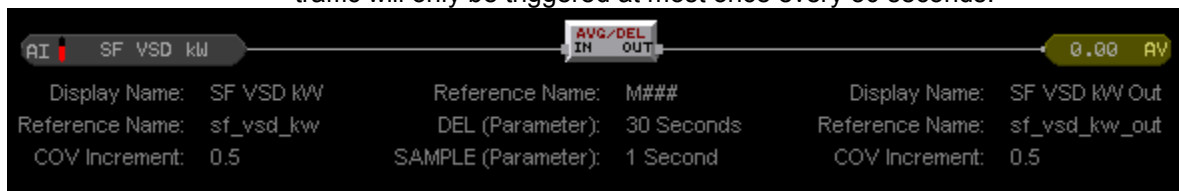   a. In this example, notice how the final output is used as an input to the PID block. This output feedback is used to ensure that the PID does not deviate too far from the output when other parameters are affecting the output besides the PID block. These parameters might be a ramp block, limit block, or switches. Use this method whenever possible.
         2. Or it can be the BACNet PID included in WebCTRL 5.2 or later.
         3. Do not use the older RIT Custom PID block, this has been superseded by the RIT OCL PID Block.
      ii. PIDs need to be properly tuned so the equipment does not cycle and the control routines are stable.
   e. Lead/Lag
      i. Use RIT's custom lead/lag block. Do not use ALCs lead/lag block.

1. This block can be found along with associated logic in the template program **lead_lag_with_switch.equipment** switch, program.
   a. This program can be used even if there is no select the appropriate subroutine from the
   b. There are more instructions within the program

f. Analog Variables for Network Linking
   i. When an analog value is expected to be referenced by an analog network input from a different program, then a dedicated BACNet Analog Value (BAV) Status block is to be created in the program with the same name as the value with the addition of "Out" to the display name and "_out" to the reference name. In between the logic generating the value and the BAV block there is to be logic that prevents the BAV value from changing more than necessary. Typically this time will be 30 seconds to 1 minute.
      1. The objective of this logic is to prevent excessive network traffic due to values changing frequently because of improperly set COV settings or because of a fluctuating input value.
      2. This can easily be accomplished by using RIT's **AVG/DEL** V1.2 OCL block or RIT's **AVG** V1.1 OCL Block
      3. Example: It is known that the kW feedback of a fan will be trended by another program. Therefore, a BAV output is created. An **AVG/DEL** block is inserted in-between the AI and the BAV. The AVG/DEL block is set so that the output only changes once every 30 seconds. In this case, even if the COV of the BAV is set lower then desired, the network traffic will only be triggered at most once every 30 seconds.

| AI	SF VSD kW		AVG/DEL IN OUT		0.00 AV
Display Name:	SF VSD kW	Reference Name:	M###	Display Name:	SF VSD kW Out
Reference Name:	sf_vsd_kw	DEL (Parameter):	30 Seconds	Reference Name:	sf_vsd_kw_out
COV Increment:	0.5	SAMPLE (Parameter):	1 Second	COV Increment:	0.5

      4. In general any value that is related to energy will be referenced by another program through the network.
         a. Examples: kW, BTU, flow, temperatures associated with flow to calculate BTUs.
      5. Outside Air Conditions are generally referenced by another program and should include a delay out.
      6. Other values that are likely to be referenced remotely are Air Flow and Water Flow values, AHU Discharge Air Temperature, etc.

g. Program block Reference Names
   i. For any logic block that might be linked to a graphic or linked by network to another program enter a meaningful reference name.
      1. This includes:
         a. All inputs
         b. All outputs
         c. Any type of adjustable setpoint (AV, BV, if Greater/Less then Constant, Constant High/Low limit, etc) that the user is likely to change.
      2. Use reference names that match existing program naming style.

h. Hand / Off / Auto
   i. All equipment programs are to include logic to support a HOA switch on the graphic screen.
   ii. The HOA logic will be programmed in such a way that when the HOA is set to Off the equipment will not run regardless of freeze protection or other logic and it will not generate alarms.
   iii. However, when the HOA switch is set to the On position, the equipment will shut down due to any software or hardware safety that would normally shut down the equipment.
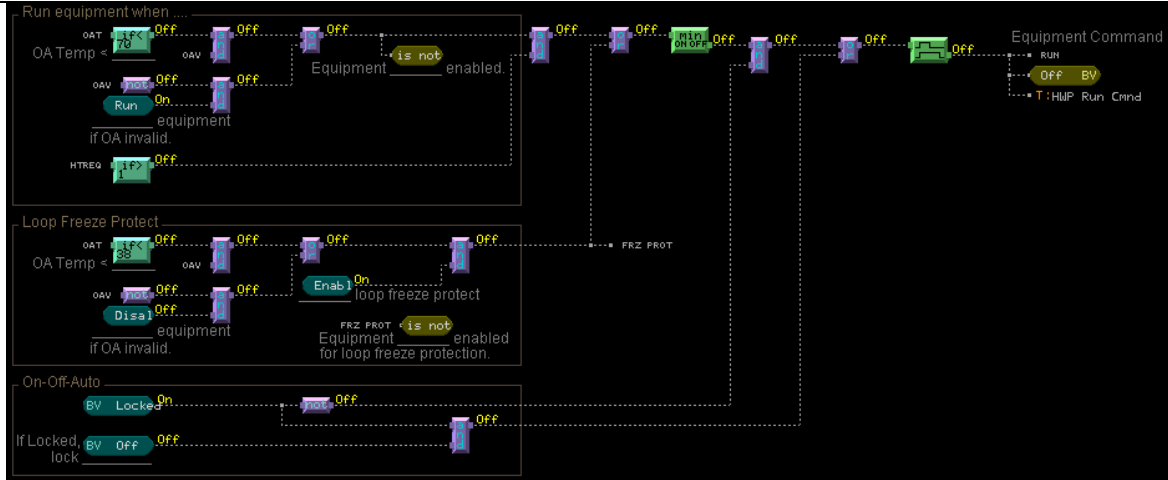
    i.   Environmental Index
- i. Every program for equipment that directly conditions an occupied space is to include the ALC Environmental index logic. The environmental index is to have provisions for Temperature, Humidity and/or CO_2 depending upon what is controlled by that program.
- ii. Each building will have a master Environmental Index that will roll up the zone EI's in the building.

    j.   Occupancy Sensor Logic for zone control
- i. Zone equipment with occupancy sensors is to have the following logic.
  1. The zone is to go occupied if the schedule is occupied or the occupancy sensor is tripped. (Note that the schedules can be left empty and then the occupancy sensor is the only determination of occupancy)
  2. If the occupancy sensor is, unoccupied then the cooling setpoint is adjusted up by 2°F (adjustable, ref name = clg_adjust).
  3. If the occupancy sensor is unoccupied, then the heating setpoint is adjusted down by 2°F (adjustable, ref name = htg_adjust).
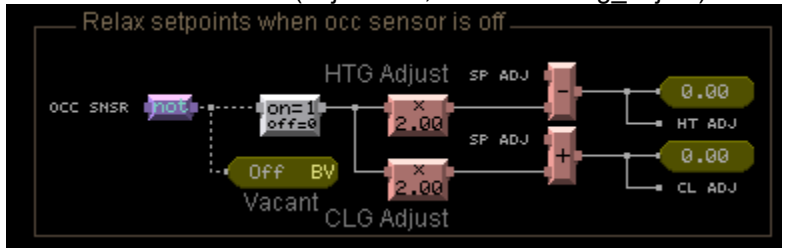

9. Program Documentation
    a.   When modifying an existing program, include your initials, date and short description of the changes at the upper right side of the program.

b. In sections of a program that are not standard design, include a text description of the program logic so that someone with little knowledge of the programming language can read the description and
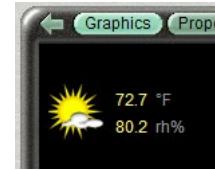
c. Determine what that program section is doing.
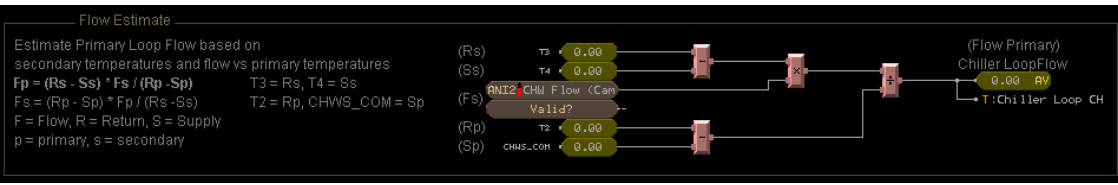
10. Graphic Screen Components and Layout

    a. Outside Air Conditions

        i. All graphic pages are to have the outside air temperature and humidity displayed in the upper left corner of the page along with a picture of the sun.

            1. The values for outside air temperature and humidity are to reference the local program if one is available.

                a. Remember that the local program should be getting its outside air conditions from #oa_conditions if it is setup correctly.

            2. If local outside air conditions are not available in the local program, then these values are to reference **exp:#oa_conditions/temperature** for temperature and **exp:#oa_conditions/humidity** for humidity.

            3. In either case, clicking on the sun will direct the user to the page associated with **#oa_conditions**.
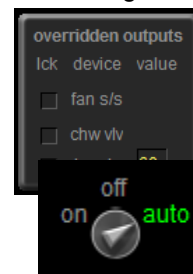
    b. Floor Plans

        i. All floor plans shall include room numbers.

        ii. All floor plans shall include an accurate location of space temperature, humidity and CO2 sensors.

        iii. All floor plans shall include a North Arrow
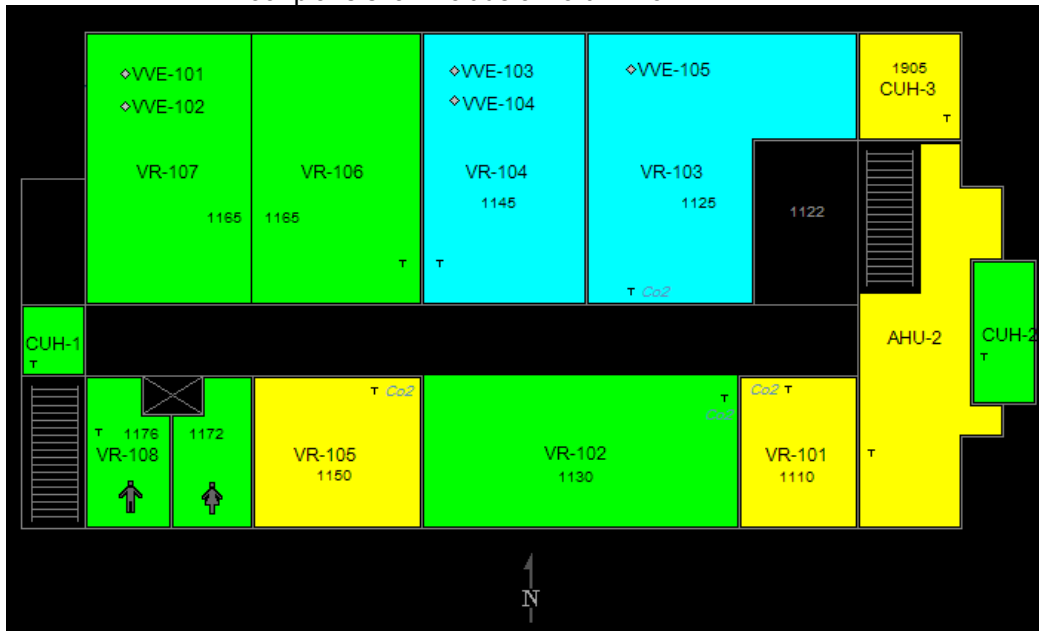
    c. Equipment Graphic Screen Locked Values

        i. All screens that primarily show mechanical equipment that is being controlled by the associated program shall have an HOA block that contains check boxes for the locked status of each output and value boxes for the locked value of each output in the lower left corner of the screen.

        ii. The locked value is to be hidden unless the value is locked to a value.

    d. Equipment Screens Master Hand/Off/Auto

        i. All equipment screens are to have master HOA switch located near the top/middle of the screen.

11. Construction Server

    a. RIT maintains multiple WebCTRL Servers. One of the servers, Webctrl03 is designated the "Construction" server.

    b. All new large scale projects shall be put on the construction server as soon into the project as possible to facilitate coordination between RIT and the contractor and to allow observation of building performance during the construction phase.

    c. While the Construction server is expected to be online the majority of the time, it is also expected and acceptable to have frequent interruptions of service to update controls programming.

    d. When the project is 100% complete, the controls contractor and RIT Building Controls Dept. shall be coordinate the transitioning of the project from the construction server to the appropriate production server.

12. Fan Arrays (Fan Wall)

    a. Air moving equipment with Fan Arrays shall be integrated into controls with the following properties:

        i. There shall be no black box controlling the fan array. This includes devices which speak BACNet and have BACNet integration.

            1. Control of the fan array shall be performed directly by the RIT ALC control modules.

            2. It is acceptable and encouraged to integrate the VSD BACNet bus into the ALC system for monitoring purposes.

        ii. The fan array shall have at minimum the following points

            1. DI – Status of each Fan

            2. DO – Start / Stop of each Fan

            3. AO – Speed control of the fan array. A shared AO can be used for all Fans.

            4. AI – Speed Feedback for each Fan

            5. AI or BACNet – Power use (kW or HP) for each Fan

            6. DI – Alarm Status for each Fan

13. Control Panels and Control Panel Drawings

    a. All control panels shall have spring loaded terminal blocks and Panduit.

    b. All control panels must be clearly labeled on the exterior of the panel.

    c. All wires entering or exiting the control panel must be labeled with permanent labels and adhere to the wire coding color standard list in the RIT Electrical Guidelines.

    d. All relays must be labeled with permanent labels.

    e. All work must be neat and tidy.

    f. Panel drawings shall include endpoint terminations on any field device that has wiring designations.
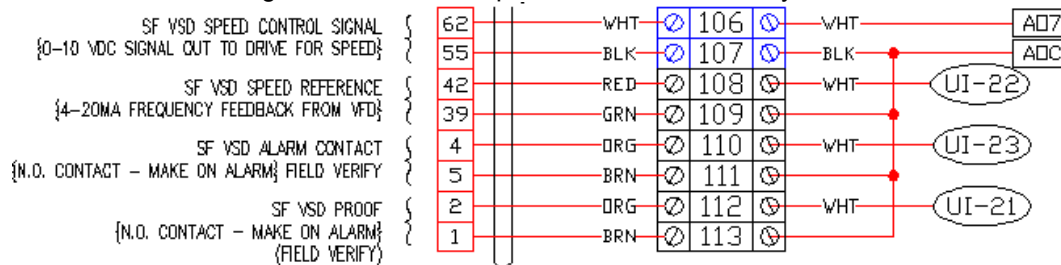
    g. Terminal Block Colors

        i. Gray   -   Inputs

        ii. Red   -   Power

        iii. Blue   -   Outputs

        iv. Yellow -   Interlocks

    h. In Panel Wire Colors

        i. White   -   Inputs and Outputs signal wire

        ii. Black   -   Inputs and Outputs common wire

        iii. Red   -   24VAC Power

        iv. Blue   -   24VAC Common

        v. Orange/Purple - 24VDC Power

        vi. Green -   Ground

    i. Fan Safety wiring

        i. Each fan safety device shall have a dedicated relay in the control panel with a permanent label indicating which device the relay corresponds with.

            1. Each relay shall have multiple throw sub circuits.

2. Each relay sub circuit shall be used to interrupt the power or continuity to one critical system.
   a. Example:
      i. Throw 1 – Supply Fan Safety Interlock
         1. If the circuit is open the fan will not run
      ii. Throw 2 – Return Fan Safety Interlock
         1. If the circuit is open the fan will not run
      iii. Throw 3 – Damper Power
         1. If the circuit is open, then the power to the dampers will be interrupted and the dampers shall use "spring" power to return to the safety position
      iv. Throw 4 – Valve Power.
         1. If the circuit is open, then the power to the valves will be interrupted and the valves shall use "spring" power to return to the safety position

ii. Each safety relay shall be energized through the safety devices NC contacts such that the relay coil is energized when the safety device is in the normal (non- alarm) state.

iii. If a safety device transitions into the alarm state then the corresponding relay shall de-energize.

iv. The safety circuit shall be wired in series through the NO contacts of all safety relays, such that if any safety device enters the alarm state or is simply disconnected the safety circuit is opened and the fan shall shut down.

v. The safety circuit shall be wired to the fan or VSD in such a way as it cannot be easily bypassed with user intervention. For example the Hand switch on a VSD shall not allow the fan to run if the safety circuit is in alarm.

14. Riser Drawings
a. Riser drawings shall show a schematic layout of controller network connections. This is to enable the correct order that the controllers are physically connected. This is to aid with network troubleshooting.
b. Riser diagrams shall include a dashed line around any controllers that are in a panel with a designation of the panel name and location. If multiple controllers are located in the same panel, then all controllers in that panel shall be inside the same dashed line.
c. Riser diagrams shall include network addresses, controller models, terminators, and equipment served by each controller.
d. Riser diagrams shall be integrated with any existing network diagrams that they are to be connected with.

15. Floor Plan Drawings
a. Building Management/Control drawings shall include:
   i. The accurate location of each controller and control panel
   ii. The accurate location of each terminator and network diagram
   iii. The accurate location of network wires and network terminations
   iv. The accurate location of any low voltage power panels that are part of the controls.
   v. The accurate location of field sensors.

16. WebCTRL Trees
a. Mechanical Rooms
   i. An area will be setup for each mechanical room. The equipment for this mechanical room shall be included under the area for that mechanical room.
   ii. The mechanical room area shall show a schematic floor plan layout of the room with approximate equipment locations.
   iii. Each piece of equipment shall be on the area floor plan with a color indication and a link to the equipment.
b. Each building shall have an area named "Chilled Water" if it is applicable
   i. This area will show a schematic representation of all the main chilled water piping and sensors in the building and how it connects to the campus chilled water system.
   ii. There will be links to each piece of equipment that is related to the chilled water.

iii. The intent is to see an overall representation of all the chilled water equipment in one place and to have an easy way to link to the various pieces of equipment which are likely located under mechanical room areas.

c. Each building shall have an area named "Hot Water" if it is applicable
   i. See Chilled Water above
d. Each building shall have an area named "AHUs"
   i. This shall be a single graphic containing a list of each AHU in the building.
   ii. The list shall contain all the AHUs regardless of which system the controls are on.
   iii. The list shall include Name, Location, Color, SF Status, RF Status, DAT, Supply Static, Filter Static 1, Filter Static 2, Filter Status 1, and Filter Status 2 as applicable.
   iv. The name shall be a link to the equipment program location if applicable.

17. Commissioning

a. Temporary Server
   i. All primary commissioning is to be performed on a local copy of WebCTRL or on the RIT Construction server, not on the RIT WebCTRL production server. The local WebCTRL is to be owned and operated by the contractor.
   ii. Larger projects are typically placed on the RIT Construction server during the commissioning process at the discretion of the RIT Controls department.
   iii. Prior to moving the project database from the construction server to the RIT production server the following shall be completed. The TC contractor shall review the project installation, confirm all details including but not limited to: DDC panel drawings, wire labels, VFS, disconnect, VAV and thermostat labels are complete and alarms shall be adjusted per Section 17.b.i (See Below)
   iv. When the project is completed and fully commissioned, the project database shall be moved to the RIT Production server.

b. Alarms
   i. Commissioning includes analyzing alarms from operating equipment. Through a combination of adjusting alarm parameters and adjusting operating parameters, the commissioning agent is responsible to ensure that the equipment does not produce false, meaningless or un-useful alarms. Every alarm should be relevant and important.

c. Point Checkout
   i. The point checkout properties page shall be used and checked off as part of the commissioning process.
   ii. All physical points for every controller shall either be checked out on or have a note explaining why it is not checked out on the "IO Points" page.
   iii. All network points for every controller shall either be checked out on or have a note explaining why it is not checked out on the "Network Points" page.
   iv. Each operator will be logged into WebCTRL under his/her own name for the point checkout. Do not use a company login.
   v. All points relevant to airflow or water flow shall be checked out and operational before the balancer is on-site to balance the system.
   vi. At the completion of the project the contractor shall create a point checkout report for all controls in the project and submit it to FMS controls for review.

d. PIDs
   i. PIDs are to have a deadband.
   ii. PIDs will be tuned so that the controlled output performs smoothly, without excessive oscillations and within parameters.

e. The following "As-Built" documentation is required:
   i. DDC Control Panel and Base Wide I/O Point Summary List
   ii. I/O Points Test List
   iii. Control Schematics
   iv. Initial Setup Value
   v. Hardware, software job specific documentation
   vi. Trend logs including setpoints, operating points, valve positions, etc.
   vii. As-Built drawings shall be provided in each DDC Cabinet. Drawings shall be at least 11"x17".

18. Sequences
    a. Heating / Cooling Source Trees
        i. All equipment able to do so is to be setup in the heating and cooling source trees.
        ii. If a sequence calls for something similar but not exactly the same as the ALC Optimized setpoint, talk to sequence designer about using Heating/Cooling source trees instead. It is easier to work within the intended ALC system than designing your own for each project. It also provides more consistent programming and operation to use the resources provided by ALC.
        iii. Use RIT mbh logic program and trend for installed hot water and chilled water coils.
    b. Heating Valves
        i. Heating valves will use one of the two following sequences for unoccupied mode.
            1. If the OA is above 45F and it is valid, then close the heating valve. If the OA is below 45F, then open the hot water valve to 50% open.
            2. If the OA is above 45F, then the hot water valve is allowed to modulate to maintain the hot water coil leaving air temperature setpoint.
                a. Use this method if there is a temperature sensor located in close proximity to both the heating coil and cooling coil.
        ii. Heating valves will be commanded to 50% open on a freezestat trip.
            1. Reason #1: Sometimes the direction of the hot water valve becomes reversed from the desired direction. If this valve is commanded to 50% then it does not matter if the valve direction is reversed or normal, in either case the coil will get a significant amount of water.
            2. Reason #2: It should not be necessary to direct 100% flow through the hot water coil to prevent freezing. By limiting the valve to 50%, more flow is available for the rest of the hot water system.
        iii. All PICV valve installations shall include a valve schedule and PICV ring positions as included.
    c. Air Handling Units
        i. OA Damper on startup
            1. As normal when the fan is off, the outside damper will be 0% open. Add in additional sequences so that when the fan first starts, the outside air damper is not allowed to open 100% right away. Instead the OA damper will be allowed to open at most 1% every 6 seconds (adjustable). This delay is only at unit startup.
                a. The intent is to prevent the freezestat from tripping and to prevent the outside air damper from oscillating.
        ii. HW Valve on startup
            2. If the HW valve is partly or fully open due to an unoccupied sequence, then the HW valve will only be allowed to close down 1% every 6 seconds. This is to prevent the discharge air from getting too cold too quickly and tripping the freezestat or freezing the coil. This delay is only at unit startup.

19. Wiring
    a. General
        i. Remove all unused wires associated with the project. Do not leave abandoned wiring in the field.
        ii. If a project description does not include removal of old control wiring and it is known that there will be abandoned control wire, then submit an alternate to remove all the old control wiring at time of bidding.
    b. Network wiring
        i. Always install ARCNet compatible communication wiring even when connecting to MS/TP devices. Ensure that the network wire is rated for both MS/TP and ARCNet.
        ii. When removing controllers or wires from the middle of a control network segment do not leave bug connections in the field. Instead pull one new network wire to span the sections that were removed so there is one continuous network wire from one device to the next. Control contractor to leave in operating condition.

        iii. Jacket Color
            1. Backbone ARCNet – Dark Green
                a. Backbone is the ARCNet directly connected to the Main Gateway such as the LGR on one end and connected to field gateways and some field devices.

  2. Secondary ARCNet – Light Green or Yellow
    a. Secondary is the ARCNet originating at a field gateway such as an AAR and connecting to field devices.
  3. Third Party MS/TP - Purple

 c. Network Sensor Wiring (RNet)
  i. Use 22/4 stranded, plenum rated, non-shielded with orange jacket rated for logistat or RNet use.
  ii. Conductors
    1. Black – Net –
    2. White –Net +
    3. Red 12V+
    4. Green – Ground

 d. Generic Sensor Wiring (Non-Networked)
  i. Use 18/2 stranded, shielded, plenum rated wire with white jacket, black and white conductors.
    1. Ground wires should be trimmed from the sensor end of the wire. A piece of tape should wrap the end of the jacket to conceal the remainder of the ground wire and shield.
    2. At the panel end of the sensor wire, leave the ground wire intact and wrap the ground wire around the wire jacket and use electrical tape to conceal the ground wire.
      a. If there are any sensor issues the ground wire is to be grounded at the panel only.

20. Miscellaneous

 a. WebCTRL shutdowns
  i. Give 24 to 48 hour advanced notifications for WebCTRL shutdowns.
  ii. For a shutdown that is expected to last for less than 30 minutes
    1. Broadcast a notification message on WebCTRL 15 minutes ahead of time. "WebCTRL will be shutting down in 15 minutes for maintenance. Expected downtime is XX-XX minutes."
    2. Broadcast a second notification message on WebCTRL one minutes ahead of time. "WebCTRL will be shutting down in ONE minute for maintenance. Expected downtime is XX-XX minutes."
  iii. For a shutdown that is expected to last for more than 30 minutes
    1. Send out an e-mail a day before to all RIT engineers and contractors using WebCTRL notifying them of the shutdown.
    2. Additionally, follow the procedure above 15 minutes and 1 minute before the actual shutdown.
 b. Clarifications
  i. "Zone equipment" refers to the equipment that controls the environment for a zone. For an example, a VAV that controls the environment for one room, that room being a zone. Three rooms controlled by a VAV count as one zone together.