

Operation Manual

Model: SC-UB04

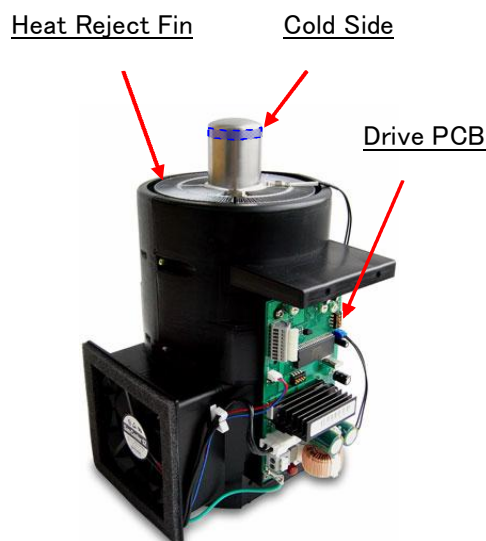
Name: 40W FPSC Module H



TWINBIRD CORPORATION
SC Business Operation

1. Warning/ Caution

- (1) The Stirling cooler (Free Piston Stirling Cooler, FPSC) must be used with a 12 V DC power source. Internal damage can result from operating this Stirling cooler directly with any input voltage other than 12 V DC.
- (2) Stirling cooler is designed for use in ambient temperatures between 0 – 40 deg. C. Internal damage could result from operating the Stirling cooler outside this temperature range.
- (3) The cold side of the Stirling cooler should be maintained between –50 and +10 deg. C. Operation outside of this temperature range could result in internal damage to the Stirling cooler. To avoid the possibility of damaging to internal parts by overheating the Stirling cooler, do not apply heating elements directly to the cold side.
- (4) Use caution when handling the Heat Reject Fin assembly to prevent damage or injury. Inspect the Heat Reject Fin assembly for deformity or breakage before use.
- (5) Reduce the output setting of the Stirling cooler if unusual noises are observed coming from inside the pressure vessel. Please contact Twinbird if the reduced output setting does not eliminate the unusual noises.
- (6) Avoid subjecting the Stirling cooler to excessive shock. It could cause internal damage.
- (7) Direct exposure of the Stirling cooler and PCB to water could cause electrical failure.
- (8) Don't put FPSC module near heater or fire. It may cause trouble.
- (9) Warning: Placing the Stirling cooler into fire or excessive heat could cause expansion of the contained gas and explosion.
- (10) Do not put excessive strain on the electrical cords. It could cause damage to the wire and cause the Stirling cooler stop operating.
- (11) To avoid the danger of burns, avoid touching the heat reject fin and certain parts on PCB with your bare hands during or immediately after operation.
- (12) To avoid the danger of frostbite, avoid touching the cold side and its immediate surroundings with your bare hands during or immediately after operation.
- (13) Please provide thermal insulation around cold side to prevent frost and dew condensation. If conditions require that you need to operate the Stirling cooler without thermal insulation, the cold side may develop a coating frost or water. If this occurs, please clean the cold side with a soft cloth. Having frost or condensation on the cold side surface can cause an apparent reduction of cooling capacity. Also, if water drips down on a power cord or balancer as it defrosts, it could cause a short circuit or corrosion.



SC-UB04 40W FPSC Module H

(14) Failure of the Stirling cooler could result from subjecting the cold side to a strong impact force. It is made of thin stainless steel sheet surrounding a precision interior structure.

(15) The Stirling cooler uses a high pressure gas inside, please contact Twinbird if you intend to scrap the Stirling cooler.

(16) The Field Of Application and Restriction Of Export

FPSC Products are produced under License Agreement with Global Cooling BV.

Said License Agreement stipulates some restrictions for manufacturing, sales and field of application for FPSC Products.

Therefore, we cannot produce an FPSC Product in the fields of application as follows:

1. Cooling to temperatures under 150 Kelvin (about -125deg.C)
2. Petroleum testing and oil exploration
3. Electric appliances for household use

*Please feel free to contact us if you have question about the field of application.

The following regulations shall be applied to Stirling cooler export. Permission for export from the Minister of Economy, Trade and Industry is required before exporting Stirling coolers from Japan.

- Foreign Exchange And Foreign Trade Law – section 1 of article 48
- Foreign Exchange And Foreign Trade Law – section 1 of article 67
- Export Trade Control Ordinance – section 2 of article 8

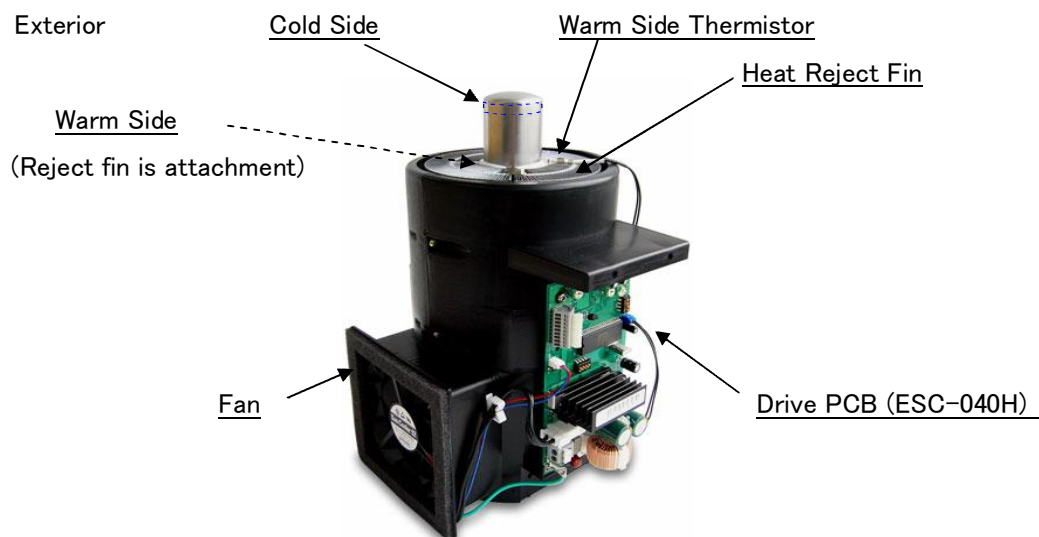
*If you wish to export our Products from Japan, please contact us prior to exporting.

*The above regulations were applicable as of November 27, 2003.

*Laws and regulations may be changed in accordance with legal revisions.

2. Specification

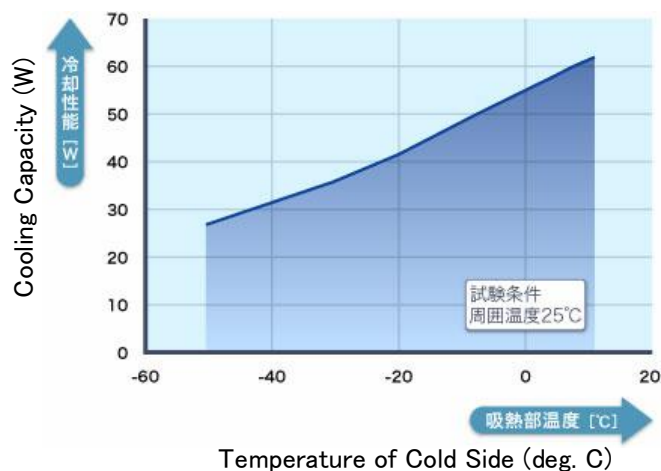
(1) Exterior



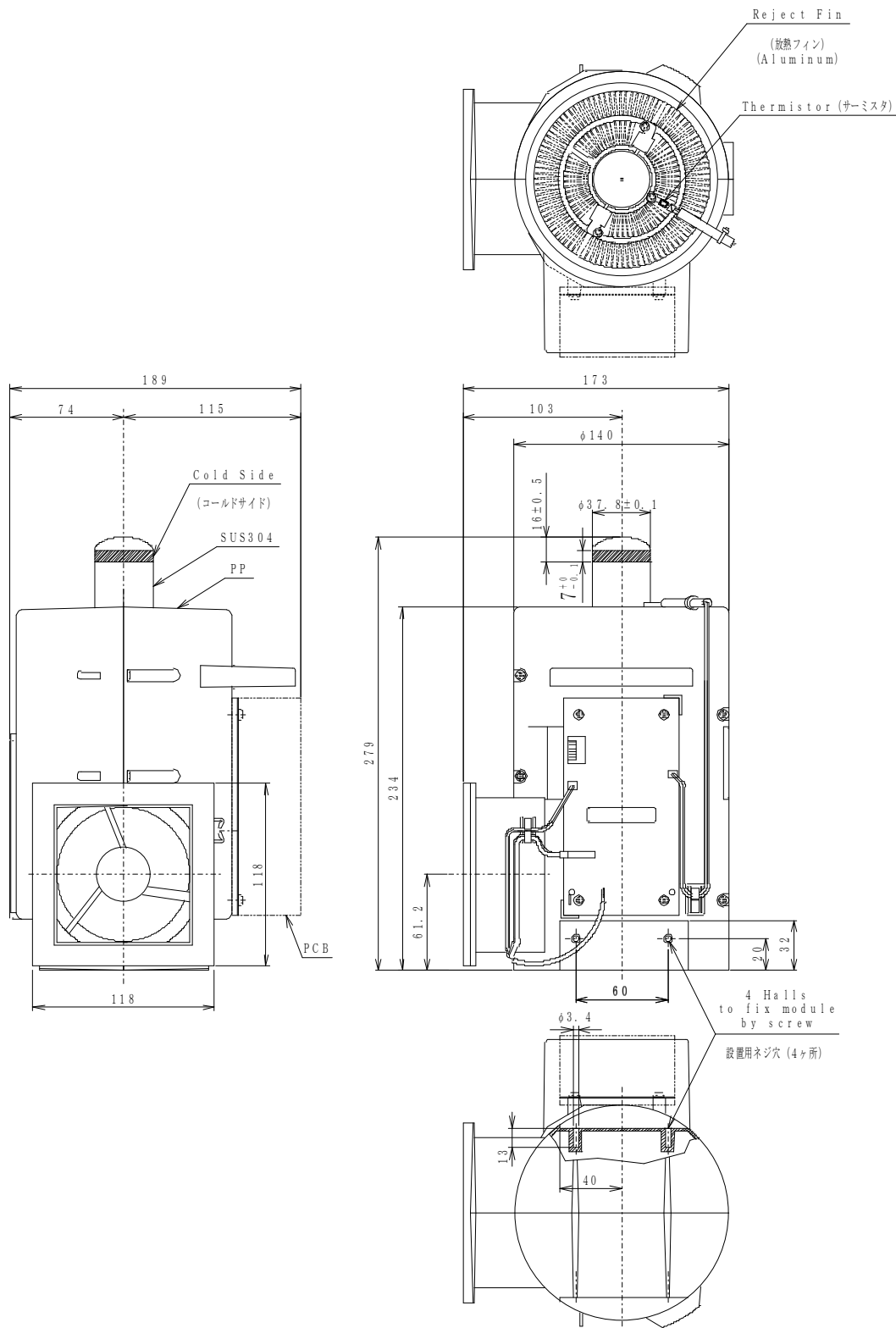
(2) Main Specification

No.	Item	Specification
1	Size	W 173 x D 189 x H 279 mm
2	Weight	Approximately 3 kg
3	Refrigerant	(He) Helium
4	Amount of Refrigerant	2.5 g
5	Internal Pressure of Stirling Cooler	2.6 MPa
6	Power Source	DC 12 V for Drive PCB
7	Cooling Capacity	40 W or Over [Condition] Cold Side Temperature: -23.3 deg. C Ambient Temperature: 25 deg. C Input Voltage to Set Output Voltage: 5V
8	Power Consumption	50 ± 10 W
9	Ambient Temperature Range to Use	0 ~ 40 °C
10	Acceptable Temperature Range at Cold Side	-50 ~ +10 °C
11	Accessories (attached on FPSC module)	Drive PCB (ESC-040H)

(3) Example Graph of Cooling Capacity



(4) Main Size

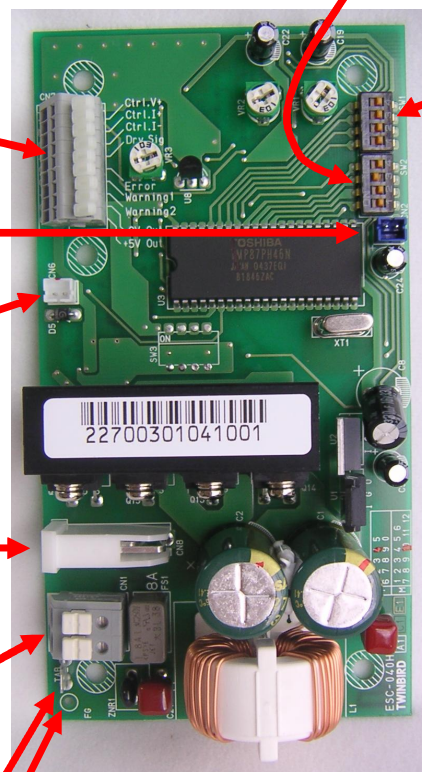
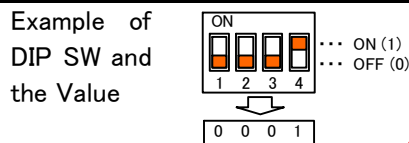


[mm]

3. Input and Output of Drive PCB

Pin	Specification						
[CN7] WAGO 233-209 Acceptable Wire: 0.08 – 0.5 mm ² , 28 – 20 AWG (Stranded conductor, Solid conductor) Strip Length: 5 – 6 mm							
1	Setting of Output 1						
	<table border="1"> <tr> <td>Input</td> <td>DC 1.0~5.0 V</td> </tr> <tr> <td>Output(CN8)</td> <td>AC 2.0~8.5 V</td> </tr> </table>	Input	DC 1.0~5.0 V	Output(CN8)	AC 2.0~8.5 V		
Input	DC 1.0~5.0 V						
Output(CN8)	AC 2.0~8.5 V						
2(+)	Setting of output 2						
	<table border="1"> <tr> <td>Input</td> <td>DC 4~20 mA</td> </tr> <tr> <td>Output(CN8)</td> <td>AC 2.0~8.5 V</td> </tr> </table>	Input	DC 4~20 mA	Output(CN8)	AC 2.0~8.5 V		
Input	DC 4~20 mA						
Output(CN8)	AC 2.0~8.5 V						
3(-)	Output(CN8) AC 2.0~8.5 V						
4	Drive / Stop of FPSC						
	<table border="1"> <tr> <td>Input</td> <td>High</td> <td>Low</td> </tr> <tr> <td>Function</td> <td>Stop</td> <td>Drive</td> </tr> </table>	Input	High	Low	Function	Stop	Drive
	Input	High	Low				
Function	Stop	Drive					
Function	Stop	Drive					
5	Emergency Signal Output						
	<table border="1"> <tr> <td>Output</td> <td>High</td> <td>Low</td> </tr> <tr> <td>Status</td> <td>Emergency</td> <td>Normal</td> </tr> </table>	Output	High	Low	Status	Emergency	Normal
	Output	High	Low				
Status	Emergency	Normal					
Status	Emergency	Normal					
6	Alarm Signal 1 Output						
	<table border="1"> <tr> <td>Output</td> <td>High</td> <td>Low</td> </tr> <tr> <td>Status</td> <td>Alarm</td> <td>Normal</td> </tr> </table>	Output	High	Low	Status	Alarm	Normal
	Output	High	Low				
Status	Alarm	Normal					
Status	Alarm	Normal					
7	Alarm Signal 2 Output						
	<table border="1"> <tr> <td>Output</td> <td>High</td> <td>Low</td> </tr> <tr> <td>Status</td> <td>Alarm</td> <td>Normal</td> </tr> </table>	Output	High	Low	Status	Alarm	Normal
	Output	High	Low				
Status	Alarm	Normal					
Status	Alarm	Normal					
8(0V)	Reference Voltage Output Output Voltage: DC 5.0 V (±10%)						
9(+5V)	Output Current Capacity: 50 mA						
[CN2] JST B2B-PH-K-E (Blue) Acceptable Connector: JST PHR-2							
1	Warm Side Thermistor						
2							
[CN6] JST B2B-PH-K-S (White) Acceptable Connector: JST PHR-2							
1(-)	Output to Fan Output Voltage:						
2(+)	Power Source Voltage +0/-0.3 V Output Current Capacity: 500 mA						
[CN8] JST S02P-XL-HDB (White) Acceptable Connector: JST XLP-02V							
1	Output to FPSC						
2	Output Voltage Range: AC 2.0~8.5 V (RMS) Output Current Capacity: 7 A (RMS)						
[CN1] WAGO 804-102 Acceptable Wire: Stranded conductor 0.5 – 2.5 mm ² , 20 – 12 AWG Solid conductor ϕ 0.8 – 2.0 mm Strip Length: 10 – 11 mm							
1(+)	Power Source Input Input Voltage: DC 12 V (± 10 %)						
2(-)	Maximum Current: 6 A (RMS) (at 12 V Input)						
[TAB] 187 Type (6.3 mm) - GND							
[FG] ϕ 1.8 mm (Hole) - GND							

[SW1] DIP SW		
Setting of Output Voltage Change		
No.	ON	OFF
4	1	0
3	1	0
2	1	0
1	1	0
[SW2] DIP SW		
Setting of Warm Side Temperature Limit Setting		
No.	ON	OFF
4	1	0
3	1	0
2	1	0
1	1	0



Function of Drive PCB (ESC-040H)

4. 1 Outline of Function

This PCB is designed to operate in conjunction with a 40W Free Piston Stirling Cooler (FPSC) and has the following functions..

- (1) To drive FPSC with around 79.1 Hz PWM output, with power inverted from 12 V DC input power.
- (2) To provide the desired drive voltage to the FPSC. The drive voltage is decided by the input voltage (1- 5 V DC) to the control terminal.
- (3) After initial start up of the FPSC, the driving voltage increases in steps at a speed determined by the DIP switch settings.
- (4) Controls output voltage in order to limit the output current to FPSC to below 7A.
- (5) While FPSC is working, it provides voltage supply to the fan motor.
- (6) The PCB outputs an emergency signal and stops power output to the FPSC when the following conditions are detected
 - ① When the temperature of the sensor on the warm side reaches the temperature set by the DIP switch.
 - ② When the FPSC is disconnected or the input power wire is cut.
 - ③ When the temperature sensor is disconnected or wire is cut.
 - ④ The input voltage is out of allowable range.
- (7) Generating an alarm signal from the prescribed terminal when the following conditions are detected.
 - ① When the temperature of the sensor on the warm side reaches 5 deg C lower than the temperature setting of the DIP switch.
 - ② When the set output signal is out of the allowed range.

4. 2 Power source

Connect power source to power input terminal (CN1).

No.	Item	Specification
1	Rating voltage	DC 12 V
2	Allowable voltage	DC 10.8 ~ 13.2 V (DC 12 V \pm 10 %)
3	Maximum input current	6A (RMS) (at 12 V of input voltage)

4. 3 Output to FPSC

Drive voltage to FPSC is supplied from FPSC output terminal (CN8).

No.	Item	Specification
1	Output wave shape	PWM
2	Frequency	79.1Hz
3	Carrier frequency	5.0635 kHz
4	Output voltage range	AC 2.0~8.5 V @79.1Hz
5	Output current capacity	7A (RMS)

4. 4 Output to fan

Drive voltage to fan is supplied from fan output terminal (CN6).

No.	Item	Specification
1	Condition for output	While FPSC is driven
2	Output voltage	Power source voltage +0/-0.3 V
3	Output current capacity	500 mA

4. 5 Drive/ stop of FPSC

FPSC is driven or stop by drive / stop signal at signal input terminal (CN7-#4).

No.	Output	Status
1	High (Open)	Stop
2	Low	Drive

*: High=DC 5V, Low=GND

*: Signal input terminal is connected to 5V DC through 47 k ohm resistor on PCB.

4. 6 Setting of output

Output voltage is decided by input voltage (CN7, Pin # 1) or input current (CN7, Pin # 2, 3).

Step No.	Out of input range	Available input range				Out of input range
		1	2	...	256	
Voltage (V)	[0.000 or over] And [Under 1.000]	1.000 $\left(1 + 0 \times \frac{4}{255}\right)$	1.016 $\left(1 + 1 \times \frac{4}{255}\right)$...	5.000 $\left(1 + 255 \times \frac{4}{255}\right)$	[Over 5.000] And [6.000 or under]
Current [mA]	[0.000 or over] And [Under 4.000]	4.000 $\left(4 + 0 \times \frac{16}{255}\right)$	4.063 $\left(4 + 1 \times \frac{16}{255}\right)$...	20.000 $\left(4 + 255 \times \frac{16}{255}\right)$	[Over 20.000] And [21.000 or under]
Output voltage [V]	2.000	2.000 $\left(2 + 0 \times \frac{6.5}{255}\right)$	2.025 $\left(2 + 1 \times \frac{6.5}{255}\right)$...	8.500 $\left(2 + 255 \times \frac{6.5}{255}\right)$	8.500

*: Input voltage has priority over input current.

4. 7 Changing speed of output voltage ramp-up

Changing speed of output voltage depends on the driving condition.

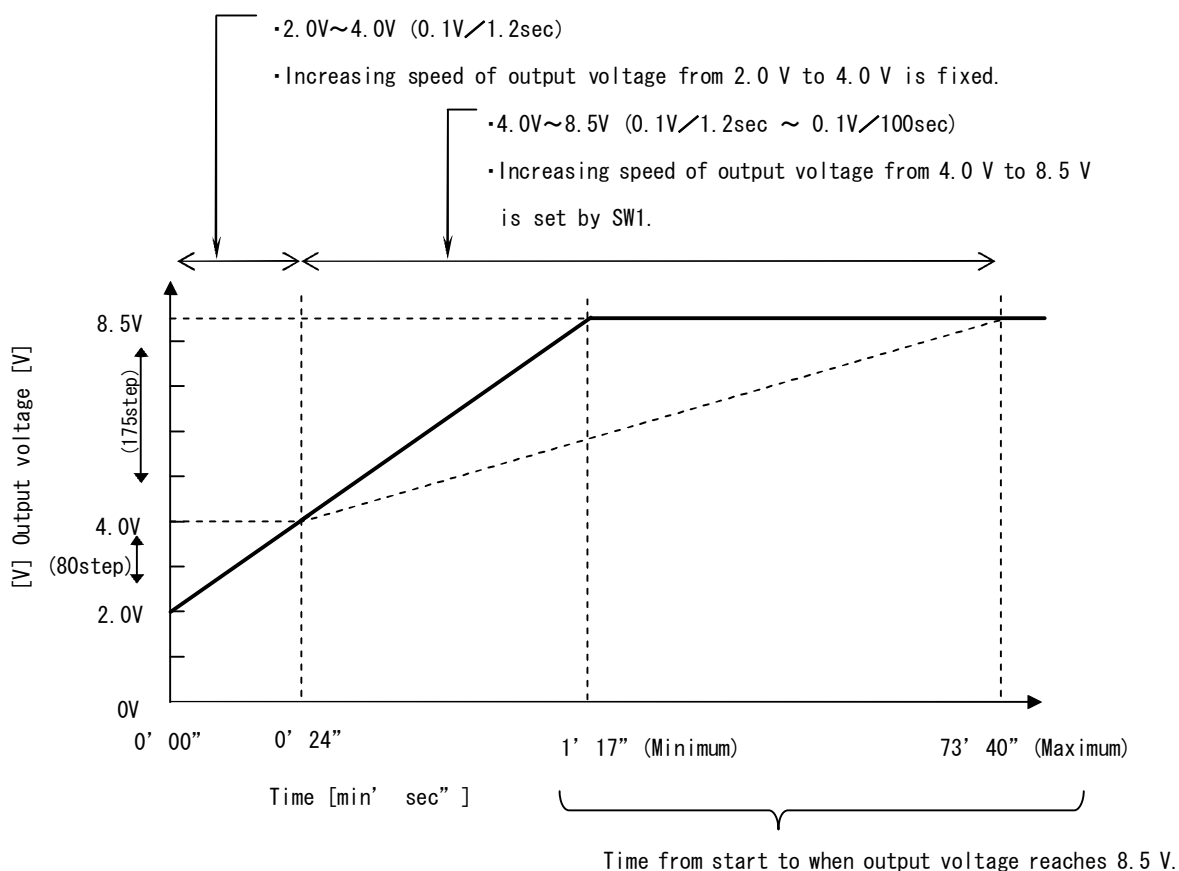
*: 1step=6.5/255[V] 0.1[V]=4step

4. 7. 1 After initial start and before that output voltage reaches the set voltage.

Changing speed of output voltage depends on SW1 setting.

SW1 value	0000	0001	0010	0011	0100	0101	0110	0111
Increasing speed of output voltage	0.1 V / 1.2 sec	0.1 V / 2 sec	0.1 V / 5 sec	0.1 V / 10 sec	0.1 V / 15 sec	0.1 V / 20 sec	0.1 V / 25 sec	0.1 V / 30 sec
SW1 value	1000	1001	1010	1011	1100	1101	1110	1111
Increasing speed of output voltage	0.1 V / 35 sec	0.1 V / 40 sec	0.1 V / 50 sec	0.1 V / 60 sec	0.1 V / 70 sec	0.1 V / 80 sec	0.1 V / 90 sec	0.1 V / 100 sec

※Example of SW1 and the Value



4. 7. 2 After changing set voltage

- a. 0.1[V] → 0.1[V] / 1.2 [s]

When the difference between current output voltage and set output voltage is 0.1 V or over, the increasing speed of output voltage is 0.1 V / 1.2 sec.

- b. 0.1[V] → 0.1[V] / 1.2 [s]

When the difference between current output voltage and set output voltage is 0.1 V or under, the output voltage reaches in 1.2 sec after changing set voltage.

4. 7. 3 When output current is limited

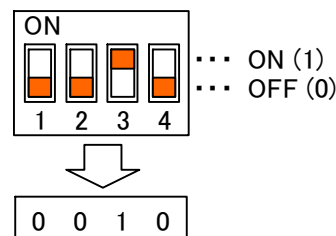
0.2 V / 1.2 sec

4. 7. 4 Process for stop

0.5 V / 0.15 sec

4. 8 Warm side temperature limit

The PCB detects insufficient heat rejection for FPSC using connected warm side thermistor connected to CN2. Limitation of temperature can be set at a suitable value for the cooling system by SW2. When the detected temperature of warm side thermistor reaches the set temperature, the PCB stops the FPSC to and outputs an emergency signal.



Default setting value is 54 deg. C (0010). With this setting, the warm side temperature will not go up to over 65 deg. C.

The limit value must be decided by dip switch settings (shown below), to control the warm side temperature to below 65 deg.

SW2 Value	0000	0001	0010	0011	0100	0101	0110	0111
Temperature Limit	+50°C	+52°C	+54°C	+56°C	+58°C	+60°C	+62°C	+64°C
SW2 Value	1000	1001	1010	1011	1100	1101	1110	1111
Temperature Limit	+66°C	+68°C	+70°C	+72°C	+74°C	+76°C	+78°C	+80°C

4. 9 Emergency signal output

(1) Emergency situations

In the following situations, power supply to the FPSC will be stopped and an emergency signal will be output from the signal output terminal (CN8-#5).

- ① Temperature sensor at warm side has reached the limit temperature set by SW2.
- ② FPSC disconnected or the input power wire is cut.
- ③ Temperature sensor at warm side is disconnected or wire is cut.
- ④ The input power voltage is out of allowable range.

(Power source voltage < 9.6 V or Power source voltage > 14.0 V)

No.	Output	Status
1	High	Emergency
2	Low	Normal

(2) Condition for cancellation of the emergency signal output

When the on / off signal goes off.

4. 10 Alarm signal 1

(1) Situation for alarm signal 1 output

In the following situation, alarm signal 1 will be output from alarm signal 1 output terminal (CN8-#6).

Power supply to FPSC will not be stopped.

- The temperature of the sensor on the warm side reaches 5 deg C lower than the temperature set by DIP switch

No.	Output	Status
1	High	Alarm
2	Low	Normal

(2) Condition for cancel the alarm signal 1 output:

- When the temperature of the sensor on the warm side temperature goes down 5 deg C lower than setting up temperature by DIP switch.

4. 11 Alarm signal 2

(1) Situation for alarm signal 2 output

In the following situation alarm signal 2 will be output from alarm signal 2 output terminal (CN8-#7).

Power supply to FPSC will not be stopped.

- The level of output set signal is out of the allowed range.
(Signal level < 1 V or signal level > 5 V)

No.	Output	Status
1	High	Alarm
2	Low	Normal

(2) Condition for cancel the alarm signal 2 output

- When the level of output set signal is within the allowed range.

3. Contact

TWINBIRD CORPORATION

SC Business Operation

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