AC218154 - CT335/CT435 Evaluation Board

Technical User Guide

MINCO

Contents

Introduction

The CT335/CT435 Evaluation Board (model number AC218154) is a development kit intended for engineers evaluating the CT335 or CT435 PCB-mount controller and developing or prototyping systems utilizing the CT335 or CT435 controllers. The Evaluation Board features:

- USB-to-SPI converter (for CT335) and USB-to-UART converter (for CT435)
- PC Software package for configuration and monitoring of CT335 and CT435
- Connections for direct UART/SPI communication
- Selectable power over USB or external source
- Onboard heating zones and RTD (Resistance Temperature Detector) sensors
- Potentiometers for RTD input simulation
- Connections for external heaters and RTD temperature sensors

Conventions

Different typestyles are used throughout this document to make it easier to convey whether the text refers to a physical feature of the Evaluation Board, or if it refers to a general term.

A word or phrase with first letter capitalization (such as Heater Output) refers to a feature on the Evaluation Board such as a terminal block connection or a feature such as Device Name.

CT335 Utilities Software

Using the CT335 Utilities software interface, the user can configure and monitor the connected controller. The Windows-based software is compatible with Windows XP and later. Instructions for its use are as follows.

Installation

Installation files for CT335 Utillities can be downloaded at *http://tinyurl.com/Minco-Downloads*. Once downloaded, extract the files to your local drive and run the .msi file to start the installation process. Follow the prompts of the installation wizard to complete the installation to the desired location. Microsoft .Net Framework 4.0 is required to run the software.

Connecting to Your Device

Ensure the device (CT335 or CT435) is inserted or removed only when power is not applied. Once the CT335 is mounted in the socket, the evaluation Board is attached to a computer, and the configuration software is started, press “Connect to Device” to connect to the CT335. On connecting the Evaluation Board for the first time, Windows will automatically install drivers for use with the USB converter. This may take some time. If the connection is successful, the device make-up and configuration stored on the CT335 are retrieved and displayed.

Settings

The device make-up is displayed at the top of the Settings Pane. This consists of features of the CT335 that are determined at the time of order and cannot be changed.

Model: The base model number of the CT335 consisting of its fixed variables.

Element: Temperature sensor input type for the unit connected. Displayed as Pt100 or Pt1000 for 100 Ohm Platinum RTD or 1000 Ohm Platinum RTD, respectively.

Output: The configuration of the outputs for the unit connected. Displayed as 1 Output of 6A, 2 Outputs of 3A Each, or 1 3A and 1 Logic Output.

Some settings are user-settable through the various boxes and radio buttons on the bottom half of the Settings Pane.

Control Type: Configures the CT335 for On/Off or Proportional control types.

Setpoint: Determines the temperature to which the corresponding sensor input is controlled.

Prop. Band / **Hysteresis:** Determines the band around the Setpoint where the output turns on and off.

When using the On/Off control type, the Hysteresis value is evenly divided around the Setpoint. For example, if the Setpoint is 55.0C and the Hysteresis is 0.1C, the output will turn on at 49.95C, and turn off at 55.05C.

When using the Proportional Type, the Proportional Band determines the temperature range across which the output will vary from 100% duty cycle to 0% duty cycle. For example, if the Setpoint is 37.0℃ and the Proportional Band is 1.0℃, the output will be 100% duty at 36.0℃ and 0% at 37.0℃, varying linearly between the two values.

Input Offset: Applies an offset to the respective sensor input. This could be used for lead wire compensation.

Read and Write Settings

Read Settings: Reads the current configuration from the CT335 and displays the configuration on the Settings Pane.

Write Settings: Writes the displayed configuration to the CT335. Any settings changes only take affect once they are written to the device. Changes are directly written to the non-volatile memory of the controller, so the configuration will be saved in the event of power loss.

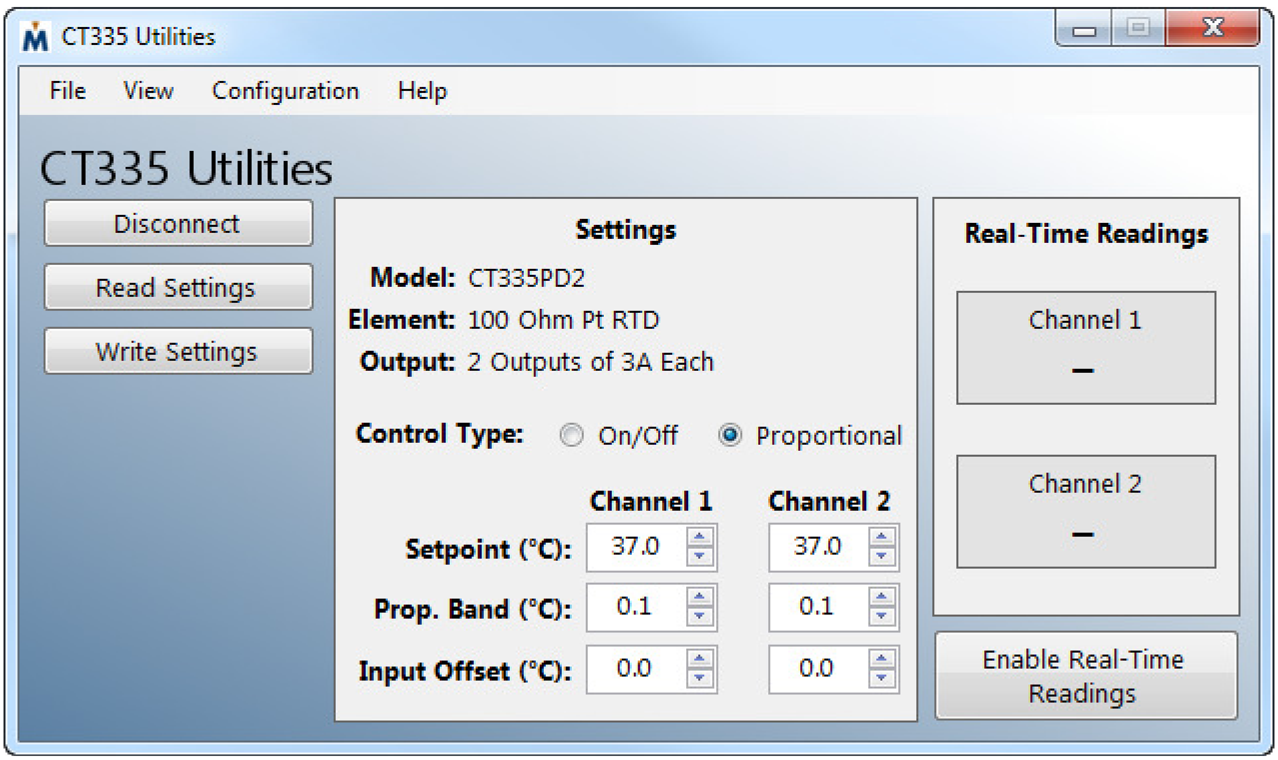

Figure 1

Real-Time Readings

Once enabled, the Real-Time Readings Pane displays the current temperatures being read by each input of the CT335.

Enable Real-Time Settings: Enables Real-Time Readings. By enabling Real-Time Readings, the Settings Pane is disabled and the user is only allowed to view Real-Time Readings until it is disabled and returned to Settings mode.

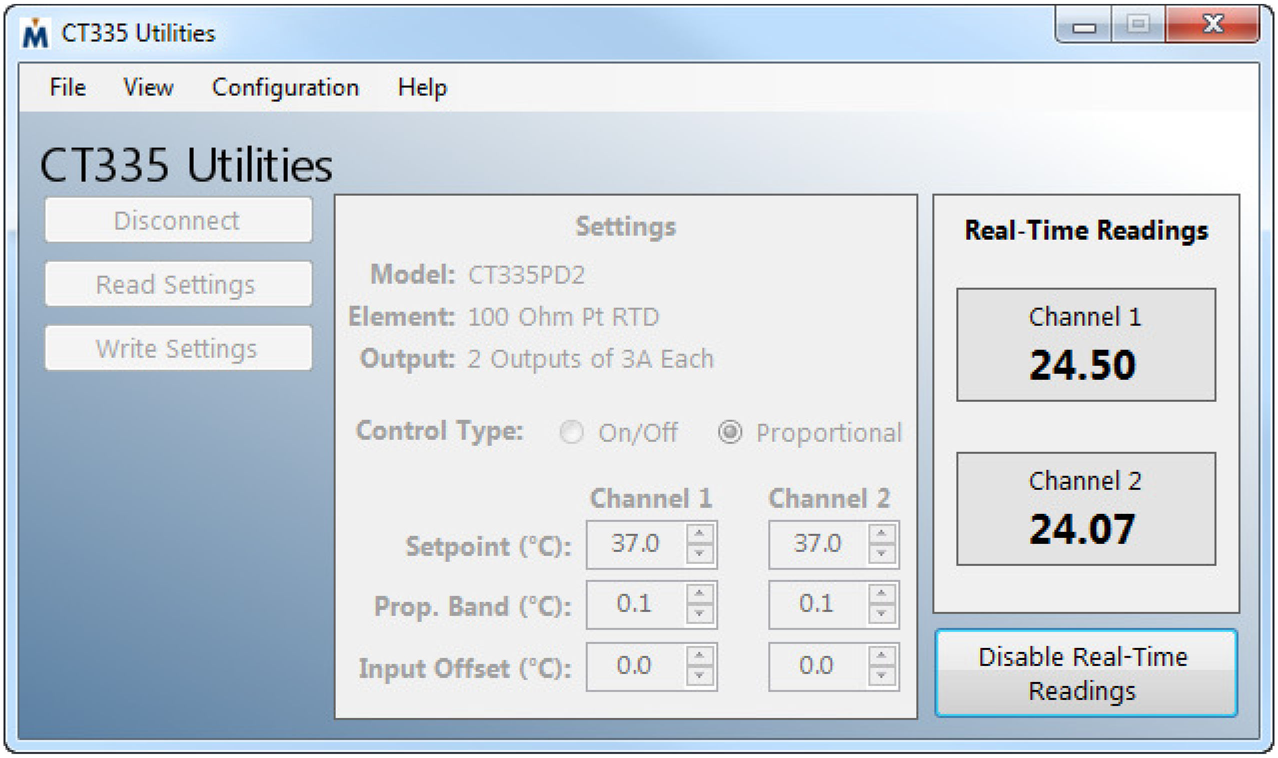

Figure 2

CT435 Utilities Software

Using the CT435 Utilities software interface, the user can configure and monitor the connected controller. The windows-based software is compatible with Windows XP and later. Instructions for its use are as follows.

Installation

Installation files for CT435 Utilities can be downloaded at http://tinyurl.com/Minco-Downloads. Once downloaded, extract the files to your local drive and run the .msi file to start the installation process. Follow the prompts of the installation wizard to complete the installation to the desired location. Microsoft .Net Framework 4.0 is required to run the software.

Connecting to Your Device

Ensure the device (CT335 or CT435) is inserted or removed only when power is not applied. On connecting the Evaluation Board for the first time, Windows will automatically install two sets of drivers for use with the USB converter. This may take some time. Once the CT435 is mounted in the socket, the evaluation Board is attached to a computer, and the configuration software is started, enter the Modbus ID of the CT435 and press “Connect to Device”. The default CT435 Modbus ID is 1, but the user may also use the Discover ID feature to search the connected device for its configured Modbus ID. This process may take some time since all 247 Modbus IDs must be searched, so use this feature only if you need to recover the Modbus ID. If the connection is successful, the configuration stored on the CT435 is retrieved and displayed, along with the measured sensor temperature and output status. The settings are grouped into tabs.

Status

The Status group displays each sensor’s current temperature and each output’s state.

If the read temperature is outside the range of the device, either “Error Lo” or “Error Hi” is displayed if the sensor resistance is below or above the input range, respectively. Note: The output status does not take the Reverse Acting setting into account.

For example, if Output 1 is at 75% duty cycle, the output will be energized 75% of the time if Reverse Acting is disabled. If Reverse Acting is enabled, the output will be energized 25% of the time yet the displayed duty cycle will still be 75%.

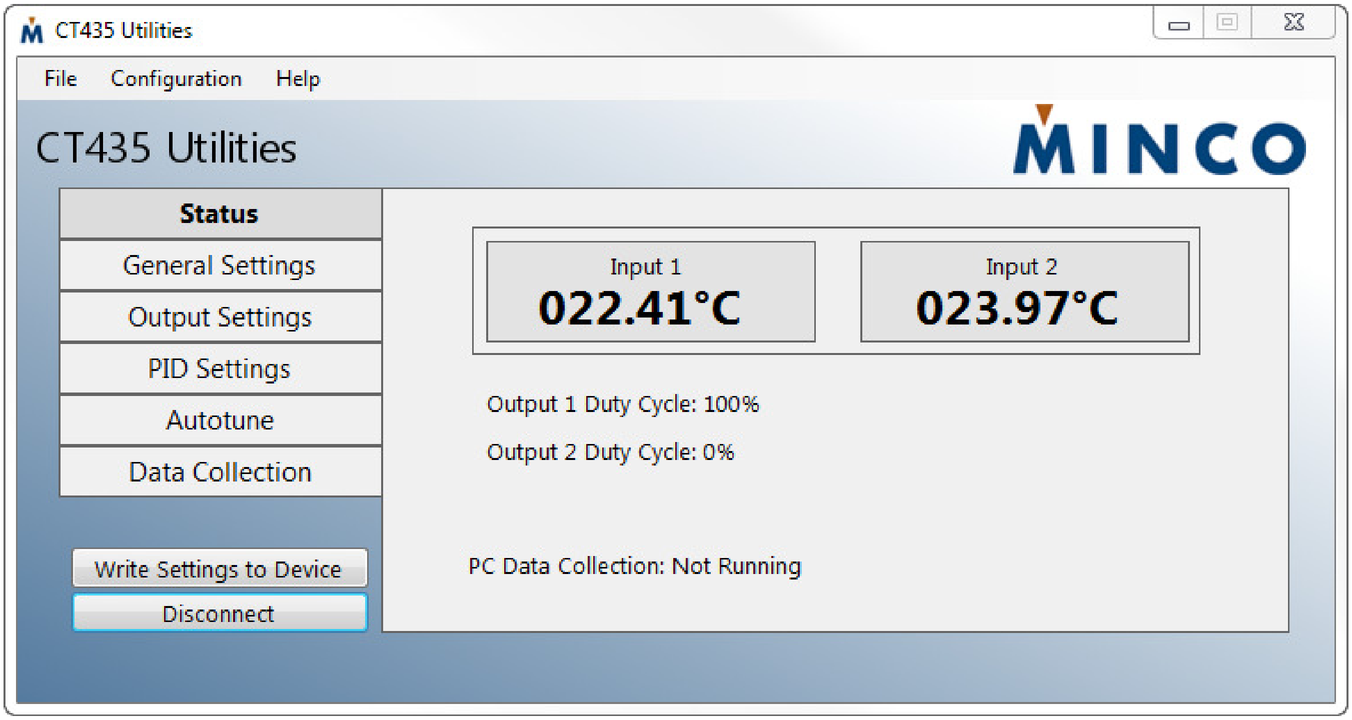

Figure 3

General Settings

The General Settings group contains the configuration for the RTD inputs, the temperature scale, and device name.

Device Name: A string of up to 20 characters that the user may change to “name” the device. This may be useful to identify multiple units.

Temperature Scale: Determines if the software Utility will interact with the user in the Celsius or Fahrenheit scale. Note that the device always operates in Celsius mode and all conversion is done by the Utility.

Type: Temperature sensor input type for the unit connected. Displayed as Pt100 or Pt1000 for 100 Ohm Platinum RTD or 1000 Ohm Platinum RTD, respectively.

Offset: Applies an offset to the respective sensor input. This could be used for lead wire compensation.

Modbus ID: The selected Modbus ID (or address) for the CT435 being used. It may be changed using this feature or found using the Discover ID button if unsure of the Modbus ID. The default CT435 Modbus ID is 1.

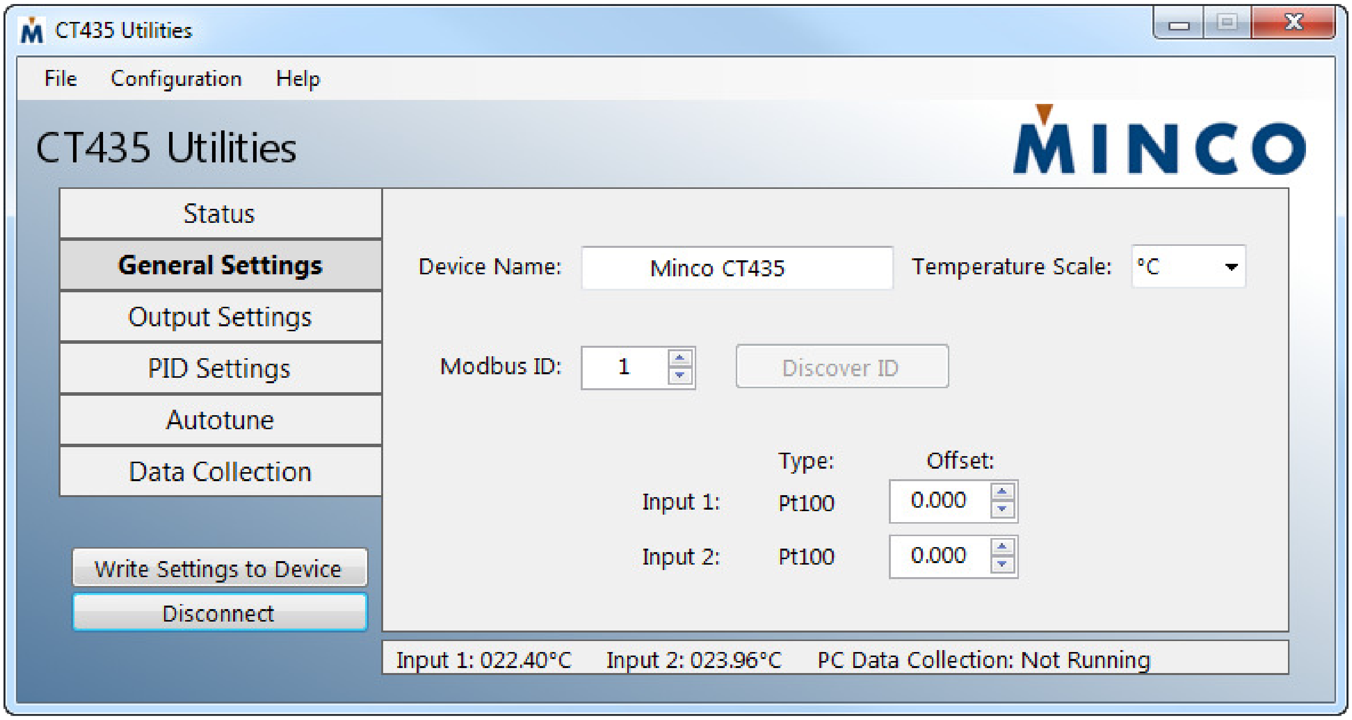

Figure 4

Output Settings

The Output Settings group contains the output configuration. Each output has its own tab within Output Settings. Some options will be unavailable (greyed out) depending upon what function is chosen.

Source: Determines which sensor input the respective output will use. Multiple outputs may share the same sensor input.

Function: Disabled, PID, On/Off, or Alarm.

On/Off and Alarm work similarly with the only difference being how Hysteresis is used. Please see the Hysteresis description for further information.

When set to Disabled, the output is de-energized regardless of the Reverse Acting setting.

Reverse Acting: Setting this to True causes the respective output to behave in the opposite manner, i.e. normally closed instead of normally open. This may be useful for cooling applications.

Note that when the output is Disabled, the respective output is de-energized regardless of this setting. Also note that despite setting Reverse Acting to True, the output will not remain “closed” when the CT435 is unpowered.

Over/Under: Determines whether the output engages when the sensor temperature is over or under the Setpoint. This applies to the Alarm Function only.

Setpoint: Determines the temperature that the selected sensor input is maintained to for PID and On/Off Functions. In the case of the Alarm Function, when the sensor is above or below this temperature the output will activate depending upon if Over or Under is selected, respectively.

Hysteresis: Determines the band around the Setpoint where the output engages and disengages.

When using the On/Off function, the Hysteresis value is evenly divided around the Setpoint. For example, if the Setpoint is 55.0C and Hysteresis is 0.1C, the output will engage at 49.95C, and disengage at 55.05C.

When using the Alarm function, the Hysteresis is placed on the side of the Setpoint that does not engage the output. For example, if the Setpoint is 55C, Over/Under is Over, and Hysteresis is 0.1C, the output will engage when the sensor exceeds 55.0C, but will disengage when the sensor is less than 54.9C.

The hysteresis value is meaningless to the PID Function and therefore is greyed out if that Function is used.

Minimum Duty Cycle: Determines the minimum duty cycle, in percent, that the output will reach. This is the duty cycle at the output terminals with respect to the Reverse Acting setting. Normally this value is set to zero, however there may be some applications that require a minimum of more than zero. When the Function is set to Disabled, this setting is irrelevant.

Maximum Duty Cycle: Determines the maximum duty cycle, in percent, that the output will reach. This is the duty cycle at the output terminals with respect to the Reverse Acting setting. Normally this value is set to 100; however there may be some applications that require a maximum of less than 100. When the Function is set to Disabled, this setting is irrelevant.

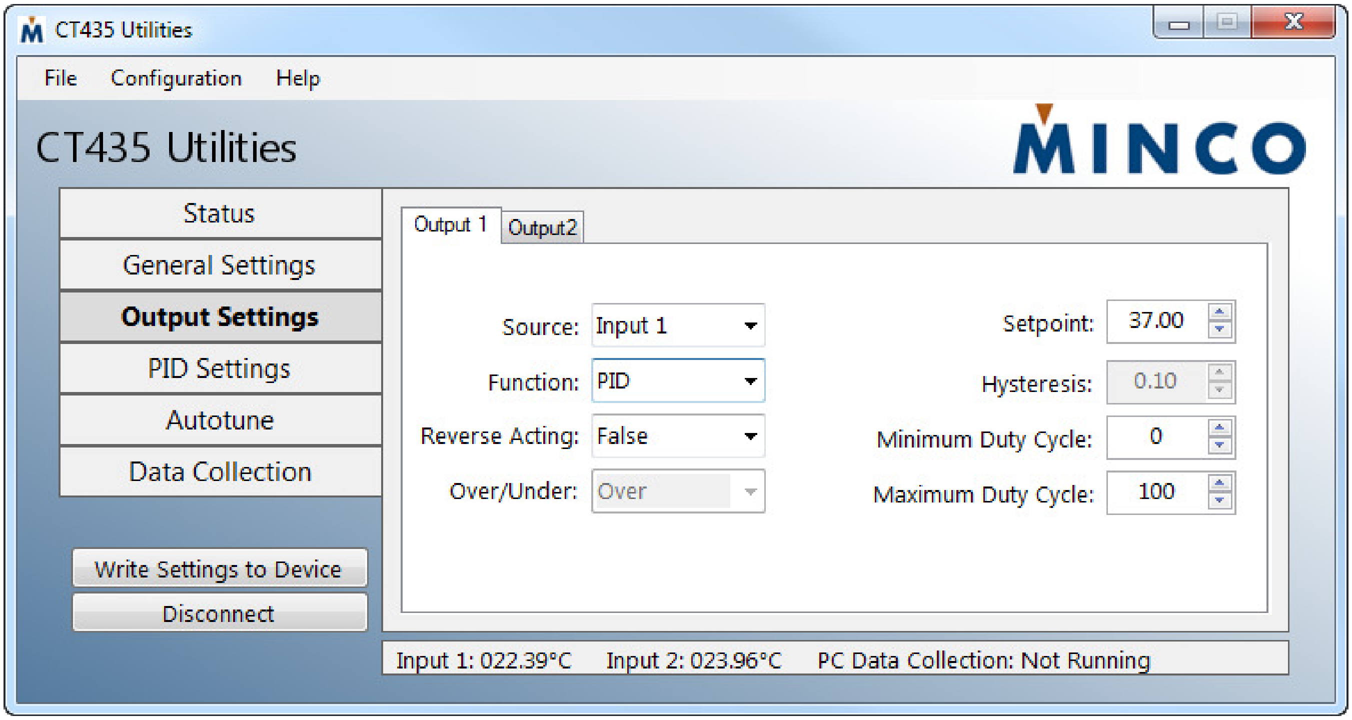

Figure 5

PID Settings

The PID Settings group contains settings specific to the PID Function. These settings will be unavailable unless the respective output is set to the PID Function.

Method: Determines if the PID coefficients (Kp = the Proportional coefficient, Ki = the Integral coefficient, Kd = the Derivative coefficient) will be entered manually by the user, or if they will be automatically generated from Autotune data by one of several algorithms.

The information gained from an Autotune procedure is saved so the Method may be changed later by the user. As with all other settings, this is preserved through a power cycle only if written to nonvolatile memory.

It should be noted that the various options listed in Method are the common names given to the various algorithms. For example, Minimal Overshoot may or may not result in the least overshoot among the other available methods due to variability in application, and accuracy of the Autotune performed. It's recommended to try different Methods to find the best performer, and if desired, manually tweak from there.

An easy, though generic option is to simply set Kp, Ki, and Kd to 100, 2, and 0, respectively. These are the default values the CT435 are shipped with, and work reasonably well in many applications. Kd could instead be set to 1000 for full PID. Again, these values are generic and are by no means intended to work in every application.

Loop Time: The loop time for the PID Function, in milliseconds. This is the amount of time between each PID Function calculation, i.e. how often output duty cycle is recalculated based on current conditions. A lower number will theoretically result in faster response time. However, a Loop Time that is too low may result in an unstable system. In general, slow moving processes should have a higher Loop Time.

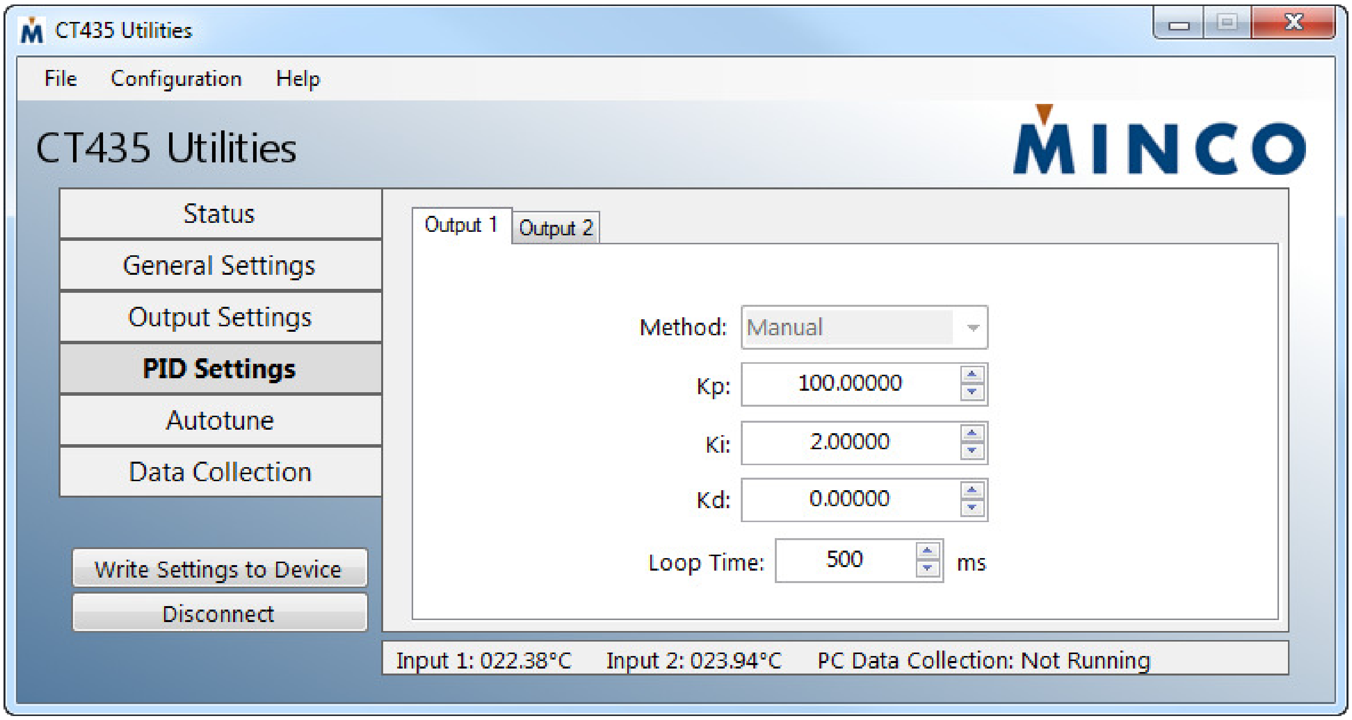

Figure 6

Autotune

The Autotune group contains settings for the Autotune feature.

Autotune Band: Determines the number of degrees above and below the Intended Setpoint the output is toggled during Autotuning, respectively. Generally this should be set as high as tolerable to improve Autotune results, although 0.5℃ is frequently sufficient. See the How Autotune Works section on page 10 for more information.

Autotune Output Step: Determines the output duty cycle while the output is engaged. The Autotune algorithm will cycle the output between fully de-energized (“off”) and the Output Step. The purpose of the Autotune Output Step is to limit heater power in applications where 100% duty cycle would cause very rapid heating, making autotuning difficult.

In general, set this value as low as possible while allowing the heater to receive enough power to reach the intended temperatures. See the How Autotune Works section on page 10 for more information.

Intended Setpoint: Determines the temperature around which the Autotune algorithm will operate. The purpose of this value is to first bring the heater to the approximate temperature at which it would normally be operated before Autotuning, which may improve Autotune results.

Be aware that simple on/off control is used while autotuning, and it’s possible that significant overshoot will occur during this Autotune step if the Autotune Output Step is set too high.

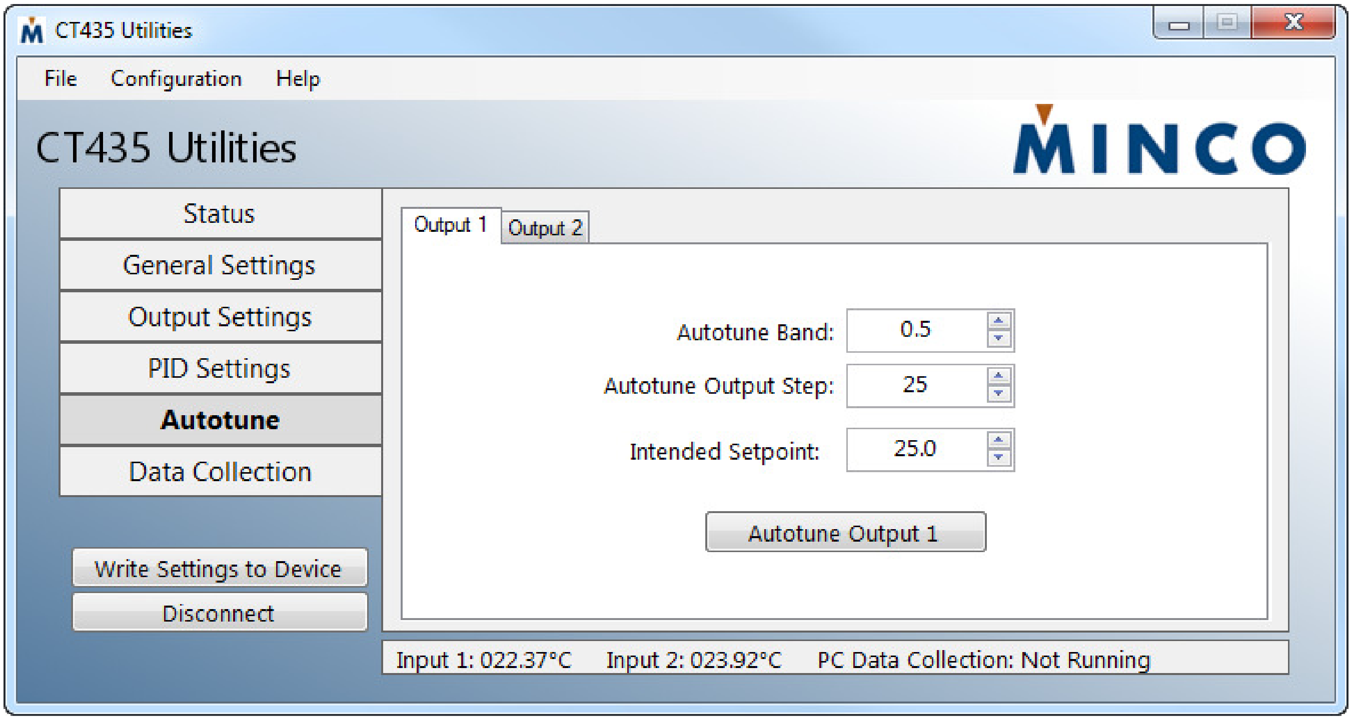

Figure 7

How Autotune Works

The Autotune feature automatically generates PID coefficients based on measurements performed using the actual sensor and load. Sometimes the values generated by Autotune are sufficient as the final operating values, but for better control, these may have to be manually tweaked.

The CT435 Autotune functions use the Ziegler-Nichols method. Autotune operates by first engaging the output to the duty cycle defined by Autotune Output Step until the temperature reaches the Intended Setpoint. This step is indicated by displaying "Pre-Heating". The output is left in the engaged state until the temperature exceeds the sum of Intended Setpoint and Autotune Band. The output is disengaged, and the temperature will begin to fall and the output is engaged again once the temperature is less than the difference between Intended Setpoint and Autotune Band. During this step, "Determining Cycle Rate" is displayed; the CT435 is measuring the approximate time required for a full temperature swing.

The output then continues to cycle in the same manner while displaying "Cycle x", where "x" is the cycle number. This gives the user an idea of how far along the Autotune process is.

Essentially, the output is toggled to cause the temperature to vary above and below the Intended Setpoint by approximately the Autotune Band. This process is repeated several times until the results are consistent.

The time between temperature peaks, the difference between temperature peaks and valleys, and the output drive duty cycle are used to determine PID coefficients.

Regardless of what Method is used to automatically generate the PID parameters, the above process is the same. The only difference is how the measured behavior is used to calculate the coefficients.

Once Autotuning is complete, control is immediately returned to the Function selected for that output.

Data Logging

The PC Data Logger simply polls the CT435 on a continual basis, then directly saves the temperature readings to a CSV file. The PC Data Collection tab in the Data Collection group contains settings for the PC Data Logger. The CT435 must be connected to the host computer when using the PC Data Logger since data is immediately stored on the host computer.

The generated file format is CSV. After specifying the collection parameters, press the Start button to begin data collection. The device will continue to perform all other activities while data collection is active. However, Autotune cannot be started while using the PC Data Logger.

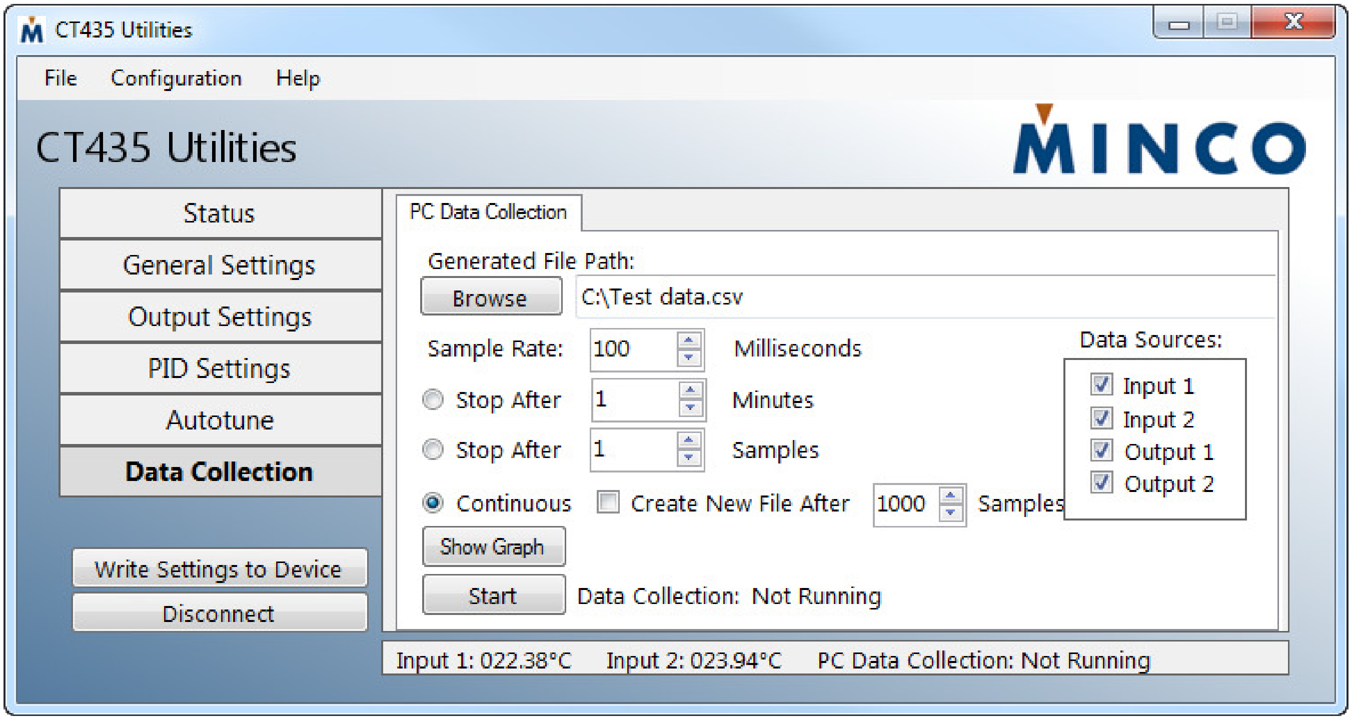

Figure 8

While collecting data, it is possible to view a real-time graph of the data by clicking 'Show Graph' before data collection. The graph displays only the selected channels both on the Graph pane and the Data Sources pane from the PC Data Collection tab. The line color for each line can be changed by clicking the color palette square located leftmost to on the legend. It is important to note that there are two scales – temperature and output percentage. Channel 1 and 2 output temperatures use the leftmost scale and the outputs use the right scale. To fit the data, right click on the chart area and select 'Set Scale to Default'. You can also zoom by left clicking and dragging or pan by middle mouse and drag.

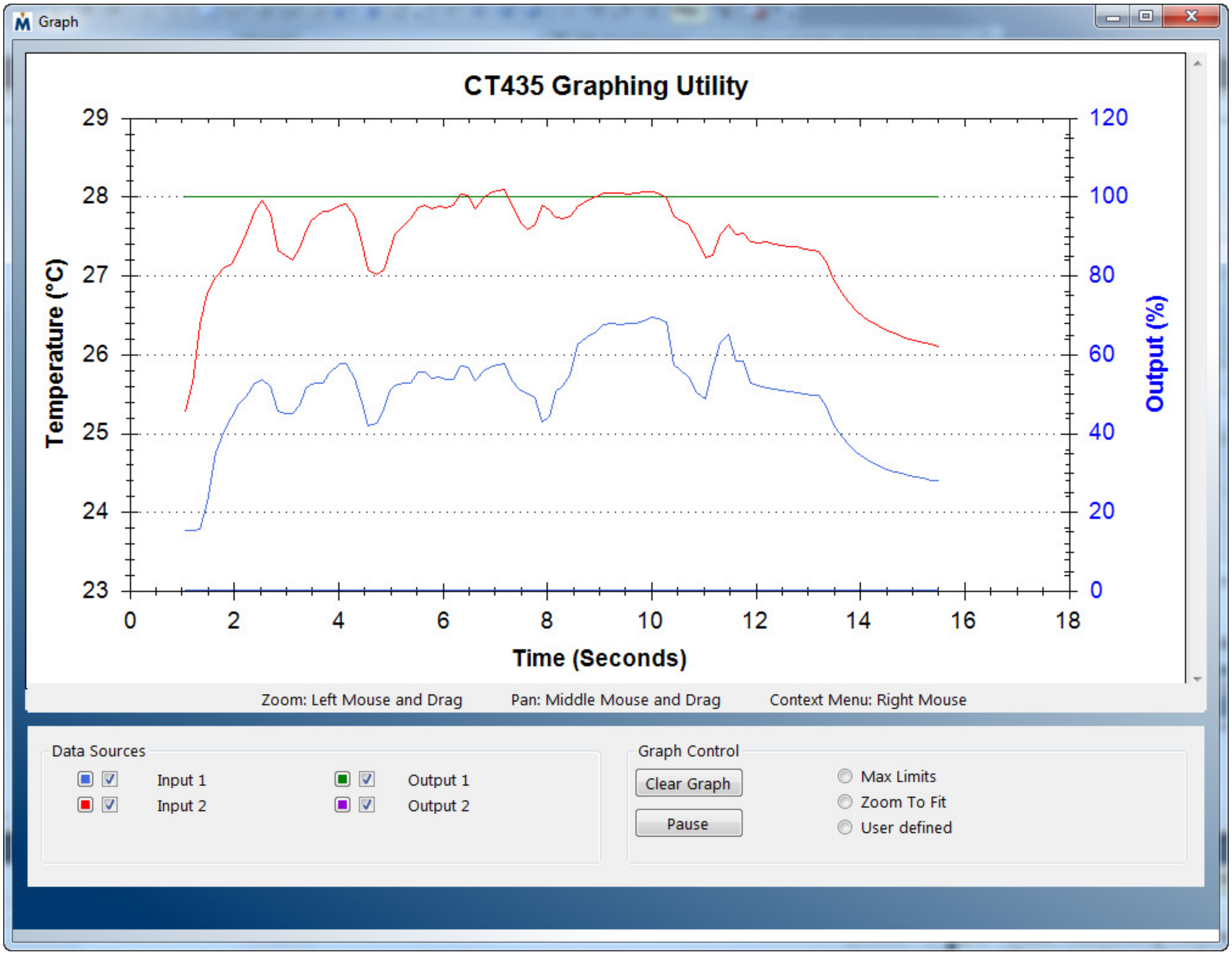

Figure 9

Submitting Settings

The Write Settings to Device button submits all changes that have been made within the utility program to the devices non-volatile memory. The user may make changes to multiple groups and tabs, however the CT435 does not receive these changes until this button is pressed; once it is, all changes in all groups and tabs are submitted to the device.

The text on the Write Settings to Device button will turn red when the device configuration does not match the software's configuration. After selecting, the button will turn black again. This color change to red serves to remind the user that a configuration is not yet active on the CT435.

The Write Settings to Device button commands the CT435 to commit the changes directly into non-volatile memory. This means that if the CT435 loses power, it will power up with this configuration. Performing this function while running a high speed PID loop could possibly disrupt it; the function halts all operations for a maximum of 30ms. Although this is unlikely to cause any issue, the user could disconnect the loads first to be safe.

As an example, assume the user has a CT435 they wish to use in a heating application. It will be connected to a sensor, heater, and source of power, but won't be connected to a computer. First the user connects the CT435 to their computer in order to configure the sensor types, outputs, set point, etc.; everything is configured as desired for this heating application. The Write Settings to Device button is pressed so this configuration is automatically loaded and used the next time power is applied to the device.

Features

Below is an in-depth explanation of the various features of the CT335/CT435 Evaluation Board.

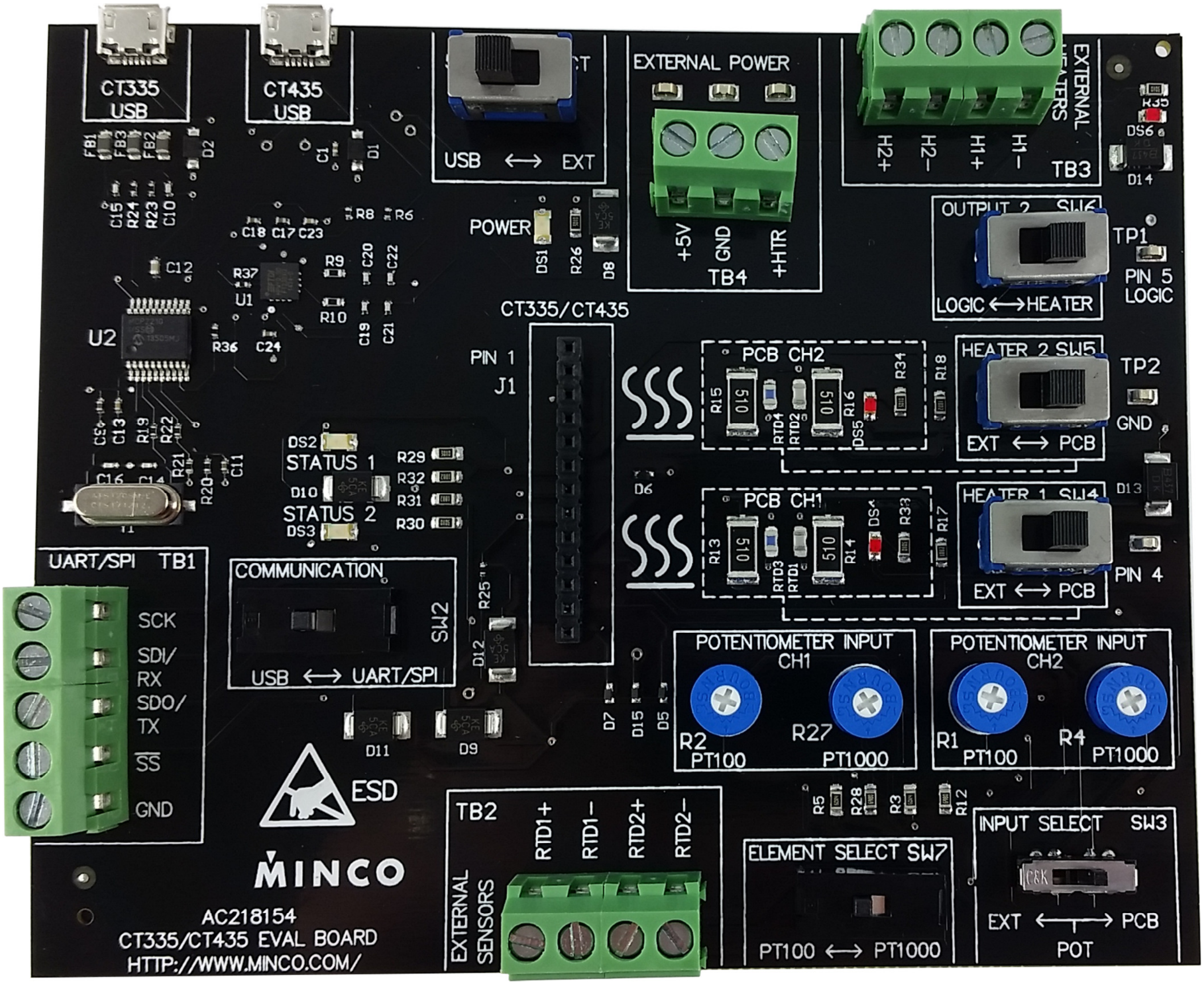

Figure 10

Controller Socket

Centrally located on the Evaluation board, J1 is the socket for the CT335 or CT435 controller. J1 is a standard 13-pin 0.1" spacing for the SIP (single in-line pin) controller package. Pin 1 is marked at the top of J1. This polarity must be observed to avoid damage to the controller.

J1 Pinout by controller model:

Pin	CT335	CT435
1	Power	
2	Ground	
3	Ground	
4	Output 1	
5	Output 2	
6	Serial Clock(SCK)	Status 1
7	Serial Data In (SDI)	UART RX
8	Serial Data Out (SDO)	UART TX
9	Slave Select (SS)	Status 2
10	Sensor Input 2 (+)	
11	Sensor Input 2 (-)	
12	Sensor Input 1 (+)	
13	Sensor Input 1 (-)	

Table 1 – J1 Pinout

Power

There are two methods of powering the Evaluation Board – USB power or External Power. The USB power input supplies 5V to the Evaluation Board, in turn powering the controller mounted in socket J1. If desired, 5V can also be supplied by connecting a DC voltage supply to the External Power TB4 across terminals +5V and GND. To select whether the Evaluation Board is using USB or External Power, use SW1, the 5V PWR SELECT switch. When powered, the Power Indicator, DS1, will be lit.

When using the on-board PCB Heaters (see Controller Outputs), the USB power will supply power to the PCB Heaters. When using External Heaters, a second power source will be required for the positive voltage on the heater. This voltage must not exceed the voltage rating of the CT335 or CT435 controllers of 60VDC. When using External Power for External Heaters, the voltage should be supplied by connecting a DC voltage supply to the EXTERNAL POWER TB4 across terminals +HTR and GND.

Controller Outputs

The output configuration of the controller depends on the model number of the controller:

- The CT335 has three output options, dependent on the Output Options variable:
  - 1 = One current-carrying, open drain output capable of sinking 6A
  - 2 = Two current-carrying, open drain outputs capable of sinking 3A each
  - 3 = One 3A open drain output and one 5V logic output
- All variations of the CT435 have two current-carrying, open drain outputs. See Additional Resources for detailed ratings.

On the Evaluation board, Output 1 is always a current-carrying output denoted as Heater 1, but Output 2 is selectable between a current-carrying Heater output and a Logic output using SW6. Logic should only be selected when using a CT335 with a 5V logic voltage output option. When using the Logic setting for Output 2, LED DS6 indicated when the output is driven high by the CT335, and the output voltage is easily accessible on TP1, which is connected to Pin 5 on the CT335 when SW6 is set to Logic.

When using current-carrying Heater outputs, there are two options for usage – PCB Heater Zones and External Heaters. This is selectable using SW4 and SW5 selection switches for Heater 1 and Heater 2, respectively.

- PCB Heater Zones are internally-connected 25.5Ohm heater loads (2 x 51Ohm power resistors in parallel, R13 – R16) powered from the 5V supplied to the board. This limits each Zone to around 200mA for safe operation from a USB 2.0 or lower power source. The PCB Heater Zones are denoted by the dotted lines surrounding the related components – two power resistors as the Heater load, surface mount RTD sensors, and an LED to indicate when current is flowing. The RTD sensors located between the power resistors are to be used as feedback to the controller when using the PCB Heater Zones. See Sensor Inputs for more details. This gives the controller on board control zones that may be used for testing or experimentation in a very controlled setting.
- Standard leaded heaters may be used with the Evaluation Board for advanced testing and prototyping of a system. To connect such heaters, connect each heater to External Heaters TB3 across terminals H1+ and H1- or H2+ and H2-. When using External Heaters, External Power must also be used. The voltage applied to the External Power connections is then applied to the heater(s) connected to the External Heaters connections. **WARNING – DO NOT exceed the voltage rating of the CT335 or CT435 controllers when using External Power. DO NOT exceed 3A per channel on the current-carrying outputs when using External Heaters.**

Sensor Inputs

Both the CT335 and CT435 use standard 100Ohm (PT100 or PD) and 1000Ohm (PT1000 or PF) 0.00385 TCR (Temperature Coefficient of Resistance) platinum RTD temperature sensors. Each controller must be ordered for a specific sensor type, and can use only that sensor type. The Evaluation Board supports both sensor types, selectable using SW7, Element Select.

There are three options for sensors that may be utilized with the Evaluation Board – PCB Sensors, Potentiometer Inputs, and External Sensors. This is selectable using SW3, Input Select.

- The PCB Sensors setting connects the surface mount RTD sensors in each PCB Heater Zone to the controller for temperature feedback. This should be selected when using PCB Heaters. The PT100 sensors are RTD1 and RTD2, and the PT1000 sensors are RTD3 and RTD4. Note: the PCB Sensor traces and switch contacts add approximately 0.4 Ohms of resistance to the sensor readings.
- The Potentiometer setting connects potentiometers R2/R27 to Input 1 of the controller and R1/R4 to Input 2 of the controller, dependent on which element type is selected. These multi-turn potentiometers are meant to simulate a sensor input for testing purposes. Each potentiometer is in series with a resistor to give a lower limit of -100℃ equivalent resistance and an upper limit beyond the input range of the CT335 and CT435 controllers, allowing the user to utilize the controllers' full input range.
- Standard leaded PT100 and PT1000 RTD sensors may be used with the Evaluation board for advanced testing and prototyping of a system. To connect such sensors, connect each sensor to External Sensors TB2 across terminals RTD1+ and RTD1- or RTD2+ and RTD2-. When 3- or 4-wire RTD sensors, connect common leads together on individual connection points.

Communication

Both the CT335 and CT435 support real-time temperature readings and configuration setting through board level digital communication:

- CT335 – SPI, slave mode operation, recommended 9.6kbps, 5V logic level.
- CT435 – Modbus (RTU) over UART operated at 115.2kbps with no flow control using 8 data bits, no parity, and 1 stop bit. The UART RX pin on the CT435 is 3.3V and 5V logic tolerant, and the UART TX line is open drain, requiring an external pull-up to the logic level voltage.

For more details on device communication, see Additional Resources.

The user may interface with each controller using either the on board USB converter or the direct UART/SPI connections. This is selectable using SW2, Communication.

- When USB is selected, the UART/SPI lines of the controller are connected to the on board USB converter electronics, which handles all UART/SPI conversion. The FTDI FT230X, U1, is used as the USB to UART converter, and the Microchip MCP2210 is used as the USB to SPI converter.

- When UART/SPI is selected, the UART/SPI lines of the controller are connected to TB1 for connection to an external system. Each connection is labeled for ease of identification.

Indication

LEDs on the Evaluation Board function as indication for various processes or states:

- DS1 – 5V power indicator.
- DS2, DS3 – Status indicators connected to Pin 6 and Pin 9 of the controller, used only by the CT435. When using the CT335, these LEDs will flash during communication.
- DS4 – Indicates when power is being applied to PCB Heater Zone 1.
- DS5 – Indicates when power is being applied to PCB Heater Zone 2.
- DS6 – Indicates when the Logic output is driven high.

Block diagram

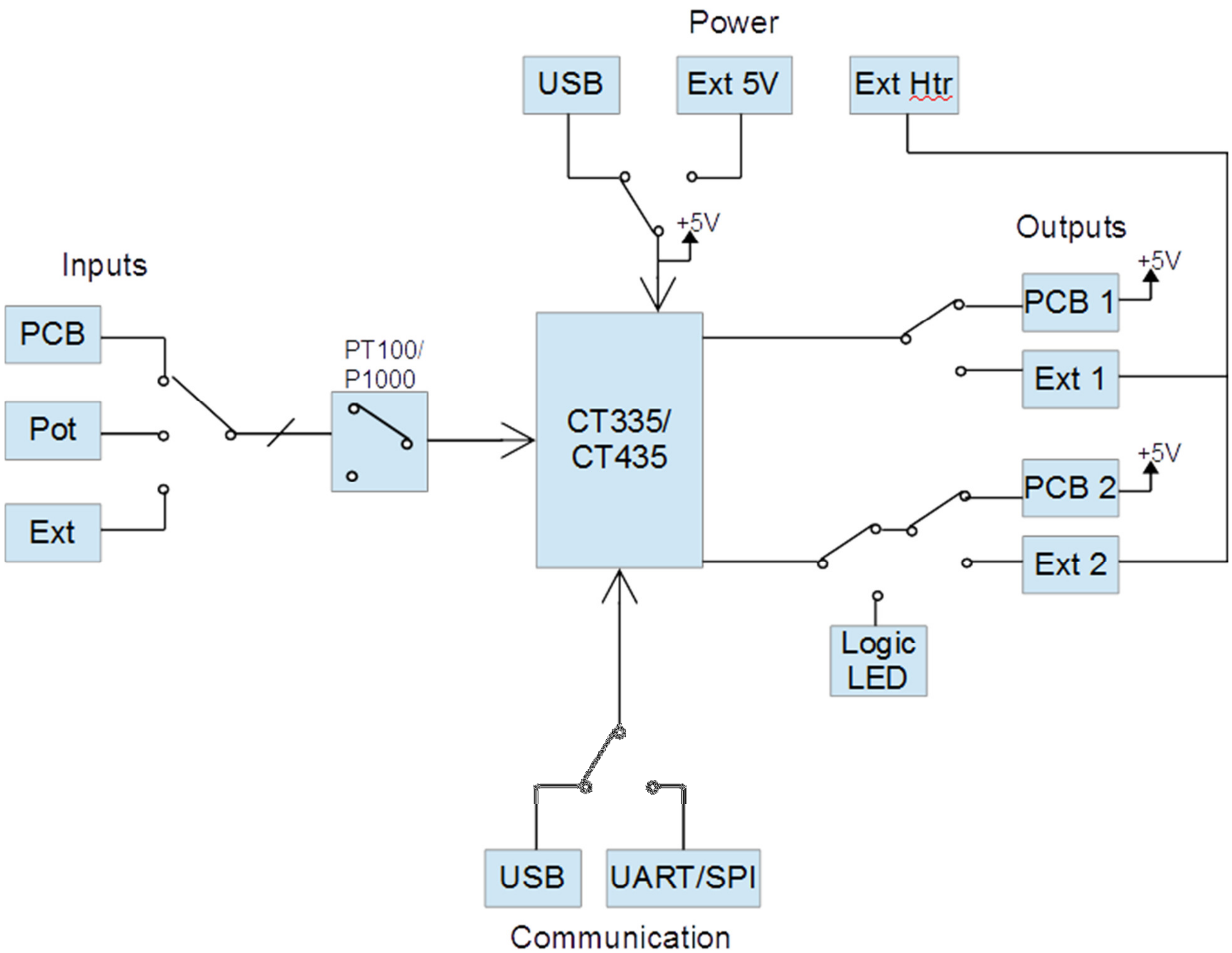

Figure 11 - Block Diagram of CT335/CT435 Evaluation Board

PCB Design

Schematic

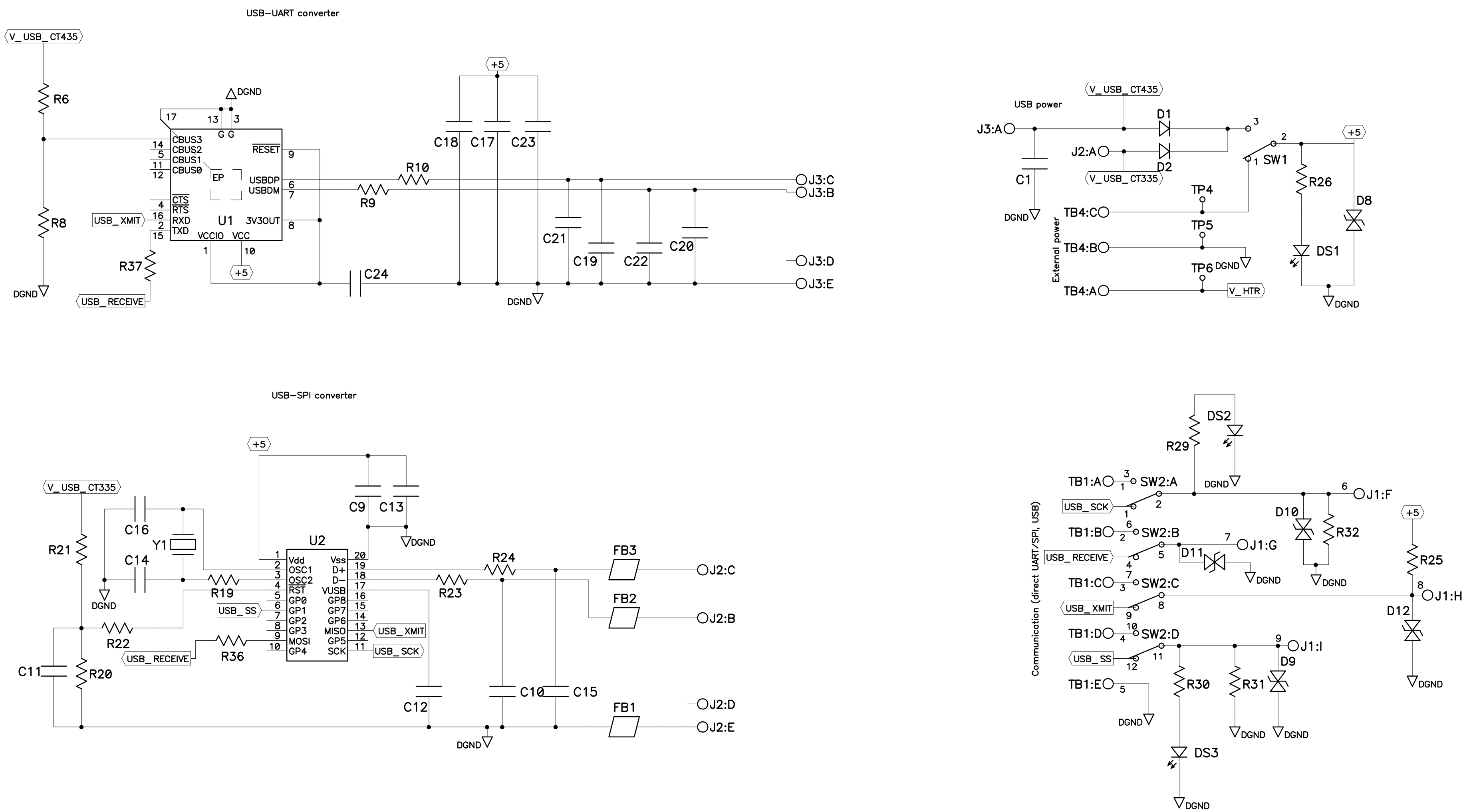

Figure 12 - Schematic Sheet 1

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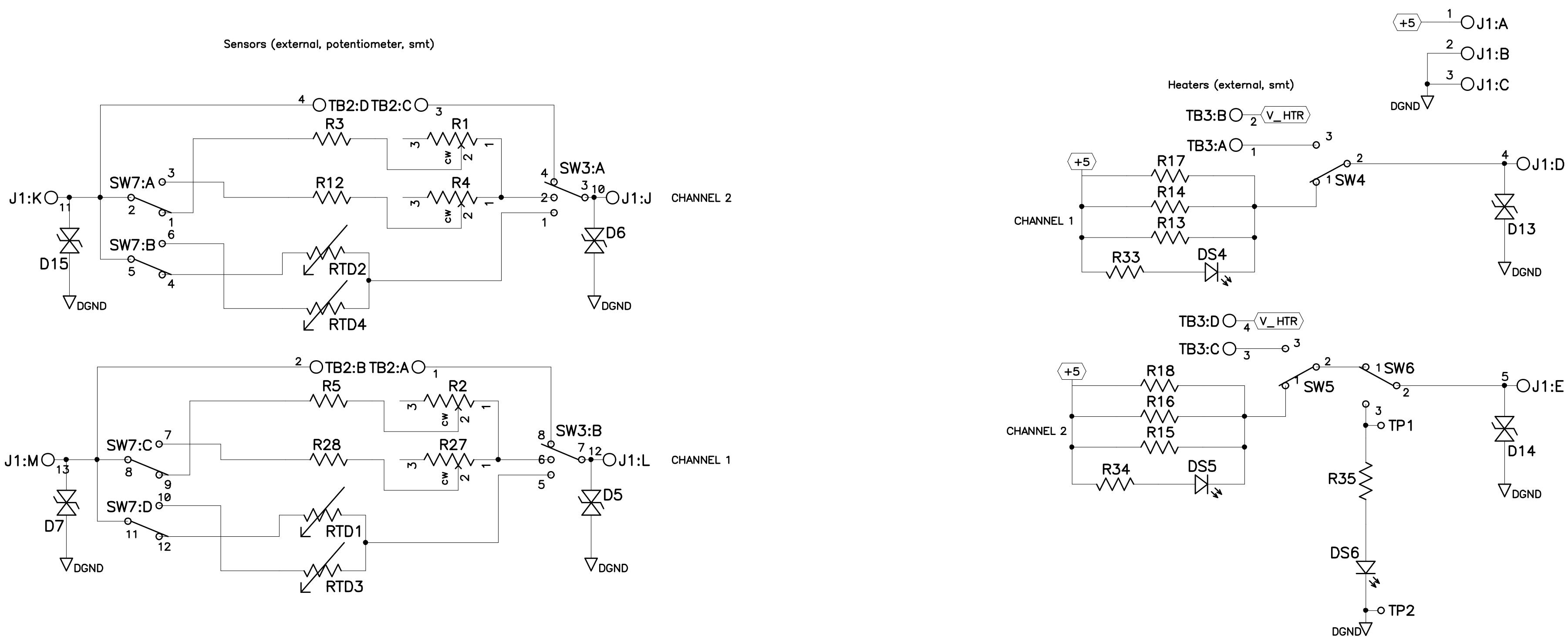

Figure 13 - Schematic Sheet 2

Assembly Drawing

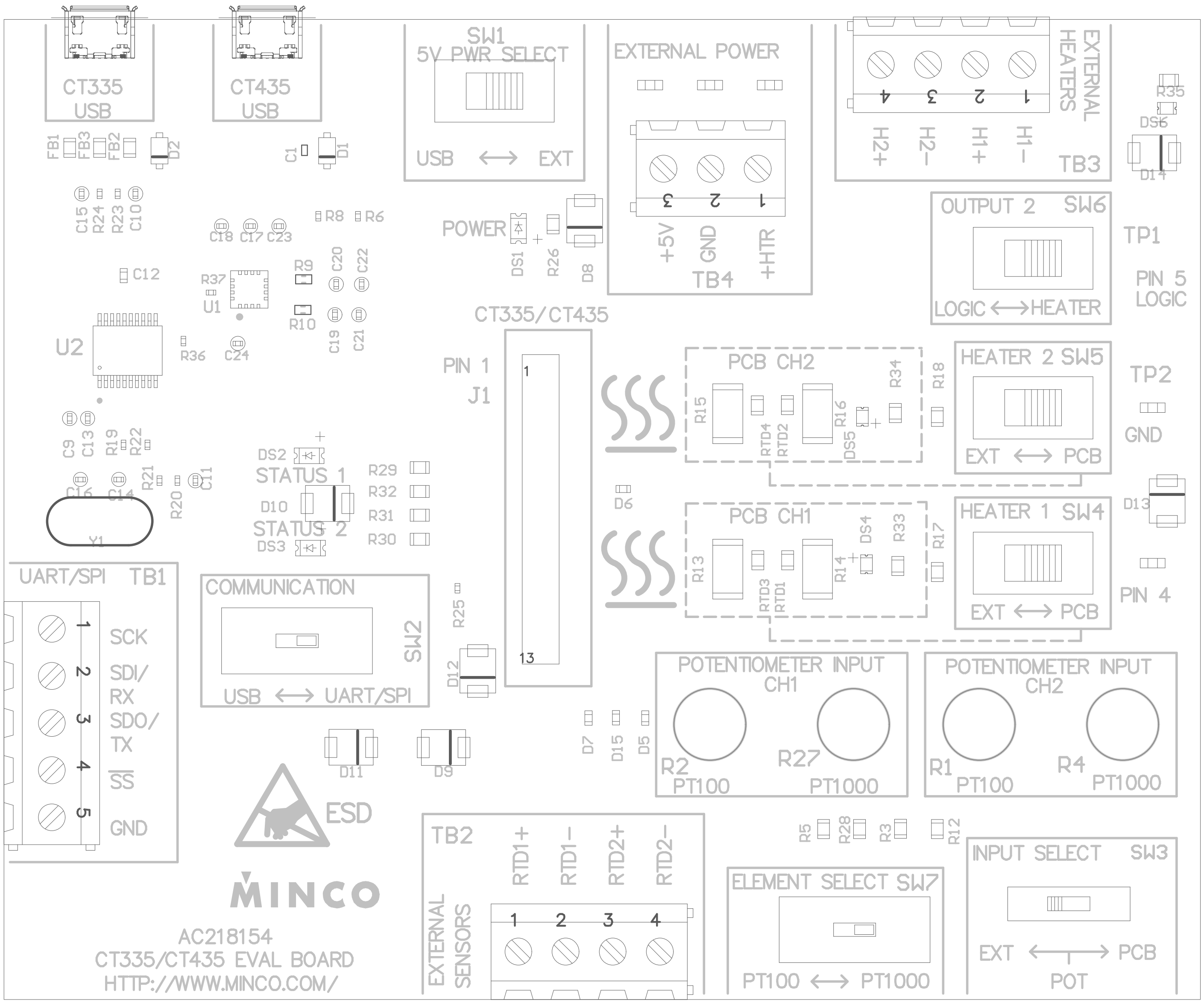

Figure 14 - PCB Assembly Drawing

Layout

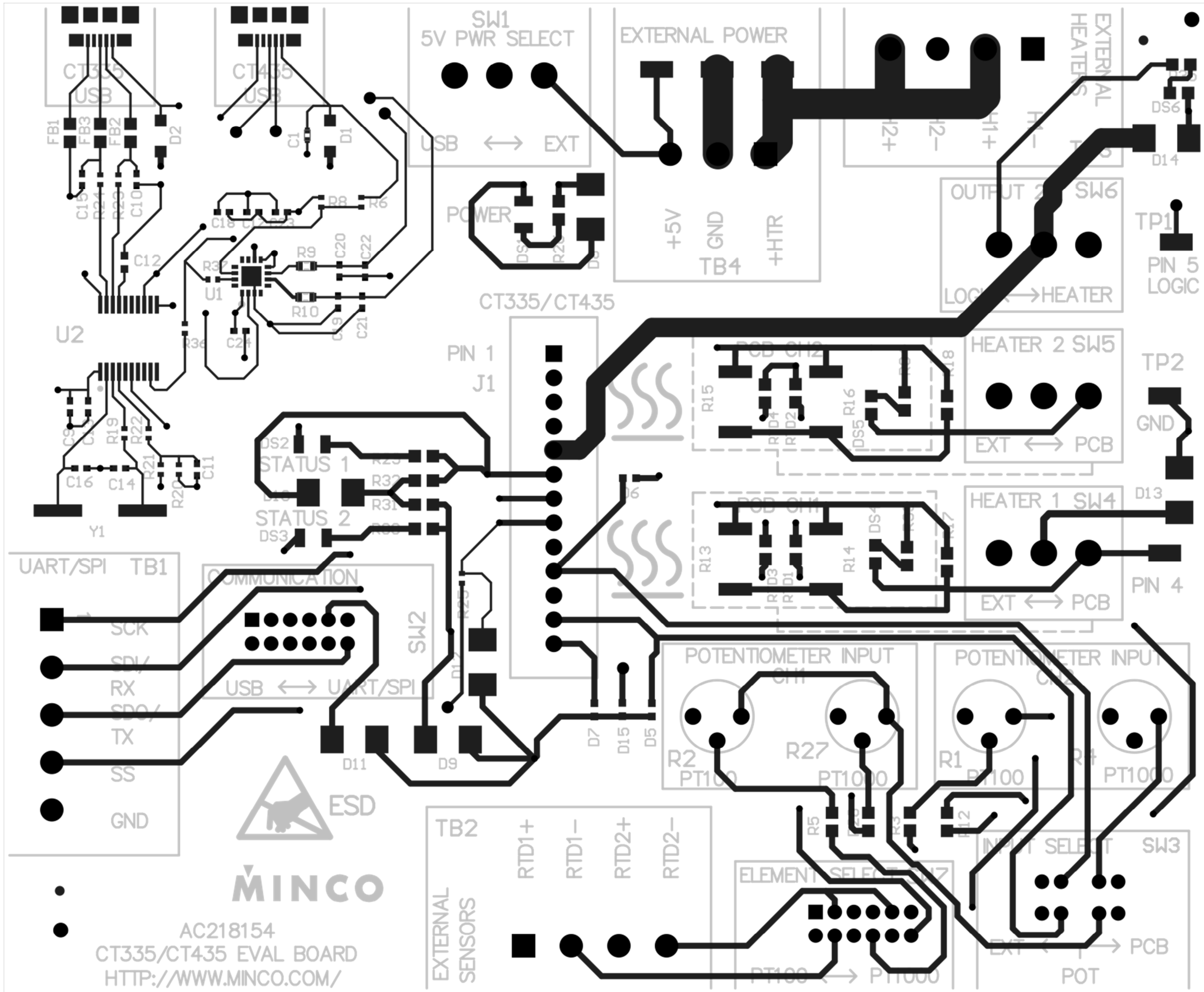

Figure 15 - PCB Top Layer

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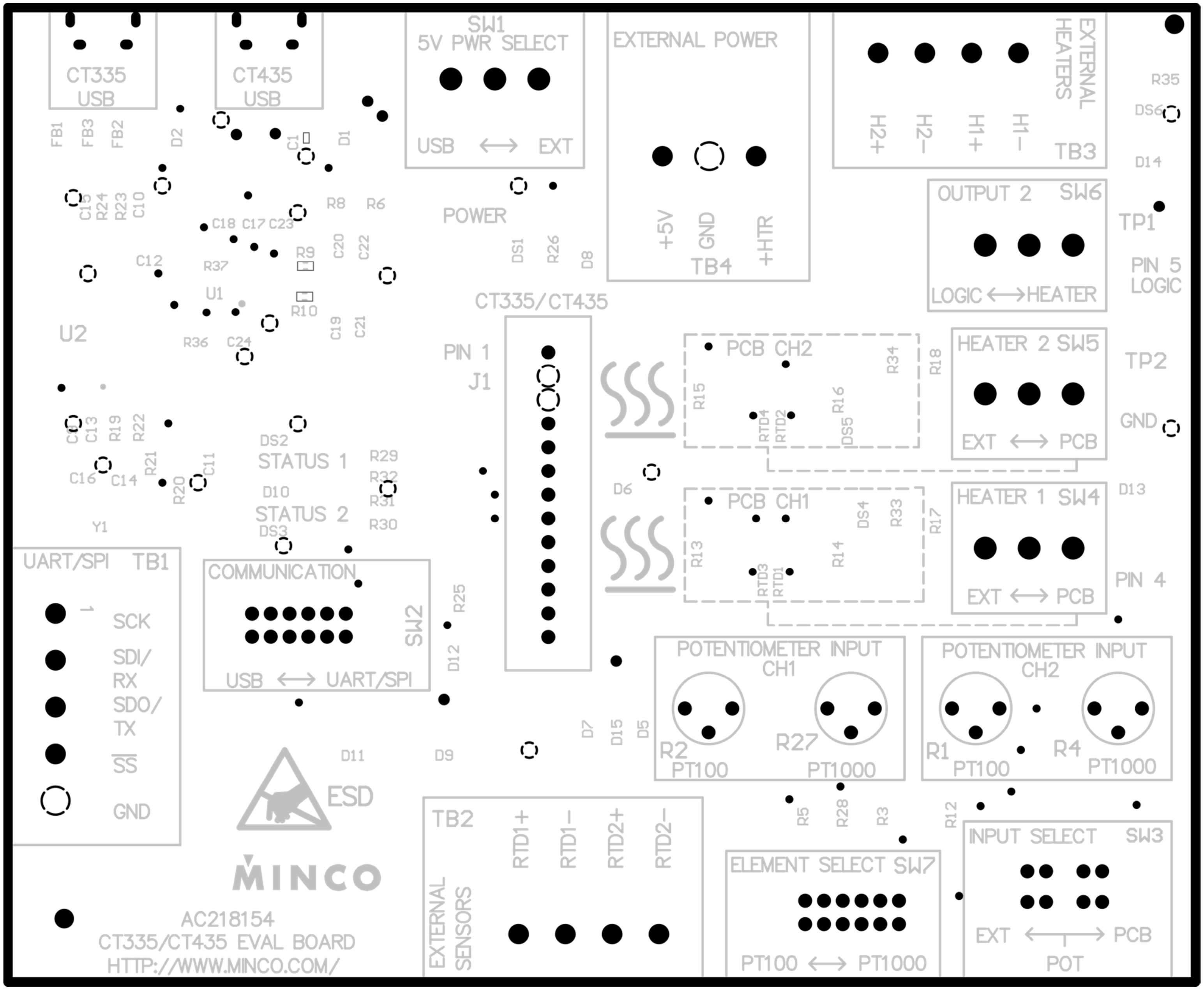

Figure 16 - PCB Layer 2

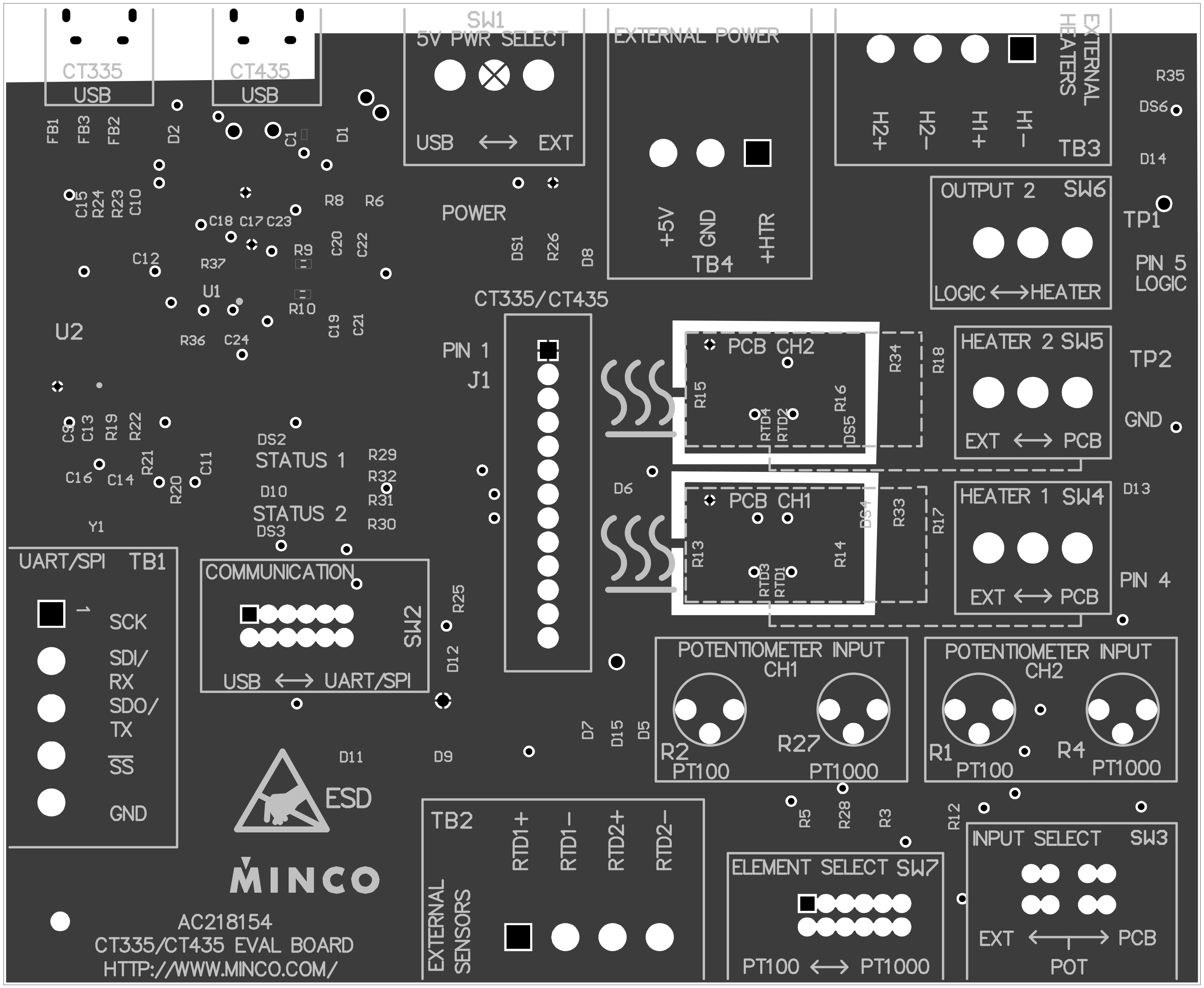

Figure 17 - PCB Layer 3

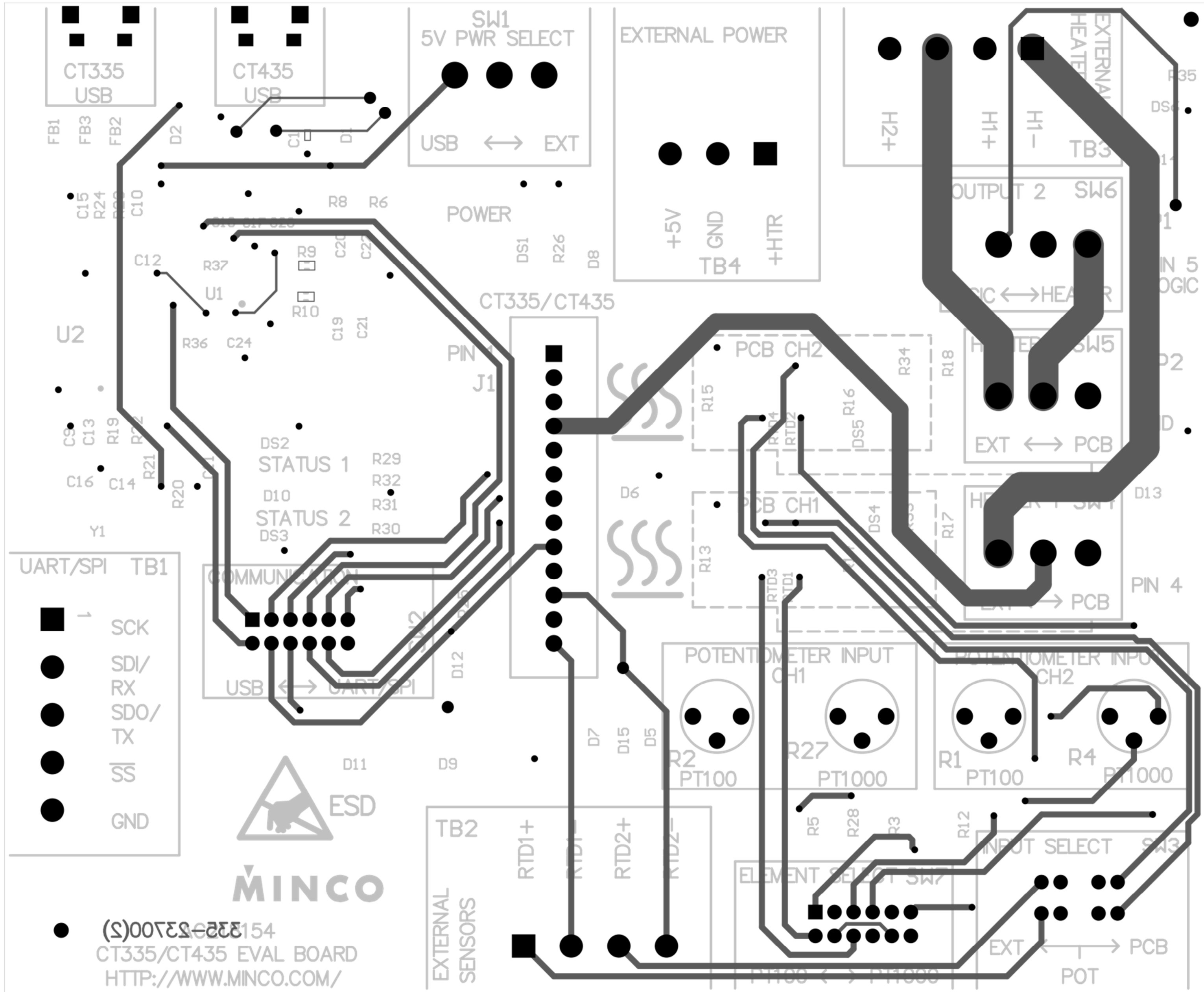

Figure 18 - PCB Bottom Layer

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Additional Resources

For additional information on the CT335 and CT435 controllers, please refer to the latest version of the following documents at *www.tinyurl.com/Minco-Downloads*:

CT335 User Guide

CT335 SPI Communication Manual

CT435 Manual Datasheet

Revision History

Version	Comment
1.0	Initial release

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