

Application Note

Ctek Automation Control Application

APN007



Ctek – Things That Move Data

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Purpose:

Ctek's Automation Manager is a key component of the Ctek Automation framework that includes analog and digital I/O modules, power control modules, the PowerMinder power management feature, and the subject of this Technical Information Bulletin, the Automation Manager application.

APN007 addresses the administration and the configuration settings required when using various Ctek I/O modules and sensors. The operation of the Control Panel, a dashboard style feature is also covered.

Scope:

This Application Note specifically addresses the configuration and operation of the Automation Manager application which is available for all Ctek SkyRouters offering USB and/or RS485 communications including the Z4200U, Z4300U, and Z4400U. For use with other models contact Ctek.

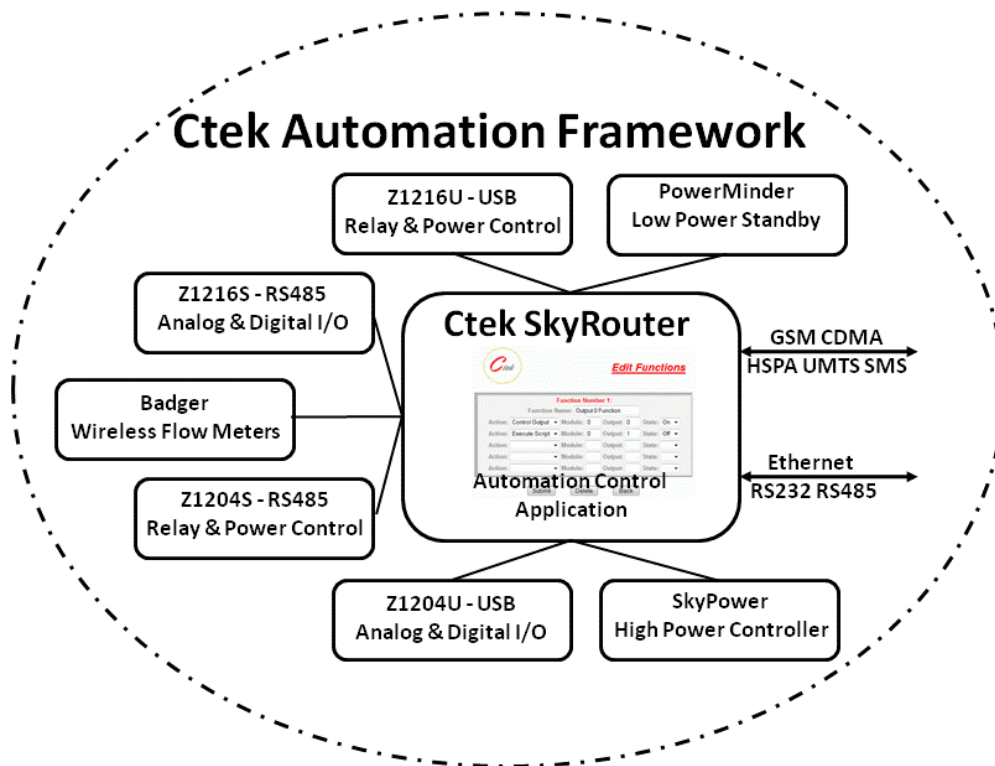


Figure 1 - Ctek Automation Framework



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Navigation and Top Level Functions:

When installed the Automation Control application is found under the applications selection on the top level SkyRouter administration screen. When selected the application presents the following navigation menu.

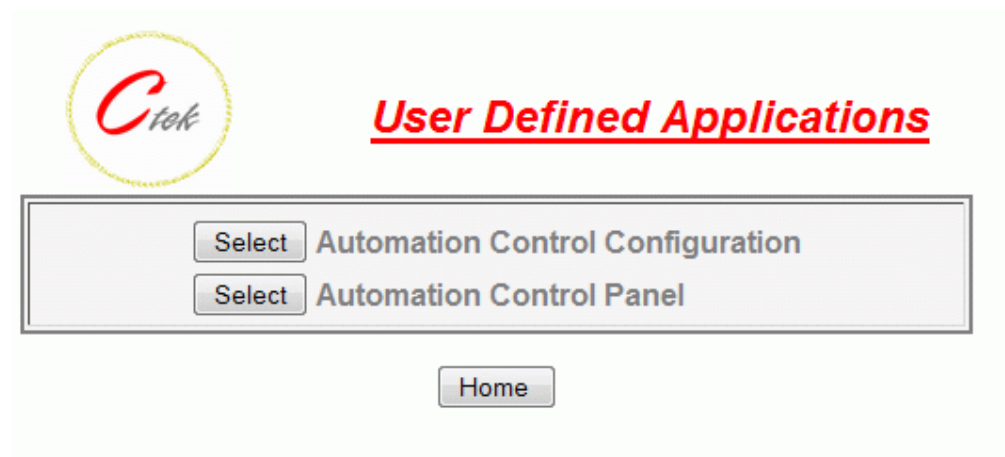


Figure 2 - Top Level Navigation

Automation Control Panel

The Automation Control Panel selections provides user access to a dashboard style control and display of inputs and outputs that have been previously selected. Portions of this functionality are covered in Unit Configuration, Inputs, and Outputs discussion. A complete description of the Control Panel is found after the configuration section.

Automation Control Configuration

The Automation Control Configuration selection provides access to the screens used to configure the application characteristics of the overall application environment, the number and type of I/O modules installed, specific characteristics for each input and output on each I/O module, and the formulas and functions that are applied to specific sensors and outputs.

For new installations the recommended sequence is:

1. Configure the unit
2. Configure the modules installed with this unit
3. Configure inputs on each installed module
4. Configure outputs on each installed module
5. Create and assign formulas as required
6. Create and assign functions as required



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Once configuration has been completed the selections are deployed using the Execute New Configuration button. If logging is used the Logs selection can provide useful information about system operation and can also be used to debug sensor and output installations.

Configuration Specifics

Selecting the Automation Control Configuration item presents the following menu from which the user can install, configure, and adjust settings on I/O modules and sensors.

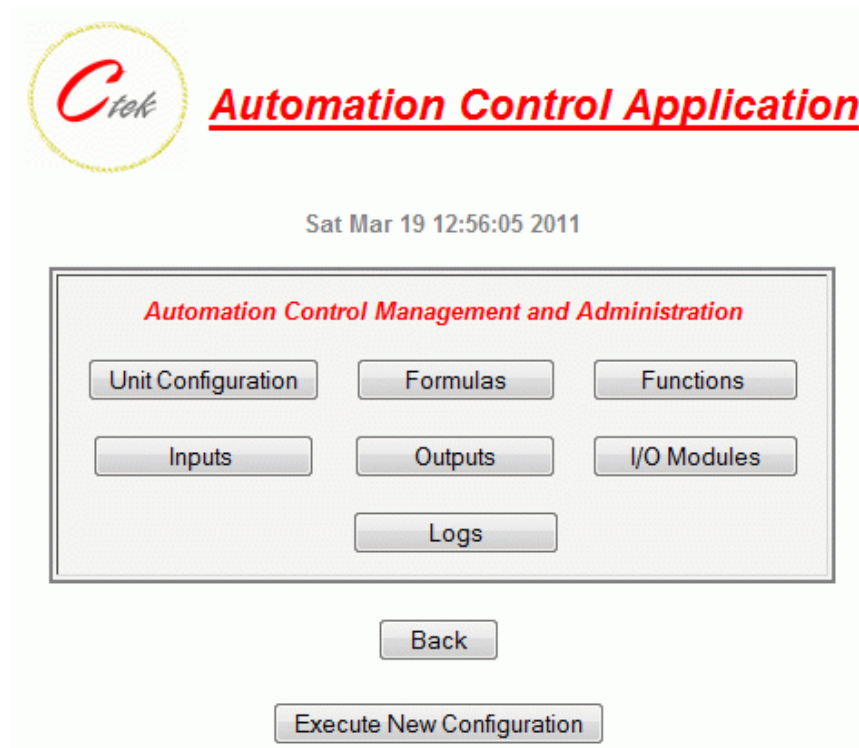


Figure 3 - Automation Control Configuration Menu



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Unit Configuration

Selecting the Unit Configuration menu item causes the screen shown in Figure 4 to be displayed. A description of each field follows the screen image.



Unit Configuration Options

Location Parameters	
Location Name: <input type="text"/>	
SMS Management	
SMS Remote Control: <input checked="" type="radio"/> On <input type="radio"/> Off	
Logging Selection and Configuration	
Logging: <input type="radio"/> On <input checked="" type="radio"/> Off	Log Rate: <input type="text" value="900"/>
Alarm Selection and Configuration	
Alarms: <input type="radio"/> On <input checked="" type="radio"/> Off	Alarm Delivery Method: <input checked="" type="radio"/> SMS <input type="radio"/> Email <input type="radio"/> Both
SMS Alarm Parameters	
Destination Phone Number For Alarms: <input type="text"/>	
Email Alarm Parameters	
Destination Email Address For Alarms: <input type="text"/>	
Log Delivery Parameters	
Deliver Log Via Email: <input type="radio"/> On <input checked="" type="radio"/> Off	Deliver To Email Address: <input type="text"/>
Deliver log on the following days after schedules run: Sun <input type="checkbox"/> Mon <input type="checkbox"/> Tue <input type="checkbox"/> Wed <input type="checkbox"/> Thu <input type="checkbox"/> Fri <input type="checkbox"/> Sat <input type="checkbox"/>	
Email Server Configuration	
Email Address For This Device: <input type="text"/>	
Email User Name: <input type="text"/>	Email Password: <input type="text"/>
SMTP Server Address: <input type="text"/>	SMTP Server Port: <input type="text"/>
Authentication: <input type="radio"/> On <input checked="" type="radio"/> Off	SSL Encryption: <input type="radio"/> On <input checked="" type="radio"/> Off
Display Group Names	
Group 1 <input type="text"/>	Group 2 <input type="text"/>
Group 3 <input type="text"/>	Group 4 <input type="text"/>
Group 5 <input type="text"/>	Group 6 <input type="text"/>
Group 7 <input type="text"/>	Group 8 <input type="text"/>

Figure 4 - Unit Configuration



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Location Name:

A descriptive name assigned to this controller and its associated I/O modules

SMS Remote Control:

Enable or disable SMS control of monitoring functions. This is a future enhancement.

Logging On/Off:

Enable or disable logging. Log files are formatted in the comma separated value (CSV) format and can be read and manipulated with a spread sheet program such as Excel.

Log Rate:

The number of second between log entries for analog or pulse inputs. Digital inputs are event driven meaning that each state change is logged.

Alarms On/Off:

Enable or disable alarms for the entire controller. Alarms can also be enabled or disabled for each individual input.

Alarm Delivery Method:

Select whether alarms will be delivered by SMS (text messaging), email, or both.

Destination Phone Number for Alarms:

The phone number of the handset or device that will receive SMS alarms.

Destination email address for Alarms:

The email address that will receive alarms

Log Delivery Parameters:

Logs are files containing comma separated values that can be directly read into a spread sheet or database application. Logging options are available for each input and output. Logs can be delivered by email on a schedule established in this panel.

Email address for this device:

If the controller is going to send email alarms and logs it will require an email address to use as the sender. This is typically an email address from the customers email domain. All boxes in a network can use the same email address.

Email User Name and Password

Login information for the SkyRouter email client to use when connecting to the customer's email server to send alarms and reports.

SMTP Server Address and Port:

Information required about the customer's email server so the SkyRouter can connect to it to send reports and alarms.

Authentication and SSL Encryption:

Settings specific to each email SMTP server.



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Display Group Names:

User assigned names of logical groupings of inputs and outputs that will be used to organize the display of the Control Panel. Both inputs and outputs can be organized under a single group name. For example a Power Control group could have a button to turn on/off power and a current measurement to display the amount of current being drawn.

I/O Modules

The I/O modules screens allow the user to Add/Delete, or Replace an I/O module. When an I/O module is added its inputs and/or outputs are automatically assigned. For relay modules four outputs (0 - 3) are automatically assigned. When a 16-port I/O module eight digital inputs (0 - 7) and eight digital outputs (0 - 7) are automatically created. To convert an input to a different type (analog or pulse) the Add function on the Inputs screen is used. See Inputs discussion further on. Replace is a special case designed for maintenance. When using the replace function only the boards address may be changed and the pre-existing configuration will be assigned to the new address.

<i>Current I/O Module Configuration Shown Below</i>		
Module Number: 0	Module Type: 4 Port Relay Module	Address: 01
Module Number: 1	Module Type: 16 Port I/O Module	Address: 20
Module Number: 2	Module Type: 16 Port I/O Module	Address: FTTF1NGH
Module Number: 3	Module Type: 4 Port Relay Module	Address: FTTF1XYZ

Figure 5 - Manage I/O Modules



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Add:

Add is used to create a new module. When Add is selected the screen shown in Figure 6 will be displayed. A module type and module address is assigned by the user and submit is pressed. The newly created module will then be displayed in the module inventory and its associated inputs and/or outputs will be displayed on those screens. As previously discussed all newly created modules having inputs will be created with all inputs defined as type Digital. An RS485 module should be assigned a two character hexadecimal address between 01 and FF. RS485 address 00 is reserved for Ctek's PowerMinder module. USB modules are assigned an eight character address which is supplied with the module.

Module Number	Module Type	Address
0	4 Port Relay Module	01
1	16 Port I/O Module	20
2	16 Port I/O Module	FTTF1NGH
3	4 Port Relay Module	FTTF1XYZ

Figure 6 - Module Add Screen



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Delete:

Delete is used to remove a module from the overall configuration. When selected the Delete screen will be displayed as shown in Figure 7. To delete a module enter the modules number and press submit.

Delete Module Number: <input type="text"/>		
<input type="button" value="Submit"/> <input type="button" value="Back"/>		
Current I/O Module Configuration Shown Below		
Module Number: <input type="text" value="0"/>	Module Type: 4 Port Relay Module	Address: <input type="text" value="01"/>
Module Number: <input type="text" value="1"/>	Module Type: 16 Port I/O Module	Address: <input type="text" value="20"/>
Module Number: <input type="text" value="2"/>	Module Type: 16 Port I/O Module	Address: <input type="text" value="FTTF1NGH"/>
Module Number: <input type="text" value="3"/>	Module Type: 4 Port Relay Module	Address: <input type="text" value="FTTF1XYZ"/>

Figure 7 - Module Delete Screen



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Replace:

Used to replace an existing module with a spare. USB modules will have a new (factory assigned) address. RS485 modules can re-use the existing address or be assigned a new address as desired. When selected the Replace Module screen will be displayed as shown in Figure 8. To replace a module in the inventory enter the module number and the address to be assigned to the new module, and press submit. The input/output configuration of the old module is assigned to the new address.

Replace Module Number:	New Module Address:	
<input type="text"/>	<input type="text"/>	
<input type="button" value="Submit"/>	<input type="button" value="Back"/>	
<i>Current I/O Module Configuration Shown Below</i>		
Module Number: <input type="text" value="0"/>	Module Type: <input type="text" value="4 Port Relay Module"/>	Address: <input type="text" value="01"/>
Module Number: <input type="text" value="1"/>	Module Type: <input type="text" value="16 Port I/O Module"/>	Address: <input type="text" value="20"/>
Module Number: <input type="text" value="2"/>	Module Type: <input type="text" value="16 Port I/O Module"/>	Address: <input type="text" value="FTTF1NGH"/>
Module Number: <input type="text" value="3"/>	Module Type: <input type="text" value="4 Port Relay Module"/>	Address: <input type="text" value="FTTF1XYZ"/>

Figure 8 - Module Replace Screen



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Configure Outputs

A representative portion of the Configure Outputs screen is shown below. This is a display only screen. Use the edit function to make changes. The default display shows the current status of outputs across all modules. The display is organized first in module number order and then with each module by output number order.

Note: Outputs can be managed in one of four ways:

1. From the individual output's edit screen (state field + Submit)
2. By an On/Off button on the Control Panel
3. By the Shutoff Timer value on an output
4. By Functions that are triggered by the threshold values of inputs

Each of these methods of changing an output state operates independent of the other. As an example, assume that an output is in its off state as a result of a function. If the user then turns the output on using the control panel the output will remain on until one of three events occur;

1. The user turns it off through the control panel or an edit screen
2. A shutoff timer assigned to that output expires thereby turning that output off
3. A different function determines that the output should be turned off

The screenshot shows the 'Configure Outputs' interface. At the top left is the Ctek logo. To the right, the title 'Configure Outputs' is displayed in red, underlined text. Below the title are two buttons: 'Edit' and 'Back'. A red heading reads 'Current Output Configuration Shown Below'. Underneath, the configuration for 'Module: 0 Type: 16 Port I/O Module Address: 22222222' is shown. Three output rows are visible, each with a table of configuration parameters.

Output	Name	State	Polarity	Initial Value	Log	Shutoff Timer	Display	Label for On	Label for Off
0	Master Power Control	On	0=Off	Last	Off	0	Group 1	Power On	Power Off
1	Water Shut Off Valve	On	0=Off	Last	Off	0	Group 2	Open	Closed
2	Output 2	Off	0=Off	Last	Off	0	Off	On	Off

Figure 9 - Output Configuration Screen



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Output:

A sequential number assigned to outputs on a controller. The Z1216U and Z1216S each have 8 outputs which will be numbered 0 - 7. The Z1204S and Z1204U have four outputs. Used to select an individual output for edit.

Name:

User assigned name of the output.

State:

The current state of the output. Can be used to toggle the output state.

Polarity:

Selects the logic level (0 or 1) to be assigned to the on and off condition

Initial Value:

Sets the condition the output will be placed in when the SkyRouter boots or recovers from a power failure. Values are On, Off, or Last where Last means restore the output to the condition it was in when the SkyRouter lost power or was caused to reboot.

Log:

On or Off. Determines if events on this output should be written to the log file

Shutoff Timer:

The number of minutes that an output should be allowed to remain on before it is automatically turned off. The value 0 disables the time thereby allowing the output to remain on indefinitely.

Display:

If this output is to be displayed on the control panel the display value will assign it to a display group. Off means do not display.

Label For On:

The label for the On state to be used on the Control Panel

Label For Off:

The label for the Off state to be used on the Control Panel

Edit (Button):

Select and modify an existing entry. When Edit is selected from the Configure Outputs screen the following screen is presented. This is a selection screen. The user enters a module and output number to be edited and presses Submit.



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Edit An Output Configuration

Module Number: <input type="text"/>		Output Number: <input type="text"/>			
<input type="button" value="Submit"/>		<input type="button" value="Back"/>			
<i>Current Output Configuration Shown Below</i>					
Module: 0 Type: 4 Port Relay Module Address: 01					
Output: 0	Name: Lamp 1	State: Off	Polarity: 0=Off	Initial Value: Last	Log: Off
Shutoff Timer: 0		Display: Off	Label for On: On	Label for Off: Off	
Output: 1	Name: Lamp 2	State: Off	Polarity: 0=Off	Initial Value: Last	Log: Off
Shutoff Timer: 0		Display: Off	Label for On: On	Label for Off: Off	
Output: 2	Name: Pump 1	State: Off	Polarity: 0=Off	Initial Value: Last	Log: Off

Figure 10 - Output Edit Selection Screen

When an Output module and specific Output are selected for edit the following detailed edit screen appears.

		<u>Configure Outputs</u>			
<i>Configuring Module 0 Output 1</i>					
Output Name: Lamp 2	Output State: Off	Shutoff Timer: 0			
Polarity: 0=Off	Initial Value: Last	Log: Off			
Display: Off	Label for On: On	Label for Off: Off			
<input type="button" value="Submit"/>		<input type="button" value="Back"/>			
<i>Current Output Configuration Shown Below</i>					
Module: 0 Type: 4 Port Relay Module Address: 01					
Output: 0	Name: Lamp 1	State: Off	Polarity: 0=Off	Initial Value: Last	Log: Off
Shutoff Timer: 0	Display: Off	Label for On: On	Label for Off: Off		

Figure 11 - Output Edit Details Screen



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Configure Inputs

A representative portion of the Configure Inputs screen is shown below. This is a display only screen. Note that the panels for individual inputs are color coded"

Purple = Analog Input

Green = Pulse Input

Blue = Digital Input

A description of fields and content follows the screen image.

Note - When an I/O module is configured in the inventory all inputs for that module are created as Digital inputs. To change the input type to Analog or Pulse a new input must be created for that board. Since inputs are created using module number and input number as a key the newly created input will replace the existing one. For instance, the New Input screen shown in Figure 14 below will replace the current Digital Input assigned to input 1 with one of type Pulse. The user will then be vectored to an Edit Screen where the Pulse input now assigned to Module 1 - Input 1 can be configured as required. From that time forward Module 1 - Input 1 will be of type Pulse.

The screenshot shows the 'Configure Inputs' interface with the Ctek logo and title. It features three input configuration panels, each with a distinct color coding: purple for analog, blue for digital, and green for pulse. Each panel includes fields for name, value, type, display, and log status, along with various alarm and function settings.

Input	Name	Value	Type	Display	Log
0	Pump Current	0.00 Amps	Analog	Off	Off
1	Tank Level	Off	Digital	Off	Off
2	Mainline Flowmeter	0.00 GPM	Pulse	Off	Off

Figure 12 - Configure Inputs



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**** Fields Common To All Input Types ****

Input:

A sequential number assigned to inputs on a controller. The Z1216U and Z1216S each have 8 inputs which will be numbered 0 - 7. Used to select an individual input for edit.

Name:

User assigned name of the input

Value:

The units of measure and current value of an input. On the edit screen the user simply enters the unit of measure, for instance Amps. On the Inputs management screen where all inputs are visible the current value of the sensor is combined with the units of measure to create a display such as 0.0 Amps for an input with no current flow.

Type:

Selects and displays the type of input; Analog, Pulse, or Digital

Display:

If this input is to be displayed on the control panel the display value will assign it to a display group. Choices are Groups 1 - 8 or Off. Off means do not display.

Log:

On or Off. Determines if events on this input should be written to the log file

Alarms:

On or Off. Determines whether alarms will be generated for this input. The values Min and Max Threshold determine the set points for alarms Min and Max Alarm.

**** Analog Input Specific Fields ****

Formula:

The numeric ID of a formula assigned to this input

Correction:

A specific correction or offset for this input. Can be used to correct for minor variations in sensors that cannot be corrected in a common input formula.

Min/Max Range and Sensor Calibration:

Range refers to the range or precision of the analog to digital (A/D) conversion. Ctek 1216 I/O modules provide 12 bit conversion resulting in a theoretical 4096 discrete values, 0 - 4095. The Z1216 a starts with a range offset of 7 making the theoretical available range 7 - 4095. Once the sensor is calibrated the actual available range may be somewhat smaller than the theoretical due to sensor characteristics and minor variations in the reference voltage.

Calibrating an Analog sensor - The Min and Max range fields can be used to automatically calibrate the sensor. To perform calibration the sensor must be powered up



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and properly configured within the Automation Control application. Once the sensor is configured the application automatically records the extremes (high/low) values for the sensor. Some sensors have a built in calibration feature. In that case select the minimum (low) level calibration on the sensor and leave it in that position for at least 10 seconds. Repeat this process for the high or maximum value, again waiting at least 10 seconds.

If the sensor does not have an internal calibration feature there are two possible approaches to calibration. First, consult the sensor vendor's literature. The vendor will certainly define the Min and Max units that the sensor is defined for, for instance -30 to +70 degrees. Also, it is common for the specifications to indicate a minimum and maximum output of the sensor at a specified reference voltage. Those values can be used to trim the Min and Max range inputs for the sensor. As an example, if a sensor is specified to output 0.25 volts on the low end of the scale for a reference voltage of 5 volts that would equate to 5% ($0.25 / 5.00$) of the total range which would make the Min Range equal to 205 ($4095 * 0.05$) and the Max Range equal to 3890.

An internal calibration feature is also available that analyzes the actual reference values available on the module. To use this feature the input pin is connected to the I/O modules ground for 10 seconds followed by connecting the input pin to the sensors reference voltage for 10 seconds. Once the input pin has been exposed to the extremes for 10 seconds each simply enter an asterisk (*) character in the MIN and Max range fields and press submit. The asterisk characters will be replaced with the Min and Max range values sensed during the calibration process.

Min Units:

A quantitative value for the low end of the expected measurement of this sensor. For example for a temperature sensor that is designed to measure between 10° and 300° the minimum Units would be 10, the Max Units would be 300, and the Units of Measure would be degrees.

Max Units:

A quantitative value for the high end of the expected measurement of this sensor. For example for a temperature sensor that is designed to measure between 10° and 300° the minimum Units would be 10, the Max Units would be 300, and the Units of Measure would be degrees.

Min Alarm:

A n On or Off setting that determines whether or not an alarm will be generated at Min Threshold.

Max Alarm:

A n On or Off setting that determines whether or not an alarm will be generated at Max Threshold.

Min Function:

Assigns a specific function to the value of Min Threshold for this input. Settings are Off or 0 - 19 where 0 - 19 are the identifiers of specific functions.



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Max Function:

Assigns a specific function to the value of Max Threshold for this input. Settings are Off or 0 - 19 where 0 - 19 are the identifiers of specific functions.

Figure 13 below shows the processing applied to analog inputs

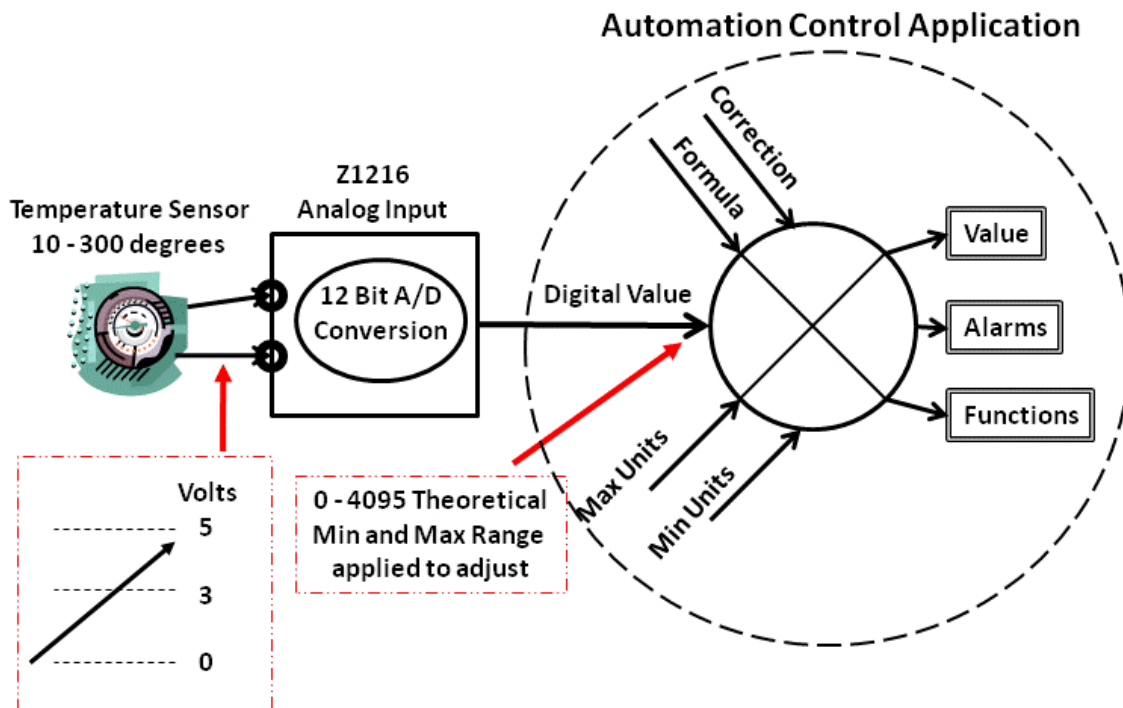


Figure 13 - Analog Input Processing

** Pulse Input Specific Fields **

Interval:

The time interval in seconds to be used in scaling the pulse input for control panel output. For instance, an input measured in gallons per minute (GPM) would use an interval of 60 second (1 minute) to scale the input.

Multiplier:

The value of an individual pulse. For example, if the multiplier value is for a gallons per minute calculation is 10 each pulse will be counted as 10 gallons and the value ($10 * \text{number of pulses} * 60$) would yield a gallons per minute value.



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Min Alarm:

A n On or Off setting that determines whether or not an alarm will be generated at Min Threshold.

Max Alarm:

A n On or Off setting that determines whether or not an alarm will be generated at Max Threshold.

Min Function:

Assigns a specific function to the value of Min Threshold for this input. Settings are Off or 0 - 19 where 0 - 19 are the identifiers of specific functions.

Max Function:

Assigns a specific function to the value of Max Threshold for this input. Settings are Off or 0 - 19 where 0 - 19 are the identifiers of specific functions.

**** Digital Input Specific Fields ****

Polarity:

Establishes the input logic level that will indicate On and Off. Choices are 0=Off or 0=On

Label For On:

Label to be used on the control panel when the digital input is On

Label For Off:

Label to be used on the control panel when the digital input is Off

Off Alarm:

Enables or disables alarms for the Off State

On Alarm:

Enables or disables alarms for the On State

On Function:

Assigns a specific function for the On state. Off means no function assigned.

Off Function:

Assigns a specific function for the On state. Off means no function assigned.



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New (Button):

Creates a new input entry. When a module is added to the configuration all inputs for that module are created as type Digital. The New function is used to change the type of input assigned to a specific pin. Selecting New displays the following selection screen.

Ctek Create A New Input Configuration

Module Number: 1 Input Number: 1 Input Type: Pulse

Submit Back

Current Input Configuration Shown Below

Module: 1 Type: 16 Port I/O Module Address: 20

Input: 0	Name: Pump Current	Value: 0.00 Amps	Type: Analog	Display: Off	Log: Off
Formula:	1	Correction: 1.00			
Min Range:	7	Min Units: 0.00	Min Threshold: 0.00	Min Alarm: Off	Min Function: Off
Max Range:	4010	Max Units: 10.00	Max Threshold: 14.00	Max Alarm: Off	Max Function: Off

Input: 1	Name: Tank Level	Value: Off	Type: Digital	Display: Off	Log: Off
Polarity:	0=Off	Label for On: High Lev	Label for Off: Normal		
Off Alarm:	Off	Off Function: Off			
On Alarm:	On	On Function: Off			

Figure 14 - Configure Inputs - New



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Edit (Button):

Used to select a specific input that will be modified. The user enters a module and input number and presses Submit which invokes the detailed edit screen. The Detailed Edit screen is also automatically invoked whenever a modules input type is changed using the New function. The Detailed edit screen will be displayed with the fields appropriate for they type of input selected above. Selecting Edit displays the following screen. The Detailed Edit screen for each Input type is shown immediately following.

Module Number: **Input Number:**

Current Input Configuration Shown Below

Module: 1 Type: 16 Port I/O Module Address: 20

Input: 0 **Name:** Pump Current **Value:** 0.00 Amps **Type:** Analog **Display:** Off **Log:** Off

Formula: 1 **Correction:** 1.00

Min Range: 7 **Min Units:** 0.00 **Min Threshold:** 0.00 **Min Alarm:** Off **Min Function:** Off

Max Range: 4010 **Max Units:** 10.00 **Max Threshold:** 14.00 **Max Alarm:** Off **Max Function:** Off

Figure 15 - Input Edit - Select

Configuring Module 1 Input 3 To Digital

Input Name: Input 3 **Polarity:** 0=Off **Log:** Off

Display: Off **Label for On:** On **Label for Off:** Off

Off Alarm: Off **Off Function:** Off

On Alarm: Off **On Function:** Off

Current Input Configuration Shown Below

Module: 1 Type: 16 Port I/O Module Address: 20

Input: 0 **Name:** Pump Current **Value:** 0.00 Amps **Type:** Analog **Display:** Off **Log:** Off


Formula: 1 **Correction:** 1.00

Min Range: 7 **Min Units:** 0.00 **Min Threshold:** 0.00 **Min Alarm:** Off **Min Function:** Off

Figure 16 - Input Edit - Details (Digital)



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Configure Inputs

Configuring Module 1 Input 2 To Pulse

Input Name:	Mainline Flowmeter	Multiplier:	1.00	Display:	Off
Unit of Measure:	GPM	Interval:	60	Log:	Off
Min Threshold:	0.00	Min Alarm:	Off	Min Function:	Off
Max Threshold:	0.00	Max Alarm:	Off	Max Function:	Off


Submit Back

Current Input Configuration Shown Below

Module: 1 Type: 16 Port I/O Module Address: 20

Input:	0	Name:	Pump Current	Value:	0.00 Amps	Type:	Analog	Display:	Off	Log:	Off
Formula:	1	Correction:	1.00								

Figure 17 - Input Edit - Details (Pulse)



Configure Inputs

Configuring Module 1 Input 0 To Analog

Input Name:	Pump Current	Formula:	1	Correction:	1.00				
Unit of Measure:	Amps	Display:	Off	Log:	Off				
Min Range:	7	Min Units:	0.00	Min Threshold:	0.00	Min Alarm:	Off	Min Function:	Off
Max Range:	4010	Max Units:	10.00	Max Threshold:	14.00	Max Alarm:	Off	Max Function:	Off

Submit Back

Current Input Configuration Shown Below

Module: 1 Type: 16 Port I/O Module Address: 20

Input:	0	Name:	Pump Current	Value:	0.00 Amps	Type:	Analog	Display:	Off	Log:	Off
Formula:	1	Correction:	1.00								

Figure 18 - Input Edit - Details (Analog)



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Configure Formulas

Ctek's Automation Control application provides support for user define formulas that can be applied to analog inputs. A standard conversion formula is released with the firmware. In many cases this standard formula will suffice for input processing. Users may create additional formulas using postfix notation, an input format colloquially known as RPN or Reverse Polish Notation.

[NB. Reverse Polish pays homage to the nationality of logician Jan Łukasiewicz, who invented (prefix) Polish notation in the 1920s. The antithesis of prefix (Polish) notation is postfix (reverse Polish) notation.]

A simple albeit useful explanation of postfix (RPN) notation is that it is a mathematical notation wherein every operator follows all of its operands. As an example 2 [Enter] 5 [Multiply] = 10. The result, 10 is then pushed on the top of the stack where it becomes the next operand in line. Therefore, 2 [Enter] 5 [Multiply] = 10 and 2 [Enter] 5 [Multiply] 7 [Multiply] = 70.

Formulas apply to analog inputs and are used to modify the values displayed on the Automation Control Panel.

From the top level Automation Control Configuration menu selecting Formulas presents the following selection screen which allows a user to select an existing formula for modification or create a new formula by entering an unused formula number.

Manage Input Formulas

Formula Number: (1-20)

Select Back

Current Formulas Shown Below

Formula Number: 1	Formula Name: Standard Conversion
Formula Number: 2	Formula Name: Square Input

Figure 19 - Input Formula Selection Screen



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Selecting a new or existing formula for edit brings up the following screen. The left hand column provides a selection of pull-down operands. The right hand column provides a pull down selection of operators. Constants are entered in the center column. An explanation of field selection follows.

Edit Formulas

Formula Number 1:

Formula Name: Standard Conversion

Step 0:	Read Input value ▾	<input type="text"/>	Ent ▾
Step 1:	Use Min Range ▾	<input type="text"/>	Sub ▾
Step 2:	Use Range ▾	<input type="text"/>	Div ▾
Step 3:	Use Units ▾	<input type="text"/>	Mul ▾
Step 4:	Use Correction ▾	<input type="text"/>	Mul ▾
Step 5:	Use Min Units ▾	<input type="text"/>	Add ▾
Step 6:	▾	<input type="text"/>	▾
Step 7:	▾	<input type="text"/>	▾

Figure 20 - Edit Input Formula

Operands

Read Input Value:

Selects the input value provided by the attached sensor as an operand

Constant Value =

Use the constant entered in the center column as the next operand

Use Correction:

The correction value associated with this input becomes the next operand

Use Min Range:

The minimum range value associated with this input becomes the next operand



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Use Max Range:

The maximum range value associated with this input becomes the next operand

Use Range:

The value (Maximum Range - Minimum Range) becomes the next operand

Use Min Units:

The minimum units value associated with this input becomes the next operand

Use Max Units:

The maximum units value associated with this input becomes the next operand

Use Units:

The value (Maximum Units - Minimum Units) becomes the next operand

Operators

Ent

Enter the defined operands value

Sub

Subtract

Add

Add

Mul

Multiply

Div

Divide

Xch

Exchange the current operand with the previous one



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An explanation of the standard conversion formula

The standard formula is released with the Automation Control application. In many cases it will provide all of the input processing required. The standard conversion formula is shown below on the edit screen. An explanation follows.

The screenshot shows the 'Edit Formulas' interface. At the top left is the Ctek logo. To the right, the title 'Edit Formulas' is displayed in red, underlined text. Below this is a window titled 'Formula Number 1:'. Inside the window, the 'Formula Name' is set to 'Standard Conversion'. The formula is configured through eight steps, each with a dropdown menu for the operation and a dropdown for the unit. The steps are as follows:

Step	Operation	Unit
Step 0:	Read Input value	Ent
Step 1:	Use Min Range	Sub
Step 2:	Use Range	Div
Step 3:	Use Units	Mul
Step 4:	Use Correction	Mul
Step 5:	Use Min Units	Add
Step 6:		
Step 7:		

Figure 21 - Standard Conversion Formula

The standard conversion formula shown above reads the sensors input value and subtracts from it the minimum range value assigned to the sensor. It then divides the resulting value by the value of (Maximum Range - Minimum Range). That result is then multiplied by the value of (Maximum Units - Minimum Units) and also by the correction value assigned. Lastly the value of Minimum Units is added to the result of all of the preceding operations. This final value will be displayed in the Value field of the Input screen and on the control panel. As a practical example assume that a 0 - 10 amp current sensor is installed and when calibrated it has a range of 7 - 4090. The following configuration would be made on that sensor's Input settings.

Min Range - 7
Max Range - 4090
Min Units 0.00
Max Units - 10.0
Correction Factor 1.0
Unit of Measure - Amps



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Sensor value (when read) = 2037

The standard conversion formula would do the following:

Read the sensor (2037) and subtract from it the Min Range (7) resulting in 2030

Divide the result by the value of (Max Range - Min Range) resulting in 0.4972

Multiply by Max Units - Min Units (10 - 0.0) resulting in 4.972

Multiply by correction factor (1.0) resulting in 4.972

Add the value of Min Units (0.00) resulting in 4.972

The Unit of measure (Amps) would then be appended to the calculated value resulting in a display of 4.972 Amps on the Input screen and the Control Panel.



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Configure Control Functions

Control functions are discrete actions that can be applied to a specific output as the result of an event occurring or a threshold being reached on an input. For instance, a control function could be used to turn off a heater when a certain temperature level is reached. Control functions can be binary as in On/Off or can invoke a custom program or script. Again, Control Functions are assigned to specific behavior (threshold, value, state change) at inputs and perform operations on outputs.

Selecting the Functions option on the main control menu brings up the following screen which displays existing functions and allows them to be selected for edit. To create a new function enter an unused function number and press the Select button. The edit screen for that function will be displayed.

The screenshot shows a web-based interface for managing control functions. At the top left is the Ctek logo. To its right, the title 'Manage Control Functions' is displayed in a large, bold, red font. Below the title is a form with three main sections. The first section contains the text 'Function Number:' followed by a text input field with '(1-20)' to its right, and two buttons labeled 'Select' and 'Back'. The second section is a header for a list, labeled 'Current Functions Shown Below'. The third section shows a single function entry with 'Function Number: 1' and 'Function Name: Output 0 Function'.

Figure 22 - Control Function Selection Screen



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Selecting function 1 on this screen brings up the following edit screen.

Function Number 1:

Function Name:

Action:	<input type="text" value="Control Output"/>	Module:	<input type="text" value="0"/>	Output:	<input type="text" value="0"/>	State:	<input type="text" value="On"/>
Action:	<input type="text" value="Execute Script"/>	Module:	<input type="text" value="0"/>	Output:	<input type="text" value="1"/>	State:	<input type="text" value="Off"/>
Action:	<input type="text"/>	Module:	<input type="text"/>	Output:	<input type="text"/>	State:	<input type="text"/>
Action:	<input type="text"/>	Module:	<input type="text"/>	Output:	<input type="text"/>	State:	<input type="text"/>
Action:	<input type="text"/>	Module:	<input type="text"/>	Output:	<input type="text"/>	State:	<input type="text"/>

Figure 23 - Control Functions Edit Screen

The control function edit screen allows the user to assign one of two actions to a specific output on a module.

1. Control output - Place the output in the state defined in the right most column
2. Execute a script associated with the defined output

A function name is created using the fields of the Edit Functions screen. The function name is in the form of:

function_name_module_pin_state

Where function_name is made up of the Function Name field with all spaces being changed to the underscore (_) character, module name is the numeric ID of the module, and pin is made up of the numeric ID of the specific Output or pin. State is derived from the State field with Off being a 0 and On being a 1.

As an example if were to create a function where: function name was: *myfunction* and the remainder of the function specification was"

Execute Script
Module 1
Output 3
Off

the function name would be: *myfunction_1_3_0*



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In the previous example if the state was changed to On the function name would be *myfunction_1_3_1*.

In each case the following arguments (parameters) are passed to the function:

board_number pin_number reason_value

If *myfunction_1_3_0* was being called because board 4 pin 6 went off (digital) or went under (analog or pulse) the following would be executed:

myfunction_1_3_0 (4 6 0) [function parameters shown in parenthesis]

If *myfunction_1_3_0* was being called because board 4 pin 6 went on (digital) or went over (analog or pulse) the following would be executed:

myfunction_1_3_0 (4 6 1)

Note - In the examples above *myfunction* could either be a script or one of the two predefined state change functions, On or Off.



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The Control Panel

The Control Panel for the Automation Control provides a consolidated view of output states, and input states or values for inputs and outputs that have been selected for display in their specific configuration. If configured it can also provide On/Off buttons for outputs. The Control Panel is accessible from the SkyRouter's top level menu at the same level as the general administration menu. It can also be accessed from applications category under the general administration menu.



Figure 24 - Control Panel Selection at Login

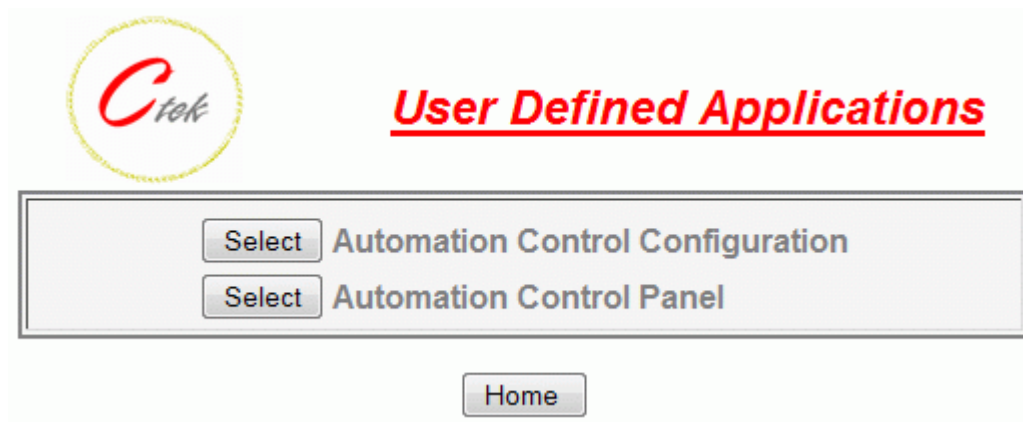


Figure 25 - Control Panel Selection Under Applications



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Displaying Inputs

To display inputs on the control panel the following fields should be configured under the Input/Edit function

Name - A user defined name for the input that will be displayed on the Control Panel.

Display - Choices are Off and 1 - 8. Off indicates do not display. The values 1 - 8 refer to groups of inputs and outputs that can be used to organize the Control Panel display

Value - Value displays the current sensor reading and the units of measure for that sensor. Units of measure is a field that can be modified under the Input/Edit function. Example 1.27 Amps where 1.27 is the current reading and Amps is the unit of measure.

Displaying and Controlling Outputs

Outputs are represented on the Control Panel by an output name and a control button labeled with the current state of the output. To assign an output to the control panel the following fields should be configured under the Output/Edit function

Name - A user defined name for the output that will be displayed on the Control Panel.

Display - Choices are Off and 1 - 8. Off indicates do not display. The values 1 - 8 refer to groups of inputs and outputs that can be used to organize the Control Panel display

Label For On - The label that will be used for the output's control button when the output is in the On state. The labeled button acts as a toggle meaning that when pressed the output will be switched to the opposite state and the buttons label will change.

Label For Off - The label that will be used for the output's control button when the output is in the Off state. The labeled button acts as a toggle meaning that when pressed the output will be switched to the opposite state and the buttons label will change.



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Provisioning The Control Panel

After the input and output configurations have been the new settings are deployed by returning to the top level configuration menu (Figure 3) and pressing the **Execute New Configuration** button. There will be a brief delay will all of the input and output settings are deployed and all of the inputs read. This activity will also create a new Control Panel display. An example of a Control Panel is shown below.

A screenshot of the 'Automation Control Panel' interface. At the top left is the Ctek logo. To its right, the title 'Automation Control Panel' is displayed in red, underlined text. Below the title, the date and time 'Tue Mar 29 12:43:58 2011' and the location 'RPV Lab' are shown. The main content is divided into two sections: 'Sensor Inputs' and 'Control Outputs'. The 'Sensor Inputs' section contains three data points: 'Current Sensor: 1.64 Amp', 'Temperature: 29.35 Degrees', and 'Router Voltage: 12.33 Volts DC'. The 'Control Outputs' section contains three controls: 'Plugs: Off', 'Lamp 1: On', and 'Lamp 2: On'. At the bottom of the panel are two buttons: 'Back' and 'Refresh'.

Figure 26 - Sample Control Panel Display



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Automation Control - A Practical Example

Example Definition

The diagram shown below defines the example to be covered. A discussion of the application configuration follows.

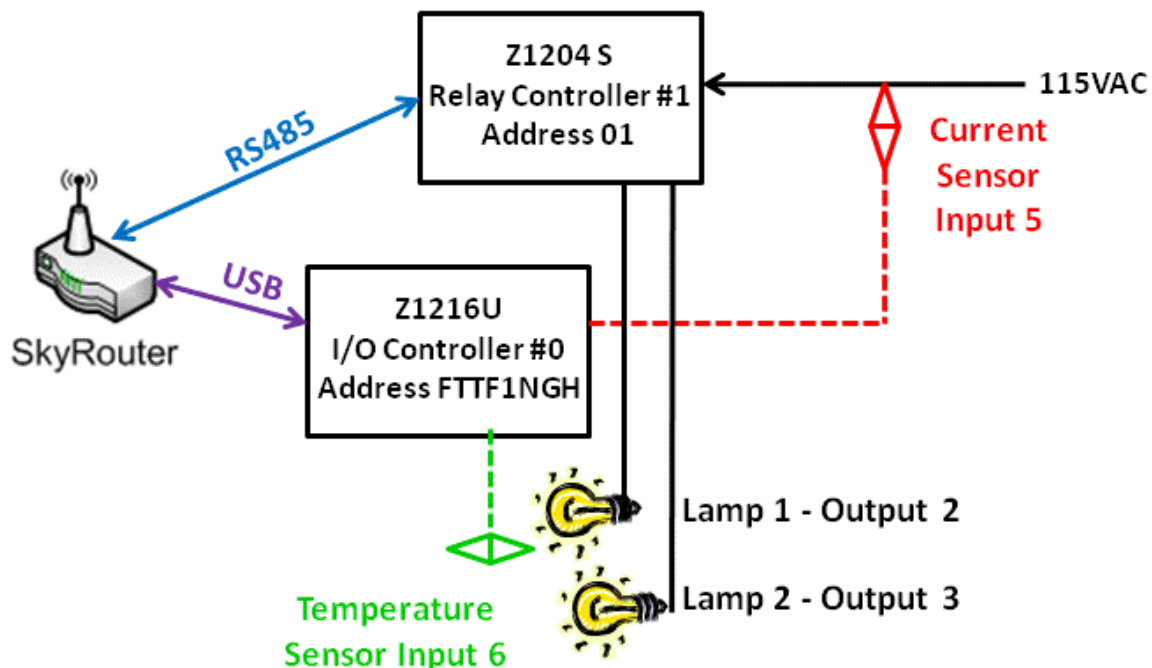


Figure 27 - Example Application

In the sample application shown in 27 the Automation Control application is connected to a current sensor and a temperature sensor as inputs and to two light bulbs as outputs. The application is configured so that the light bulbs are powered up when the temperature sensor falls below 27° C and powered down when the temperature (raised by light bulb produced heat) goes above 43°C. The current sensor monitors the current flow on input power to the SkyRouter and both light bulbs.

In the example there are two I/O modules connected to a SkyRouter running the Automation Control application. Module 0 is a 16-port I/O module that uses a USB connection for power and communications. It was assigned address FTTF1NGH during manufacturing. Module 1 is a 4-port relay output module. It is powered externally and communicates over an RS485 serial



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connection. Module 1 has been assigned an RS485 network address of 01 using onboard jumpers.

Example Unit Configuration

The following screen shows the details of the Unit Configuration settings used in this example. Specific details follow the diagram.



Unit Configuration Options

Location Parameters Location Name: <input type="text" value="RPV Lab"/>	
SMS Management SMS Remote Control: <input type="radio"/> On <input checked="" type="radio"/> Off	
Logging Selection and Configuration Logging: <input checked="" type="radio"/> On <input type="radio"/> Off Log Rate: <input type="text" value="900"/>	
Alarm Selection and Configuration Alarms: <input checked="" type="radio"/> On <input type="radio"/> Off Alarm Delivery Method: <input type="radio"/> SMS <input checked="" type="radio"/> Email <input type="radio"/> Both	
SMS Alarm Parameters Destination Phone Number For Alarms: <input type="text"/>	
Email Alarm Parameters Destination Email Address For Alarms: <input type="text" value="mike@ctekproducts.com"/>	
Log Delivery Parameters Deliver Log Via Email: <input checked="" type="radio"/> On <input type="radio"/> Off Deliver To Email Address: <input type="text" value="mike@ctekproducts.com"/> Deliver log on the following days after schedules run: Sun <input type="checkbox"/> Mon <input checked="" type="checkbox"/> Tue <input checked="" type="checkbox"/> Wed <input type="checkbox"/> Thu <input type="checkbox"/> Fri <input type="checkbox"/> Sat <input type="checkbox"/>	
Email Server Configuration Email Address For This Device: <input type="text" value="skyrouter@ctekproducts.com"/> Email User Name: <input type="text" value="skyrouter@ctekproducts.com"/> Email Password: <input type="text" value="••••••••"/> SMTP Server Address: <input type="text" value="smtp.coxmail.com"/> SMTP Server Port: <input type="text" value="25"/> Authentication: <input checked="" type="radio"/> On <input type="radio"/> Off SSL Encryption: <input type="radio"/> On <input checked="" type="radio"/> Off	
Display Group Names Group 1 <input type="text" value="Sensor Inputs"/> Group 2 <input type="text" value="Control Outputs"/> Group 3 <input type="text"/> Group 4 <input type="text"/> Group 5 <input type="text"/> Group 6 <input type="text"/> Group 7 <input type="text"/> Group 8 <input type="text"/>	

Parameters Successfully Updated

Figure 28 - Example Unit Configuration Specifics



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Location Name - The user assigned name of this control unit. This will be used on the Control Panel display

SMS Remote Control - Off. Not used in this example

Logging Selection and Configuration - Logging is turned on at a rate of once every 900 seconds (15 minutes) for analog and pulse values. Digital inputs are logged upon state change.

Alarm Selection and Configuration - Alarms are turned on and will be delivered by email.

SMS Alarm Parameters - SMS alarms are not used in this example.

Email Alarm Parameters - Email alarms are delivered to the specified address.

Log Delivery Parameters - Log files are delivered by email to the address specified on Sunday and Monday of each week.

Email Server Configuration - Alarms and logs delivered by email will originate from the email account set up in this panel. The control unit (SkyRouter) required access to a POP3 email account for this feature.

Display Group Names - These user assigned labels are used on the Control Panel display to organize information. The assignment of inputs and outputs to these display groups is made on the screen used to edit the input or output. In this example all sensor inputs are organized in group 1 and all control outputs are organized in group 2. See Control Panel display.

Module Configuration

Figure 29 shows the I/O module inventory installed in this controller. To add a module the user needs to know the module type and in the case of USB modules the factory assigned address.

The screenshot shows a web interface for configuring I/O modules. At the top left is the Ctek logo. To the right is the title 'Configure I/O Modules' in red, underlined text. Below the title is a control bar with four buttons: 'Add', 'Replace', 'Delete', and 'Back'. Underneath these buttons is a header 'Current I/O Module Configuration Shown Below'. The main content is a table with two rows of configuration data.

Current I/O Module Configuration Shown Below		
Module Number: 0	Module Type: 16 Port I/O Module	Address: FTTF1NGH
Module Number: 1	Module Type: 4 Port Relay Module	Address: 01

Figure 29 - Example I/O Module Configuration



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Example Inputs


Figure 30 shows a partial view of the Inputs Management screen that is focused on the example inputs of Module 0 - Input 5 and Module 0 - Input 6.

Input: 5	Name: Current Sensor	Value: 0.00 Amp	Type: Analog	Display: Group 1	Log: Off
Formula: 1	Correction: 1.00				
Min Range: 7	Min Units: 0.00	Min Threshold: 0.20	Min Alarm: On	Min Function: Off	
Max Range: 4095	Max Units: 5.00	Max Threshold: 0.00	Max Alarm: Off	Max Function: Off	

Input: 6	Name: Temperature	Value: 27.10 Degrees	Type: Analog	Display: Group 1	Log: On
Formula: 1	Correction: 1.00				
Min Range: 204	Min Units: -50.00	Min Threshold: 27.00	Min Alarm: Off	Min Function: 1	
Max Range: 3890	Max Units: 150.00	Max Threshold: 43.00	Max Alarm: Off	Max Function: 2	

Figure 30 - Example Input Management Screen

The next figure shows the specifics of the configuration of module 0 - input 6, the temperature sensor.



Configure Inputs

<i>Configuring Module 0 Input 6 To Analog</i>							
Input Name:	Temperature	Formula:	1	Correction:	1.00		
Unit of Measure:	Degrees	Display:	Group 1	Log:	On		
Min Range:	204	Min Units:	-50.00	Min Threshold:	27.00	Min Alarm:	Off
Max Range:	3890	Max Units:	150.00	Max Threshold:	43.00	Max Alarm:	Off
						Min Function:	1
						Max Function:	2
Submit Back							
<i>Current Input Configuration Shown Below</i>							
Module: 0 Type: 16 Port I/O Module Address: FTTF1NGH							

Figure 31 - Example Temperature Sensor

Input Name - The name of this sensor that will be used on the control panel.

Formula - The formula assigned to process this input. Figure 31 shows that Formula 1 (Standard Input Conversion) is assigned. Later in this example we will assign a formula that converts the Celsius values of this sensor to Fahrenheit .



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Correction - This value is set to 1 or unity meaning that no correction is applied. Corrections are sometimes used to trim or make fine adjustments to sensors.

Range - The Min and Max range values These values establish the useful range of the sensor input which has a theoretical range of 0 - 4095. The values shown in the example screen are based on the sensor vendor's nominal specifications. Specifically lthe the vendor indicates that the sensor has a nominal output of between 0.25 and 4.75 volts when supplied with 5 volts. Using that information the Minimum range of the sensor is determined by the following steps:

1. Divide 0.25 by 5.0 resulting in 0.05
2. Multiply 4095 by 0.05 resulting in 204.75.
3. This process is simply expressing the low end value as a percentage of the nominal input voltage and then determining what that percentage of the total range is. Note For some inexplicable reason the user in this example elected to truncate rather than round.
4. The Maximum range could be determined using the same process. It would be more accurate to use the automatic calibration feature provided with the Automation Control application.

Units - The value of Minimum and Maximum units was supplied by the sensor vendor, in this case -50° C - 150° C. A Celsius to Fahrenheit conversion could have been accomplished here by simply applying the conversion to these values, making MIN and Max Units -58° F - 302° F.

Min and Max Threshold - The selected values (27° C and 43° C) for this example application. Used to trigger functions and send alarms if required.

Alarms - Alarms are not enabled on this input

Functions - The Minimum and Maximum function assigned to this input will be used to turn the light bulbs on at 27° C and off at 43° C.



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Example Outputs

Two outputs are in play in this example. Module 1, Output 2 and Module 1 Output 3. Both are connected to the lamps described above and both outputs are managed by functions 1 and 2 which are in turn assigned to temperature thresholds on Module 0, Input 6. The details of the settings for Output 2 (Lamp 1) are shown below. Lamp 2 settings are identical.

The screenshot shows a web interface titled "Configure Outputs" with the Ctek logo. The main configuration area is titled "Configuring Module 1 Output 2" and contains the following fields:

Output Name:	Lamp 1	Output State:	Off	Shutoff Timer:	300
Polarity:	0=Off	Initial Value:	Last	Log:	On
Display:	Group 2	Label for On:	On	Label for Off:	Off

Below the configuration fields are "Submit" and "Back" buttons. A section titled "Current Output Configuration Shown Below" displays the following information:

Module: 0 Type: 16 Port I/O Module Address: FTTF1NGH

Output:	0	Name:	Output 0	State:	Off	Polarity:	0=Off	Initial Value:	Last	Log:	Off
---------	---	-------	----------	--------	-----	-----------	-------	----------------	------	------	-----

Figure 32 - Example Output 2

Output Name - User defined name that will appear on the control panel

Output state - The current state of the output

Shutoff timer - The number of seconds the output will be allowed to remain on independent of functions.

Polarity - Assign definition of 0 and 1 state of output

Initial Value - The state that the output will be placed in on a power fail recovery or reboot. The last setting indicates that the output will be returned to the state it was in before the reboot.

Log - On or Off, enable or disable logging

Display - The group to which this output will be assigned on the control panel.

Label For On/Off - The label for the output that will be used on the control panel



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Control Functions

Control functions 1 and 2 manage the on and off state of the lamps at the temperature thresholds assigned to the temperature sensor input. Figure 33 shows the top level function management screen. Figure 34 shows the details of the Lamps On function.

Manage Control Functions

Function Number: (1-20)

Select Back


Current Functions Shown Below

Function Number: 1	Function Name: Lamps On
Function Number: 2	Function Name: Lamps Off

Figure 33 - Example Manage Functions Screen



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Edit Functions

Function Number 1:

Function Name:

Action:	<input type="text" value="Control Output"/>	Module:	<input type="text" value="1"/>	Output:	<input type="text" value="2"/>	State:	<input type="text" value="On"/>
Action:	<input type="text" value="Control Output"/>	Module:	<input type="text" value="1"/>	Output:	<input type="text" value="3"/>	State:	<input type="text" value="On"/>
Action:	<input type="text"/>	Module:	<input type="text"/>	Output:	<input type="text"/>	State:	<input type="text"/>
Action:	<input type="text"/>	Module:	<input type="text"/>	Output:	<input type="text"/>	State:	<input type="text"/>
Action:	<input type="text"/>	Module:	<input type="text"/>	Output:	<input type="text"/>	State:	<input type="text"/>

Figure 34 - Example Lamps On Function



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Example Formulas

The example application uses the standard conversion formula which was described earlier in this document. At the end of this example application section we will assign the Celsius to Fahrenheit conversion formula and observe the changes.

The screenshot shows the 'Manage Input Formulas' screen. At the top left is the Ctek logo. To its right is the title 'Manage Input Formulas' in red, underlined text. Below the title is a form with the following elements:

- A label 'Formula Number:' followed by an input field containing '1' and a '(1-20)' constraint.
- Two buttons: 'Select' and 'Back'.
- A section header 'Current Formulas Shown Below' in red.
- A table listing current formulas:

Formula Number	Formula Name
1	Standard Conversion
2	Fahrenheit

Figure 35 - Example Formula Management Screen



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Example Control Panel

The Control Panel portion of Ctek's Automation Control application provides a concise visual representation of input and output states and values. It provides a mechanism for the user to change the state of outputs.

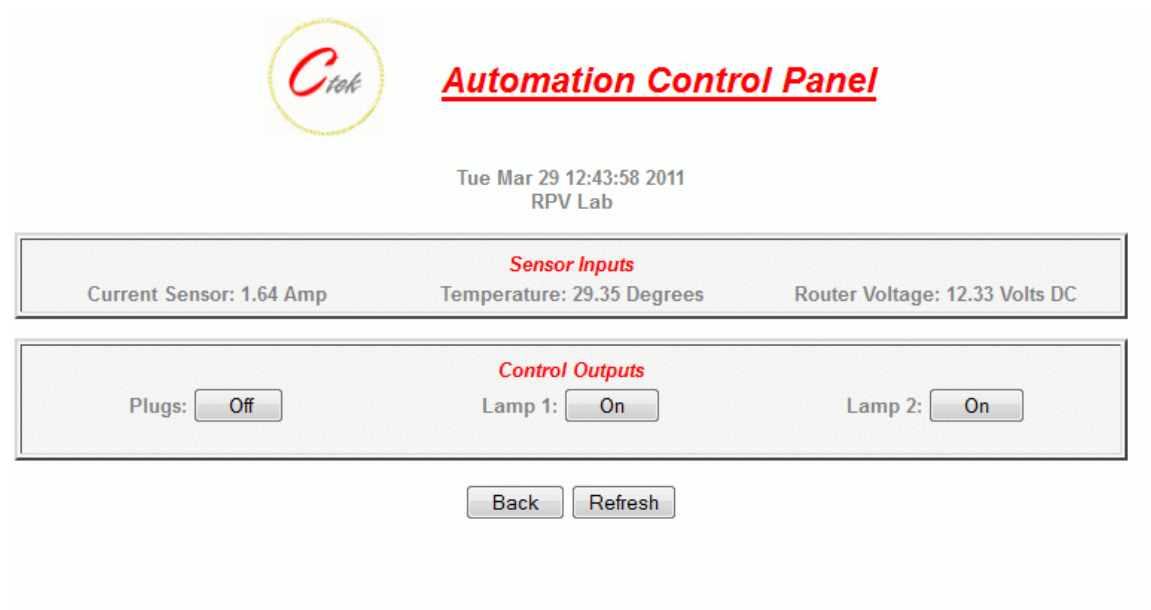


Figure 36 - Example Automation Control Panel

Application of Fahrenheit Formula

The Celsius to Fahrenheit conversion formula is shown below. It simply extends the standard conversion formula by adding the conversion logic $F = C \times 1.8 + 32$. The new conversion formula, formula 2 is applied to the Module 0, Input 6 analog I/O entry in place of the standard conversion formula.

Important Note - When a formula such as this is applied the Min and Max threshold values must be adjusted accordingly. In this example The Min and Max thresholds would be set to 80 and 110 degrees F respectively.



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The screenshot shows the 'Edit Formulas' window with the following configuration:

Formula Number 2:		
Formula Name: Fahrenheit		
Step 0:	Read Input value	Ent
Step 1:	Use Min Range	Sub
Step 2:	Use Range	Div
Step 3:	Use Units	Mul
Step 4:	Use Correction	Mul
Step 5:	Use Min Units	Add
Step 6:	Constant value = 1.8000	Mul
Step 7:	Constant value = 32.0000	Add
Step 8:		
Step 9:		
Step 10:		

Figure 37 - Example Fahrenheit Conversion Formula

Note - The Celsius to Fahrenheit conversion could have also been accomplished by simply converting the vendor specified range of the sensor (-50C - +150C) to Fahrenheit for the Min and Max units values on the sensor's input entry.

Example Conclusion

In the example described above the Automation Control application applies current to two light bulbs which in turn heat a temperature sensor. When the sensor is below 27° C the lights come on and stay on until the sensor reaches 43° C at which time current is removed and the sensor is allowed to cool. When the sensor once again goes below 27° C the process repeats. The entire application uses two outputs, one input, two functions to power or turn off the lamps, and the standard conversion formula. Optional methods of converting the Celsius values to Fahrenheit are demonstrated.