Instruction Manual

EZboil, Power Regulator for Boiling Process Automation DSPR100

Version 1.0 (Dec 2015)

Caution

- This controller is intended to control equipment under normal operating conditions. Failure or malfunction of the controller may lead to abnormal operating conditions, which result in personal injury or damage to the equipment or other property. Devices (limit or safety controls) or systems (alarm or supervisory) intended to warn of or protect against failure or malfunction of the controller must be incorporated into and maintained as part of the control system.
- Installing the rubber gasket supplied will protect the controller front panel from dust and water splash (IP54 rating). Additional protection is needed for higher IP rating.
- This controller carries a 90-day warranty. This warranty is limited to the controller only.

1. Specifications

Input type	Thermocouple (TC): K RTD (Resistance Temperature Detector): Pt100
Accuracy	± 0.2% Full scale
Temperature range	-328°F ~ +1076°F, -200°C ~ +580°C
Response time	≤ 0.5s (when FILt = 0)
Display resolution	1°C or °F
Control mode	Manual control, ON/OFF
Alarm function	Process high alarm
Power supply	85~260VAC/50~60Hz
Power consumption	≤ 5 Watt
Ambient temperature	0~50ºC, 32~122ºF
Dimension	48 x 48 x 86 mm (W x H x D, from the front panel to the back)
Mounting cutout	45 x 45 mm

2. Front Panel

Figure 1. The front panel of a Digital SSR Power Regulator (DSPR100).

1). Top display. This display will indicate the sensor read out value. When timer is activated, it will show timer value and sensor readout alternatively.
2). Bottom display. Boil Output Setting. This display will show the percentage of power been sent to the external SSR after the initial heat up phase.
3). Rotary switch (knob). Turn it clockwise to increase the output power (or selected parameter value); turn it counter-clockwise to reduce the output power (or selected parameter value). Press and hold it for 5 seconds to enter parameter settings. Press it briefly to reset the timer (if enabled). Please see section 6 for details.
4). Output indicator (OUT). It shows how much power the regulator is sending out (as a 12VDC control signal pulse through terminal 9 and 10). When it is on solid, the output is 100% on. You should be able to measure 12VDC between the terminals. The LED light on the SSR should also be on. When it is off, there should be no output. The LED light on the SSR should also be off. When it is flashing, the frequency of the flashing is an indication of high or low power output. Higher frequency means higher power output. However, the frequency of the flashing is not synchronized with actual pulse sending out, or the LED on the SSR. This is because the regulator switches the power at higher frequency than the human eyes can tell. The flashing rate of the indicator is generated at lower frequency to allow the operator to tell the level of the power output.
5). Acceleration indicator (ACC). When this indicator is lid, this regulator is operating under initial heating phase with high power output to accelerate the heating.

3. Wiring Terminals

The pin assignment of the back terminals of DSPR100 is shown in Figure 2.

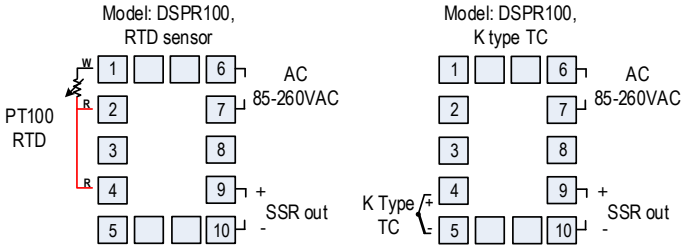

Figure 2. Terminals assignment of DSPR100.

3.1 Sensor connection

Please refer to section 6, note 5 for the input sensor type (Sn) setting codes. The initial setting for input is for a PT100 RTD (Pt). Set Sn to the correct sensor code if another sensor type is used.

3.1.1 Thermocouple

The thermocouple should be connected to terminals 4 and 5. Make sure that the polarity is correct. There are two commonly used color codes for the K type thermocouple. US color code uses yellow (positive) and red (negative). Imported DIN color code uses red (positive) and green/blue (negative). The temperature reading will decrease as temperature increases if the connection is reversed. Set controller input type, Sn to "K" (it looks like backwards "4").

When using ungrounded thermocouple that is in touch with a large conductive subject, the electromagnetic field picked up by the sensor tip might be too large for the controller to handle, the temperature display will change erratically. In that case, connecting the shield of thermocouple to terminal 5 (circuit ground of the controller) might solve the problem. Another option is to connect the conductive subject to terminal 5.

3.1.2 RTD sensor
For a three-wire RTD with standard DIN color code, the two red wires should be connected to the terminals 2 and 4. The white wire should be connected to terminal 1. For a two-wire RTD, the wires should be connected to terminals 1 and 2. Jump a wire between terminals 2 and 4. Set controller input type, Sn to Pt.

3.2 Power to the controller
The power cables should be connected to terminals 6 and 7. Polarity does not matter. It can be powered by 85-260V AC power source. Neither a transformer nor jumper is needed to wire it up. For the sake of consistency with the wiring example described later, we suggest you connect the hot wire to terminal 6 and neutral to 7.

3.3 SSR output connection
The SSR control output of the DSPR100 provides a 12V DC signal that can control up to 5 SSRs in parallel. Connect terminal 9 to the positive pole of the SSR (terminal 3 for Auber's SSR). Connect terminal 10 to the negative pole of the SSR (terminal 4 for the Auber SSR). Please make sure the SSR is installed on the heat sink with proper current rating.

4. Display Status

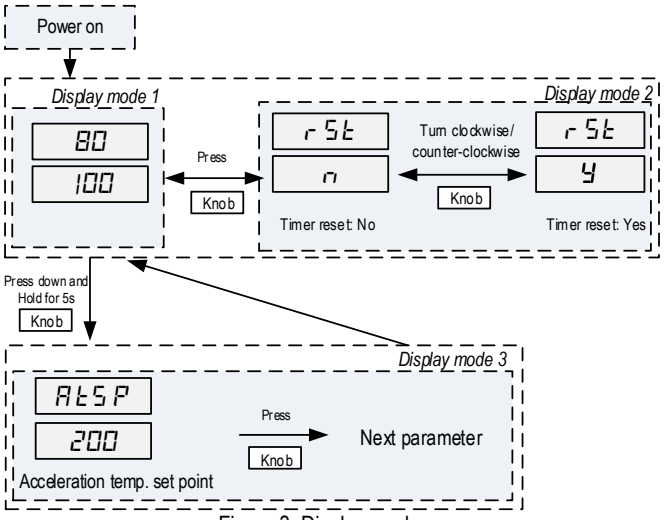

Figure 3. Display modes

Display mode 1: When power is turned on, the top display window shows the current reading temperature. When timer is activated, the top display will be switched between the current temperature and current time alternately, every 6 seconds. Bottom display window shows the percentage of power output at boil phase.

Display mode 2: (To reset the timer), press the knob down momentarily, the display will show "rSt" on top and "n" at the bottom, rotate the dial clockwise will change the bottom display to "y". Then press the knob down again will reset the timer. The reset button has two purpose. A) if you want to use the timer as regular timer without correlation to the temperature, you can start the timer at any time by the reset button (see Note 2 below). B) After timer is timed up and process ended, you can restart the boil process again by the reset button instead of power off the system and power it on again.

Display mode 3: Press down and hold the knob for 5 seconds to enter the display mode 3. This mode allows users to change the system parameters.

5. Setting flow chart

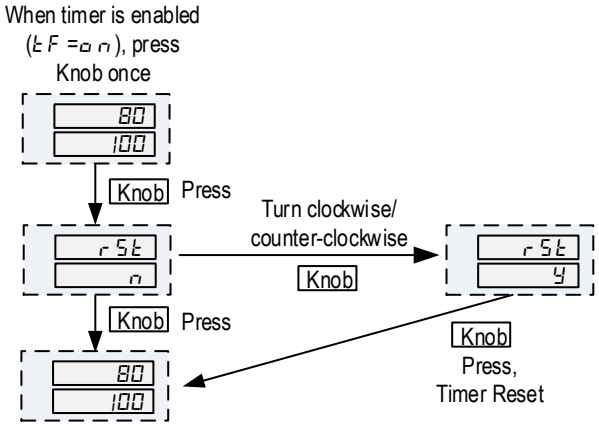

Figure 4. Timer reset flow chart

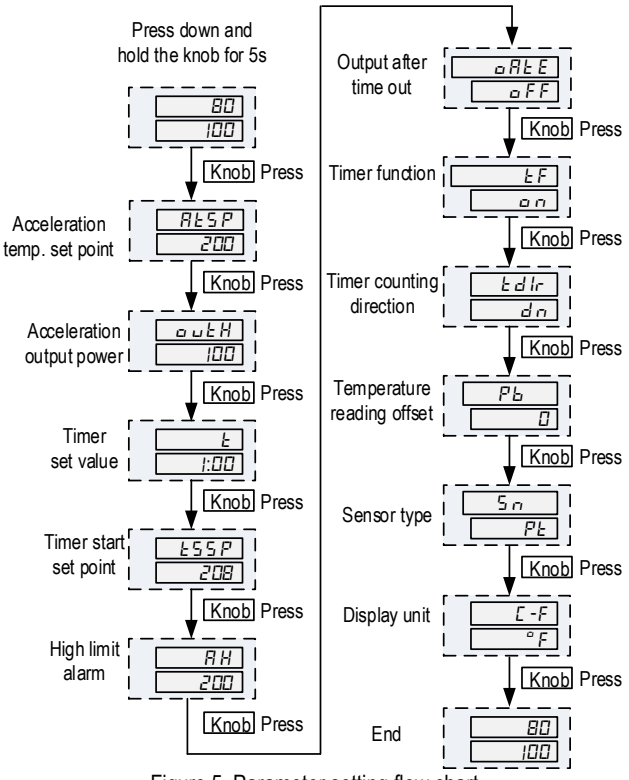

Figure 5. Parameter setting flow chart

To enter parameter setting mode, press down and hold the knob for at least 5s. Then you will see on the "AtSP" on top display. The top display shows the current selected parameter name, and the bottom display shows the parameter value for the selected parameter. Turn the knob clockwise to increase the value, and turn the knob counter-clockwise to reduce the value. Faster rotating speed will change the value quickly. Once finished, press down knob again to confirm and go to next parameter. You can keep pressing down the knob repeatedly to exit the setting quickly.

6. Parameter Settings
For the easy of discussion, we divide the entire boiling process into two phases, the **initial heating phase** and **boil phase**. During the initial heating phase, power output is set high to accelerate the temperature rise. We name the output setting for the initial heating phase as **acceleration power output setting**. It is set by parameter **outH**. During the boil phase, the power output is lowered to prevent the boil over. We name the output setting for the boil phase as "**Boil Output**" setting. Its value is always displayed on the bottom LED display and can be adjusted by turning the knob (either in the initial heating phase or in the boil phase). The acceleration power output setting will not be displayed at bottom

display during initial heating, because it rarely changes once the system is set up. You can tell that the regulator is in the initial heating phase, if the red LED indicator (at the up left corner of front panel) is on.

Table 1. System parameters.

Code	Description	Setting Range	Initial Setting	Remark
Press down the knob momentarily (Figure 4)				
rSt	Timer reset	n,y	n	Note 2
Push down the knob for 5s (Figure 5)				
AtSP	Acceleration temperature set point	0~+9999°C or °F	200	Note 1
outH	Acceleration power output Setting	0~100%	100	
t	Timer set value	00:00~99:99 (hour: minute)	1:00	Note 2
tSSP	Timer start set temperature	-999~+9999 °C or °F	208	
AH	High limit alarm	0~+9999°C or °F	200	Note 3
oAtE	Output after time out	on, off	off	Note 2
tF	Timer function enable	on, off	On	
tdlr	Timer counting direction	dn, uP	dn	
Pb	Temperature reading offset	-100~+100 °C or °F	0	Note 4
Sn	Input type	Pt, K	Pt	Note 5
C-F	display unit	°C, °F	°F	Note 6

Note 1: Acceleration heating function
EZboil can accelerates heating speed of the initial heating phase by running the heater at high power, then reduce the power once the temperature is getting close to the boil. The heating acceleration is controlled by two parameters, **Acceleration temperature set point, AtSP** and **acceleration power output setting, outH**. The AtSP set the temperature limit that below this temperature, the controller will output at a high power determined by the **outH**. When temperature rise to the AtSP, the output will automatically reduce to a lower level to prevent a messy boil over. The boil over is caused by several factors including the amount of foam on the surface and the power of the heater. The more foams there is, the easier it is to boil over. The vigorous the boil is, the easy it is to boil over. To preventing the boil over, operator should skim the foam out and reduce the power as the temperature approaching the boil. Since the heater power and liquid volume varies between each application, we suggest the **AtSP** to be set at least 10 degree (Fahrenheit) below the boiling point for the first time use. As you getting familiar with your system, you can change this setting to higher or lower. The **outH** is the power used during initial heating phase. The unit is in percent of power. It should be set to 100% unless you have a very powerful heater with very small amount of liquid. The **outH** setting does not limit the power regulation range for boil phase.

Note 2: Timer Function
The timer function allows the controller to showing the boil time. It makes a beeping sound when timed out and will display the process is ended. It can also automatically shut off the controller's power output after time out. The **timer function** is controlled by parameter **tF**. When it is set to **ON**, the timer function is enabled. When tF is set to **OFF**, the timer function is disabled. The **time duration** is set by the **t** parameter. The unit is hour: minutes.

When timer function is enabled, the timer counting will be started by **timer start set temperature, tSSP**. When temperature reaches **tSSP**, the timer starts to count. After timer started counting, it will continue even if the temperature drops below the **tSSP**. The timer can be reset to start from beginning again. To reset the timer, press the knob momentarily, the display will show **rSt** on top and **"n"** at the bottom, rotate the dial clockwise will change the bottom display to **"y"**. Press the dial again will reset the timer (Figure 4)

After the timer starts, the top display will be switched between the current temperature and current time alternately, every 6 seconds. The temperature and time display can be easily differentiated with their appearance. The temperature reading has two or three digits. For example, 212 degrees will be displayed as "212". The timer display has four digits with flashing colon in the middle. For example, "01:20" for 1 hour 20 minutes. After the timer is activated, the bottom display still shows the power output setting. User can set the time display to count up, or count down with parameter **timer counting direction, tdlr.** Set it to **up** for counting up and **dn** for counting down. When time counting ends, the controller will generate six long beeps. The top display will be switched between the current temperature and "**End**". After timer ends, the power output can be configured either to continue heating, or shut off. It is controlled by the parameter called **output after time out, oAtE**. Set it to **ON** for continue heating, set it to **OFF** to turn off the output.

If you want to use the timer as a regular timer without correlating to the temperature setting, you can set the tSSP below the ambient temperature. The timer will start as soon as the regulator is powered up. You can use the reset button (rSt) to reset the timer at any time.

Note 3: Alarm Function
EZboil has a built-in buzzer that can be programmed to beep when temperature reaches the alarm set temperature, AH. The alarm will generate four short beeps every time the temperature rise from below AH to higher than AH. The alarm function can be used to notify the operator when temperature is approach the boil. The alarm function does not affect the heating or the time function, it only provides the alarm sound.

Note 4: Input offset "Pb"
Pb is used to set an input offset to compensate the error produced by the sensor or input signal itself. For example, if the controller displays 2ºC when probe is in ice/water mixture, setting Pb = -2, will make the controller display 0ºC.

Note 5: Input selection code for "Sn"
Sn is the sensor input selection for this controller. Two available options:
Pt: PT100 RTD sensor
K: K type thermocouple

Note 6: Temperature unit setting C-F
You can set the regulator's display to either Celsius or Fahrenheit.
C: Celsius display
F: Fahrenheit display

7. Application examples:

1. Timer operation example:
The timer can be used for several ways to help the boil process.
1) Use it to automatically control the boil time.
Set the parameter as following
tF=on, tSSP=210, tdlr=dn, oAtE=OFF, t=1:30,
The timer will start to count when temperature reaches 210 degrees. The timer will count down from 1:30, when time out, the controller will stop heating, beeps, and flash "End".

2) Use the timer as a regular clock.
Set tSSP below the ambient temperature so that timer is available, Set t to a very long time so that it will not end before operator decide to end the boil. The counting direction should be up. Use the reset button (rSt) to reset the timer at any time
tF=on, tSSP=50, tdlr=up, oAtE=on, t=5:00.

2. Using it as an ON/OFF controller.
This controller can also be used as an advanced ON/OFF controller. The **AtSP** is equivalent to the set temperature (SV). The **outH** is the power output when it is "On" phase. The Boil Output it is "off' phase. If you set outH = 100, and Boil Output = 0, it will be the same as standard ON/OFF control with one-degree

hysteresis band. However, this controller allows you to reduce the power of the ON phase so that overshot can be minimized. This is done by setting the outH to less than 100%. With a little tuning, you can easily optimize the outH so that the temperature overshot is controlled to be less than two degrees. You can also increase the Boil Output to more than zero for a more stable control. However, for most applications, leave the Boil Output at zero is sufficient unless the system has very slow response time and the heater is under powered. For application that has good liquid circulation and good response, the ON/OFF control can provide very good control.

Example: AtSP=152, outH=30, Boil Output=0. It will hold the water between 152Fand 153F.

8. Wiring Examples

Example 1. Here are two wiring diagrams of how to connect a DC triggered AC SSR with this power regulator.

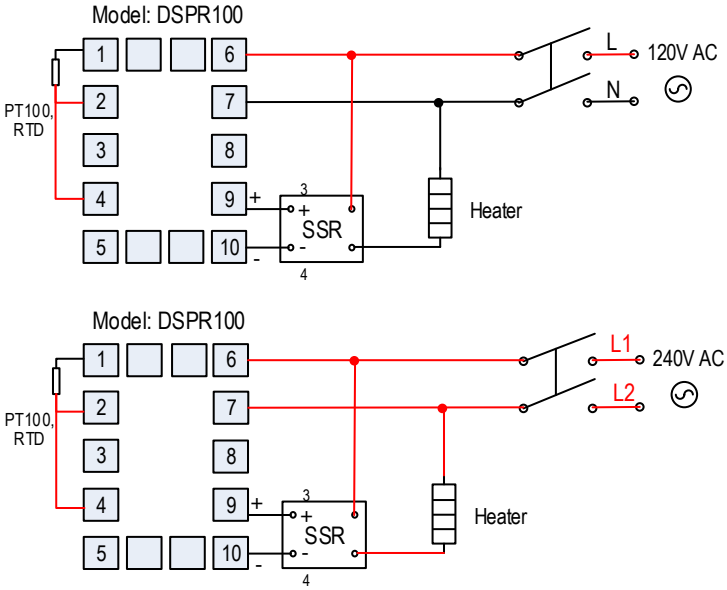

Figure 6. Wiring examples of controlling a heater with SSR and DSPR100 in a 120VAC system (upper) and in a 240VAC system (lower).

Example 2. A DSPR100 and a PID controller such as SYL-2352 can be used together to control the same load through a solid state relay. A double pole double throw switch is needed to select which controller/unit will supply the control signal to the SSR.

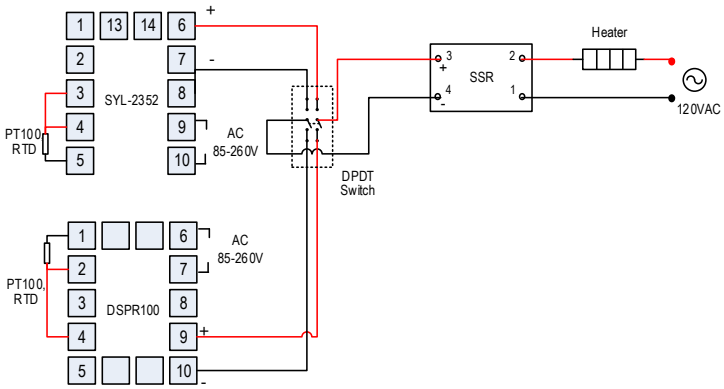

Figure 7. Wiring diagram for switching the control signal between a PID controller and a DSPR100 unit to control the SSR. (For K type thermocouple wiring, please check figure 1).

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Appendix

Technical Talk -- How does it Work? v1.1

There are three commonly used methods for AC power control.

1) **Phase angle firing**. In this method, the AC power control is achieved by firing the SCR at different phase angle. This is how our SSVR works. This method offer the most uniform power output. But the output is very difficult to be adjusted linearly due to the shape of the sine wave. Because of the sharp cut off, there is a potential electromagnetic interference (EMI or RFI) if there are inductive devices on the power line. Some of the inductive devices cannot be controlled by this method.

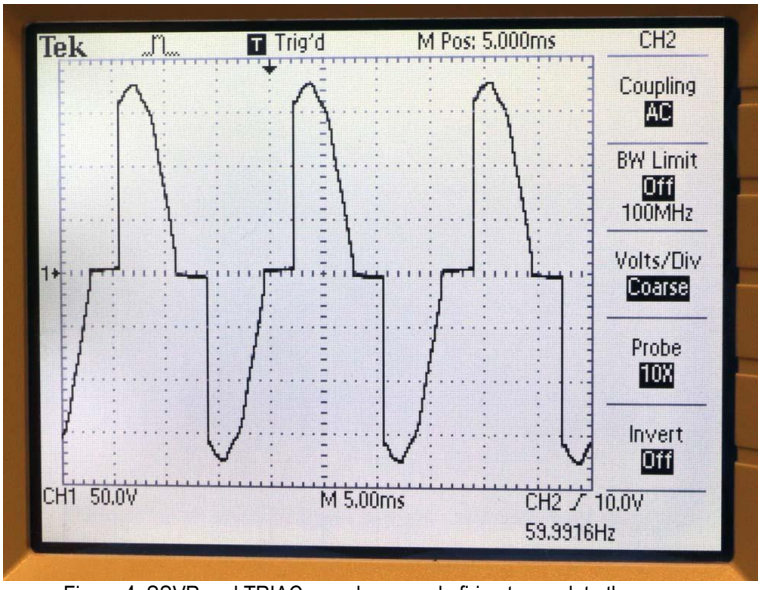

Figure 4. SSVR and TRIAC use phase-angle firing to regulate the power.

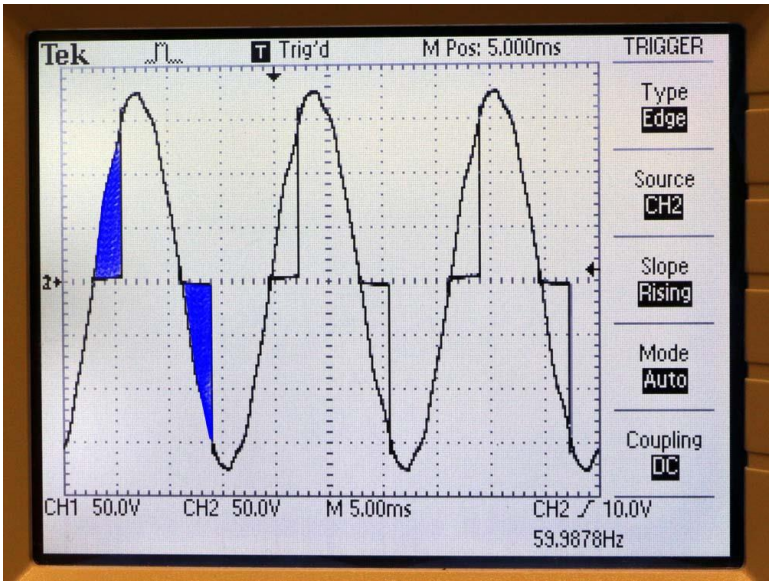

Figure 5. Original AC sine wave is overlaid with SSVR output wave form. The blue colored area shows the power output that has been blocked.

2) **Time proportional firing**. A fixed cycle time needs to be defined in this method. Then, the controller or regulator adjusts the on time during each cycle to achieve the power control. For example, if the cycle time is 1 second, turn on the power for 0.25 second for every 1 second means a 25% power output. Most of PID controllers use this method to control SSRs. This is also how the manual mode of Auber's PID controller works, except the cycle time has to be 2 second or longer.
Using this method, the user can linearly adjust output. But the power output is pulsed at each cycle. The shortest cycle time for most PID is either 1 or 2 second. Therefore, power is pulsed at 1 or 2 seconds. When heating a liquid, heat is not transferred as smooth as the phase-angle fire method.

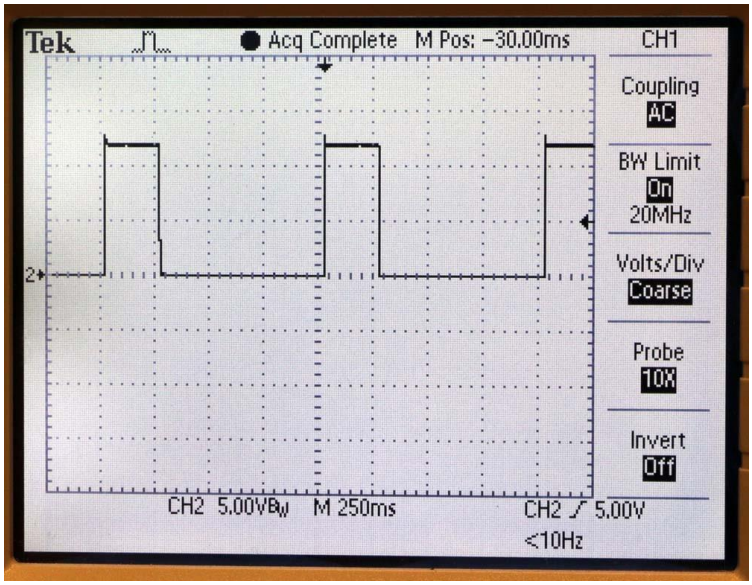

Figure 6. A 25% output control signal from a PID controller in the time proportional firing mode. Cycle time is 1 second. The output signal is 250 millisecond (ms) on, and 750 ms off during each cycle period.

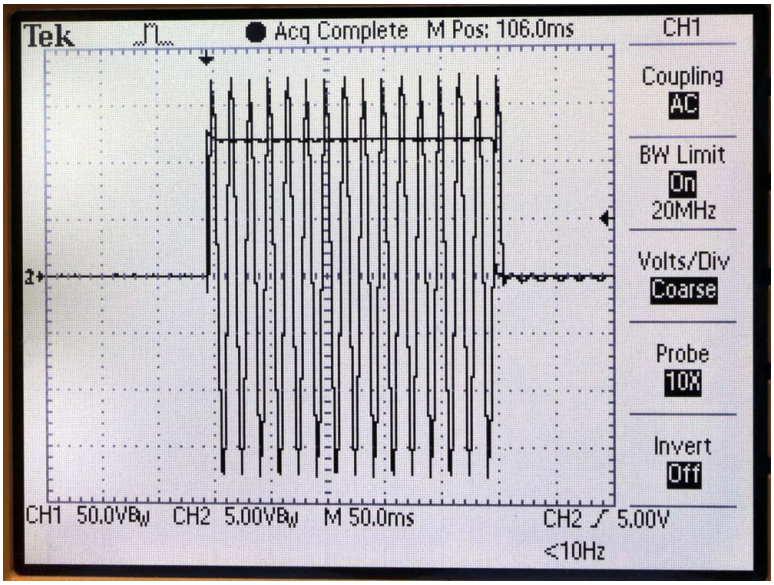

Figure 7. The control signal and SSR output waveform overlaid. When the DC signal (Channel 2, square wave) is on, the AC power can go through (Channel 1). When the DC signal drop to zero, the AC power is blocked.

3) **Burst firing**. This method is similar to time proportional firing (section 2). But in contrast to the time proportional mode, where the SSR is fired once for each fixed cycle period (which are usually 2 seconds or longer), the regulator will find the minimum cycle time to achieve the desired output percentage. The on pulse can be as short as one AC cycle. So power is distributed more evenly over cycle time. This leads to of a more uniform power output. Several PID controllers on the market use this mode. Our DSPR also uses this approach as the default mode to regulate power.

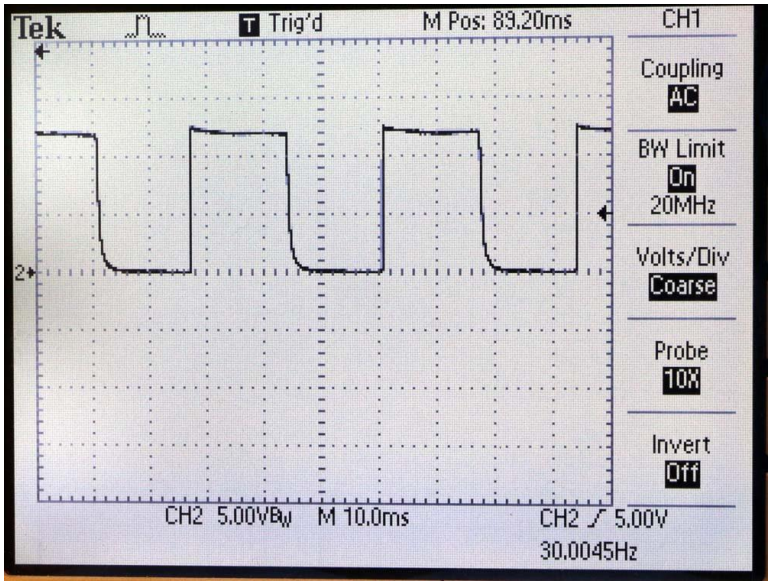

Figure 8. A 50% output control signal from DSPR when it is operating in the bust firing mode. Each pulse is 16.67 ms long, which is the same as a 60 Hz AC cycle. So one pulse on and one pulse cycle off is equal to 50% output.

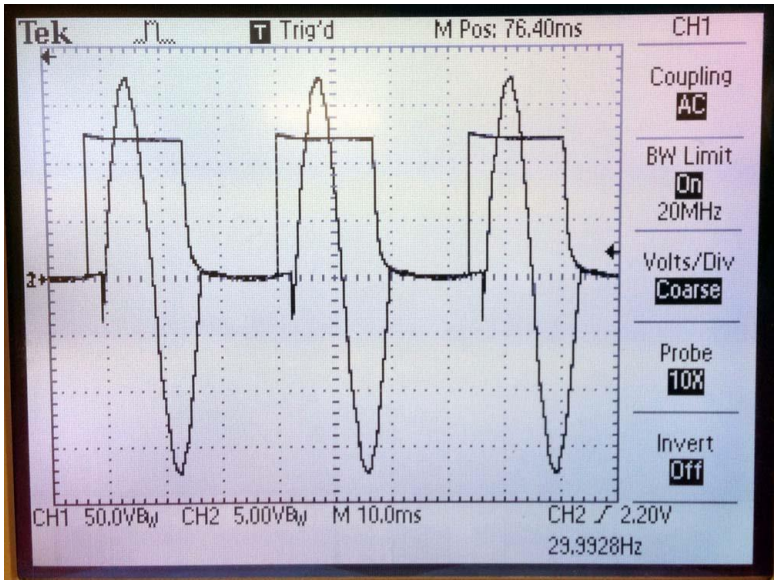

Figure 9. The DSPR control signal and SSR output waveform overlaid. The DSPR detects the frequency and phase of the AC power line, so that the pulse width and firing time is synchronized with AC cycle. The detection causes a small delay for the pulse generation. So the SSR will not be fired at the first zero crossing where the pulse is generated. It will fire the second and third zero crossing to pass a full AC cycle.

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