Photon Technology
— Every Photon Counts —

PRODUCT OPERATION MANUAL

Photon Technology Co.,Ltd.

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About this manual

This manual is considered as the essential part of the superconducting nanowire single-photon detection (SNSPD) system. Please store this document properly.

All the users are invited to carefully read this manual in all its parts. Any abnormal operation in violation of the manual is not allowed.

For related references: please refer to the corresponding instructions for details of the cryostat, controller and vacuum pump in the following attachments.

*Note: The SNSPD acronym refers to superconducting nanowire single-photon detector when not specified in this manual.

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Catalogue

1. Safety

Be sure to read the safety instructions in detail to avoid personal injury and instrument damage due to unproper operations. Without the authorization of the supplier's engineer, the users cannot conduct the maintenance operation privately.

	Avoid tilting the cryostat.
	Avoid moving or jogging cryostat during its operating status.
	The cryostat lowest temperature is < 2.3 K. Avoid opening the cryostat when the system is not at room temperature.
	WARNING! Disassembly only by the professionals.
	Avoid tilting the compressor.
	The compressor contains a high-pressure vessel, avoid moving or jogging during its operation, avoid private disassembly.
	Avoid electric shock. All power supply equipment must meet the safety standards and shall be installed by qualified personnel. Disconnect the compressor power supply before repairing the electrical components. With power on and wire exposes, only qualified electrical engineers are allowed to open the electrical box for circuit inspection or testing.
	All cables and optical fibers on the equipment are precision parts. Avoid serious bending.
	Keep away from the water while using the electronic equipment.
	If using a laser, avoid direct eye shooting.
	Strong magnetic fields can disrupt electronic devices such as pacemakers, and disruption persist even when the device is turned off. Keep the pacemaker 20 cm away from the vacuum gauge.
* For other matters not mentioned above, please refer to the laboratory operation and management rules.	

2. Aftersales service

- Shanghai-China Technical Service Center

Address: 10/F, 855 Changning Road, Shanghai, 200000

Tel.: 021-5101-2842

Email: photon@cnphotec.com

- Jiaxing-China Technical Service Center

Address: No.11 Guigu Second Road, Jiashan, Jiaxing, Zhejiang Province, 314000

Tel.: 021-5101-2842 /+86 13375838126

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- Naples-Italy Technical Services Center

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3. System introduction

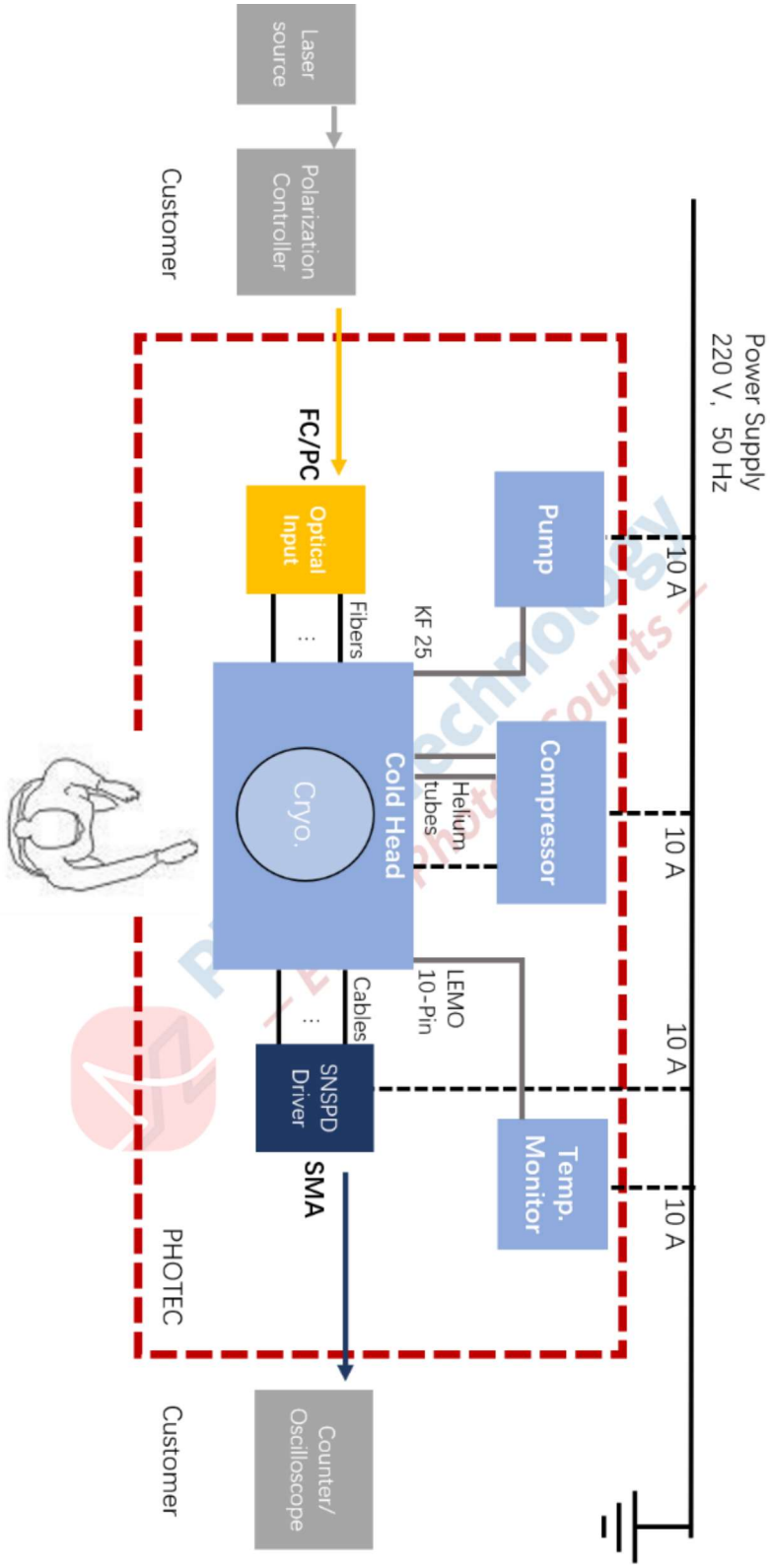


Figure.3.1.1. SNSPD system overview

SNSPD system consists of SNSPD devices, cryostat unit, vacuum unit, electronics unit (Figure 3.1.1.). It can be distributed in the desktop or cabinet version (Figure 3.1.2).

SNSPD device: SNSPD device is fabricated by superconducting materials such as NbN, NbTiN, mainly applied for high-efficient single-photon detection. The packaged device is installed on the secondary cooling stage of the cryostat. Conventional device package includes an electrical connector and a light interface. The electrical connector is connected to the SMA flange via a cryogenic RF cable, used to bring the supply current and to read the output voltage pulses. The light interface is connected to the cryostat flange surface via an optical fiber and FC/UPC or FC/APC connector.

Cryostat unit: This unit is composed by a Gifford-McMahon (GM) refrigerator and by a low-pressure chamber, where the temperature is kept stable guaranteeing the proper working environment (T< 2.3 K) for the SNSPD device.

GM refrigerator consists of a cold head and a compressor. The cold head is a two-stage refrigeration structure. On the primary stage the cooling capacity is 3 W@60 K and the lowest temperature is below 40 K. On the secondary stage, the cooling capacity is 0.1 W@4.2 K, and the lowest temperature is below 2.3 K. The compressor can be air-cooled or water-cooled, in accordance with the required cooling capacity.

The low-pressure chamber is composed of multiple shields and cold stages. The primary 300 K shield is vacuum-sealed, it can isolate the heat exchange between the chamber and the outside. The surface includes multi-channel electrical flange interfaces, optical fiber flange interfaces, vacuum gauge interface and thermometer DC electrical interface. The 40 K shield is the secondary thermal isolation used to shield the heat radiation of the 300 K shield: the cold stage at 40 K is the heat sink for the cryogenic cables and thermometer wires, and it can also host other cryogenic components such as low-temperature amplifiers. The 4 K shield is the last thermal isolation to shield the thermal radiation of the 40 K shield, and the corresponding cold stage is used to install the SNSPD devices and the thermometer.

Vacuum unit: Vacuum unit consists of a rotary pump and a molecular pump, which maintains the cryostat vacuum environment during the temperature cooling and raising process.

Electronics unit: This unit is composed by the Bias module, the voltage amplifiers, the counter and the data communication module. It can control the device working current, it can amplify and readout the device response signal, as well as monitor the SNSPD working

status.

Desktop	Standard cabinet
	

Figure.3.1.2.

4. Installation /calibration & training requirements

4.1 Equipment installation and operation requirements

Equipment installation and operation requirements		
		Remarks
Electric environment	Power supply AC, 220V, > 2.2 kW	
	Resistance to ground < 4Ω	Good and stable grounding helps suppressing the electromagnetic interference noise which might affect the SNSPD performances.
	No high-power equipment in the power supply circuit	Independent "clean" power supply circuit helps suppressing the electromagnetic interference noise.
Space	Desktop: length>500 mm, width>500 mm, height> 550 mm	Cryostat put on the desk (length>500 mm, width>500 mm), compressor put under the desk.
	Standard cabinet: length= 600 mm, width= 600 m, height=1500 mm	
Environment temperature	4 ~ 25 ℃	System startup power consumption is 1.5 kW, operating power consumption is 1.3 kW.
Location requirements	Consider 0.5 m from walls to guarantee the spare compressor air inlet and outlet.	

4.2 SNSPD calibration & training requirements

SNSPD calibration requirements		
Counter	For the users not choosing controller B (including a counter module), please prepare one high-speed counter.	Counter trig level support 50 mV and above.
Light source	Except for 1550 nm, users need to prepare the corresponding light source at other wavelengths.	Light source stability <0.2 dB in 2 h, single-mode fiber output power >10 mW.
Polarization	The users need to prepare a polarization	

Controller	controller if not purchased.	
Training		
Personnel requirements	Please nominate one user as the long-term equipment administrator. Relative users and the equipment administrator shall receive the operation training from our engineer. The equipment administrator is responsible for communicating with the engineer about the related issues.	

4.3 Unpacking & Installation setups

Unpacking& Installation setups		
Items	Operations	
Unpacking & Inspection	Compressor packaging Equipment: compressor	Check packaging: watch the tilt Label, if red, take pictures before unpacking and communicate with supplier.
	Cryostat packaging Equipment: cryostat (with vacuum gauge and valve connected, thermometer inside) Document envelope	Check whether the surface of the cryostat has scratches, bumps, or visible mechanical damages.
	Gas lines box Accessories: Helium gas lines (2 PCS), compressor power cord, cold head drive power cord Tools: M19 wrench, air supply valve, seal rings (2 PCS)	Check whether goods are complete.
	Vacuum pump packaging Equipment: vacuum pump, corrugated pipe	

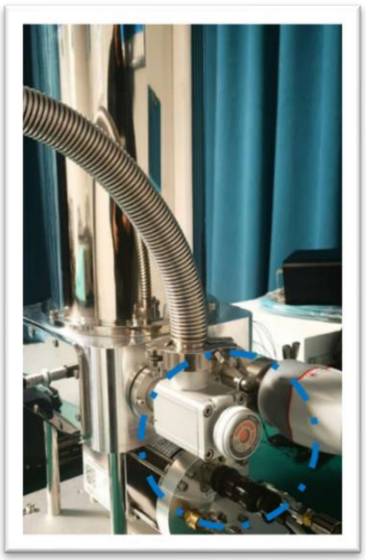
	Accessories boxes Controller P-EM-B, thermometer display, power supply, transformer, flex lines, power cords, etc.	Check whether goods are complete.
Cryostat installation	Place the cryostat on the platform of the rack, or on the desktop	Avoid tilting the cryostat.
Compressor Installation	① Install the power cord on the compressor (CNA-11) andconnect it with the transformer. ② Place the compressor at the bottom of the cabinet or the desktop. ③ Confirm the label on each pipe joints before installation, ensure SUPPLY to SUPPLY, RETURN to RETURN. Use M19 wrench to connect and tighten one end of the SUPPLY/RETURN helium gas line with the cryostat SUPPLY/RETURN joint, connect the other end of the SUPPLY/RETURN helium gas line with the corresponding SUPPLY/RETURN joint on the compressor. ④ Connect the cold head drive cord between cold head and compressor.	
Vacuum pump installation	① Plug in the corresponding power cord, connect the network cable to the gauge. ② Connect the pump inlet and the vacuum valve on the cryostat with KF25 bellow.	
Controller installation	Place the controller on the desktop placement or install on the standard cabinet. Connect one end of the ground wire on the grounding stud with a split plug and the other end on the base of cryostat.	

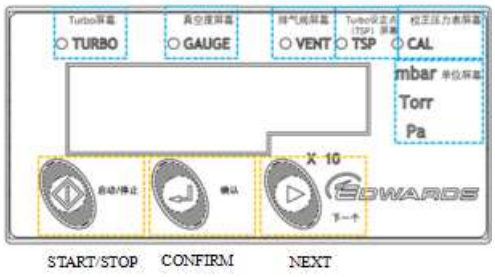
Thermometer display installation	Place the thermometer display on the desktop, connect it to the cryostat with data cable, connect it with the 15V power supply.	

5. Operation instructions

5.1 Cooling down - System startup

<table>
<tr><th colspan="3">Parameter confirmation before startup</th></tr>
<tr><td>Compressor</td><td>EASYCOOL KDC-1000A</td><td>SUMITOMO CNA-11</td></tr>
<tr><td>Helium gas pressure</td><td>17~ 19 bar (4~38 deg. C)</td><td>1.9 to 2.0 MPa at 20 deg. C</td></tr>
<tr><td>System Temperature</td><td colspan="2">The system is at room temperature (290 ~ 300 K)</td></tr>
<tr><th colspan="3">Vacuum pumping station startup</th></tr>
<tr><td rowspan="3">Vacuum interconnection</td><td colspan="2">Shut the vent valve fully.
 
</td></tr>
<tr><td colspan="2">Connect the vacuum valve on the cryostat and the vacuum pumping station inlet with a KF25 bellow.
Turn counterclockwise the vacuum valve on the cryostat to fully open it, then turn it clockwise half turn.</td></tr>
<tr><td colspan="2">※Note 1：The valve stroke is 7 turns in total, clockwise rotation is “SHUT” and counterclockwise rotation is “OPEN”.
※ Note 2： Rotate the valve slowly to avoid rapid vacuum breaking.</td></tr>
</table>

<table>
<tr><td></td><td>  
</td></tr>
<tr><td rowspan="2">Molecular pumping group T-Torr-10 startup</td><td>Turn on the power switch of the rotary pump.
  
※Note 1：The noise from the pump during the first 20 s after the power switch is normal. If the noise lasts more than 1 min turn off the power switch and verify that the VENT is fully closed.</td></tr>
<tr><td>Press “NEXT” button on the control panel, select “GAUGE” interface, monitor the vacuum degree and wait until it reduces ⩽ 8.0 E-1 mbar, then select “TURBO” interface and press “START/STOP” button to start molecular pump.</td></tr>
</table>

		
	Molecular pump speed gradually increases to 100%.	
	Select “GAUGE” interface, monitor the vacuum degree and wait until it reduces to ⩽ 5.0 E-3 mbar. This operation requires approximately 30 mins.	
Cryostat startup		
Compressor	EASYCOOL KDC-1000A	SUMITOMO CNA-11
Power supply connection	Connect the AC 220 V, 50 Hz power supply	
	/	Turn on the transformer switch, and the output voltage is 95V ~ 105V.
Cryostat startup	Open the POWER switch on the front panel of the compressor, and the self-test running lights on.  After about 10 seconds, the BYPASS and POWER indicators stay on and turn green, the other indicators are off. 	Open the Main POWER switch on the rear panel of the compressor. 
	Open the DRIVE switch on the front	Open the DRIVE switch of the front

	panel, after the BYPASS light runs off, the POWER indicator light stays on, the compressor operating pressure circulates between 21 bar and 25 bar, and the temperature gradually cools down.	panel, and the compressor operating pressure circulates between 2.1 MPa and 2.3 MPa, and the temperature gradually cools down. 
System cooling down	The system will cool down below 2.3 K within 9 hours and remain stable (P-CS-4K-Mini cooling time is within 3 hours), corresponding vacuum degree turns lower than 10E-6 mbar.	

5.2 Heat up - System shutdown

Parameter confirmation before shutdown			
※Note : The QEye system support 365*24 hours continuous operation, please shut down the system if not used for a long time. If possible, restore the vacuum degree periodically to keep the SNSPDs under vacuum.			
	Turn off the power switch of Controller P-EM-B16		
Pump status	STATUS 1#: The pump is well connected to the cryostat, the pump is running.	STATUS 2#: The pump set is well connected to the cryostat, the pump is turned off.	STATUS 3#: The pump is disconnected from the cryostat, the pump is turned off.
Vacuum valve	The vacuum valve is fully "OPEN".	The vacuum valve is fully "SHUT".	The vacuum valve is fully "SHUT".
Vacuum interconnection	/	/	Connect the pump and the cryostat with KF25 bellow.

	Confirm the molecular pump vent valve is fully shut.	
Vacuum pump startup		
	Turn on the vacuum pumping station, please refer to 5.1 for the startup details.	
	After TURBO speed is fully accelerated to 100%, fully OPEN the vacuum valve and SHUT counterclockwise half turn, current vacuum degree should better than 10E-6 mbar since the system was operating at low temperature.	
Cryostat shutdown		
	EASYCOOL KDC-1000A	SUMITOMO CNA-11
Compressor shutdown	Turn off the DRIVE switch on the front panel, the BYPASS and POWER indicator lights stay on.	Turn off the DRIVE switch on the front panel.
	Turn off the POWER switch on the front panel, and the BYPASS and POWER indicators are off.	Turn off the Main POWER switch on the rear panel.
Power supply	/	Turn off the transformer switch
	Disconnect the AC220 V, 50 Hz power supply	
System heat-up	The system will return to room temperature in 48 hours, the corresponding vacuum degree is below10^{-3} mbar. ※Note 1：Keep the pumping system on during warm up procedure till the temperature reaches room temperature (>290 K).	

5.3 Power failure protection

When the system is running at low temperature, unexpected power failure will break the high-vacuum environment inside the cryostat. Please confirm the vacuum valve is fully shut first to maximally keep the vacuum inside, then turn off the power switches of the controller, compressor and vacuum pump. Abrupt vacuum breaking at low temperature will possibly damage the SNSPD device.

After the power supply is restored, recover the cryostat vacuum as soon as possible. Check the vacuum degree, if < 1.0E-2 mbar, start the vacuum pump as instruction, and open the valve after pump TURBO speed accelerating at 100%. If >1.0E-2 mbar, open the vacuum valve at the time after rotary pump running 2 mins. Re-cooling down startup shall be operated after the system heats up to room temperature first.

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Please prepare an UPS (Uninterrupted Power Supply) for the system power supply if there are the conditions. The system operating power consumption is about 1.3 kW.

If power interruption has been announced, please heat up the system to room temperature at vacuum state and fully shut the vacuum valve in advance. Without enough time, heat up to the temperature as high as possible, and shut the vacuum valve before power interruption.

6. Appendix

6.1 Polarization controller

Conventional SNSPD is a polarization sensitive device, so the polarization controller is commonly used in the SNSPD application experiments to optimize the detection efficiency. The user can adopt the electrical or manual polarization controller, and the three-paddle polarization controller is recommended.

The three-paddle polarization controller (Figure 6.1.1) connects a quarter-wave plate, a half-wave plate and a quarter-wave plate together, can transfer a polarization state to any other polarization state. The first quarter-wave plate transforms the input polarization state to the linear polarization state, then the linear polarization state is rotated by the middle half-wave state, and the last quarter-wave state transforms the linear state to the other arbitrary polarization state. Therefore, adjusting the three blades can fully control the output polarization state in the wavelength range from 300 to 1650 nm.

Wavelength (nm)	# of Loops for ~1/2λ		# of Loops for ~1/4λ		Recommended fiber
	Dia 27 nm	Dia 56 nm	Dia 27 nm	Dia 56 nm	
480	3	2	/	3	HP460
630	4	3	2	4	HP630
780	2	4	1	2	HP780
850	2	4	1	2	HI780
1064	2	4	3	2	HI1060,1060XP
1310	3	6	4	3	SEM28E
1550	3	6	2	3	SEM28E

Table.6.1.1.

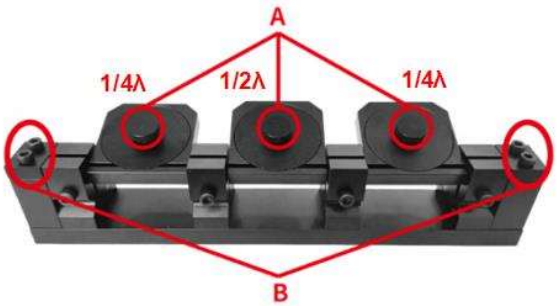


Figure.6.1.1. Three paddle polarization controller

Three paddle polarization controller mount procedure:

1. Release the slide cover (A) on every blade.

2. Each end of the fiber polarization controller has two rectangular cover plates (B). Remove the two screws and remove the rectangular cover plate.

3. Place the groove ring horizontal upwards, the grooves on the blades shall be aligned with those at both ends of the base supports.

4. Place the optical fiber in the groove under the cover one side, continue to lay the optical fiber along the groove path, lay the required number of loops on every blade, and finally pass through the other end of the controller. The fiber should always be inside the groove, but should not be pulled too tight, since this will lead to induced birefringence during the blade's rotation, thereby increasing the optical loss.

5. Ensure that the fiber is inside the groove of every blade. Before fixing the fiber on the next blade, gently tighten the slide cover on the previous blade to fix the fiber in place.

6. Gently tighten the screws on the rectangular cover plate at both ends of the controller.

7. Control the tightness of every blade by tightening the inner hexagonal screw (C) shown in Figure 6.1.2.

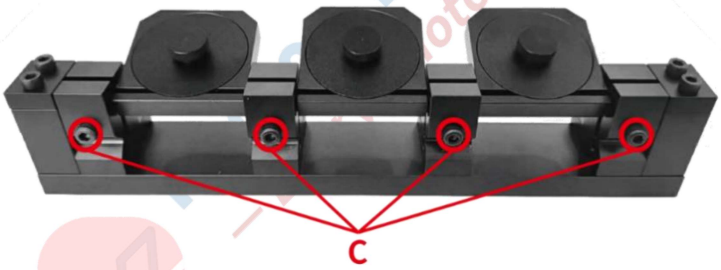


Figure. 6.1.2.

6.2 Controller P-EM-B16

6.2.1 Product description

P-EM-B16 (Figure 6.2.1) is an external amplifying measurement equipment for SNSPD developed by Photon Technology, configured with a corresponding computer operation software. SNSPD transforms from superconducting state to resistive state when photons are absorbed and this transient generates a rapid electric pulse, which can be collected, amplified and measured by P-EM-B16. The related data can be further processed with the operation software.

P-EM-B16 is a measurement equipment with high integration, high scalability, high precision, high resolution, low noise, supporting up to 16-channel conventional SNSPDs simultaneous measurements. It can be extended to support the program control of 8-channel devices with low-temperature amplifiers. P-EM-B16 includes two RS485 interfaces and one USB serial interface. The computer software supports data recording and alarm recording functions.

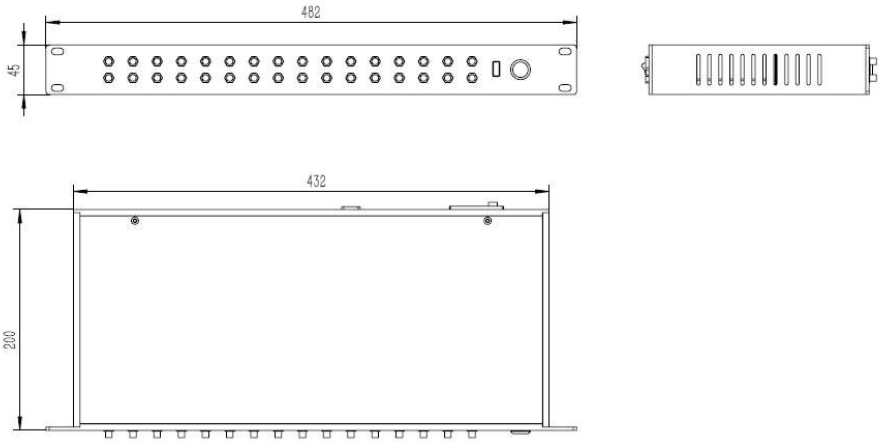


Figure. 6.2.1

6.2.2 Technical parameters

P-EM-B16 performance parameters

Bias current setting range	0~40 μA
Bias current setting precision	0.01 μA
I_c scan error	±0.1 μA

Work bandwidth	0.01~600 MHz
Maximum counting rate	20 MHz
Trigger level setting range	5~400 Mv
Scan time setting range	10 ms~60 s
Output signal	1.1V TTL
Signal connection interface	SMA
Number of channels	Max 16
Data communication protocol	Modbus
Data communication interface	USB-A, DB9, HT3.96K
Power consumption	Max 30 W
Supply voltage	Tpy 220 V AC
Size	482(L)*200(W)*45(H) mm

Table. 6.2.1

6.2.3 Installation instructions

The P-EM-B16 supports two installation methods: desktop placement and standard cabinet integration (Figure 3.1.2.).

6.2.4 Panel definition

*NOTE: Please verify the input AC voltage meets the standard requirements and reconfirm before inserting the power cord and turning on the controller. Turn off the controller before making any front and rear panel connections.

Figure. 6.2.2.

① SMA interface

As a part of the front panel (Figure. 6.2.2.), SMA interface includes 16 channel input

(IN) and output (OUT) connection ports, the IN port receives the SNSPD system signal, the OUT port provides a TTL waveform.

② Communication connection port 1#

As a part of the front panel, port 1# is a USB serial communication interface, a corresponding USB adapter cable connected to computer is supplied as accessory.

③ Power switch

As a part of the front panel, power switch is used to turn on/off the power supply of main controlling and amplifying module. Press the button, when the light turns on, the power is turned on. Reset the switch button, the light turned off and the power supply turned off.

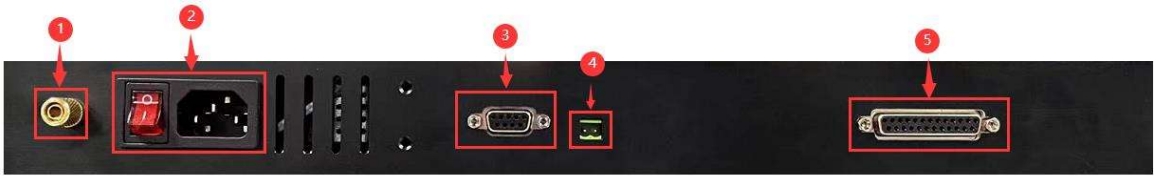


Figure. 6.2.3.

① Grounding stud

Connect one end of the ground wire on the grounding stud with a split plug and the other end on the base of cryostat to reduce the dark counts.

② Power supply input interface

As the AC voltage power input interface, this interface can input 85~264V AC for internal power supply module, the corresponding power switch controls the power on/off of the equipment. Please shut off the switch during long-term inactivity. Corresponding power cord is supplied as accessory.

③ Communication connection port 2#

Communication connection port 2#(Figure.6.2.4.) is a RS485 communication interface, as defined in the table 6.2.2. below.

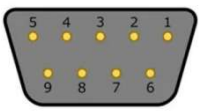


Figure. 6.2.4.

PIN	DESC.	PIN	DESC .
1	B	6	NC
2	A	7	NC
3	NC	8	NC
4	NC	9	NC
5	GND		

Table.6.2.2.

④ Communication connection port 3#

Communication connection port 3#(Figure.6.2.5.) is a RS 485 communication interface, as defined in the table. 6.2.3. below.

Figure. 6.2.5.

PIN	DESC.
1	A
2	B

Table.6.2.3.

⑤ Cryogenic amplifier interface

The cryogenic amplifier interface (Figure. 6.2.6.) supplies voltage VCC and bias voltage Vbias for the internal amplifier. The specification is defined in the table 6.2.4. below.

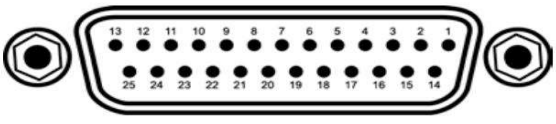


Figure. 6.2.6.

PIN	DESC.	PIN	DESC.
1	Vbias 1	14	Vbias 2
2	Vbias 3	15	Vbias 4
3	Vbias 5	16	Vbias 6
4	Vbias 7	17	Vbias 8
5	VCC 1	18	VCC 2

6	VCC 3	19	VCC 4
7	VCC 5	20	VCC 6
8	VCC 7	21	VCC 8
9	NC	22	GND
10	GND	23	GND
11	GND	24	GND
12	GND	25	GND
13	GND		

Table.6.2.4.

6.2.5 Software instructions

Please download the installation package on the official website: https://www.cnphotec.com/zlxz, or ask the engineer for the latest-version software of P-EM-B16.

*Note: One computer software interface only supports controlling one P-EM-B16, multiple P-EM-B16 controllers working in parallel can be achieved in the way of multiple interfaces simultaneous operation.

A. Driver Installation

Please install those drivers before running the software, compete the installation in the following steps:

① Install the USB-serial drive: open the folder DRVSETUP64, double-click to run **DRVSETUP64.exe**, click the installation button, installation completed after the interface display the success dialog window.

② Install the Microsoft.NET6 Runtime: Double-click **windowsdesktop-runtime-6.0.8-win-x64** to complete the runtime installation.

③ Install the Webview2 environment: Double-click to run **MicrosoftEdgeWebview2Setup.**, automatically complete downloading and installation.

④ Microsoft Runtime installation: Some windows system lacks runtime for SNSPD_CH16B software, double-click to run **Microsoft common runtime libraries collection.exe.**, install the Microsoft Runtime.

⑤ Complete the above installations and run SNSPD_CH16B.exe.

B. Display interface introduction

*Note: The software is continuously updated, any feedback on the interface operation and requirements on the software are welcomed. Please contact the after-sales service Email: photon@cnphotec.com, your suggestions will be taken into account.

A. Login

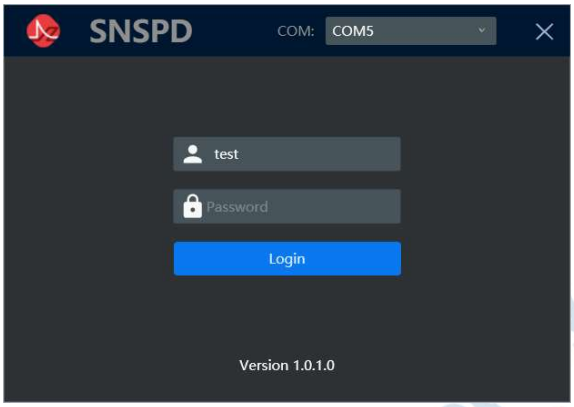


Figure. 6.2.7.

Connect the controller, turn on the power switch, double click to run the software, the Login interface is displayed as Fig.6.2.7. The interface menu bar contains the LOGO, COM bar and close button, the COM bar can automatically identify and display the COM serial number. The home page contains username, login password, login button and version number. Input the login information and ensure the COM connected, then click login to enter the operation interface.

B. Channel selection

The channel selection window is displayed as Figure. 6.2.8. All channels are initially unselected. Click to select the working channels and press OK to enter.

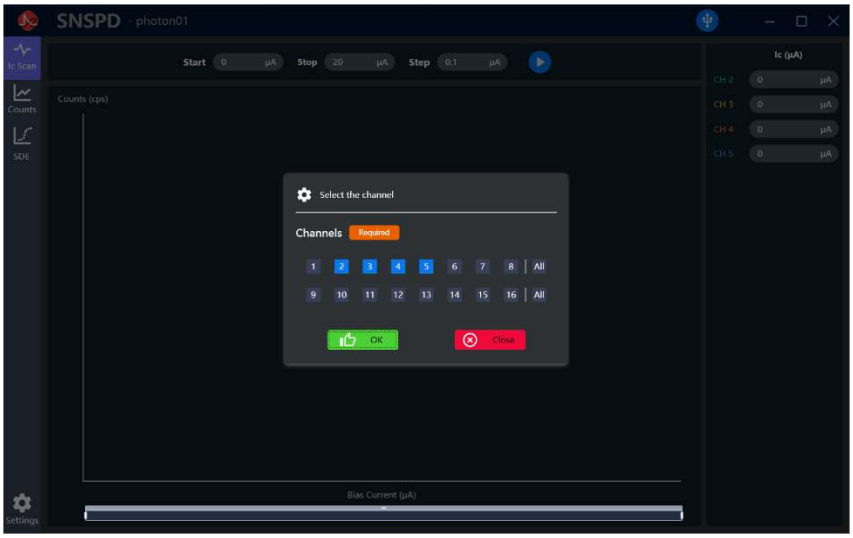


Figure. 6.2.8.

C. IV scan

Figure. 6.2.9. is the IV scan interface, including scan start current point menu bar (default 0 μA), stop point bar (default 20 μA), scan step bar (default 0 μA) and scan start /pause button on the upper border, the I_c value is displayed on the right bar, the real-time scanning curves display in the middle area.

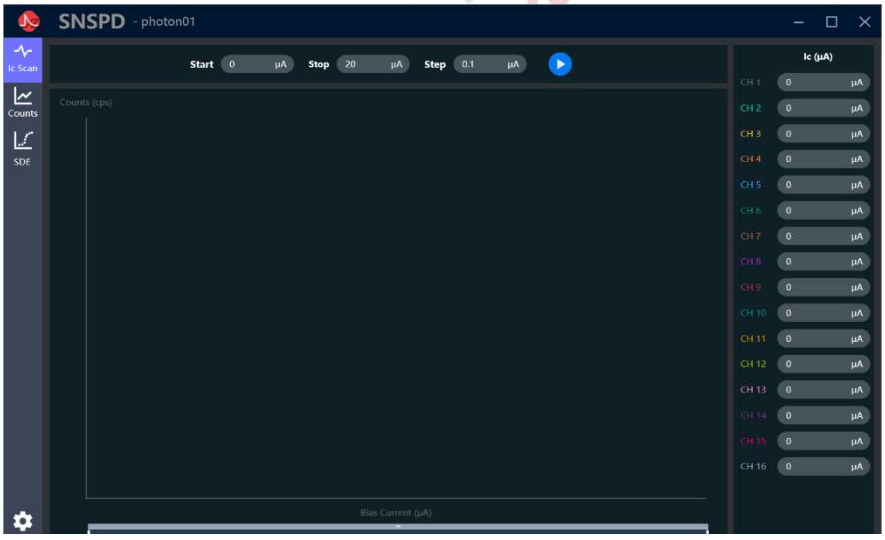


Figure. 6.2.9.

D. Counts

Click counts menu on the left, the counts interface shows as in Figure. 6.2.10.

The real-time collected counts value shows in the middle area. The START/STOP button, the integral time setting bar, the counts curve refreshing button and data download button

are in the bottom. The data will be saved in the default document folder as shown in Figure. 6.2.11., the default file name and format are **ChannelCountInfos-2022-09-13-16.csv**. The right column shows the channel number, corresponding channel counts value display bar, I_b setting bar (default setting value same as last closed) and trigger level setting bar (default 50 mV).

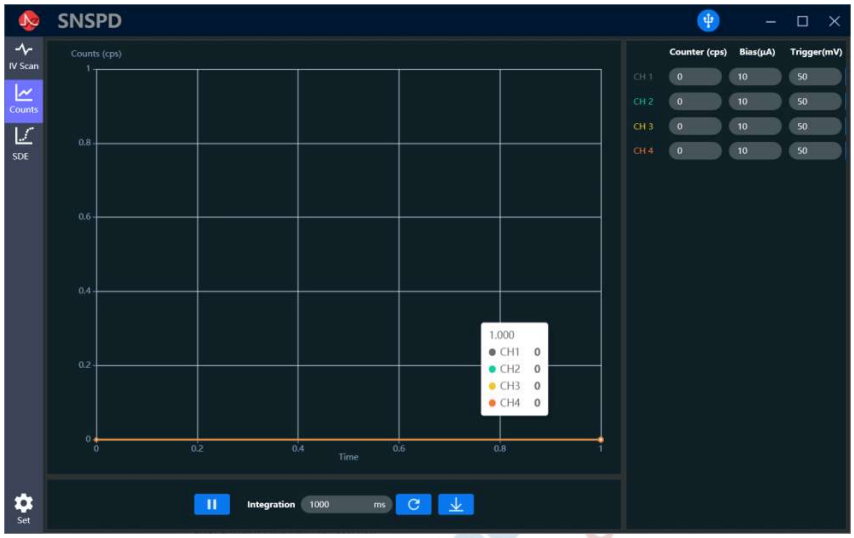


Figure. 6.2.10.

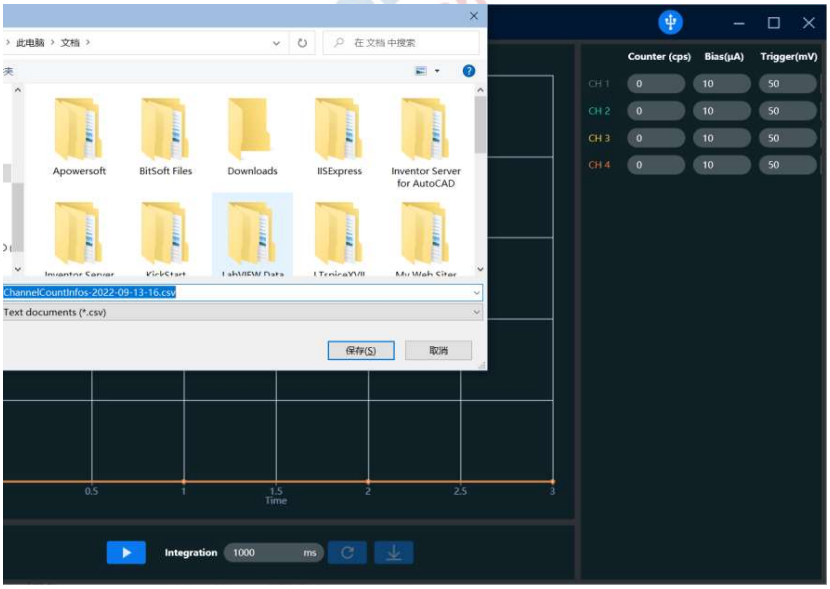


Figure. 6.2.11.

E. SDE

As shown in Figure 6.2.12, the SDE interface contains SDE curve display bar in the middle

frame, the trigger setting bar (default 50 mV), scan time setting bar (default 1000 ms), scan start point setting bar (default 0 μA), scan stop point setting bar (default 20 μA), scan step setting bar (default 0.1 μA), photon counts setting bar (default 100000 Hz), and the START/STOP button on the upper, and the channel counts/s display bar on the right.

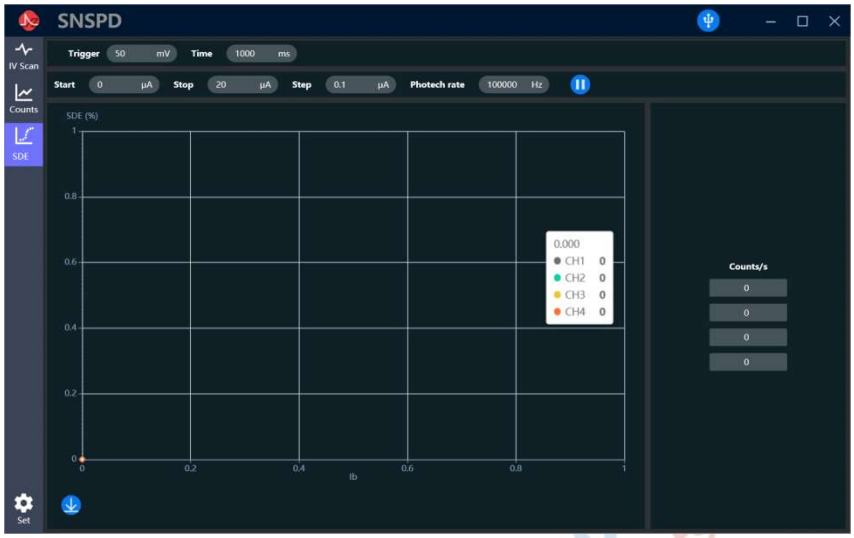


Figure. 6.2.12.

F. Settings

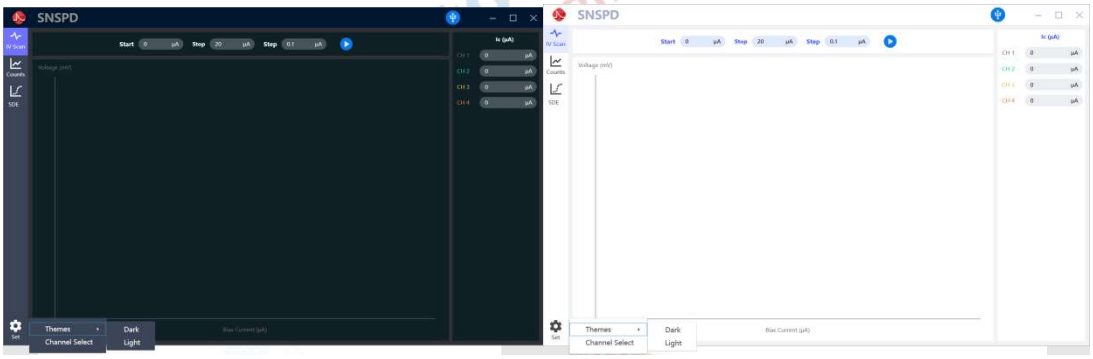


Figure. 6.2.13.

As shown in Figure 6.2.13, click the set button, select the Theme to modify Dark and Light theme style, select Channel Select to reset the working channels.

Functions

- SNSPD superconducting transition current I_c scanning

Set the related bias current interval on the IV scan interface, and the software can automatically scan and display the superconducting transition current I_c for each active

channel. Scan accuracy is ± 0.1 μA. It is recommended to operate IV scan once a month.

- SNSPD working current I_b auto setting

When the scanning generates I_c value, the SNSPD working current I_b will automatically set in the Bias bar of the corresponding channel on the count interface. Click the Bias bar of the corresponding channel and press enter key to start the SNSPD operations.

- SNSPD response pulse signal counting

I_b is automatically set at the optimal signal to noise ratio. It is recommended to keep the default settings of the trigger level and integral time. Press the START/STOP button to start the photon counting. The OUT interface output is a 1.1 V TTL waveform.

- Device latching monitoring and auto reset

SNSPD generally works stable, but the inevitable latching probability increases during untra-long-period counting operation and the interruption may affect experiment purpose. This issue can be well resolved by this function. The software can detect the device latching by algorithms and auto reset it to work in 20~200 ms.

- Device SDE curve scanning

Set the related values on the SDE interface (Figure. 6.2.14.), the software can automatically scan a corresponding SDE Curve of the device. This function can facilitate the SNSPD calibration.

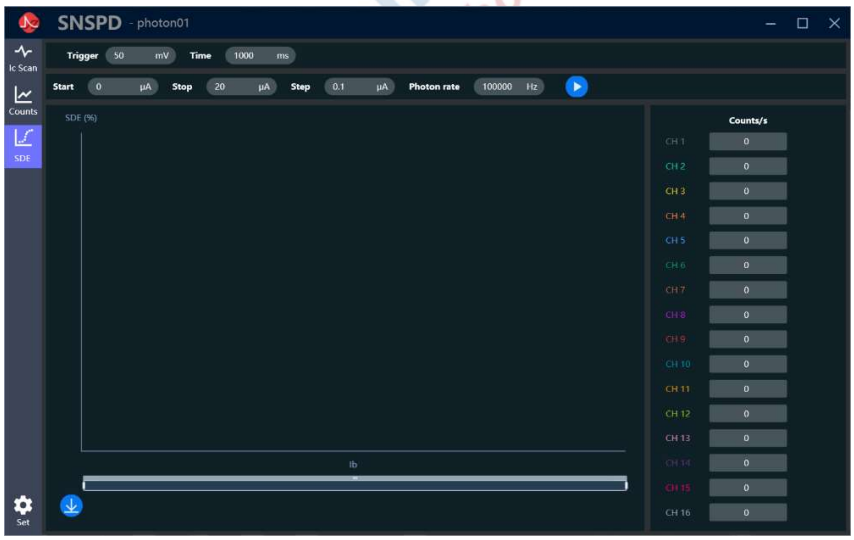


Figure. 6.2.14.

6.2.6 Modbus protocol introduction

The P-EM-B16 has two computer interfaces: USB and DB9. Each interface shares the

same set of Modbus protocol instructions and simultaneous operations are supported. The USB serial interface is suitable for short-distance connections, The recommended maximum length of USB line is 2 m. The USB interface connection supports one computer controlling only one P-EM-B16, hence the computer interface only supports one-to-one control. DB9 is a RS485 interface, suitable for long-distance connections and for multiple equipment parallel communication.

Serial interface specification	
Connector type	USB-A/DB9
Voltage level	USB Specified /RS485 Specified
Transmission distance	2 meters max /100 meters max
Timing method	Asynchronous
Transmission mode	Half-duplex
Baud rate	115200 bits/s
Command rate	50 instructions/s
Verification	CRC

Table.6.2.5.

Here the instructions for data communication between the computer and the P-EM-B16 are provided.

Data Send Instructions			
Data bits	Functions	Examples	Remarks
1	Device address	0x11	0x11 indicates the CH16B device
2	Data direction	0x03	0x03 indicates the upper computer send instruction
3	Function: High	0x00	Not temporarily used, used for the extension
4	Function: Low	0x00	0xFF: Reserved The 0x00-0xFE indicates different functions, respectively
5	Data length: High	0x00	Data length: High
6	Data length: Low	0x00	Data length: Low
...	Data area	...	Effective data area

7	CRC16 high		
8	CRC16 low		

Table.6.2.6.

Data read instruction			
Data bits	Functions	Examples	Remarks
1	Device address	0x11	0x11 indicates a programmed B-CH16 device
2	Data direction	0x10	0x10 indicates the lower computer read instructions
3	Function: High	0x00	Not temporarily used, used for the extension
4	Function: Low	0x00	0xFF: Reserved The 0x00-0xFE indicates different functions, respectively
5	Data length: High	0x00	Data length: High
6	Data length: Low	0x01	Data length: Low
	Data area		The returned data
7	CRC16 high		
8	CRC16 low		

Table.6.2.7.

For example:

Example 1: Function bit 0000 Confirm whether the device is connected, reply is connection OK, do not reply is connection failed	[09:05:29.731] Send→◇ 11 03 00 00 00 00 47 5A [09:05:29.741] Read←◆ 11 10 00 00 00 00 C2 99
Example 2: Function bit 0001 Set the V_b bias voltage, the upper computer set the I_b to 10 μA, then the V_b needs to	[09:26:54.032] Send→◇ 11 03 00 01 00 20 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 00 00 00 00 00 00 04 4C 04 4C 04 4C 04 4C D2 44 [09:26:54.045] Read←◆ 11 10 00 01 00 00 93 59

be send to 10 μA * 110 KΩ =1100 Mv	
Example 3: Function bit 0002 Read the current V_b voltage: 04 4C> 1100> 10 Ma	[09:29:51.112] Send→◇ 11 03 00 02 00 00 E6 9A [09:29:51.124] Read←◆ 11 10 00 02 00 20 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 00 00 00 00 00 00 04 4C 04 4C 04 4C 04 4C 5D F0
Example 4: Function bit 0003 Read the current AIN0 voltage value	[09:30:41.812] Send→◇11 03 00 03 00 00 B7 5A [09:30:41.823] Read←◆11 10 00 03 00 20 04 B5 04 B5 04 B5 04 B2 04 B6 04 B6 04 B1 04 B5 04 B5 00 03 00 00 00 04 04 B8 04 B7 04 B8 04 B8 9B FC
Example 5: Function bit 0004 Set the integral time	[09:49:50.861] Send→◇11 03 00 04 00 02 00 0A 63 CC [09:49:50.872] Read←◆11 10 00 04 00 00 83 58
Example 6: Function bit 0005 Read integral time 00 64> 100 ms	[09:44:30.077] Send→◇ 11 03 00 05 00 00 57 5B [09:44:30.087] Read←◆ 11 10 00 05 00 02 00 64 FD 21
Example 7: Function bit 0006 Set the count trigger level, set 50mV to send 01 F4> 500	[09:56:51.100] Send→◇ 11 03 00 06 00 20 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 FF FF 73 FA [09:56:51.112] Read←◆ 11 10 00 06 00 00 22 98
Example 8: Function bit 0007 Read the current count trigger level	[09:57:07.685] Send→◇ 11 03 00 07 00 00 F6 9B [09:57:07.696] Read←◆ 11 10 00 07 00 20 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 01 F4 A4 AC

Example 9: Function bit 0008 Read the count value, every 4 bit is a channel count value. In the example,the channel 5 count value 0001B6C4> 112324	[10:16:43.035] Send→◇ 11 03 00 08 00 00 C6 98 [10:16:43. 047] Read←◆ 11 10 00 08 00 40 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 B6 C4 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 B6 57

Table.6.2.8.

6.3 Molecular pumping station (T-Torr-10)

Caution

Pump power supply: 220 V/ 50 Hz

Caution: Avoid moving the pump station or opening the vent valve once the pump is on.

6.3.1. Station description

The T-Torr-10 molecular pumping station is composed of a rotary dry pump, a molecular pump, an active instrument controller and an air-cooling system. The station can implement such functions as single button start/stop, vent valve control (optional), and the turbine molecular pump startup delay in conformity with the time or vacuum degree (if meter installed). The Modbus 485 multi-address control box parameter reading is also provided to realize the integrated control function.

Figure. 6.3.1.

6.3.2. Technical parameters

Molecular Pumping Station	T-Torr-10	D-Torr-10
Flange	KF40, KF25	KF40, KF25
Ultimate pressure	<5*10^{-9}mbar	<5*10^{-9}mbar

Pumping speed for nitrogen N_2		47 l/s	47 l/s
Operating environment temperature		5 to 40 ℃	5 to 40 ℃
Dimensions (L*W*H)		217*385*367 mm	217*323*312 mm
Weight of pumping station		21 kg	14.5 kg
Power consumption of pumping Station		144 W	56 W
Backing pump	Types	Turbo pump	Diaphragm pump
	Pumping speed at 50 Hz	50 Hz: 3 m^3/h 60 Hz: 3.6 m^3/h	50 Hz: 1.2 m^3/h 60 Hz: 1.4 m^3/h
	Pumping speed at DC 24V	/	600 rpm 0.6 m^3/h 1700 rpm 1.4 m^3/h
	Power consumption	120 W	64 W
	Noise level	55 dBA	45 dBA
	Weight	9.5 kg	4.5 kg

Figure. 6.3.1.

6.3.3. Operation instruction for T-Torr-10

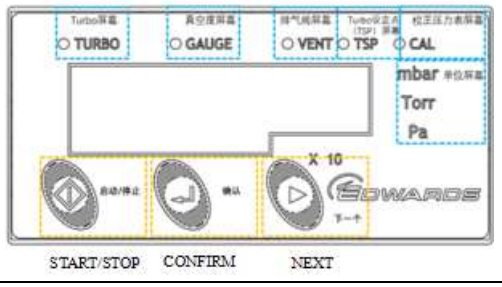
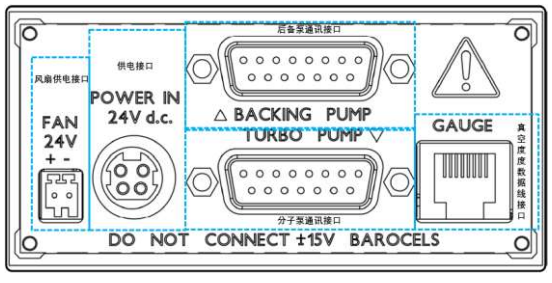
Front Display	Rear panel wiring diagram
	

Figure. 6.3.2.

On the top of the controller display, different LED indicators represent different digital menu interfaces displaying on the current screen. Press NEXT button to switch menu, press START / STOP button to return to the TURBO menu, press the CONFIRM button to run the function, all the menu marks and key functions are shown in the figure above.

➢ **TSP (Turbo set point) settings**

The Turbo set point interface is used to configure the startup delay of the turbo molecular pump. When you select the Turbo set point interface, the TSP LED lights up and displays the current set point. The default setting is “Closed”. The TSP interface is not available if Turbo is running or the selected unit is Volt.

Change the Turbo set point: Press CONFIRM button, and then press NEXT between the close, delay and vacuum set points, and press CONFIRM to select.

After selecting the delay, the display indicates the delay time within a few seconds. The default time is 120 s, which means the turbine molecular pump will startup after 120 s since the START/STOP button is pressed. If you want to change the delay time value, press CONFIRM to start the digital login mode.

If the vacuum gauge is connected to the system, the turbine molecular pump can be activated when the vacuum degree drops below the set point by the vacuum set point function. Select the vacuum, the display indicates the set point vacuum degree. The default vacuum degree is "5.00" mbar. If you want to change the vacuum setting point, press CONFIRM to start the digital login mode.

Digital login mode is entered by pressing CONFIRM at the time or vacuum set point menu. The first number starts flashing, and the time and vacuum degree value can be edited.

Press NEXT to adjust the first number to a fit value, press CONFIRM to select the first number. Then adjust the second number at the same way. Then the time set point last number or vacuum set point index value shall be selected from -10 to +6. Press CONFIRM to confirm the complete number and then the display of set point value restored.

*Note: If the Turbo set point is set to the vacuum degree but the vacuum gauge is not connected to the system, the turbine molecular pump will not startup.

Startup

No Turbo set point

Vortex dry pump startup: After the vacuum connection is completed, turn on the rare switch of the vortex dry pump manually. After the vacuum degree drops to **8.0E-1** mbar, start the molecular pump.

Molecular pump startup: Operate the active instrument controller, switch the interface to “Turbo”, the interface displays “0%”, and then press "start / stop" button, the percent sign flashes in the upper left of the display, representing the molecular pump is accelerating, when the Turbo reaches the normal speed (default value > 80%), the digital will stop

flashing and remain stable, finally stabilize at “100%”, and then switch to the vacuum interface to display the vacuum degree.

Set the Turbo set point

If the Turbo set point is set, the backup pump starts at the “Start / stop” button pressed , the TSP LED light flashes until turbo value reach the set point. Then the molecular pump automatically started, the TSP LED light is off, the Turbo interface displays 0%, the percent sign flashes in the upper left of the display, when the Turbo reaches normal speed (default value > 80%), the percent sign stops flashing and remains stable, finally stabilized at 100%. Then switch to the vacuum interface to display the vacuum degree.

Shutdown

Switch the display to the Turbo interface, press "START/STOP" button, the screen displays "STOP" for 3 seconds. During this time, press "CONFIRM" button to stop the molecular pump, and the percent sign will flash until Turbo completely stop rotating, and the Turbo interface displays 0%.

For the pump station without Turbo set point, press the "STOP" confirmation button. After the molecular pump speed is 0%, close the vortex dry pump.

For the pump station with Turbo set point, press the "STOP" confirmation button, the backup pump and the molecular pump turn off at the same time, after the molecular pump speed is 0%, the pump station has stopped working.

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6.4 Compressor

According to the user area distribution, QEye system is optionally equipped with products of RDK-101D from Sumitomo Heavy Industries, Ltd. or KDC-1000A of CSIC Pride (Nanjing) Cryogenic Technology Co., Ltd. Two brands of compressors option have no impact on the performance of QEye system.

The instructions of compressor and the cold head of SUMITOMO and EASYCOOL can be downloaded at https://www.cnphotec.com/zlxz