DSPR-5 User Manual

Ver 1.2 (July 25, 2024)
(Firmware DSPR-5 ver1.2.1)

1. Specifications

Input Sensor Type	Thermocouple: K RTD (Resistance Temperature Detector): PT1000, PT100 NTC Thermistor (Negative Temperature Coefficient): 50K at 25°C
Accuracy	± 0.2% of full scale
Sensor Input Range	Thermocouple Type K: 0°F ~ 2372°F, -17°C ~ 1300°C RTDs: 0°F ~ 932°F, -17°C ~ 500°C NTC Thermistor 50K: 32°F ~ 392°F, 0°C ~ 200°C
Response Time	≤ 0.5 s
Display Resolution	1°C or °F
Control Mode	Automatic (PID, ON/OFF), Manual
Timer Range (HH:MM)	00 H 00 M to 99 H 59 M
Main Output	12 V DC for solid-state relays
Power Supply	85 V ~ 260 V AC / 50 ~ 60 Hz
Power Consumption	≤ 5 Watt
Working Ambient Temperature	32°F ~ 122°F, 0°C ~ 50°C
Dimensions (W x H x D)	48 x 48 x 120 mm
Mounting Cutout	45 x 45 mm

2. Front Panel

Figure 1. Front panel of DSPR-5.

Descriptions

1. PV Window: Displays the probe reading (and timer if activated).
2. SV Window: Displays the Set Value in either temperature or power percentage.

3. Editing Indicator: If this dot lights up, it indicates that the set value has been changed by the user and has not been saved.
4. Rotary Knob: Rotate to adjust values. Press down to save values, confirm selection, or access menus.
5. OUT Indicator (Green): Indicates the output status from the controller.
6. A-M Indicator (Yellow): Auto/Manual mode indicator. This LED turns on to indicate Manual Control Mode.

3. Terminal Assignment

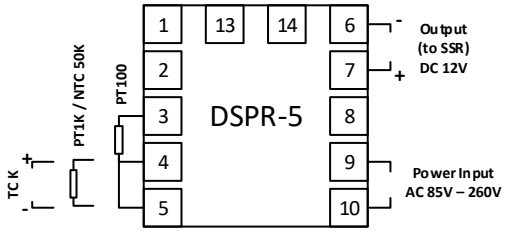

Figure 2. Terminal assignment of DSPR-5.

4. Getting Started

Before connecting the power to this controller or installing it to a control panel, please read the manual thoroughly to understand how the controller works. You should understand the following before you start using the controller:

1. Identify the correct terminals for connecting the power supply, the temperature sensor, the output to drive external solid-state relays.
2. Understand what information will be conveyed by each display window and indicator.
3. Be familiar with how to change the set temperature or power percentage on the controller.
4. Be familiar with how to access the menus and understand the function of each parameter.

5. Connecting the Controller

5.1. Power Input

The controller requires an AC power supply of either 120VAC or 230VAC. The input AC power should be connected to terminals #9 and #10.

5.2. Sensor Input and Connection

This controller can accept several commonly used temperature sensors, including Type K thermocouple, PT1000 RTD, NTC 50Kohm thermistor, and PT100 RTD.

- **Type K**: Connector the positive lead to #4 and the negative lead to #5.
- **PT1000 RTD**: Connect the sensor leads to #4 and #5. No polarity.
- **NTC 50Kohm thermistor**: Connect the sensor leads to #4 and #5. No polarity.
- **PT100 RTD**: Connect two wires of the same color to #4 and #5; connect the other lead to #6.

The Input Sensor Type, parameter Sn (Sn), must be set to match the actual sensor type that is connected. By factory default, the controller is set to read Type K thermocouple (Sn = K). Please see section 8.2 for more details.

5.3. Control Output

The output signal from this controller is a 12V DC signal, suitable for driving solid-state relays. The status of the output is indicated by the green OUT LED on the front panel.

5.4. Set Value (SV) Range

The range of the Set Value (SV) is limited by a parameter called mSV (mSv) in the System Configuration menu, which determines the maximum value of the SV. By default, the mSV is set to 932°. Users may need to adjust the mSV to a suitable value to match the input sensor or the specific requirements of their application.

6. Changing the Set Value

The default Set Value (SV) is 100°F. To change the Set Value:

1. Turn the knob, and a flashing dot will appear on the lower right corner of the SV window.
2. Turn the knob to clockwise to increase the SV; turn the knob counter-clockwise to decrease the SV. Once you reach the desired SV, press down the knob to save the new value. Otherwise, the old SV will be restored.
3. Once the new SV is confirmed, the dot in the lower right corner will disappear.
4. The SV can be continuously changed between temperature values and power percentage values. Please refer to the next section for details.
5. If the SV is set to a percentage value, the lower window will show letter “P” on the left window. The A-M LED diode turns on to indicate that the controller is working in Manual Control Mode (refer to Figure 3).

Auto Control Mode *Manual Control Mode*

Figure 3. A DSPR-5 controller in Auto Control Mode with the SV set at 100°F (left) and the controller in Manual Control Mode with the SV set at 100% output (right).

7. Switching between Auto Mode and Manual Mode

One of the most convenient features of the DSPR-5 is its ability to continuously adjust the Set Value (SV) between a temperature value (default range: 0°F to 932°F) and a power percentage value (0% to 100%). Additionally, the corresponding control mode can be changed between Auto Control Mode and Manual Control Mode.

Auto Control Mode

When the Set Value (SV) is a temperature value, the controller operates in Automatic Control Mode (or Auto Mode for short), which means the controller will automatically adjust the output power to bring the temperature to the target value.

In Auto Mode, the lower window will display a temperature set value without any letter. Additionally, the yellow A-M indicator should be off.

There are two control algorithms available in Auto Mode: the PID control algorithm and the ON/OFF control algorithm.

- *PID Control Algorithm*

In the PID control algorithm, the controller calculates the output level based on the temperature reading and the Set Value (SV) using a PID algorithm. The parameters P, I, and D affects the calculation results of the PID algorithm.

This control algorithm is the recommended for loads that can be switched on or off frequently such as electric heating elements, and for applications where the user wants to avoid any temperature swing or fluctuation.

To use PID control mode, you can start with the default P, I, and D settings and tune these parameters if needed.

- *ON/OFF Control Algorithm*

In ON/OFF control algorithm, the controller sends power until the Process Value (PV) reaches the Set Value (SV). When the PV drops out of the hysteresis band (SV - Hy), the controller sends power again.

In some cases where the load being controlled should not be switched on or off frequently, users may consider using ON/OFF control algorithm and setting up an appropriate hysteresis band (Hy).

To use ON/OFF control mode, please set P = 1, I = 0, and D = 0.

Manual Control Mode

When the SV is set to a percentage value, the controller operates in manual control mode (or Manual Mode for short), meaning the controller will send the power percentage determined by the user. The lower window will display the letter "P" on the left to indicate that the SV is a percentage value. Additionally, the yellow A-M indicator should be illuminated.

Please refer to the two images in Figure 3. The left image shows a controller in Auto Mode, while the right image shows a controller in Manual Mode. In the Manual Mode image, the A-M indicator is illuminated, and the letter "P" (P) is displayed in the lower window.

To switch between Auto Mode and Manual Mode:

1. Simply turn the knob to change the Set Value (SV) to either a temperature (Auto Mode) or a percentage value (Manual Mode). The SV can be continuously adjusted from 0% to 100% and from 0°F to 932°F.
2. As the SV value transitions between percentage value "P 100" and the temperature value "0" degrees, the lower window will briefly display either "TEMP" (tEMP) or "PCT" (PCt) to indicate whether the new SV will be a temperature value or a percentage value.
3. When the SV is set to a percentage value, the lower window will display the letter "P" on the left, and the A-M indicator will turn on.
4. When the SV is set to a temperature value, the lower window will only display a number, and the A-M indicator will turn off.

8. Access the Menu

Press down the knob and hold it for 2 seconds to bring up the menu. The top window will show "go to" (goto). Turn the knob to change the lower window to "CTRL" (CtrL) or "SYST" (SYSt), then press down the knob briefly to enter the next level of the menu. When the controller is in the menu system, if there is no action from the user for 30 seconds, the controller will automatically return to the normal operating mode.

8.1. Control Configuration (CtrL)

Table 1. Parameters in CTRL menu.

Parameter	Symbol	Description	Range	Default Value	Details	Additional Note
P	P	Proportional Band	0 ~ 9999	20	Unit in degrees. The larger the value, the wider the band, resulting in weaker action from the proportional control. If P = 1, I = 0, D = 0, it is ON/OFF control mode.	1
I	I	Integral Time	0 ~ 9999	100	Unit in seconds. The larger the value, the weaker/slower the action from the integral control.	2
D	d	Derivative Time	0 ~ 9999	10	Unit in seconds. The larger the value, the stronger the action from the derivative control.	3
T	t	Control Cycle Time	2 - 120	2	Unit in seconds.	4
Hy	HY	Hysteresis Band	0 ~ 999	2	The hysteresis band determines when to reactivate the output. This specification applies exclusively to the ON/OFF Control Mode, with P = 1, I = 0, and D = 0.	5
OUTL	oUtL	Output Low-Limit	0 ~ 100	0%	The minimum output percentage. This only applies to the Auto Control Mode	6
OUTH	oUtH	Output High-Limit	0 ~ 100	100%	The maximum output percentage. This only applies to the Auto Control Mode	6
AT	At	Auto-Tune	N, Y	N	N: Not starting the auto-tuning. Y: Start the auto-tuning. This only applies to the Auto Control Mode.	7
TF	tF	Timer Function	OFF, ON	OFF	OFF: Disable the timer function. ON: Enable timer function.	8
TIME	tIME	Timer Setting	00:00 ~ 99:59	01:00	The duration of the countdown timer. Displayed in hours and minutes (HH:MM).	9
EO	Eo	Ending Output	OFF, ON	OFF	OFF: Disable the output at the end of the timer countdown. ON: Allow the output and continue maintaining the temperature at the end of the timer countdown.	10

Details About Each Parameter

Note 1. Proportional Band (P)

This parameter determines the proportional output based on the difference between the measured and set temperatures. It is measured in degrees Fahrenheit (°F) or Celsius (°C). A larger P value signifies a weaker action or lower gain. For example, when P = 20, the proportional band is 20 degrees. When the temperature reading is 25 degrees below the set value (SV), which is 5 degrees outside the proportional band, the proportional part of the output will be 100%. If the sensor reading is 5 degrees below the set value (SV), 15 degrees above the proportional band, the proportional part of the output

will be 25%. When the sensor reading equals the set point, the controller will have 0% output from its proportional part. This constant also affects both integral and derivative actions. A smaller P value makes both integral and derivative actions stronger. It's important to note that the P value is temperature unit-sensitive. If an optimized P value is found when operating the controller in Fahrenheit, one needs to divide the P value by 1.8 when changing the temperature unit to Celsius.

A special case is when P = 1, I = 0, and D = 0, the controller will work in ON/OFF mode, not using PID algorithm to determine the output.

Note 2. Integral Time (I)

This parameter determines the integral output based on the difference between the measured and set temperature integrated over time. The unit is in seconds. For instance, when I = 1000, it means that if the temperature difference between the pit temperature and set temperature remains constant, the output will double after 1000 seconds. Integral action is utilized to eliminate temperature offset. A larger value for I results in a slower integral action.

Note 3. Derivative Time (D)

The derivative action contributes to the output power based on the rate of temperature change. The unit is in seconds. A larger D value results in stronger derivative action. The derivative action adjusts the output based on the rate of change rather than the net amount of change. This allows the controller to respond more promptly.

Note 4. Control Cycle Time (T)

The Control Cycle Time (T), or duty cycle, determines the frequency at which the controller updates the output, measured in seconds.

For example, if the current output level is 60%, and the controller calculates that it needs to reduce the output to 30%, it will wait till the end of the current control cycle. Once the next control cycle begins, the controller will adjust the output to 30%.

Note 5. Hysteresis Band (Hy)

The hysteresis band (Hy) is used only in ON/OFF control mode to determine when to re-engage the output after the temperature drops below the Set Value (SV).

When the temperature surpasses the SV, the controller stops output. However, once the temperature falls below (SV - Hy), the controller starts output.

The default value of Hy is 2 degrees.

Note 6. Output Low-Limit (OUTL) and Output High-Limit (OUTH)

These two parameters allow users to set a minimum percentage value (OUTL) and a maximum percentage value (OUTH) to limit the output level. Both parameters can be configured within the range of 0% to 100%, with the condition that OUTH must be greater than OUTL.

Note 7. Auto-Tune (AT)

This is an automatic tuning process performed by the controller to adjust the P, I, and D parameters. If the default P, I, and D values do not work well for your system or a particular target temperature, you can try Auto-Tune to see if the new parameters work better.

To activate auto-tuning, set AT to "Y" and then exit the menu. The display will start flashing alternately between AT and the current temperature reading, indicating that auto-tuning is in progress. When the display stops flashing, the auto-tuning is finished. A new set of P, I, and D parameters are saved, and the controller returns to normal operating mode.

It's important to note that sometimes the auto-tune result may not necessarily give you a better result than before. If you want to stop the auto-tune process, set AT to "N" and exit the menu.

Note 8. Time Function (TF)

The Timer Function parameter enables (TF is set to "ON") or disables (TF is set to "OFF") the timer function. The timer is designed to operate in Auto Mode, i.e., when a target temperature has set by the user. The countdown time is specified in another parameter, TIME (see Note 9 below).

The timer can be activated only in Auto Mode when the Process Value (PV) has reached or exceeded the Set Value (SV), i.e., PV ≥ SV. The timer cannot be activated in Manual Mode. However, once activated, the timer can continue to run even if the PV drops below the SV or if the control mode is changed to Manual Mode.

During the timer countdown, the top display window will alternate between displaying the probe reading (PV) and the remaining time. During this process, if the temperature probe is unplugged (or controller detects a probe input error), the timer countdown will pause till this error is resolved.

At the end of the timer countdown, the top display window will alternate between "END" and the probe reading (PV). The controller can either stop sending power or continue to send power to maintain the temperature, depending on the setting of another parameter, EO (see Note 10 below).

Note 9. Timer Setting (TIME)

The parameter TIME represents a time value in HH:MM (Hours: Minutes) format. The Timer Setting is only valid when the Time Function is enabled (TF is set to “ON”) and when the controller is operating in Auto Mode. It does not apply to Manual Mode.

Note 10. Ending Output (EO)

The parameter EO determines whether the controller should stop sending output at the end of the timer countdown. When EO is set to “OFF”, the controller will stop sending output at the end of the timer countdown. However, if the EO is set to “ON”, the controller will continue to maintain the temperature at the Set Value (SV) even after the timer has reached zero.

8.2. System Configuration (SYSt)

Table 2. Parameters in SYST menu.

Parameter	Symbol	Description	Range	Default Value	Details	Additional Note
Sn	Sn	Input Sensor type	K, PT1K, P100, N50K	K	K: Type K thermocouple. PT1K: PT1000 RTD. P100: PT100 RTD. N50K: 50K NTC thermistor.	12
Pb	Pb	Probe Offset	-20 ~ +20	0	Apply an offset to the temperature input from the sensor, allowing for adjustment in either direction.	13
C-F	C-F	Temperature Unit	°C, °F	°F	Display the temperature reading from the sensor in Celsius or in Fahrenheit units.	14
PMOD	Pmod	Power Regulating Mode	TP, BF	TP	TP: time-proportional mode. BF: burst-firing mode.	15
MMOL	mmoL	Manual Mode Open-loop	Y, N	N	Whether to permit output in open-loop (no sensor) situation during Manual Mode. N: Disable output in open-loop situation (i.e., no sensor is connected). Y: Enable output in open-loop situation. This setting only applies to the Manual Mode.	16
mSV	mSv	Maximum Set Value	0 ~ 2372	932	The upper limit for temperature Set Value.	17
VER	ver	Firmware Version			Display the firmware version.	18
RST	rSt	Factory Reset	N, Y	N	N: No action. Y: Reset all parameters to factory default values.	19

Details About Each Parameter

Note 12. Input Sensor Type (Sn)

Set the Input Sensor Type (Sn) appropriately to match the sensor connected to the controller. The DPSR-5 controller can support four different types of temperature sensors:

- K (K): Type K thermocouple.
- PT1K (Pt 1K): PT1000 RTD sensor.
- P100 (P 100): PT100 RTD sensor.
- N50K (n50K): 50K NTC thermistor.

By default, the controller is set to read Type K thermocouple sensors.

Note 13. Probe Offset (Pb)

The Pb parameter is used to apply an offset to compensate for a fixed error produced by the input probe. This offset is measured in units of 1 degree. The range for Pb is from -20 to 20.

For example, if a user calibrated a probe with this controller against a calibrator where the temperature reading should be 32°F but the probe reading is 33°F, the user can set Pb to -1. This adjustment will ensure that the displayed probe reading will be 32°F.

Note 14. Temperature Unit (C-F)

The parameter C-F determines the temperature unit (Celsius or Fahrenheit).

Note 15. Power Regulating Mode (PMOD)

The Power Regulating Mode (PMOD) parameter determines how the controller sends the output signal to the external solid-state relay (SSR). The DSPR-5 offers two power regulating modes: Time-Proportional Mode (TP) and Burst-Firing Mode (BF).

In Time-Proportional Mode, the controller switches the control signal ON or OFF for a portion of each control cycle (T) to achieve the desired output percentage. In Burst-Firing Mode, the controller switches the control signal ON and OFF in short bursts and finds the shortest control cycle to achieve the desired output percentage.

Burst-Firing Mode can be used with electric heating elements for heating water or other liquids.

Note 16. Manual Mode Open-Loop (MMOL)

Manual Mode Open-Loop (MMOL) is the parameter to determine whether the controller should send output in Manual Mode when where is no sensor connected, which is an open-loop situation. This is a useful feature for situations when the connected sensor has failed or no sensors are available to use.

In Manual Mode, a user can manually adjust the output power percentage between 0% to 100%. Set MMOL to "Y" to allow the output in an open-loop situation. By default, MMOL is set to "N" for no output.

Please note that this function only applies to Manual Mode and does not apply to Auto Mode.

Note 17. Maximum Set Value (mSV)

Maximum Set Value (mSV) parameter sets the maximum value of the Set Value (SV) that a user can dialed in the normal operating mode. This parameter serves two main purposes:

- Preventing Accidental Adjustment: It can be used to establish an upper limit for the SV to prevent the target temperature from being inadvertently set too high.
- Adjusting for Sensor Range: In cases where the sensor type has been changed from a wide range sensor (e.g., type K thermocouple) to a narrower range sensor (such as P100 or N50K), the mSV parameter can be used to restrict the SV to a meaningful range and avoid setting values outside the sensor's capability.

Setting the mSV parameter appropriately helps ensure accurate and safe operation of the controller in various operating conditions.

Note 18. Firmware Version (VER)

The Current Firmware Version (VER) parameter displays the current firmware version installed on the controller. This parameter is for display purposes only and cannot be modified.

Note 19. Factory Reset (RST)

To reset all parameter values to factory default values, set RST to Y.

9. Reset the Timer

Important Note: this operation is only available in situations:

1) When the timer function is enabled (i.e., parameter TF is set to ON) AND
2) When the countdown timer has been triggered (i.e., after the PV has reached the SV).

To reset the timer, briefly press down the knob. The controller will display "tr5t" in the top window and show "n" in the lower window. Turn the knob to change the letter in the lower window to "y", then press down the knob again to reset the timer.

Timer Reset (tr5t)

Parameter	Symbol	Description	Range	Default Value	Details	Additional Note
TRST	tr5t	Timer Reset	N, Y	N	N: No action. Y: Reset the timer to its original value.	

(End)