# Product Manual

TCS Basys Controls®


## SZ2166

Chiller Controller

SUPERTROL™ Communicating Controls

## Description

The SZ2166 is a microprocessor based chiller controller. It is designed for use on multi-stage chiller applications and includes boiler support and control.

## Features

- Stand-alone or network operation
- 365-day time clock with two holiday schedules, automatic leap year and daylight saving correction
- No backup battery required for control parameters, schedule or clock
- Hot water supply and return temperature inputs
- Chilled water supply and return temperature input
- Two digital outputs for boilers
- One digital output for alarm
- Mixed water temperature input
- Outdoor air temperature input
- Separate set point for ice making sequence
- Outdoor air reset control
- Two digital inputs for pump status
- External time clock input
- Six digital outputs for chillers, pumps and chiller stages
- Adjustable offsets and differentials on digital outputs
- Lead/Lag sequencing of up to four chillers
- Two modulating analog outputs for valves and VFDs
- Adjustable P+I+D control on modulating outputs
- LEDs for monitoring status
- Automatic rotation of pumps
- Automatic rotation of chiller and boiler stages
- Pump lube feature

## Contents



## Mounting

The SZ2166 is designed for mounting using four #10 sheet metal screws. Prior to mounting, the jumpers should be placed. (See setup instructions.) If the unit will be stand-alone, all programming should be completed. If the unit will be wired for communications, a unique address should be programmed into the unit. (See programming instructions.)

# Wiring

The SZ2166 terminal designations are shown below.

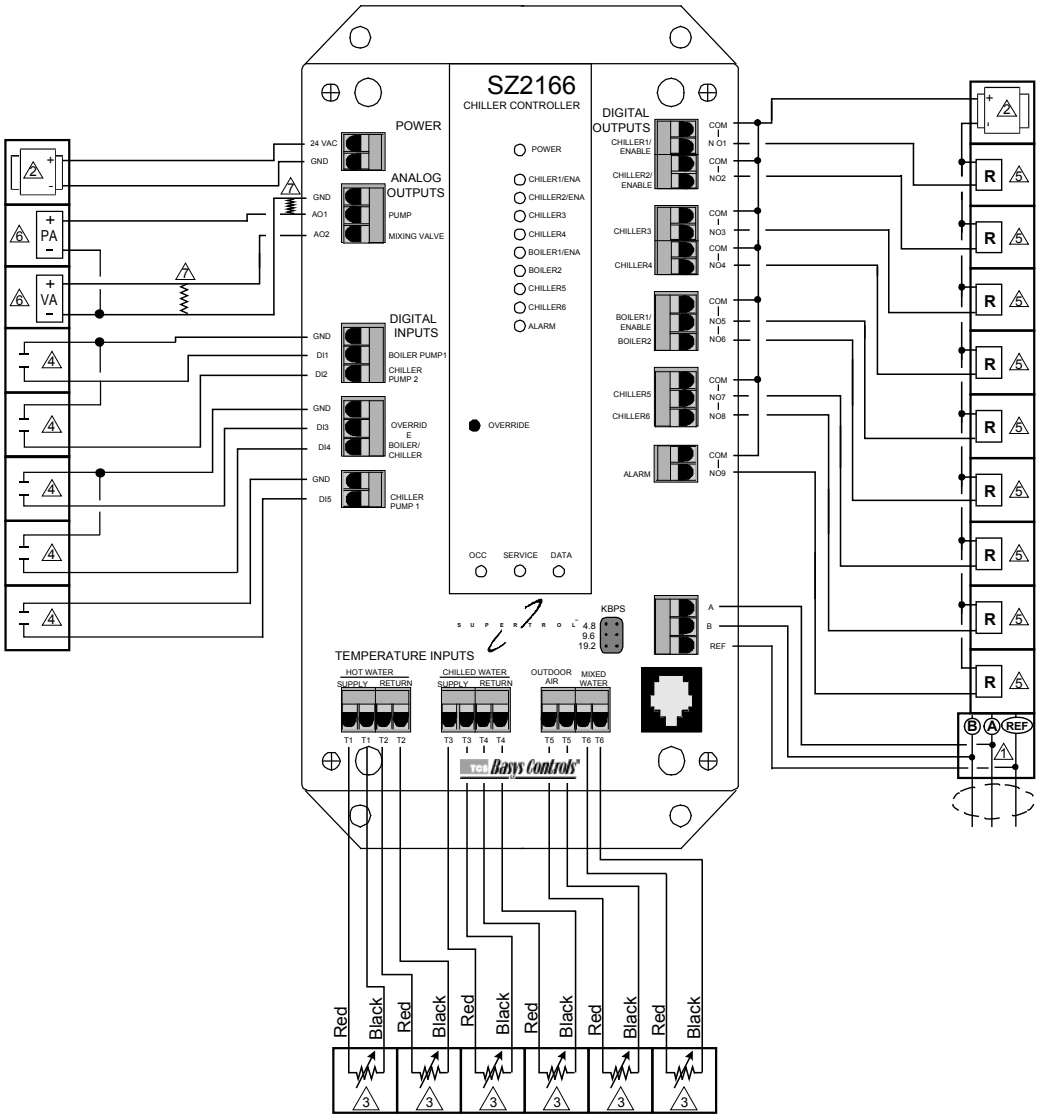
## REMOTE SENSOR WIRING

The SZ2166 accepts six 1000 Ω two-wire platinum sensors. Consult the TS Series Temperature Sensor submittal datasheet for a complete listing of packaging and application styles. When using TCS Basys Controls three-wire sensors, use the black and red leads, and either clip or twist off the white lead. The wiring length should not exceed 250 feet.

## POWERING THE SZ2166

The SZ2166 is powered from 24 VAC +/- 20 %. If wiring for communications, dedicated power must be used to power the SZ2166. Several S-series controllers may be powered from the same transformer, provided that the transformer has enough power.

**Caution:** When multiple TCS/Basys Controls devices are using a single transformer, the polarity of the power wiring must be maintained because all TCS devices are half-wave rectified.

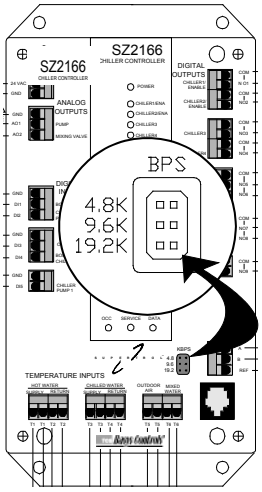


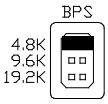

1. For communication wiring, use twisted, shielded 22 AWG. Must be run separately.
2. 24 VAC transformer. See powering instructions.
3. Sensor input wiring 18 AWG, twisted, shielded pair.
4. Dry contact. Must not be powered.
5. External relay. 24 VAC Coil
6. 4 to 20 mA output. 600 ohm max. Do not power actuator with power from the controller. The controllers are half-wave rectified, whereby the power ground is common with the signal ground.
7. Add 500 ohm resistor (included in bag) to convert 0/4 to 20mA to, 0/2 to 10 VDC.

# Setup

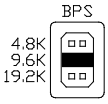
## BAUD RATE SELECTION

The SZ2166 must be programmed using a PC and TCS Basys Controls software. A communication baud rate must be set by placing one jumper in the area shown above. This baud rate must be the same for all devices.

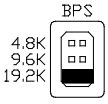



For a 4.8K baud rate.




For a 9.6K baud rate.




For a 19.2K baud rate.

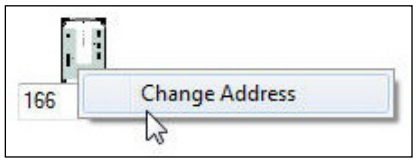
# Programming

The SZ2166 must be programmed with a PC. A jack on the face allows local access for programming. If you plan to program the controller while it is on a network, prior to putting the controller on the network, a unique address must be set in the controller by accessing it through the port on the front.

For more information on programming using a PC and the TCS Insight software, consult your TCS software manuals.

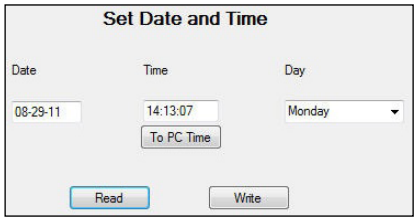
## CONTROLLER ADDRESS

The factory default address for an SZ2166 is 166 . On the "Network> Poll" tab, right click on the desired controller and select "Change Address from the menu that appears. Next, select the desired address from the use the drop-down menu and hit ENTER. Finally, click "Yes" in the Change Controller Address window that appears.



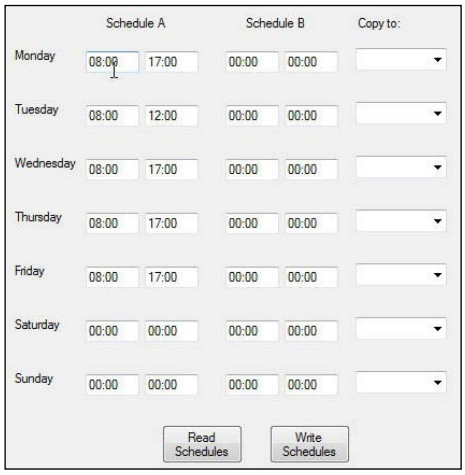

## INTERNAL TIME CLOCK

On the "Schedules> Date and Time" tab, you can see and modify the controller's time (military time), day of the week, date and year. Click on "Read" if you would like to see the current time, day of week and date in the controller. Click on "To PC Time" read these parameters from your computer instead and automatically program them into the SZ2166. Finally you can click on "Write" to send the updated time, day of week, and date to the controller.




## EVENT SCHEDULING

There are two occupied time periods per day, and thus two time schedules (A and B). Let us say that the occupied time for a particular day is from 8:00AM to 12:00PM and from 1:00PM to 5:00PM. In the "A" schedule you could enter 8:00 to 12:00, and in the "B" schedule you could enter 13:00 to 17:00. You can reverse the "A" and "B" schedules also. You can also enter 8:00 to 17:00 for the "A" schedule and 0:00 to 0:00 for the "B" schedule. 0:00 (12:00AM) starts the day, and 24:00 (12:00AM) ends the day. Occupied times that span midnight have to be coordinated using time schedules of two days.




## HOLIDAY 1 / HOLIDAY 2

Two sets of holidays can be programmed, each using a different occupied/unoccupied time schedule. To program holidays into the controller, enter the dates as well as the length in days, for all of your holidays.

## MONITORING

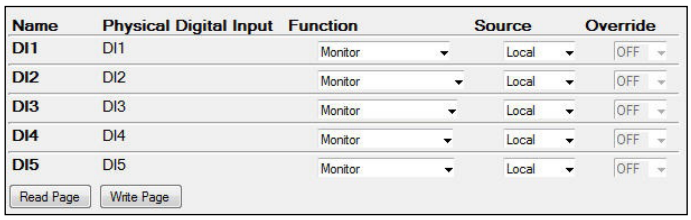
The "Monitoring" tab displays the current temperatures and the status of all inputs and outputs. These values are automatically read when accessing this tab initially and are automatically refreshed periodically while viewing the tab. By right clicking on a particular point, you can view a live graph of that point over time.


## SERVICE/ALARM STATUS

If the "Service" LED is ON, the Service Status field on the in the Monitoring TAB shows more specific information as to why

the Service LED is ON.

## DIGITAL INPUTS




Select whether you want “DI”, “DI2”, “DI3”, “DI4” or “DI5” to be “Local” or “Remote”. Local means that the controller uses its own control program when looking at these inputs. Remote means that it will take a PC to make any changes to these inputs.

### DI1

DI1 can be used for “Boiler Pump Proving” or “Monitoring”. If Boiler Pump Proving is selected, the controller will turn on the Boiler Pump and then wait 30 seconds to make sure the Pump is on (DI1 is shorted). This can be accomplished with a flow switch, current switch or some other device. Any time the Boiler Pump is on but DI1 is not shorted, “Heating” will be shut down.

### DI2

DI2 can be used for “Chiller Pump 2 Proving” or “Monitoring”. If Chiller Pump Proving 2 is selected, the controller will turn on the Chiller Pump and then wait 30 seconds to make sure the Pump 2 is on (DI2 is closed). This can be accomplished with a flow switch, current switch or some other device. Any time the Chiller Pump 2 is on but DI2 is not shorted, “Cooling” will be shut down. To restart cooling, you must short DI2 to GND.

### DI3

DI3 can be used for “Monitor”, “External Override” or “External Time Clock”. If External Override is selected, the controller will use its built in time clock and schedule to determine whether to be occupied or unoccupied, and will also be occupied as long as DI3 is On (Shorted). If External Time Clock is chosen, the controller will not use its built in time clock and schedule to determine whether to be occupied or unoccupied. The thermostat will be occupied as long as DI3 is On (Shorted) and unoccupied as long as DI3 is Off (Open).

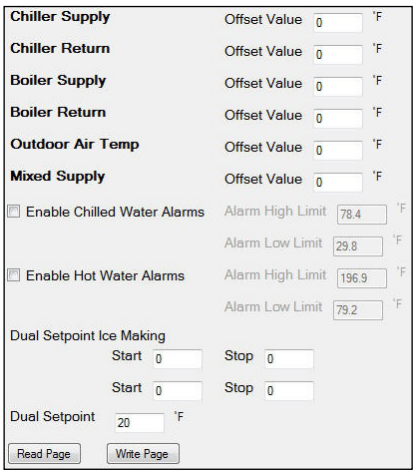
### DI4

DI4 can be used for a “Boiler/Chiller Alarm” input (High Temperature, Low Water Level, etc.) or just “Monitoring”. In either case, this input is monitored.

### DI5

DI5 can be used for “Chiller Pump Proving” or “Monitoring”. If Chiller Pump Proving is selected, the controller will turn on the Chiller Pump and then wait 30 seconds to make sure the Pump is on (DI5 is shorted). This can be accomplished with a flow switch, current switch or some other device. Any time the Chiller Pump is on but DI5 is not shorted, “Cooling” will be shut down.

## TEMPERATURE INPUT CALIBRATION




The six temperature inputs are factory calibrated. However, depending on the application (long wire runs, etc.), there may need to be a field adjustment done to these readings. The “Adjusted Reading” is the reading that the SZ2166 actually uses for control. The “Offset Value” is the number of degrees that the actual input temperature has been adjusted. For example: You measure the hot water supply temperature and it reads 71°. The SZ2166 reading is 72° and the Hot Water Supply Temperature already has an offset of -2.0°. All you need to do is change the offset value to -3.0° and you’re done. The SZ2166 will now read 71°.

The Hot Water Supply and Return inputs are scaled 40 to 240°F (4.4 to 115.6°C). The Chilled Water Supply and Return inputs are scaled 0 to 100°F (-17.8 to 37.8°C). The Mixed Water input is scaled 20 to 220°F (-6.7 to 104.4°C). The Outdoor input is scaled -40 to 160°F (-40 to 71.1°C). These ranges are fixed and cannot be changed.

## HOT WATER ALARMS

Choose whether to enable High and Low Hot Water Temperature Alarms. You will then need to enter High and Low Hot Water Temperature Limits.

## CHILLED WATER ALARMS

Choose whether to enable High and Low Chilled Water Temperature Alarms. You will then need to enter High and Low Chilled Water Temperature Limits.

## DUAL SETPOINT

The SZ2166 provides an option for what is called “Dual Setpoint”. This will allow control of chilled water at some lower temperature during the unoccupied time period with the intent of making ice for consumption the next day.

**NOTE:** *This function is performed 7 days a week.*

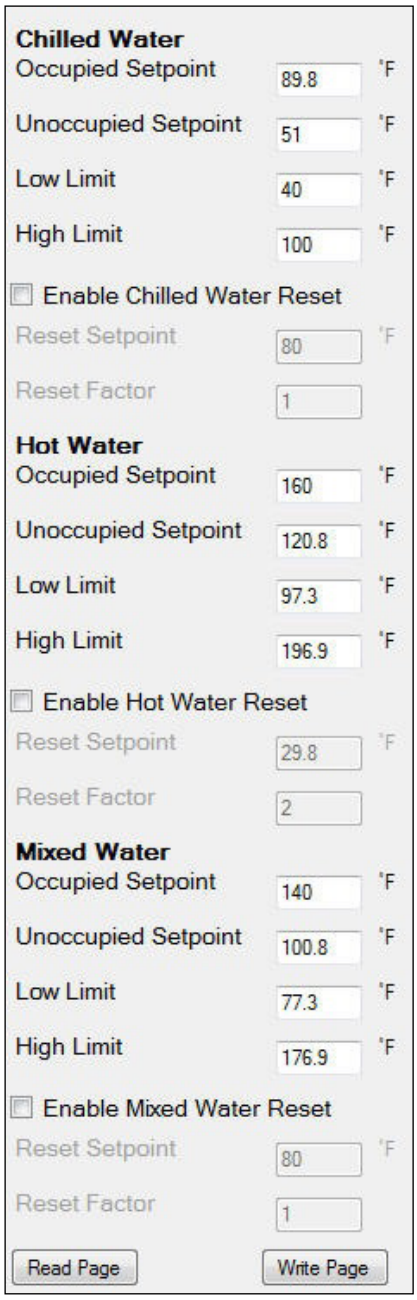
Here you must enter a time period (in military time) when this alternate setpoint will be used. Enter the starting hour and ending hour of the current day, and the starting hour and ending hour of the next day. Next enter the Dual Setpoint to be used.

For example: Suppose we wish to run our chiller every day from 9PM until 5AM at a reduced setpoint of 25°F (-3.9°C). For the current day, select “21” as the start time for the current

day and “24” as the end time for the current day. Select “0” as the start time for the next day and "5" as the end time for the next day. Enter 25 in the Dual Setpoint location.

## SETPOINTS

Enter the Occupied and Unoccupied temperature setpoints for the Hot Water Supply, Chilled Water Supply and Mixed Water. Also enter a High and Low Setpoint Limit for each, if desired.




## RESET

The analog outputs and digital output stages on the SZ2166 can be setup to use a reset function. This is done by placing a check in the appropriate “Enable Reset” box. When using the reset function, the Hot Water Supply, Chilled Water Supply and/or Mixed Water are the “Primary” temperature inputs and the Outdoor Air Temperature is the “Reset” input.

You need to enter primary occupied and unoccupied setpoints in the “Setpoints” section above. These setpoints will be adjusted up and down based on the outdoor air temperature, the reset setpoint and the reset factor. The analog output(s) and digital output(s) will be controlled using these calculated setpoint(s).

You need to enter a reset setpoint. A comparison between the outdoor air temperature and this setting will be used in determining the calculated setpoint for each respective input.

You need to enter a reset ratio factor. This is the number of units that the respective input setpoint is raised when the outdoor air temperature falls below the reset setpoint by 1 unit, or the number of units that the respective input setpoint is lowered when the outdoor air temperature rises above the reset setpoint by 1 unit.

**Example -** A hot water valve is controlled using an outdoor air reset schedule. If the outdoor air temperature is 0°F, the hot water temperature is controlled at 200°F. If the outdoor air temperature is 60°F, the hot water temperature is controlled at 80°F.

The hot water supply temperature setpoint is set to 140.

(200 + 80) / 2 = 140

The reset setpoint for the hot water supply temperature is set to 30.

(0 + 60) / 2 = 30

The reset factor for the hot water supply temperature is set to 2.

(200 - 80) / (60 - 0) = 120 / 60 = 2

## OUTPUTS

For the Pump Outputs you need to enter Occupied and Unoccupied Outdoor Air Temperature Setpoints.

For a “Cooling” output (Chiller Stages) the relay energizes when the input equals the “Chilled Water Setpoint” + “Offset” + “Differential” and de-energizes when the input falls to the “Chilled Water Setpoint” + “Offset”.

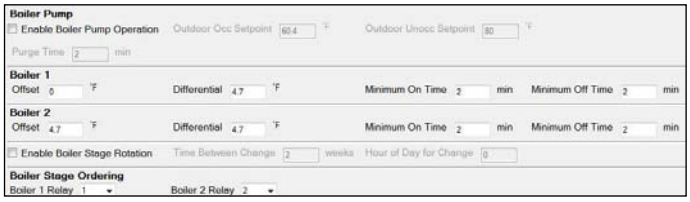
For a “Heating” output (Boiler Stage(s)) the relay energizes when the input equals the “Hot Water Setpoint” - “Offset” - “Differential” and de-energizes when the input rises to the “Hot Water Setpoint” - “Offset”.

Enter the “Offset” and “Differential” values here.

## DELAYS

Enter the “Minimum ON” and “Minimum OFF” times (in seconds) here for all of the output stages, as well as a “Purge Time” and “Minimum ON and OFF” times (in minutes) for the Loop pump. A “Purge Time” is the amount of time (in minutes) that the pump will continue to run after all of the stages are off.

## BOILER 1 / PUMP ENABLE




Boiler stage 1 can either be the first of two stages of boiler control, or it can be treated like a pump (or enable) function. If selected as a pump (or enable) function, outdoor air temperature will determine when this output energizes. If selected as boiler stage 1, hot water temperature will determine when this output energizes.

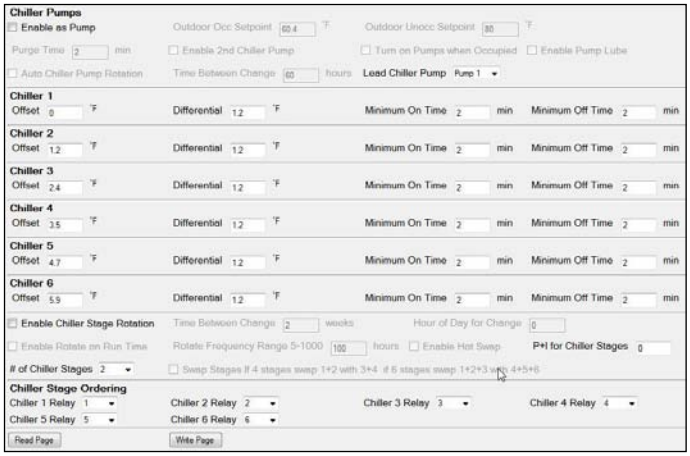
## BOILER STAGE ROTATION

Choose whether to enable Boiler Stage Rotation. Boiler rotation is cyclical, i.e. before rotation, Boiler 1 is the first stage and Boiler 2 is the second stage. After the rotation, Boiler 2 is the first stage and Boiler 1 is the 2nd Stage. If using Boiler Stage Rotation, select the number of weeks between rotations and select the time of day which you would like the rotation to occur.

## BOILER STAGE ORDERING

Select the boiler stage ordering here. The term Boiler refers to the physical connections to the SZ2166. The term Stage refers to the order in which the boiler stages cycle on and off. The factory default is to have Boiler 1 be Stage 1 and Boiler 2 be Stage 2. Note: the boiler stages can be placed in any order whether using boiler rotation or not. Boiler Stage 1 must not be enabled as a “Pump” when using rotation. If boiler rotation is used, this is the starting order, after which the boiler stages will be rotated in order.

## CHILLER / PUMP ENABLES




Chiller stage 1& 2 can either be the first two of six stages of chiller control, or they can be treated like a pump (or enable) function. If selected as a pump (or enable) function, outdoor air temperature will determine when this output energizes. If selected as chiller stage 1, chilled water temperature will determine when this output energizes.

For program version 1.1 and greater, Chiller stage 1 can either be the first of six stages of chiller control, or it can be treated like a pump (or enable) function. If selected as a pump function, outdoor air temperature will determine when this output energizes. If selected as chiller stage 1, chilled water temperature will determine when this output energizes. Chiller stage 2 can either be the first of five stages of chiller control, the second of six stages of chiller control or it can be treated like a second pump. If selected as a second pump function, then if the first pump (chiller stage 1) fails, the second pump (chiller stage 2) will energize if DI5 is set to Chiller Pump Prove. Also there then is an option to rotate the "pumps" based on the number of hours of operation.

## LEAD CHILLER PUMP

When both stages are as a pump/or enable function. You can also choose whether the first or second pump (chiller stage 1 or chiller stage 2) will be the lead pump.

## CHILLER STAGE ROTATION

If Chiller Stage 1 was not selected to be a pump in the above step, choose whether to enable Chiller Stage Rotation. If using Chiller Stage Rotation, select the number of weeks between rotations and select the time of day which you would like the rotation to occur.

## CHILLER STAGES

Select the number of Chiller Stages which will be used in the Chiller Stage Rotation.

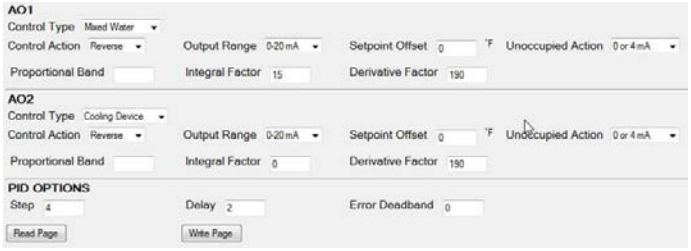
## PROPORTIONAL + INTEGRAL

The Proportional + Integral function implements a way to anticipate the need for cooling using the chiller stages. This function works in conjunction with the programmed offsets and differentials. Select whether to enable the Proportional + Integral function. By default, this function is disabled when the “Integral Setting” is zero. When enabled, the integral setting can be from 1 to 255. Larger numbers speed up the response, while smaller numbers slow down the response.

## CHILLER STAGE ORDERING

Select the chiller stage ordering here. The term Chiller refers to the physical connections to the SZ2166. The term Stage refers to the order in which the chiller stages cycle on and off. The factory default is to have Chiller 1 be Stage 1, Chiller 2 be Stage 2, Chiller 3 be Stage 3 and Chiller 4 be Stage 4; etc. Note: the chiller stages can be placed in any order whether using chiller rotation or not. If chiller rotation is used, this is the starting order, after which the chiller stages will be rotated in order. If Chiller Stage 1 is enabled as a “Pump”, then only stages 2 through 6 will be rotated.

## ANALOG OUTPUT 1




Analog output one on the SZ2166 can be used to control Chilled Water Supply Temperature or Mixed Water Temperature. Choose how analog output one will be used by selecting the desired operation mode from the drop-down.

***NOTE:*** *If Mixed Water is selected, AO1 will be used to control the Mixed Water Temperature independent of Hot Water or Chilled Water control.*

During the occupied time, an analog output modulates to maintain a heating or cooling temperature setpoint. During the unoccupied time you will need to choose whether the analog output will modulate, remain at 20mA, or remain at (0 or 4)mA.

A proportional band (throttling range), whether you want the analog output to modulate from 4 to 20mA or 0 to 20mA, and direct or reverse action must also be programmed.

For control without “Integral” and “Derivative”, enter 0 for both. The proportional band is 0 to 100%, while the integral and derivative values are numbers from 0 to 255. The default PID values for AO1 are P=4, I=15, D=190. See the PID Control Factors section for more details.

## ANALOG OUTPUT 2

Analog output two on the SZ2166 can be used to control a Heating Device (based on Hot Water Supply Temperature) or a Cooling Device (based on Chilled Water Supply Temperature). You need to choose what analog output two will be used for.

During the occupied time, an analog output modulates to maintain a heating or cooling temperature setpoint. During the unoccupied time you will need to choose whether the analog output will modulate, remain at 20mA, or remain at (0 or 4)mA.

A proportional band (throttling range), whether you want the analog output to modulate from 4 to 20mA or 0 to 20mA, and direct or reverse action must also be programmed.

For control without “Integral” and “Derivative”, enter 0 for both. The proportional band is 0 to 100%, while the integral and derivative values are numbers from 0 to 255. The default PID values for AO2 are P=4, I=15, D=190. See the PID Control Factors section for more details.

### PID CONTROL FACTORS

There are three main factors involved in PID control - the proportional, the integral and the derivative factors. The proportional factor dictates how much gain the input signal error should be given with respect to the derivative and the integral error terms. A large integral factor will cause the output to respond quickly to changes on the input however the output could oscillate and overshoot the setpoint. A large derivative factor will cause the output response to be sluggish and slow to change and the output will settle above the desired set point. The derivative term is divided by the PID delay. The default values programmed at the factory are a good point; however, those values should be adjusted/tuned as needed for your particular installation to achieve the desired operation.

### PID OPTIONS

The default values are Step Constant=1, PID delay=10 and PID Error DB=0. The Step Constant determines how large of step the output takes - the larger the number, the smaller the step size. The Step Constant is typically 1, but should NEVER be 0 (doing so will cause the system to stay at full output). The Delay parameter specifies how quickly the output should evaluate error between the current output and the desired output. The PID delay can be used to offset a slow moving motor allowing the motor to catch up to its input signal before the error term is reevaluated. The Error Deadband allows the system to overlook error between the desired setpoint and the input signal to help the system stabilize. The Error Deadband is typically 0. It is predominantly used in a situation where a small amount of error would cause a large swing in the output or response (for example, CFM output versus supply or input pressure).

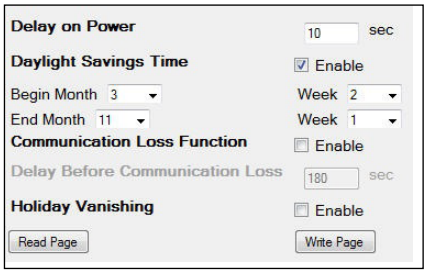
## OVERRIDE STATUS


The "Time Allowed" field is the number of minutes from 0 to 255 (4 hr., 15 min.) which the controller will hold an unoccupied system occupied, when its override button is pressed. You can also enable "Occupied Override" which allows the override to work during occupied periods. In that case, the controller would go from occupied to unoccupied when its override button is pressed.

## REMOTE OVERRIDE

In order to override the controller (put it to Occupied Mode), select “ON” from the drop-down and then click on WRITE PAGE. This will bring the controller to occupied mode for the amount of time set on the previous screen in the “Time Allowed” box. If the override time needs to be extended, make sure that "On" is selected and then click WRITE PAGE. This will restart the override timer. To stop the override, select “OFF” from the drop-down and then click on WRITE PAGE.

## DELAY ON POWER




On a loss of power, when the power comes back, the controller will wait this amount of time before starting to control. Different controllers in one building can have different delays so that all units don’t come on at the same time. Enter a delay time (in seconds) that you want the Controller to use on power up.

### DAYLIGHT SAVING TIME

Daylight Saving Time (DST) in the U.S. is currently from the 2nd Sunday of March to the 1st Sunday of November. Products shipped starting in 2007 with firmware version 1.5 or higher accommodate the new DST schedule. Products shipped starting in 2008 with firmware version 2.0 or higher accommodate the new DST schedule and have the ability to be programmed to accommodate any future schedules that may be used. Should the schedule change and you need to customer program the DST start and end dates, simply enable the "Daylight Saving Time" option within the software and enter the starting month + week and the ending month + week.

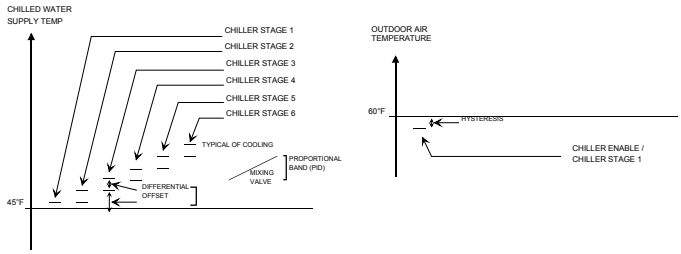
### COMMUNICATION FAILURE

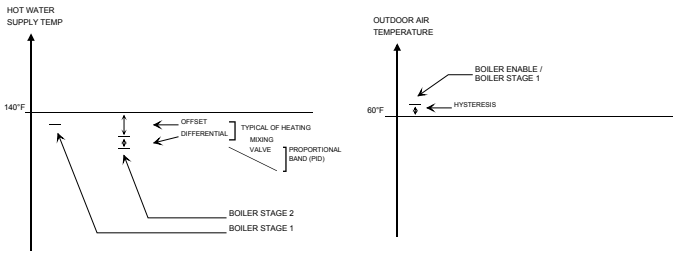
If "Enable Comm. Loss Function" is selected, the SZ2166 will go into occupied control mode if communications with it is lost and it will stay in the mode until communications returns. The "Delay Before Loss of Comm Function" value is the number of seconds the unit will wait after communications are lost before engaging the Comm. Loss Function. Be sure to set the Comm. Delay time to at least 60 seconds as the QD2040 and QD2010 poll the local controller network once per minute.

### HOLIDAY VANISHING

Choose whether to enable the Holiday Vanishing Feature. If checked, the SZ2166 will make the number of days for a holiday 0 after the holiday is over. This will keep the holiday from occurring in subsequent years if it is not reprogrammed.

## Sequence of Operation




## Checkout & Troubleshooting

### CHECKOUT

1. Be sure to check and verify all wiring before powering the SZ2166.
2. Turn power on. The SZ2166 “Power” LED should light up. Then the Service LED will blink for 15 seconds while the electronics stabilize.
3. If the SZ2166 has not been pre-programmed, it should be programmed at this time.
4. Increase and decrease the Heat and Cool setpoints. This must be done from a PC. Observe the operation of the relay stages and or analog output(s).
5. Note that the operation of the SZ2166 will depend on how it is programmed.

The SZ2166 is now ready for operation.

### TROUBLE SHOOTING

#### Power LED will not come on

Check for 24 VAC on terminals “24 VAC” and “GND”.
The rest of the trouble shooting must be done with a PC and the Revelation Professional software.

#### No communications

Make sure baud rate selection jumper for the QD1010 and the SZ2166 are the same, and that Revelation is configured for that same baud rate. Address 248 will always work provided that the SZ2166 is NOT connected to a network.

#### Inputs do not read correctly

The SZ2166 is calibrated at the factory. For the loop supply temperature and other temperature readings make slight adjustments (+/- 12% of the input span) on “Screen D” of the SZ2166 programming screens. (See Temperature Input Calibration on page 4.)

#### Output operation is not correct

Check programmed parameters, in particular “Reverse” and “Direct” acting selections and “Heat” or “Cool” selections for the analog outputs, and “Offset”and “Differential” selections and “Delay Times” for the relay outputs. Check wiring.
Thirteen LEDs on the unit allow the occupant to view the current operating status of the SZ2166.

## LED Description

**POWER**: This LED will be lit whenever the unit has power.

**DIGITAL OUTPUTS**: These LEDs will be lit when the corresponding relay outputs are on. Relay outputs include pumps, boiler stages, chiller stages, etc.

**OCC**: This LED will be on whenever the unit is operating in the occupied mode.

**SERVICE**: This LED will be on whenever the unit has a service condition. This LED also blinks on powerup until the electronics stabilize.

**DATA**: This LED will blink when the unit is being accessed by a PC.