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PRODUCT FAMILY: SOLO Controllers
Subject: Temperature control examples

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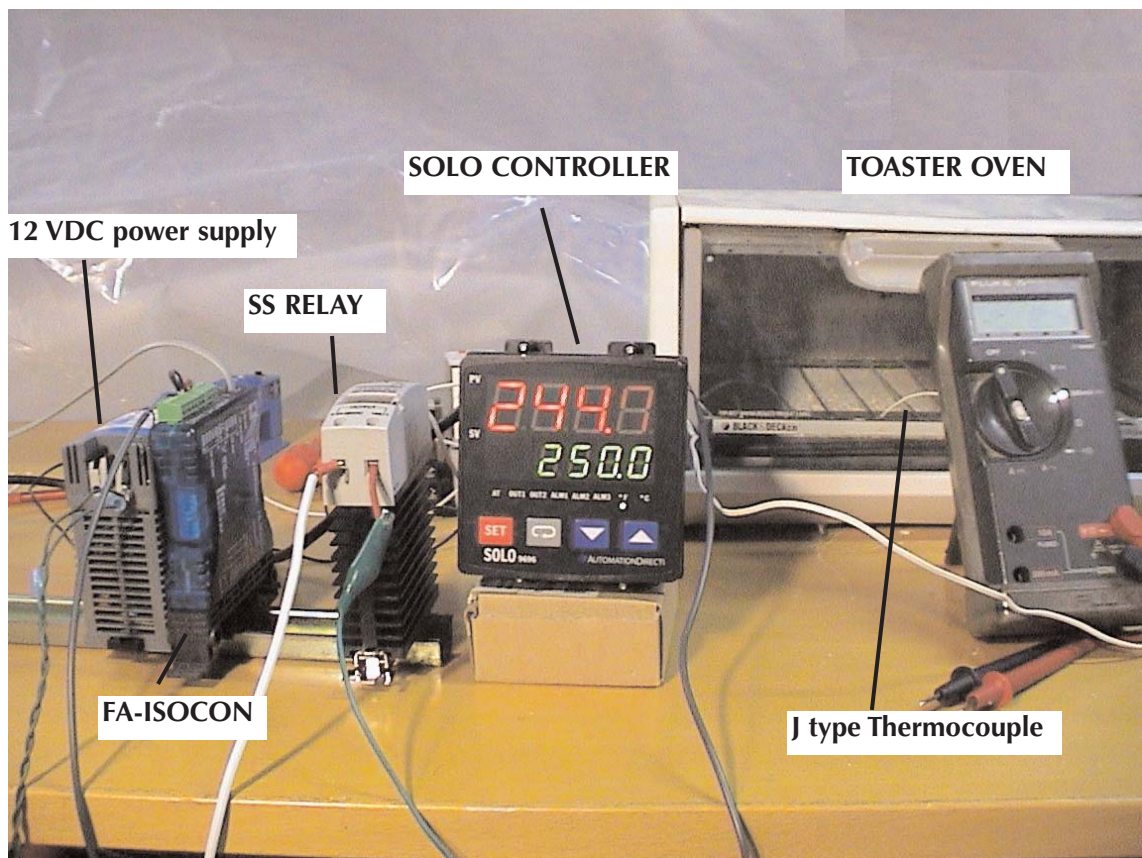
The SOLO controller comes in different flavors. There are versions with analog output, pulse output or relay outputs. The controller to be used in this example is the SOLO SL9696-RRE. Most of the time the clients need to use ON/OFF control or PID control. These 2 examples will show a simple application and will compare the results for learning purposes.

The application note considers a toaster oven of 120 Volt, but the internal control has been bypassed to allow the SOLO controller to regulate the temperature.

The oven has a heating element with a resistance of 11.8 Ohm cold. We have implementing the control thru a solid state relay.

Please see the arrangement below:

We have used other AUTOMATION DIRECT products, namely the adapter FA-ISOCAN, a power supply of 12 Volt, and the solid state AD-SSR225-DC, for 10 A rated current.











ON/OFF temperature control




















In this example we will use the mentioned SOLO controller to control the temperature of the electrical oven between 50 to 400° F with a relay output. The controller will work in this example as ON/OFF control, using a thermocouple type J.

First, we will set the controller to the **factory default condition**.

For that, we do the following, after turning the controller ON:

- 1 Press the key  until the display shows **LoL** in front of SV. Press parameter key  once in order to select **LoLi** and then press the key .
- 2 Press and hold the keys  and  simultaneously for one second. When you let go, the display should show **SHoU** in PV and **oFF** in SV.
- 3 Press the key  until the display shows **PASS**. Use the key  to change the value in SV to **135**. Press the key .
- 4 Cycle power to the controller to reset it to factory default values. All the values defined by the user will be erased. When turning on the controller, the display shows the version of firmware (example **6.160**) and the type of controller, in this case, **rRE** for 3 seconds.
- 5 The display shows **na** in front of PV and **Cont** in front to SV.

It is necessary now to go to the **initial configuration mode**:

- 1 Press the  key for three seconds. Press the key  until **Ctrl** appears. Press one of the keys  or  until the type of control **oNoF** appears. Press the  key in order to accept the value.
- 2 Press the key  until **S-Hd** appears. **HEAL** will show up. Then press the  key.
- 3 Press the  key for three seconds. **EnPt** appears in the display. Press one of the keys  or  until the type of thermocouple appears (J in this case). If it is different, select from the table on next page.
- 4 The display shows **Pt** in front of SV, and it should be changed in this case to thermocouple J with the key . The press the  key in order to accept this value.
- 5 Press the  key for less than three seconds to see **HLS**. Press one of the keys  or  to define the hysteresis. Let's leave the value in 0 in this case. Then press the  key.
- 6 Press the key  until **EPUn** appears, Unit of temperature, in the display.
- 7 If the display shows **F** then it should be changed to F (Fahrenheit) with the  key.
- 8 Press the key  until the parameter **EP-H** appears, upper limit of the input range.

Thermocouple Type	
Input Temperature Sensor Type	LED Display
Thermocouple TXK type	TXK
Thermocouple U type	U
Thermocouple L type	L
Thermocouple B type	B
Thermocouple S type	S
Thermocouple R type	R
Thermocouple N type	N
Thermocouple E type	E
Thermocouple T type	T
Thermocouple J type	J
Thermocouple K type	K
RTD Type	
Input Temperature Sensor Type	LED Display
Platinum Resistance (Pt100)	Pt
Platinum Resistance (JPt100)	JPt
Voltage Input Type	
Voltage Input Type	LED Display
0~50mV Analog Input	50
0V~10V Analog Input	10
0V~5V Analog Input	5
Current Input Type	
Current Input Type	LED Display
4~20mA Analog Input	20
0~20mA Analog Input	20

- 9 The display shows 999.9 in front of SV, that it must be changed in this case to 400.0 with the key \blacktriangle . Then press the key **SET** in order to accept this value. If the value of temperature is greater than this selected value, it will create an error.
- 1 1 Press the \square key until the display shows **EP-L**, lower limit of the input range. The **-99.9** in front of SV should be changed to 50.0 with the \blacktriangle key.
- 1 2 Then press the **SET** key to accept this value and then press **SET** to return to the operation screen.
- 1 3 Press the \square key until the displays show **SP**. Use keys \blacktriangle or \blacktriangledown to select a \square , which will indicate the degrees directly or a \square , the value that will indicate the temperature in tenths of a degree. Then press the **SET** key to accept this value then press **SET** to return to the operation screen.

- ①④ Press the key **↶** until the display PV shows **r--S**. Use the key **▼** to change the value on the display SV to **rUn**. Press the key **SET**.
- ①⑤ If the temperature shows a small constant offset in the range, you can adjust the reading by pressing the key **SEE** for less than 3 seconds. Press the key **↶** until you see **EPoF** on the display. Use the keys **▼** or **▲** to set a positive or negative offset to the actual value of temperature shown by the controller. Then press the key **SET** to accept this value and then press **SET** to go back to the operation screen..

ALa2 and **ALa3** are left as 0, that is, disabled.

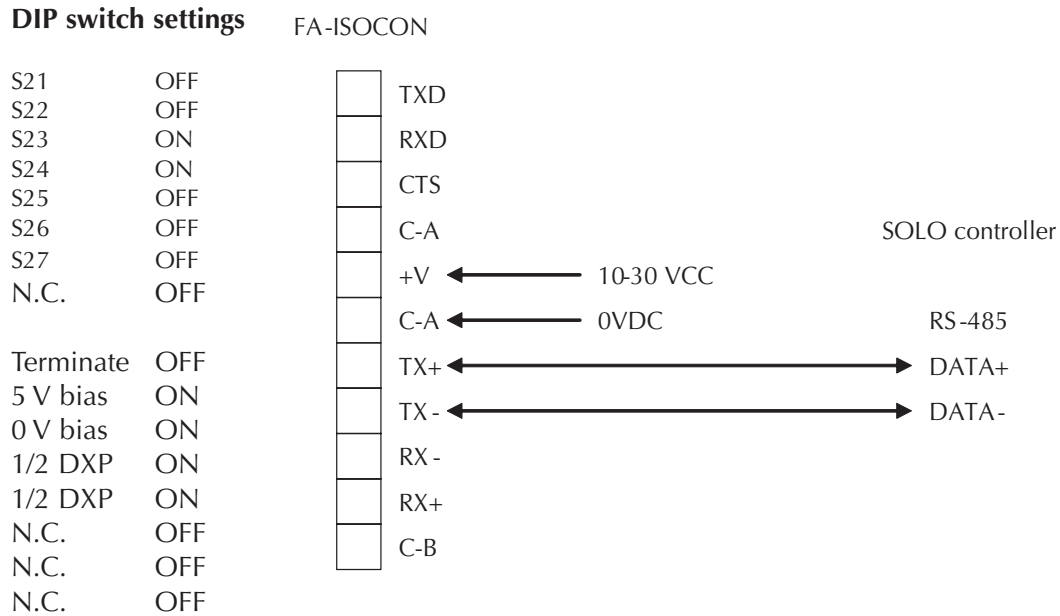
The alarm **SALA** is left **OFF**.

The parameter **CO5H** will be activated to allow the use of MODBUS RS-485 communications, MODBUS mode **C-SL** as **rLU**, slave address **C-no** **2**, Baud rate **bPS** as **1942**, data lengths **LEn** as 8, parity **odd**, and stop bits **StoP bTE** as **1**.
















Now it is the time to run the controller.

Link the SOLO configuration software to the controller.

In order to monitor the operation we will link the SOLO controller to a PC with the program SLSOFT, and for that we need to use a RS-232 to RS-485 adapter (Normally the PC's do not have a RS-485 port, only RS-232) such as the module FA-ISOCON. It will be connected according to the following diagram:



- ① Press the key **SET** for 3 seconds to go to the initial Setting mode. The display shows **LnPE**.
- ② Press the key **↶** until the display shows **CO5H**. Use one of the keys **▼** or **▲** to change the display to **On**. Press the key **SET**.
- ③ Press the key **↶** until the display PV shows **C-SL**. Use one of the keys **▼** or **▲** to change the display to **ASCII**. Press the key **SET**.

- 4 Press the key  until the display shows **E-nd**. Use one of the keys  or  to change the display to 2 (Slave 2). Press the key **SET**.
- 5 Press the key  until the display shows **bPS**. Use one of the keys  or  to change the display to **19Hz**. Press the key **SET**.
- 6 Press the key  until the display shows **LEn**. Use one of the keys  or  to change the display to **7** (bits) . Press the key **SET**.
- 7 Press the key  until the display shows **Prty**. Use one of the keys  or  to change the display to **EEEn**. Press the key **SET**.
- 8 Press the key  until the display shows **STOP**. Use one of the keys  or  to change the display to **1**. Press the key **SET**.

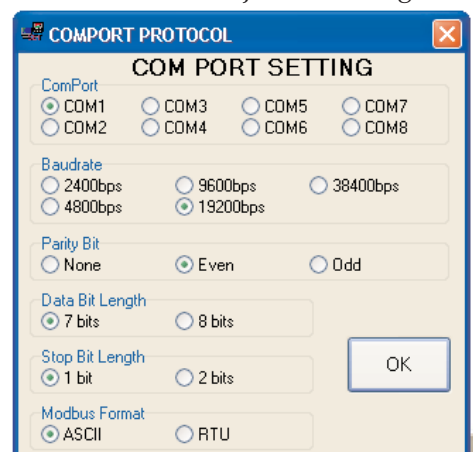
The allows to enable three communication between a PC with the software SOLO and the controller. It is assumed that you have already installed the program into your PC. When the program is started, you will see the following screen:



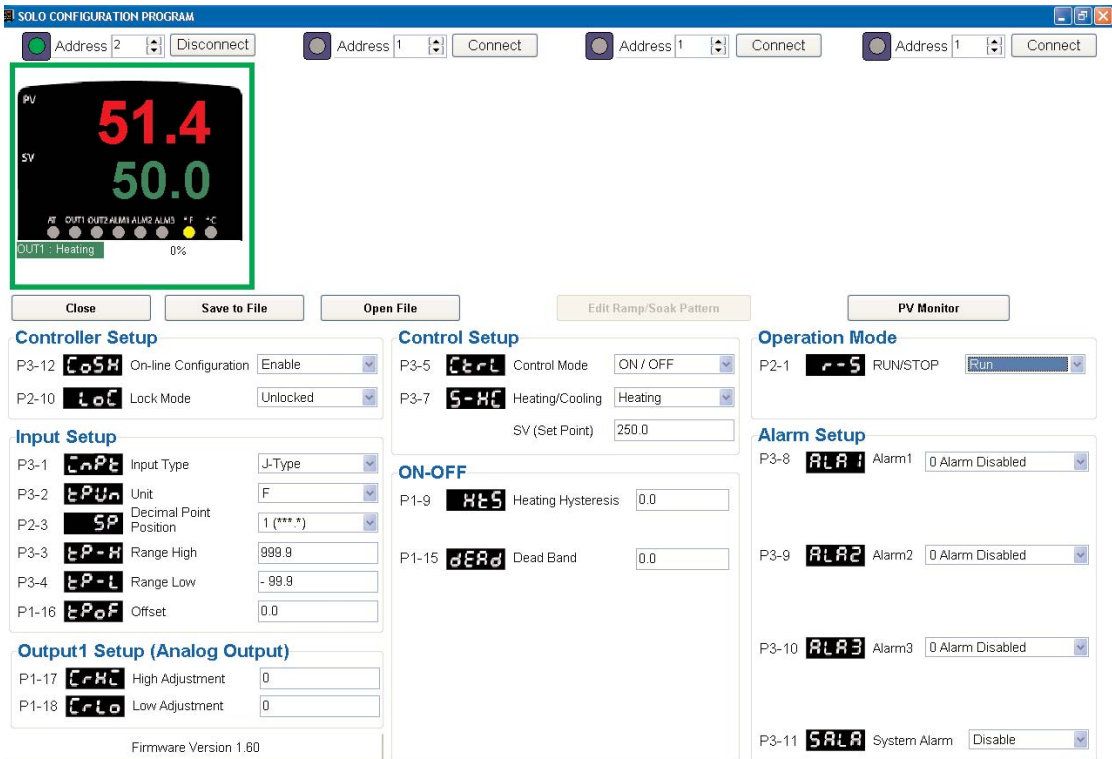
Click the menu **PROTOCOL** in the upper left corner and the adjacent dialog will pop up, shown as the previous set up.

Adjust the address to **2** (Slave 2) on the set up screen and then click in **Connect**.

The specific data of the linked controller will be displayed on the screen, as it is shown on the figure of the following page:

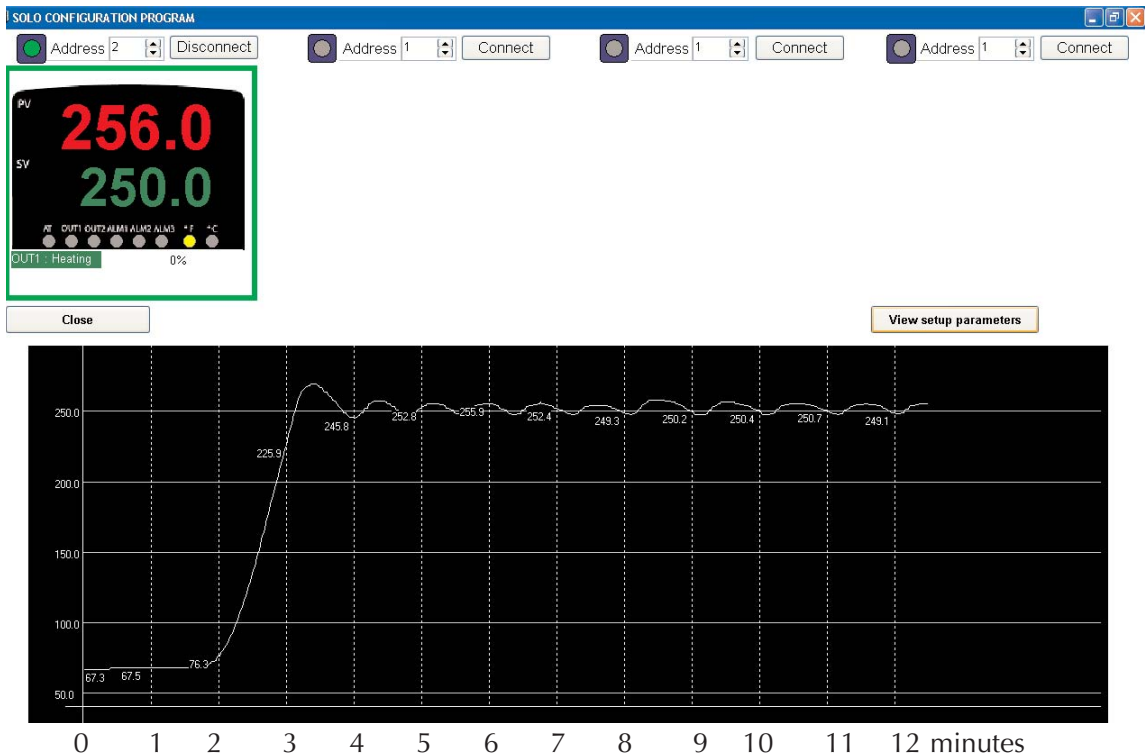


Solo controller example AN-LC-009



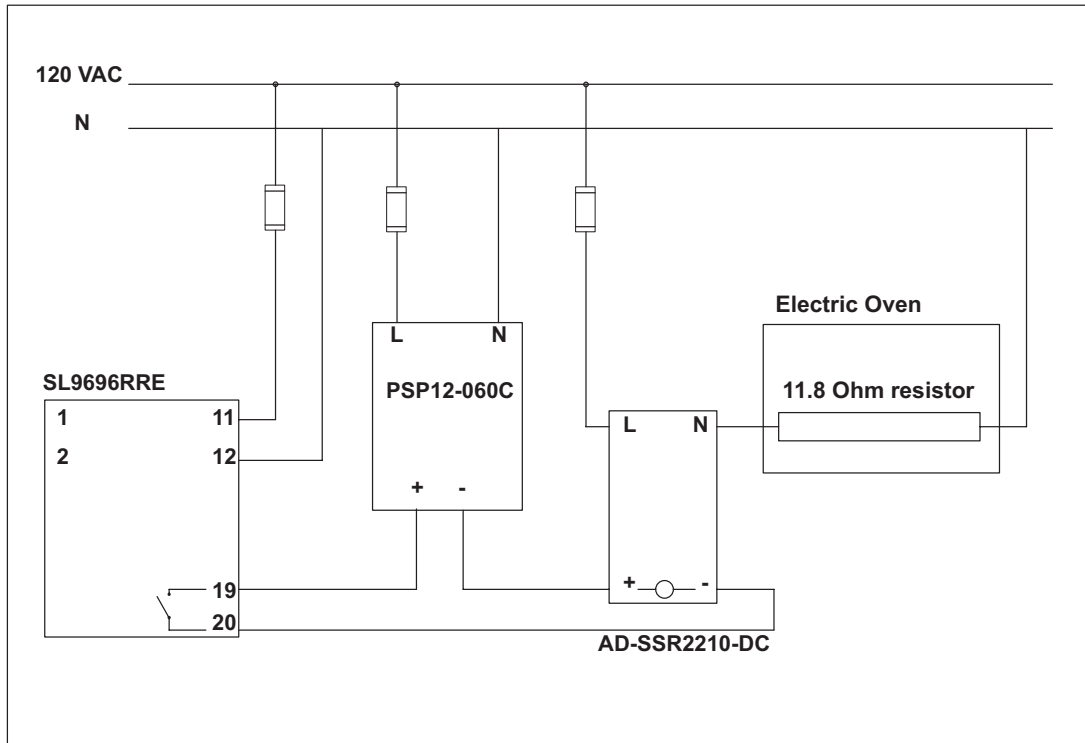
When in the **operation mode**, the temperature controller can now initiate the real temperature control if the power has been energized. Adjust the desired temperature SV to 250 degrees and turn on the controller by setting the parameter **r-s** to **run**.

See below the temperature characteristic along the time as seen with the SOLO configuration software.



Wiring diagram

See below the wiring diagram for this specific case.



Comments

The initial temperature was 67.3 degrees F. There was one overshoot at about 3 seconds since the controller output was turned on for 3 minutes continuously on.

After the actual temperature overpasses the desired temperature value, the controller turned OFF the output contact until the temperature dropped below 250 degrees. Immediately the output contact closed again to deliver energy to keep the temperature inside the oven close to 250 degrees.

Observe that the controller determines when the actual temperature value has crossed the reference value (the desired value) and this keeps turning on and off the output contact. This works similar to the home control of heating during winter.

This completes this example. In this example we have not considered alarms.

Please also note that we have left a hysteresis value of 0. On other applications it could be necessary to change the values to allow the controller to get a delay before the output contact is turned on after the actual temperature crosses the reference point into the lower temperature.

PID control example

In this example we will use the same temperature control on the electric oven with the same temperature range of 50 to 400° F with a relay output. See the picture of the system on page 1.

Recall that a PID control has an analog output. In this case, the output is in reality a relay, that will open and close in certain period in such a way that when the output is 100% the relay will be closed 100% if the time on the mentioned period. If the output is, let's say, 50%, the output will be on for 50% of the time, and off for the rest of the cycle, being the time proportional to the analog output. This is sometimes called *time proportioning control*.

Set the controller as a **factory default conditions** as explained on page 2.

If you have not done the initial setting, use the procedure to set the thermocouple type, as shown on page 3. If done, just change the `CTRL` parameter to PID.

Make a MODBUS communication link from a PC with a SOLO configuration program to the SOLO controller. See the instructions on page 4.

Now you can set up the PID loop.

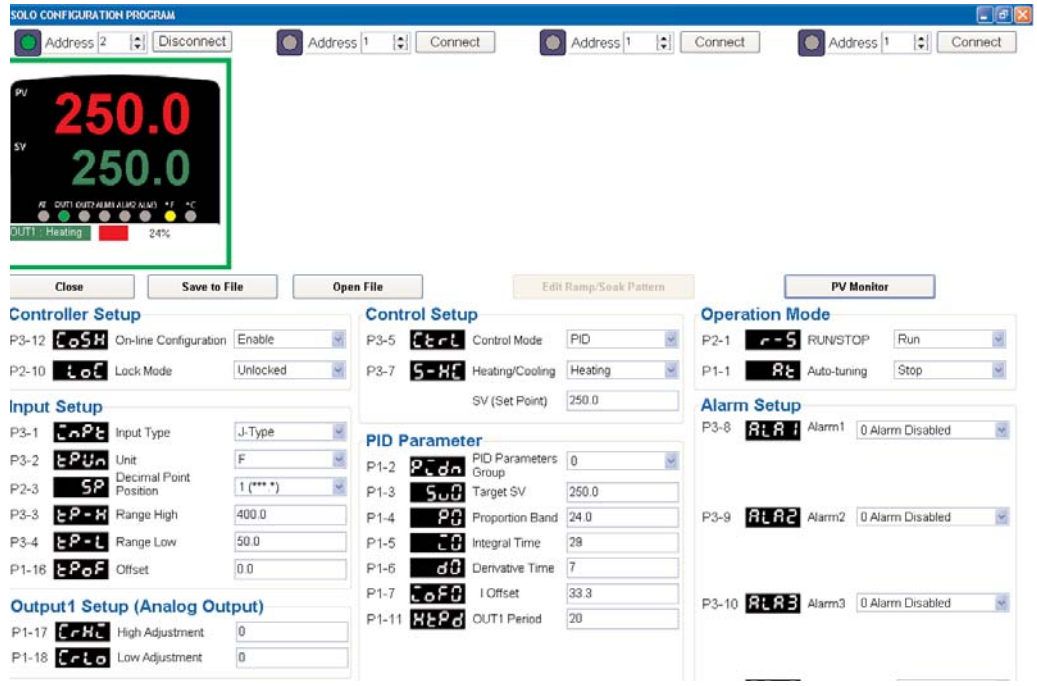
There are 4 parameter groups for storing control values for the PID loop, namely `PLD0` to `PLD3`.

- 1 Press the key `SET` for more than 3 seconds. Press the key `↩` until you see `CTRL`. Use one of the keys `▼` or `▲` to change the display to `PLD`. Press the `SET` key to accept this value.

Since at this point you are doing time proportioning control, the `HTPD` value is important. The default value may be fine but you should take care of the proper value there. The HTPD value is the cycle period (default is 0.5 second) and this is the value we are working with in this example.

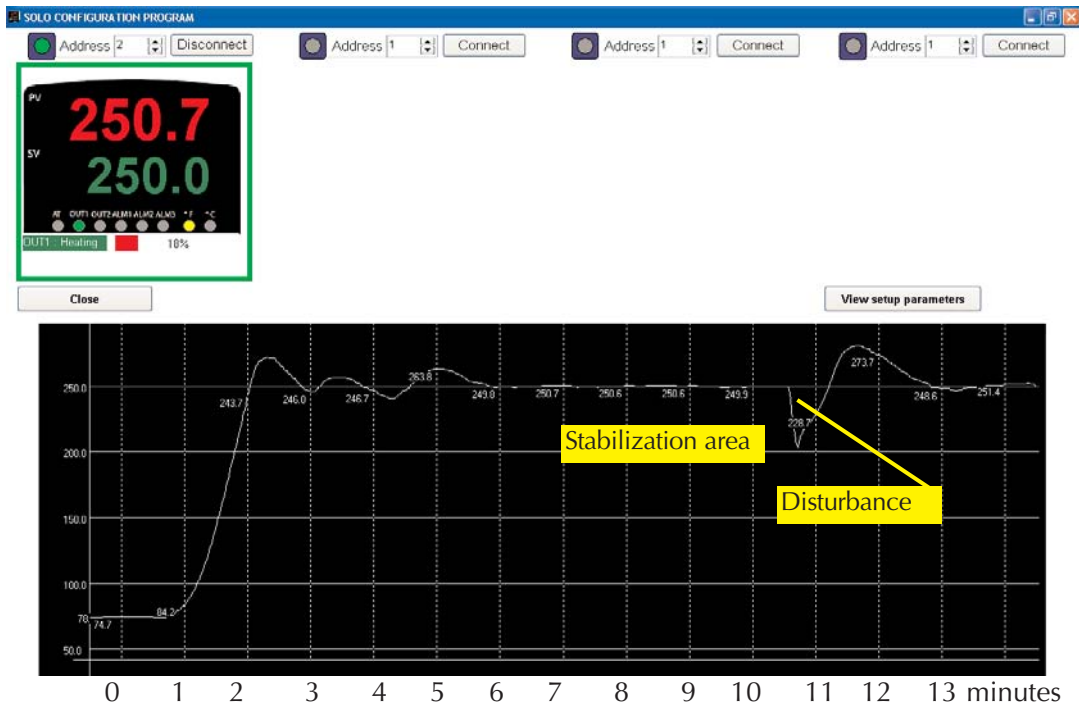
- 2 Press the key `↩` until you see `S-HC`. It should show up `HEAL`. Then press the key `SET`. You can also set the values of these parameters from the screen of the configuration software SOLO.
- 3 The controller should be now in Operating mode. Adjust the temperature set point to 250 degrees F.
- 4 Observe that the control output (the relay) will begin to close and open on the period defined. Press the key `SET` and set the controller to `run`. Then search `PL` on the display with the key `↩`.
- 5 Press the key `▲` and press `SET` to start the auto tuning.

Observe the temperature curve in the figure at the bottom of the next page.



- ⑥ The LED AT will begin to blink to indicate that the controller is tuning the loop. When the tuning is completed, the LED AT is turned OFF and the controller determines the values in **PD** (24) , **IO** (29) and **DO** (7) , **COFF** offset of 33.3 and a cycle period of 20 seconds (Actual values may vary).

This initiates the temperature control. Observe the figure below.



Solo controller example AN-LC-009

Note on the temperature curve, on the time 2 to 6 minutes, there are temperature oscillations around the set point. This is a elapsed time when the controller is doing the automatic tuning. When the LED **AT** is turned OFF, close to 6 minutes, the temperature is stabilized.

We provoked a disturbance on about 10.5 minutes by fully opening the oven door, which caused a decrease in temperature. Then, following that, the door is closed and the controller applies heat to correct the temperature. There is an overshoot at about 12 minutes, that is corrected after about 3 minutes and the temperature is stable again.

Naturally, when the oven door is closed, the temperature can be kept very close to the set point and the controller only needs to create small adjustments applying heat to keep the value in 250 degrees.

In order to test the controller in harsher conditions, let's open the door about 5%, to create more release of heat or simulate that there is more heat consumed. See the figure below.

Observe that the output of the controller becomes 35%. This means that, in the period of 20 seconds of the cycle, the controller output control contact has been closed for 7 seconds and (35% of 20 seconds) on each cycle and has been maintained open for 13 seconds.

This is the specific case on this oven. Obviously, in your case, this will be different..

