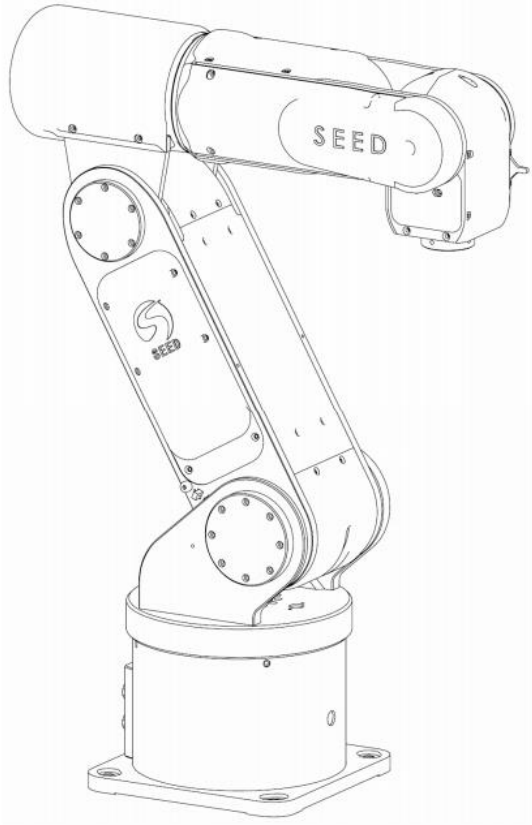
S6H4D-plus Robot Arm Operation Instructions

S6H4D-plus is a lightweight six-axis robot arm. The control system is embedded in the manipulator body, omits the external control cabinet, especially suitable for desktop operation, as well as mounted on AGV and humanoid robot.

Read this user manual before powering on the device.



Email: forrestxiao26@gmail.com,

Website: seedrobotarm.com

A. **Brief Introduction**

Robot arm, also called industrial robot, is "the pearl on the crown of manufacturing industry", integrating the latest technologies in machinery, electronics, software, control, communication, intelligence and other fields. Users need to have basic knowledge of robots to operate robots. This manual only introduces the use of seed intelligent robot arm.

The main function of the robot is to move to a series of positions as required and complete certain functions.The seed intelligent robot uses communication instruction or G code to control the movement of the robot. Electronic control claws, suction cups, or special tools can be installed at the end of the robot to achieve specific functions.In addition, we also designed a joystick teaching device for direct manual control by users

①. Using G code

G code is widely used in the field of CNC machining, and its main function is target location. For example, a G1 instruction contains X, Y, Z values, speed and other data.A series of G code positioning instructions form a motion path, and write the G code into a text file and store it in the SD card, and the robot reads the G code positioning instructions in the file in sequence when working to complete a series of continuous actions.

There are two ways to control the movement of the robot. One is only concerned with the positioning position of the end of the robot. At this time, as long as the coordinate value and positioning attitude of the end of the manipulator are given, the manipulator will automatically calculate the angles of each axis and automatically run linear interpolation to the positioning point.Second, only the Angle of each axis is concerned. At this time, only the target value of each axis Angle is input, and the robot arm automatically synchronously interpolates each axis to the target attitude according to the Angle value. In this case, the coordinate value of the target point is difficult for users to understand.Instructions G1, G222 and so on are used for positioning by target point, while G331 is used for interpolation by axis Angle.Users can choose which mode to use based on actual operation requirements.

②. Using communication instructions

Some users need to use the computer to send control instructions to make the robot move, so we provide serial communication interface and share communication protocol for free.We use C++Builder6 designed a general PC software, provide all source code to the user as a template, which can be quickly modified for the user PC software.The serial instruction has a fixed length of 48 bytes, which contains all the

control and motion functions of the manipulator.In the 48-byte serial communication instruction, some data is represented by a floating point number with 4 bytes, which needs to be realized by the data conversion function in the routine, please refer to the C source code.TTL serial port is standard, wireless serial port, Ethernet and WiFi communication are optional for payment

③. Use a teaching device

In some cases, people need to remotely control the Robot arm, then you can use the teaching device.The joystick control is intuitive and can be used flexibly without training.Wireless remote control is optional, we can provide technical solutions separately.The main function of the teaching device is to control the robot arm to the target point through the THREE-DIMENSIONAL rocker, and then click the touch screen to store the positioning data. It can quickly and accurately program and debug complex path planning without special training.

The robot also supports dragging and teaching, and you can directly push the robot to a series of points for recording.(There are video tutorials for reference)

The robot has programmable switch input and output interfaces, with 8 input ports and 8 output ports.If a user needs more ports, or needs an optically isolated I/O controller, it can be expanded upon

request.

Due to the continuous upgrading of the product, if the newly purchased robot arm functions are different from the manual, please contact our technical support for the latest technical information.

Model	S6H4D-plus
Number of axes	6，2 extra axes for optional
Radius (mm)	760
Range J 1	±150°
Range J 2	[-65°,110°]
Range J 3	±167°
Range J 4	[27°,188°]
Range J 5	±270°
Range J 6	[-34°,208°]
Load Capacity	3kg, ultimate load 4kg
Max Speed	Linear 1000mm/s J1&J2: 120°/s， J3&J4: 120°/s， J5&J6:240°/s
Repeatability	±0.05mm
Power	24VDC/12A，average working current 1.5A

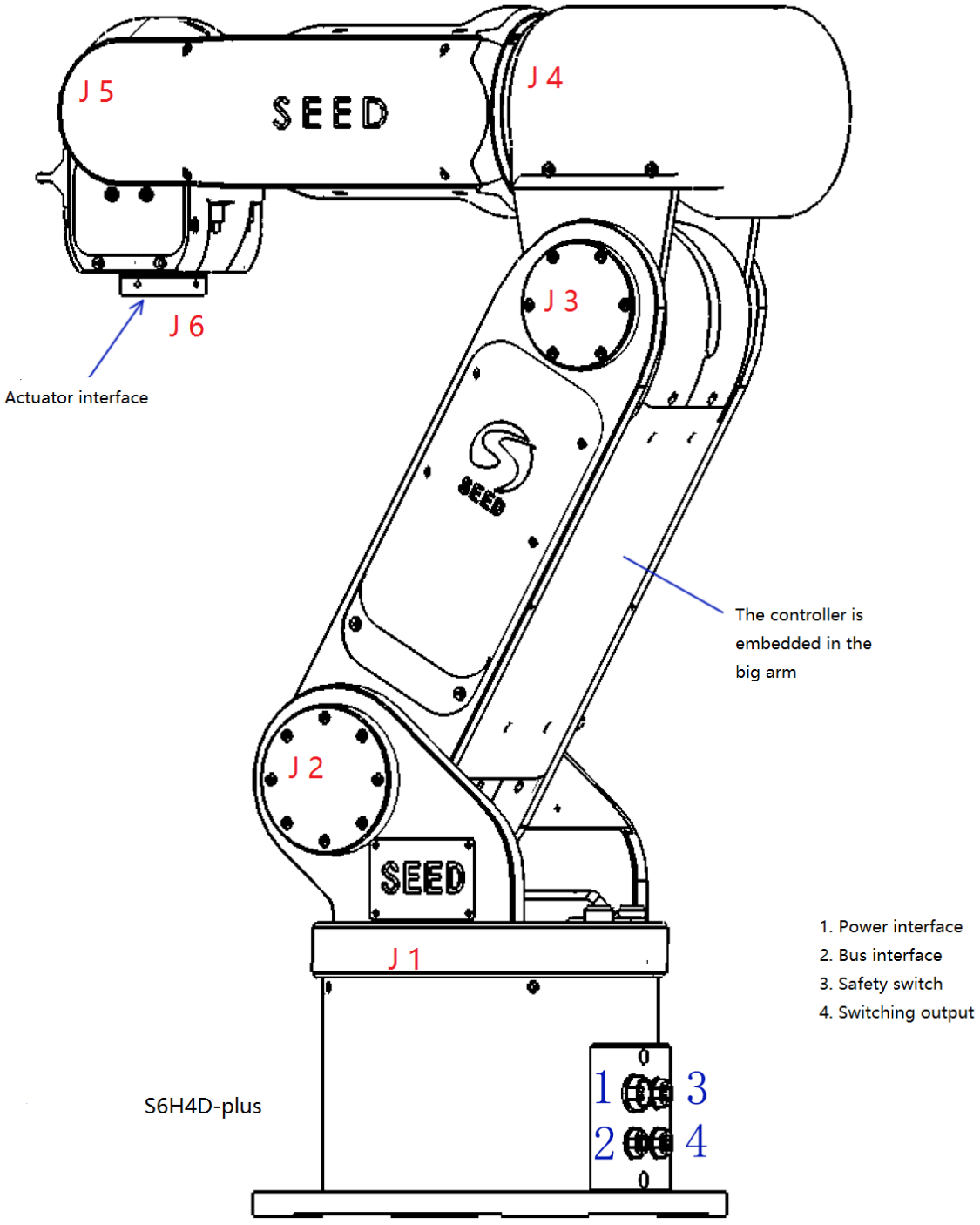
Total Weight (kg)	17
Body Material	Aluminum Alloy
Transmission Structure	J1 to J4 with harmonic reducer, J5 with timing belt and spiral bevel gear, J6 with straight gear transmission
Motor	DC servo motor
Control Interface	The standard configuration is a ttl serial port, and wireless serial port, Ethernet, and WiFi communication are optional.

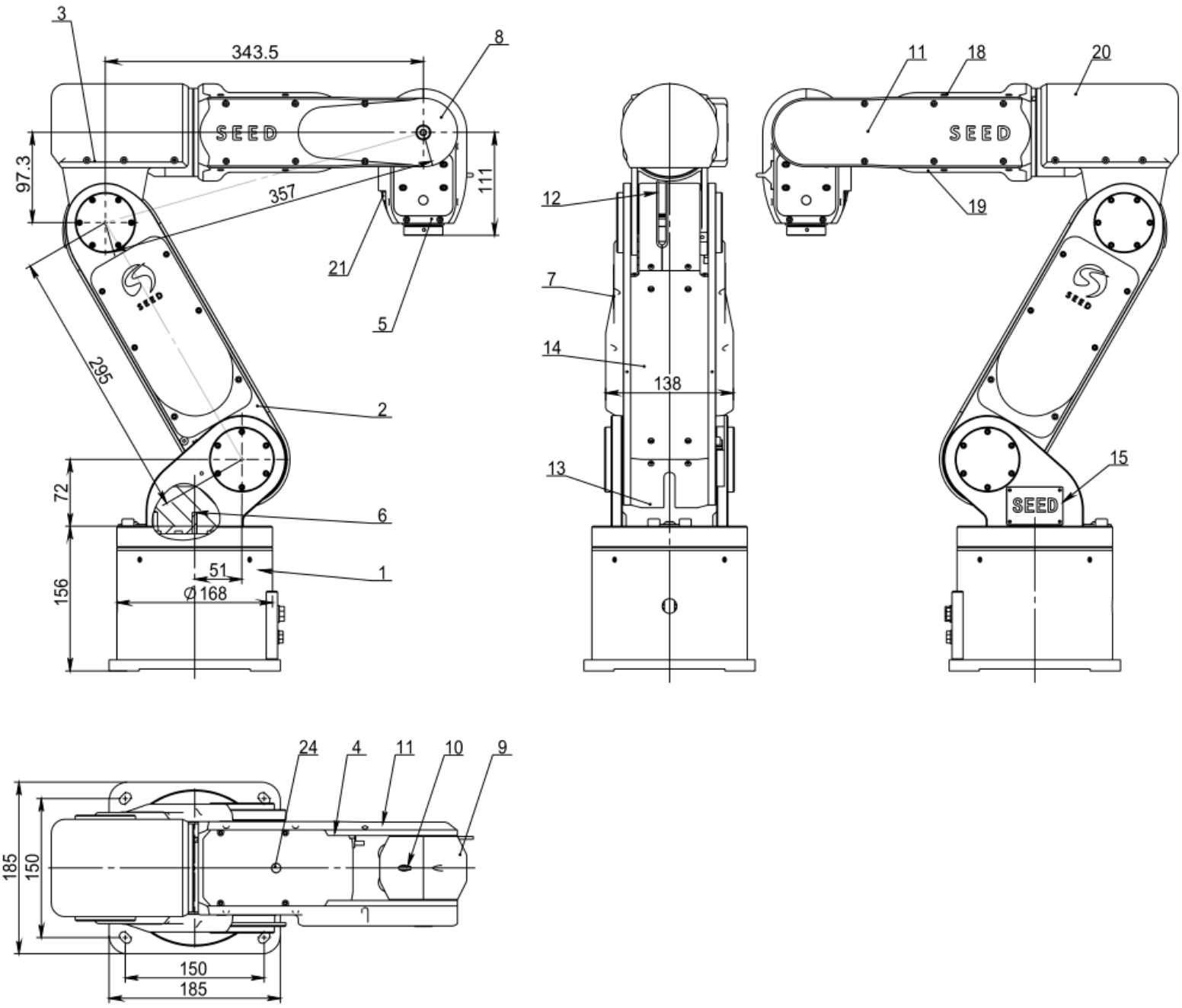
The Specifications of Reducer

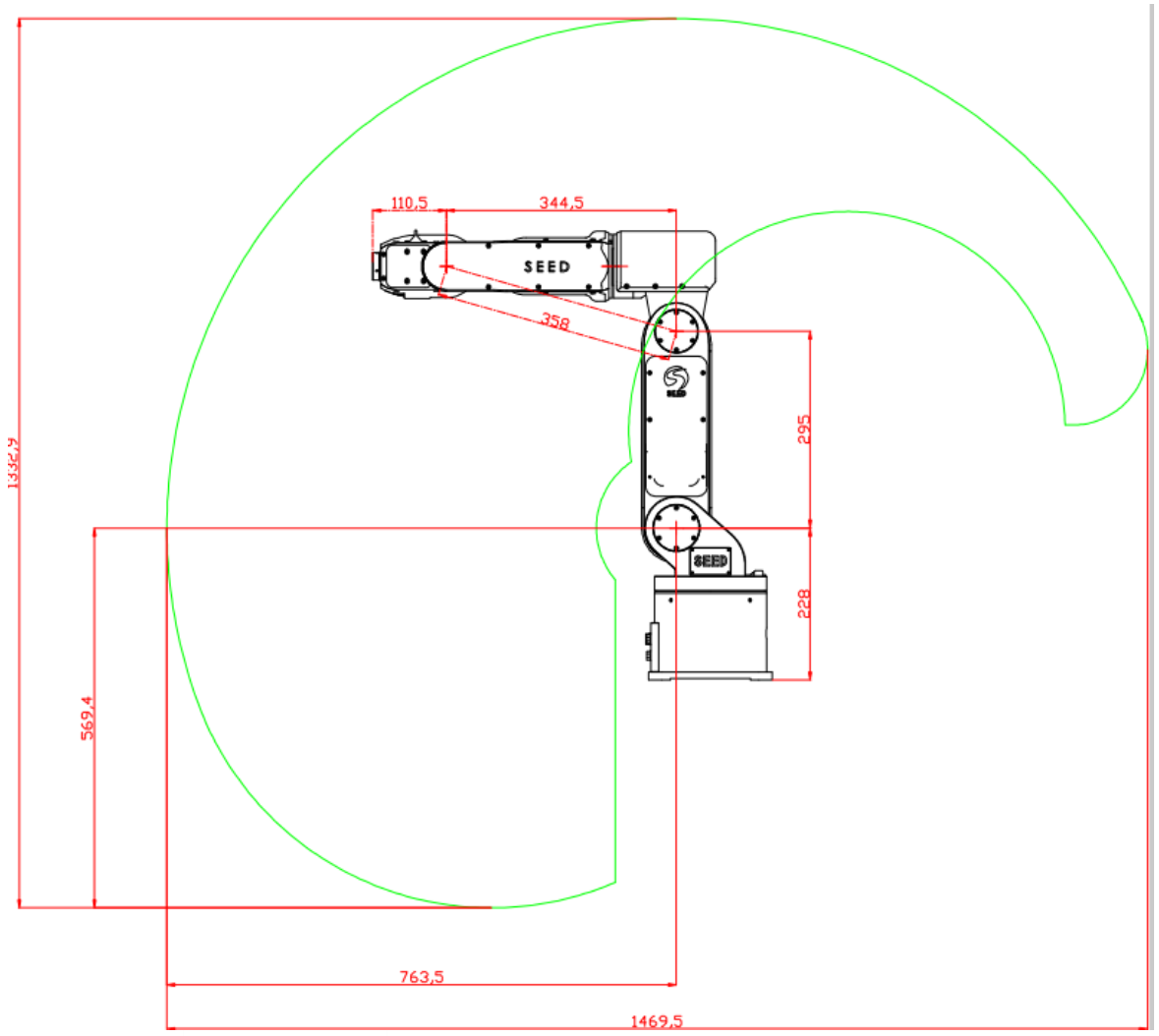
Name	Specification
J1	20-50 harmonic
J2	20-50 harmonic
J3	17-50 harmonic
J4	14-50 harmonic
J5	gear reduction，Reduction ratio :16
J6	gear reduction，Reduction ratio :12

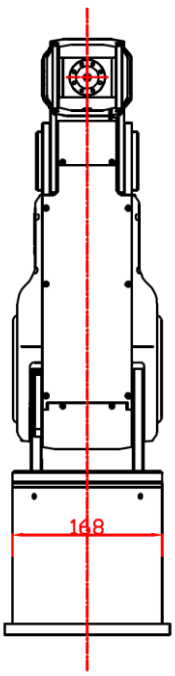
The Specifications of Motor

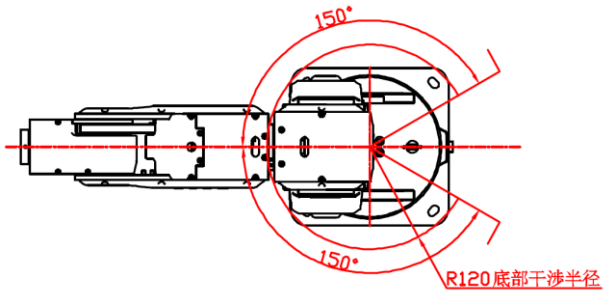
Name	Specification
J1	200W
J2	200W
J3	100W
J4	50W
J5	50W
J6	50W


J 5
SEED
J 4
J 3
J 6
Actuator interface
SEED
The controller is
embedded in the
big arm
J 2
SEED
J 1
1. Power interface
2. Bus interface
3. Safety switch
4. Switching output
S6H4D-plus
1
3
2
4


3
343.5
8
SEED
97.3
357
111
21
5
295
2
72
6
156
51
1
Ø168
12
7
14
138
13
11
18
20
SEED
19
SEED
15
SEED
24
4
11
10
9
185
150
150
185

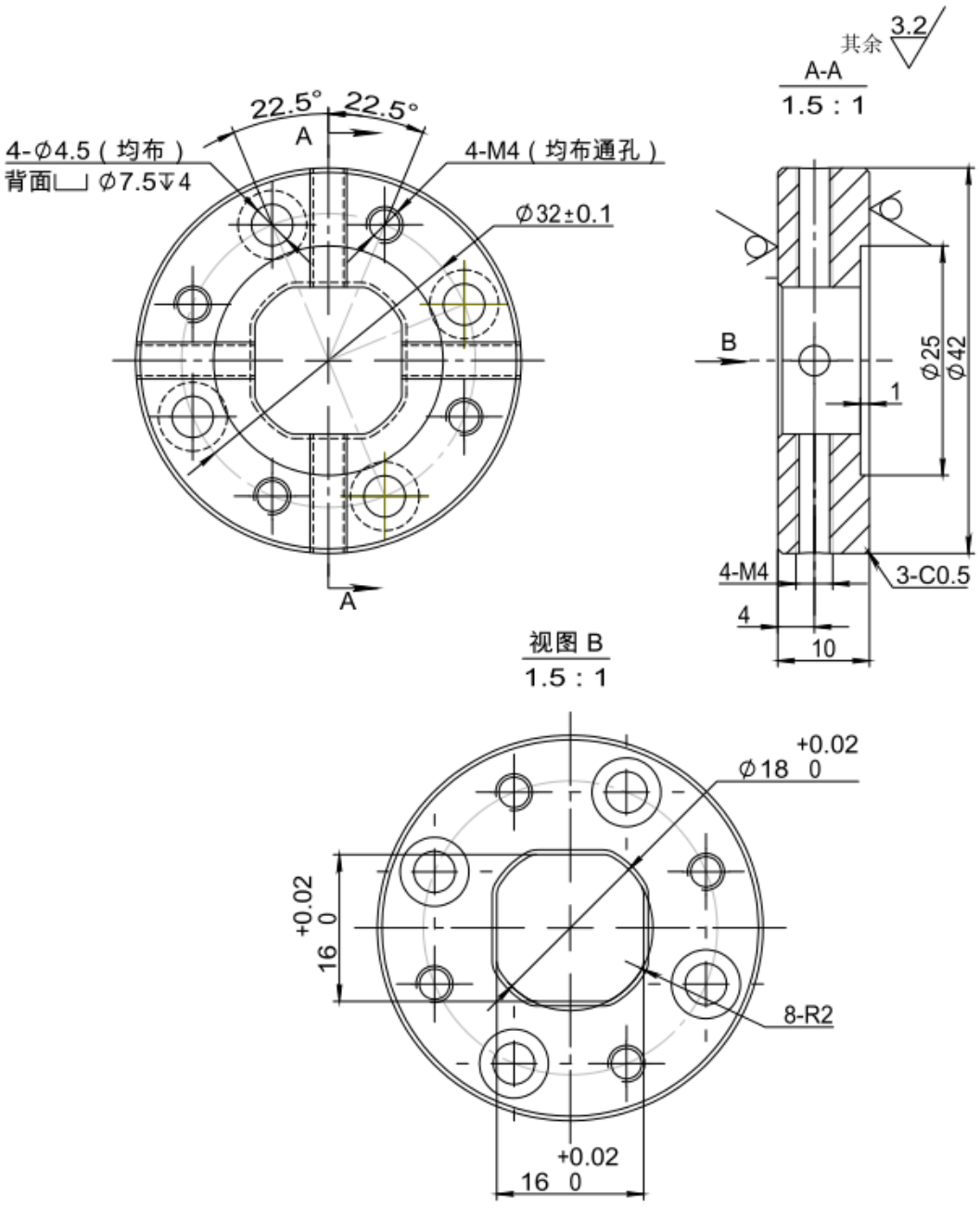

110,5
344,5
358
295
228
569,4
763,5
1469,5
SEED


168


150°
150°
R120底部干涉半径

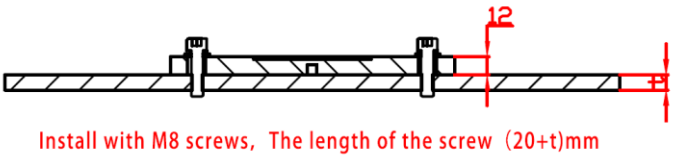
Flange Diagram:

.

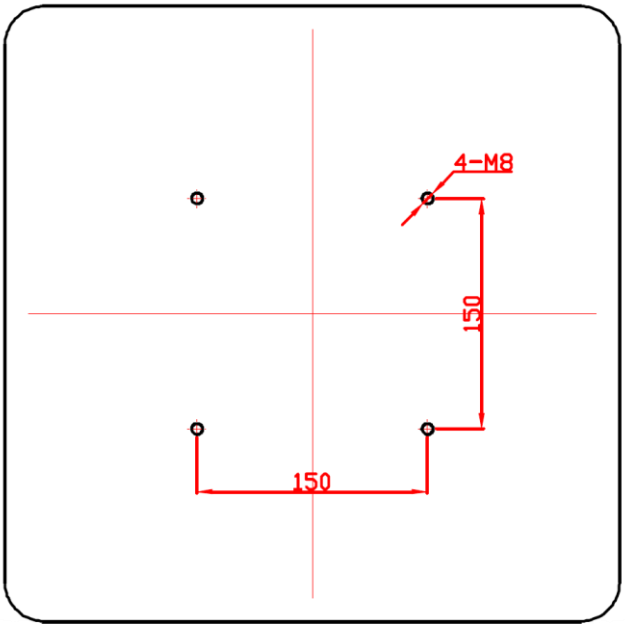


Robot arm installation: please install it on a firm workbench reliably

M8 screws are used for installation. The screw length is 20+mm



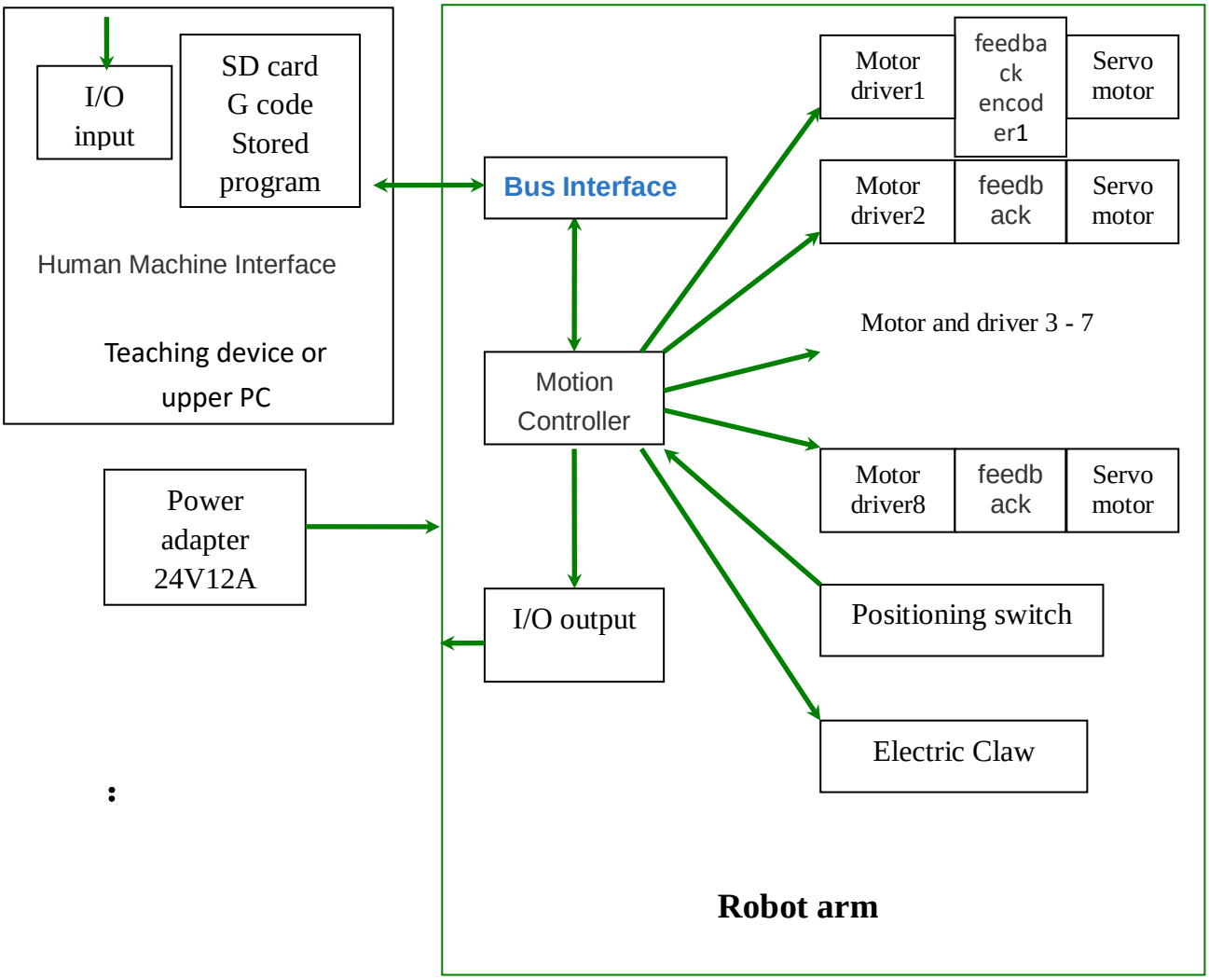
installation (1) Table punching diagram



Mounting table perforating diagram

*Teaching device

B. Internal control structure



:

Main Control Function

7 "touch screen, joystick control, offline programming, teaching programming , path planning using G code;Linear interpolation, circular interpolation, acceleration and deceleration interpolation, multi-axis synchronous rotation interpolation, table coordinate setting;Internal CAN bus, external serial communication or Ethernet CAN be connected to the upper computer control.The teaching device can be remotely

controlled wirelessly or via Ethernet.With extensible switching input and output signals.The opening and closing volume and speed of the claw can be flexibly controlled by the signal, and different end tools such as suction cups can also be used.The wrist can be lengthened but the load capacity is reduced accordingly.Automatic calibration after power-on.

TTL serial port communication is standard. Ethernet, WiFi or wireless serial port communication is optional by payment.

C. Power on, start, reset and calibrate

①. The robot arm is powered by 24V safe voltage, and we provide a dedicated power adapter(110v-220v AC to 24V DC). Additional 24V lithium battery power supply is optional.

The robot arm uses batteries to maintain location memory. The internal battery provides seven days of data retention , automatic charging when switching on power. In the state that the battery does not lose power, users are required to check if any axis over limit before starting operation normally, if there is axle over limit, turn off the power firstly and Push the wrong position axis to the normal place and then power it on.If the memory battery loses power, the robot arm will not move after startup, so it needs to be adjusted

.The robot can be automatically calibrated by one key through the

calibration switch or the calibration button of the teaching device

The calibration button is on the parameter setting page of the teaching pendant

After starting automatic calibration, each axis rotates in a predetermined direction, and each axis stops after reaching the corresponding positioning switch.

The robot rotates to a fixed starting attitude after the axes are all at the anchor point. The positioning switch is a photoelectric switch.

Avoid direct sunlight during the process. Ordinary light has little influence on the photoelectric switch, but also avoid direct strong light.

During automatic calibration, the robot should be fixed in a relatively spacious space to avoid bumping into obstacles during calibration.

When the shaft is in the out-of-limit state, the robot will not perform

calibration. At this time, it is necessary to power off first and push the out-of-limit shaft to the normal state manually.

After the reset or calibration is completed, the robot enters the waiting motion instruction state. If the motion Command of the upper computer is received, the robot arm immediately calculates and starts interpolation movement from the current position to the target point. Without the motion command, the robot remains in its current attitude. At the same time, the robot sends real-time information including positioning coordinates and axis angles state information to the upper computer

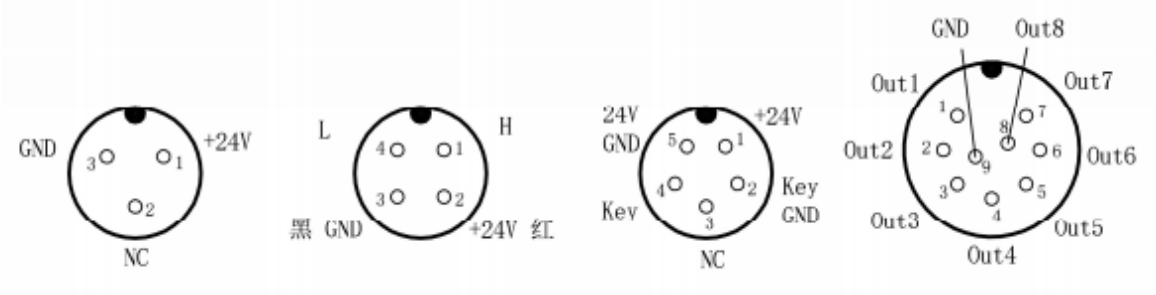
Do not power off the robot immediately after it is powered on. After the robot arm is powered on, it takes 5 to 6 seconds to start the software and detect the hardware components. Do not power off during the power-on process for a few seconds, otherwise the internal data will be easily damaged.

D. Wiring instructions

Teach pendant and the wire connect with robot

24DC power adapter(110v-220v AC to 24V DC)

Four aero sockets for the robot arm



24V DC, Teach pendant or PC, safety switch , output signer

The teaching interface is connected to the teaching device or the upper computer. Power socket Connects to the power adapter we provide.

Safety switch interface uses short circuit interface plug, users can also lead out wiring external switch. Safety switch ④ to GND

②When short-circuited, the manipulator can move normally. If the safety switch Key ④ is on Key_GND② open, the robot stops immediately, wait for the signal to the ground short circuit after continuing to move

The output control signal interface is a programmable switching output. Signal high level 3.3V, low level less than 0.4V,

Push-pull output, high level and low current should be less than 10mA.The output is programmatically controlled using M code, for example:

M0 represents Out1 output low level, M1 represents Out1 output high level;

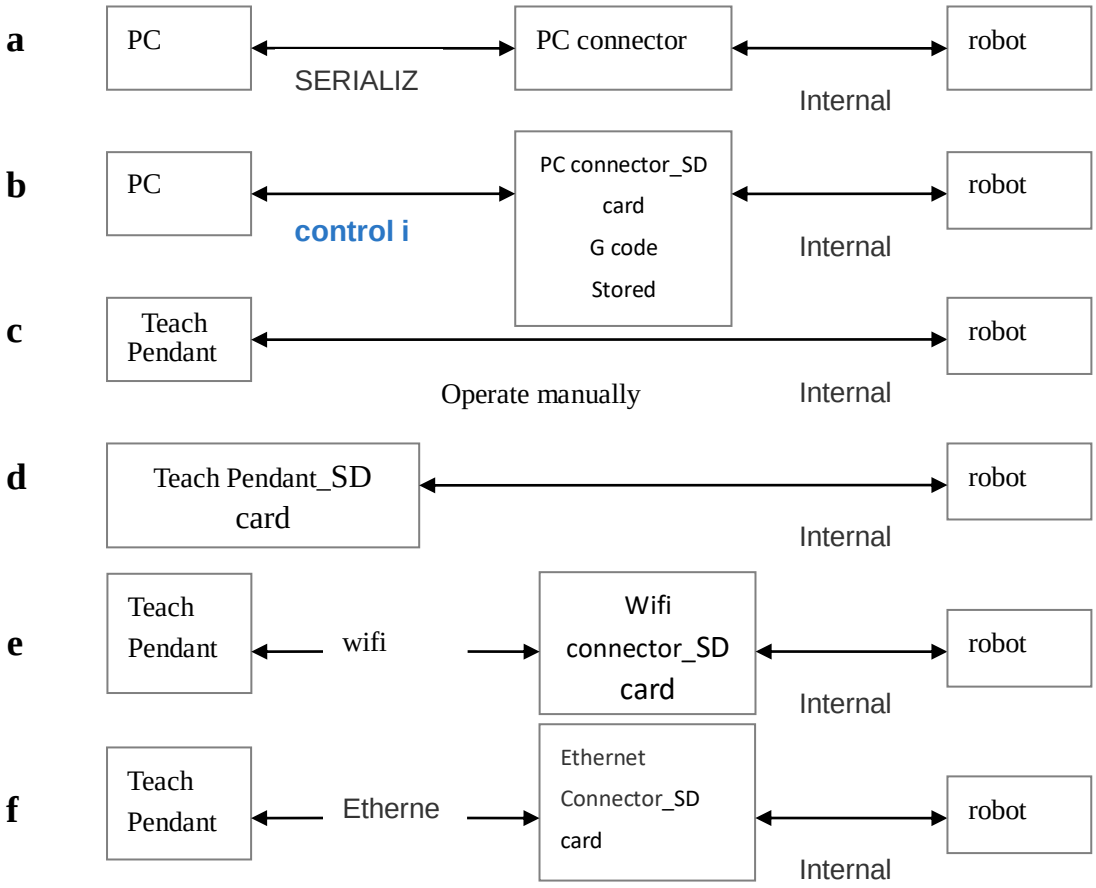
M2 represents Out2 output low level, M3 represents Out2 output high level;

Each M instruction should have a single line ending with the enter key.

The robot is reserved with an electronic control gripper interface, which can be connected with the steering gear driven gripper as the executive mechanism. Electric control Claw as optional accessories

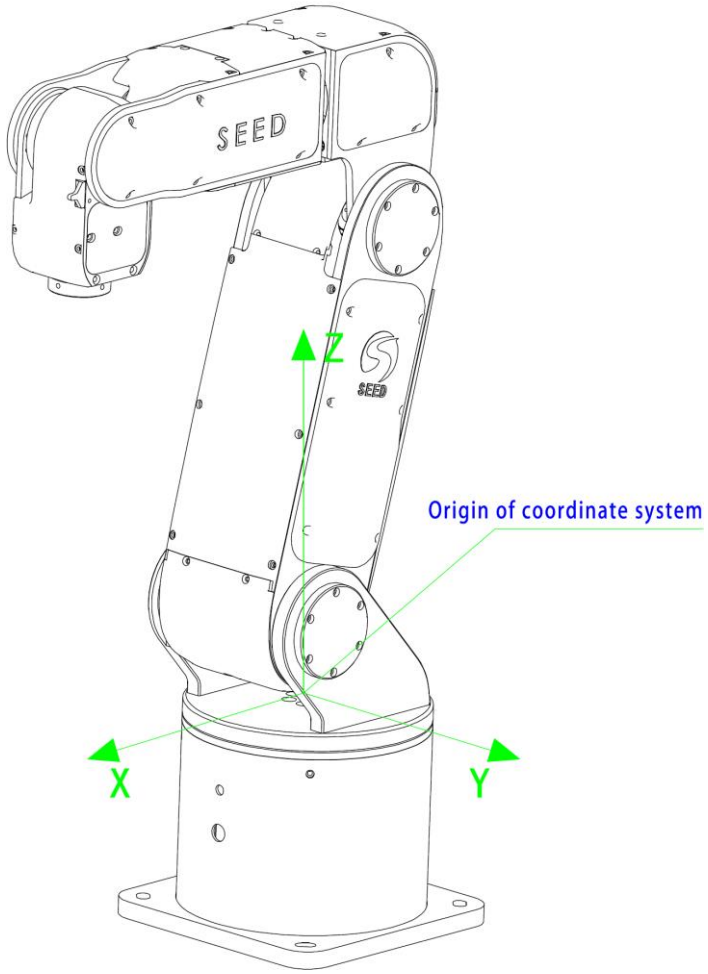
E. **Mode of operation**

The upper computer or teaching device sends motion signals to the robot in the following ways：



The rocker of the teaching device and the program running of the teaching device cannot control the movement of the robot at the same time. It is switched by the switch on the teaching device.The upper computer and the teaching device cannot be connected to the robot at the same time.

F. The Robot coordinate and table coordinate



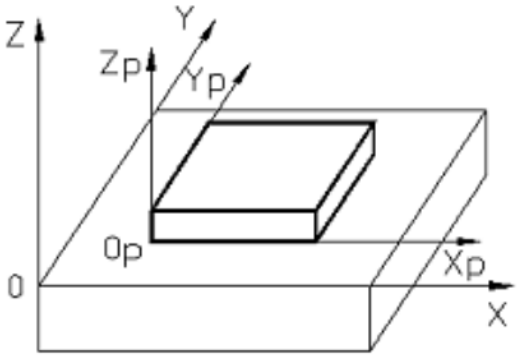


Table coordinate

The table coordinates can be set using the G54 command.For example,

G54 x122.0Y-20.5Z180.0 is represented by the robot coordinates X122, Y-20.5, Z180 as the origin of the table coordinates, the coordinate values after this instruction are calculate with the origin of table coordinates.You can shift the table coordinates to a new position at any time with the G54 command

G. Supported G code

G code extends instructions		
G code	Function Definition	Instruction
G0	quick positioning	Basic G code
G1	Processing positioning	
G4	pause	
G50	cancel scale scaling	
G51	scale scaling setting	
G54	workbench coordinate system setting	
G100	G code file end instruction	Extends G code
G220	single acceleration or single deceleration linear movement, +Q acceleration, -Q deceleration	
G222	accelerate and then decelerate in a straight line, take a positive value of Q only	
G230	accelerate from the initial velocity to the target velocity, Q just needs to be positive	
G300 、G301	3Dcircular interpolation, G300intermediate point ， G301end point	
G302 、G303	Continuous 3D circular interpolation	
G330	Axis Angle interpolation motion instruction, 6 axis Angle synchronization	
G336	Uniaxial motion command, uniaxial increment control	
G361-G36	Additional PWM signal output ，	

3	according to PWM1,2,3	

G code extends instruction parameters			
Code	parameter definition	unit	instruction
G	G code		
A，B，C	attitude angle b0，b1，aw, angle	degree	
S	speed of mainshaft		Not to use
M	M code		I/O signal
X，Y，Z	coordinate positioning	mm	
R	circular arc radius	mm	
P	Pause time, or zoom scale	Ms、scale	
D	The initial speed of acceleration and deceleration	mm/min	Replace PWM
E	Speed G0	mm/min	
F	Speed G1, G220,G222,G230	mm/min	
Q	Acceleration value of acceleration and deceleration command	Mm2/s	-3200～+3200
U，V，W	Set motion controller parameters		internal use only
T	Electric Claw PWM	PWM value	Steering gear control signal
I，J	External axis angle E0，E1	degree	
a,b,c,d,e,f	Six axis angles of multi-axis motion	degree	
h	Incremental Angle of uniaxial motion	degree	
i	The speed of the rotating shaft	degree/s	
j	Axis number of a single axis motion	integer 0-7	0 represents axis a0
q	Acceleration and deceleration control of rotating shaft motion	integer 0-6	0 No

			acceleration and deceleration

M Code Definition		
code	function	instruction
M101	Input, wait signal 1, active low	Custom M code, If the input signal is valid, continue the program action，Wait if Invalid, High 3.3V Low 0V, High or low pulse width≧50 ms
M102	Input, wait signal 2, active low	
M103	Input, wait signal 3, active low	
M104	Input, wait signal 4, active low	
M105	Input, wait signal 5, active low	
M106	Input, wait signal 6, active low	
M107	Input, wait signal 7, active low	
M108	Input, wait signal 8, active low	
M201	Input, wait signal 1, active high	
M202	Input, wait signal 2, active high	
M203	Input, wait signal 3, active high	
M204	Input, wait signal 4, active high	
M205	Input, wait signal 5, active high	
M206	Input, wait signal 6, active high	
M207	Input, wait signal 7, active high	
M208	Input, wait signal 8, active high	
M0	output 1_Low low	Custom M code, Output switching signal,
M1	output 1_High	
M2	output 2_ Low	
M3	output 2_ High	
M4	output 3_ Low	
M5	output 3_ High	
M6	output 4_ Low	
M7	output 4_ High	

M8	output 5_ Low	Push-pull output, high3.3V Low 0V
M9	output 5_ High	
M10	output 6_ Low	
M11	output 6_ High	
M12	output 7_ Low	
M13	output 7_ High	
M14	output 8_ Low	
M15	output 8_ High	

* Acceleration and deceleration interpolation instruction without PWM data, can not control the CHANGE of PWM output value.

G code Examples：

G code is stored in SD card in text format to record coordinate point position, attitude Angle, delay and other motion instructions

.G code has a fixed format and instruction letters are case sensitive. A G-code instruction ends with the enter key.

Note that the last line of the G code program file must end with the enter key, otherwise the end instruction will not be executed

G1 X0 Y-50 Z0.0 A0.0 B0 C0 F9000 T1800

This is a complete G code instruction, which means to move the robot from the current position to the specified XYZ position, the moving speed is 9000mm/ min, T1800 represents the output PWM cycle value, used to control the steering gear claw.

G222 X0 Y-50 Z0.0 A0.0 B0 C0 F9000 Q200

G222 indicates both of the start and stop with acceleration and deceleration, and the acceleration value is 200 mm/s squared

G4 P500 indicates pauses for 500 milliseconds and then continues。

G51 P0.75 means that all coordinate values after this sentence are scaled in proportion to the value after P. After the part that needs to be scaled, it must be marked with G50 instruction to restore the normal proportion (1:1), otherwise it is easy to locate errors.G50 has no parameters behind it, so enter exclusively on the line.

①. Linear interpolation instruction

G1： uniform m motion

G1 X134.7 Y382.7 Z9.0 A0.0 B0.0 C0.0 F4800 T1500

F：Terminal linear velocity of robot， mm/min

G220: Single acceleration or single deceleration in a straight line

+Q Acceleration, -Q deceleration

G220 X312.9 Y28.5 Z28.3 A0.00 B0.69 C901 F9000.0 Q-200

Q: Acceleration value of acceleration and deceleration command,mm^2/s, -3200～+3200 , F means the maximum speed in the command of G220andG222.

G222: linear motion of first acceleration and then deceleration, initial speed and final speed are 0, Q only needs to take positive value

G222 X134.7 Y382.7 Z9.0 A0.0 B0.0 C0.0 Q120.0 F4800

G230: Accelerate from initial speed to target speed, Q only needs to

take positive value (automatic positive and negative value)

G220 X333.8 Y-73.5 Z260.9 A-0.01 B8.68 C0.17 F9000.0 Q1200 T1500

G230 X333.8 Y69.9 Z260.9 A-0.01 B8.68 C0.17 D9000.0 F18000 Q2000 T1500

G220 X333.8 Y141.8 Z260.9 A-0.01 B8.74 C0.17 F18000.0 Q-2000 T1500

D: Initial speed of acceleration and deceleration, mm/min

F: final velocity in G230

②.Axis Angle interpolation instruction

G330：

G330 a35.4 b-6.1 c66.8 d-46.28 e34.73 f0.02 i36.0 q1 T1800

G330 a-10.3 b-16.4 c71.2 d34.84 e34.73 f0.02 i36.0 q2 T1800

I: Rotation speed of the shaft, degree /s

Q: acceleration and deceleration control of the rotating shaft movement, an integer from 0 to 6, 0 indicates no acceleration and deceleration.

G336：

G336 j1 h-30 i36 q3

G336 j2 h18 i30 q3

J: Axis number of uniaxial motion, an integer from 0 to 7, 0 represents a0 axis.

③Circular interpolation instruction

G300: Intermediate point

G301: The end point

G0 X50 Y0 Z0 E1800 A0.0 B0.0 C0.0 I0 J0

G300 X100 Y0 Z0 R50 F1200

G301 X100 Y50 Z0 F9000

R: Radius of arc, mm

I, J: external axis E0, E1 Angle

G302: The middle point of each arc interpolation

G303: End point of each arc interpolation

G220 X319.0 Y0.0 Z399.9 A0.00 B45.00 C-0.01 F12000.0 Q900 T1500

G302 X242.0 Y-170.8 Z304.3 A0.00 B45.19 C-0.01 R36 F12000.0 T1500

G303 X303.1 Y-49.0 Z420.0 A0.00 B46.87 C-0.01 F18000.0 T1500

G302 X303.1 Y-49.0 Z420.0 A0.00 B46.87 C-0.01 R36 F18000.0 T1500

G303 X188.5 Y246.8 Z312.9 A0.00 B43.93 C-0.01 F18000.0 T1500

G302 X188.5 Y246.8 Z312.9 A0.00 B43.93 C-0.01 R36 F18000.0 T1500

G303 X380.0 Y0.0 Z399.9 A0.00 B45.00 C-0.01 F12000.0 T1500

G220 X380.0 Y0.0 Z399.9 A0.00 B45.00 C-0.01 F12000.0 Q-1200 T1500

④Miscellaneous Instructions

G4：suspend

G4 P128

P: Indicates the pause time in the pause instruction, milliseconds

G54: Workbench coordinate system setting

G54 X350.0 Y-50.0 Z180.0

Means taking the follow coordinates (350.0,-50.0,180.0) as (0,0,0),after that, sending commands G1 X0.0 Y0.0 Z0.0 A0.0 B0.0 C0.0 F4800, The end of the arm will be positioned at(350.0,-50.0,180.0)

G51: Setting

G50: cancel the proportion setting, in the use of G51 program must be after the proportion adjustment is completed with G50 cancel setting fixed, otherwise it is easy to cause motion positioning error, or resulted in collision.

G51 P0.5

G50

P: Indicates the scaling factor in the scaling instruction

G361：

G361 X134.7 Y382.7 Z9.0 A0.0 B0.0 C0.0 F4800 T1200

This instruction is the same as G1 except for the G code label, indicating the opening and closing of no. 2 electric control claw.

G362：

G363：

G100: A G code file end flag

G100 P2

P: This indicates the pause time after program execution is complete, in milliseconds

After the robot arm runs to this end mark, it will send a task completion

signal to the upper computer, which contains

Task number (file number) and number of cycles, instruction format:

0xce,0,0,0,0,loop_nb,job_nb,105,0 XCF.

The upper computer can judge the completion of the file according to this return instruction. The last line of each G code file must be The above instruction.

⑤. M code

M0: Line 1 outputs low level

M1: Line 1 outputs high level

M2: Line 2 outputs low level

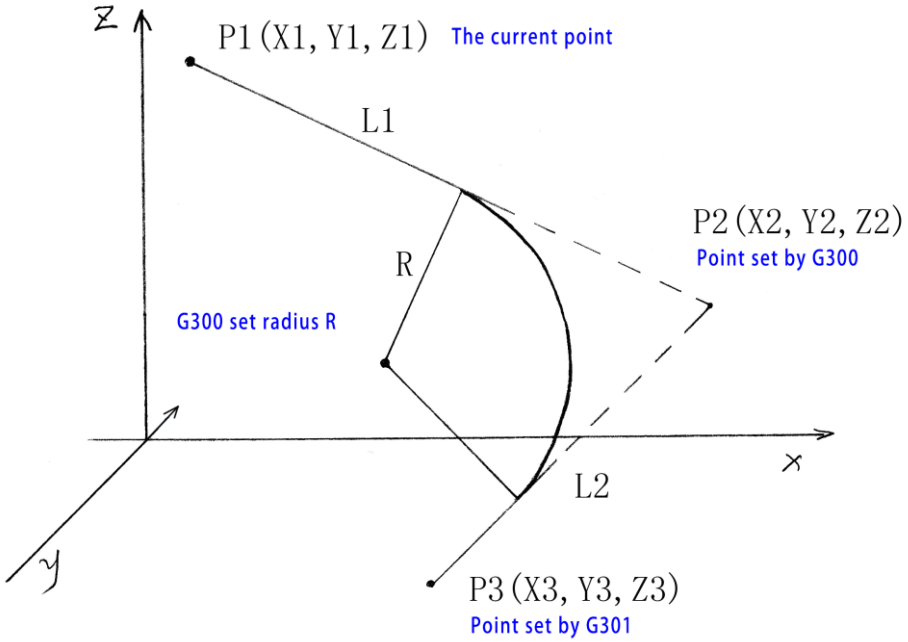
M3: Line 3 outputs high level

M201: Wait for signal 1, and the high level is effective. the robot arm always detects the input signal line 1while in low level, and pauses Motion, continue to run G code program after the signal becomes high level

H. 3D arc interpolation and path optimization

This is the expanded G code, replacing G2 and G3 with enhanced features. Take the current point as the initial point, G300 defines Interpoint and radius of arc, G301 defines end point, G300 must be followed by G301, used in pairs. In the G300, F of the surface is set to the initial speed, F of G301 is set to the final speed, and the circular

interpolation process automatically transitions the speed evenly. The dynamic path is shown below:



G code routines:

3D circular interpolation routine:

G222 X-80 Y-160 Z0.0 F9000 Q80

G222 X-80 Y-160 Z30 F6000 Q80.0

G300 X-80 Y-160 Z90 R58 F6000

G301 X50 Y50 Z90 A0.0 B0.0 C0.0 F12000

G300 X180 Y260 Z90 R58 F12000

G301 X180 Y260 Z30 F6000

G222 X180 Y260 Z0.0 F6000 Q-80.0

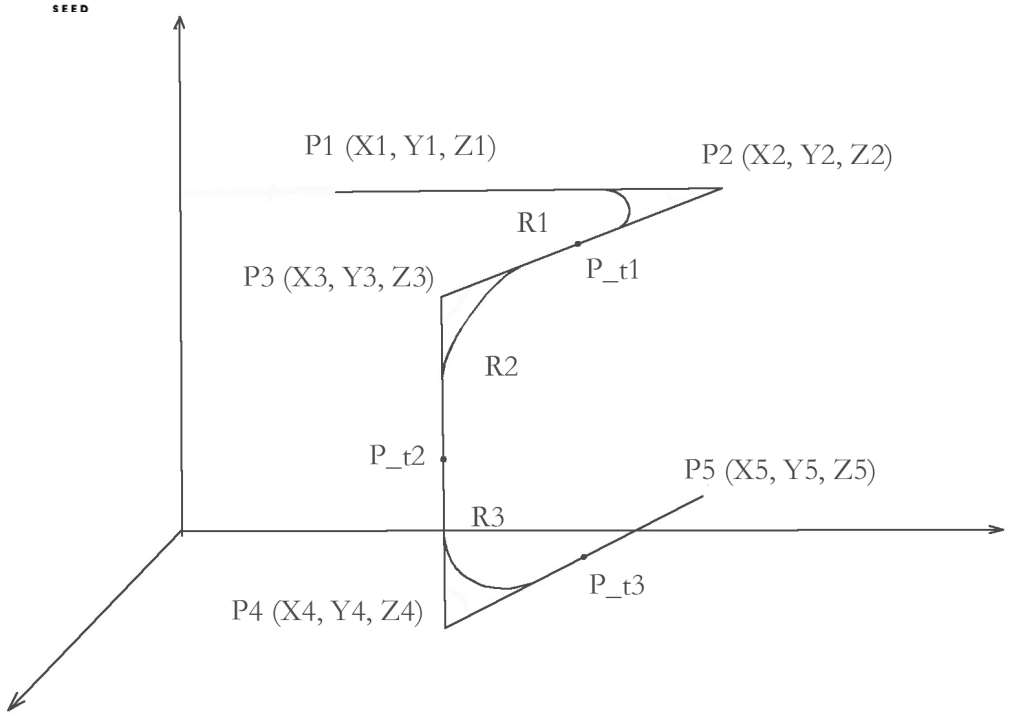
G300 sets the initial speed and arc radius R, and G301 sets the final

speed and attitude Angle (A, B, C).random

The SD card(inside with the carton package) has a variety of complete G code path procedures, provided to the user as a programming reference.

Circular interpolation of continuous turns If there are two or more consecutive arc interpolation, G302 and G303 instructions can be used to facilitate the trajectory Optimization.G302 sets the coordinates of the intermediate point, the initial velocity and the radius of the arc R, and G303 sets the coordinates of the end point and the final velocity and attitude Angle. With G300, G301 instructions almost exactly the same application, the difference is the end of each step of arc interpolation the point P(Xt, Yt, Zt) is located at the midpoint of P2 and P3, but not P3.So at the end of the last turn after continuous arc interpolation, a G1 or G220 or G230 command is needed to make the robot reach the target site.

For example, the trajectory from P1 to P5 is shown below：



g code programme：

G302 Xx2 Yy2 Zz2 RR1 F6000 G303 Xx3 Yy3 Zz3 A0.0 B0.0 C0.0 F12000	In the first arc interpolation, P_t1 is the temporary termination point
G302 Xx3 Yy3 Zz3 RR2 F6000 G303 Xx4 Yy4 Zz4 A0.0 B0.0 C0.0 F12000	In the second arc interpolation, P_t2 is the temporary terminating point
G302 Xx4 Yy4 Zz4 RR3 F6000 G303 Xx5 Yy5 Zz5 A0.0 B0.0 C0.0 F12000	The third arc interpolation, P_t3, is the end point
G220 Xx5 Yy5 Zz5 F6000 Q-1200	Add a location

	instruction， Move from P t3 to target anchor point
1、In the user's G code, the orange symbols are replaced with specific data. 2、P_t1 is automatically generated at the midpoint of P2 and P3, as are P_t2 and P_t3.	

Optimize motion performance and reduce vibration of robot

If the motion path is not optimized when the mechanical arm runs at a fast speed, it is easy to produce vibration, especially when it is close to the mechanical resonance point, such as start-stop, turning and so on. Path optimization can avoid vibration. Path optimization methods:

①.Acceleration and deceleration are used when the start, stop and speed change sharply;

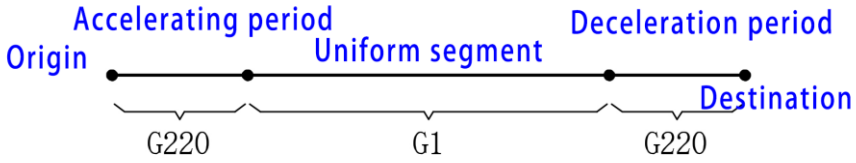
②.Circular interpolation is used when the moving path has sharp angles;

③.Adjust the speed appropriately to avoid the mechanical resonance point.

④.In some cases, such as large attitude Angle changes, axial Angle interpolation should be used.

Acceleration and deceleration interpolation controls the process of velocity change at the end of the robot to make the motion speed soft. The G220 instruction accelerates the terminal speed uniformly from 0 to the specified target speed according to the specified acceleration value, or slows down to 0 from a certain initial speed. F specifies the initial or final speed. Q is accelerated when it is greater than 0 and decelerated when it is less than 0.Refer to the G code extension instruction parameter table to analyze the path instruction below:

```
G220 X150 Y-200 Z30 F18000 Q200.0
G1 X150 Y200 Z30 F18000
G220 X150 Y250 Z30 F18000 Q-200.0
```

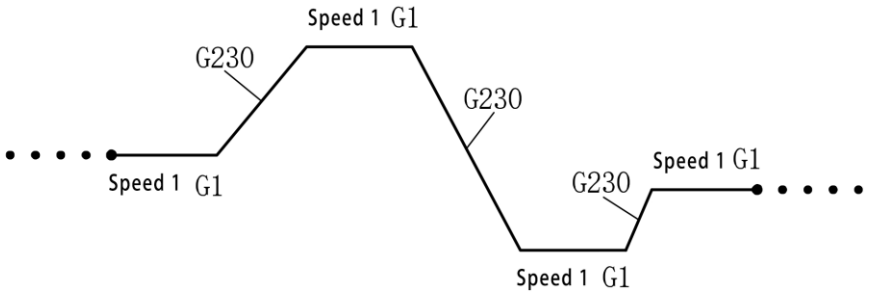


The G222 instruction accelerates the terminal speed from 0 to the specified maximum speed, and then slows to 0 as it approaches the target point, with a Q value that does not differentiate between positive and negative.G222 will cause mechanical resonance at some time. If there is obvious vibration when executing this command, G220 plus G1 command can be used instead.

The G230 instruction increases/slows the terminal speed from the current value to the target speed. It is convenient to use G230 instruction when the speed changes a lot in the process of movement. D specifies the initial velocity, F specifies the final velocity, and Q does

not distinguish between positive and negative values. Acceleration and deceleration instructions can not control PWM value output, if you need to control PWM electric control claw, can add another G1 instruction.

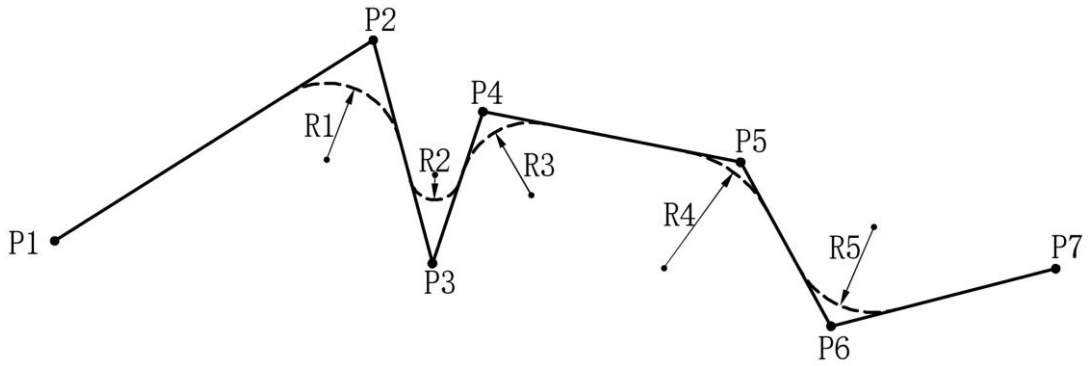
```
G220 X150 Y-200 Z30 F6000 Q200
G230 X150 Y-150 Z30 D6000 F18000 Q200.0
G1 X150 Y-100 Z30 F18000
G230 X150 Y-50 Z30 D18000 F36000 Q600.0
G1 X150 Y50 Z30 F36000
G230 X150 Y100 Z30 D36000 F18000 Q-200.0
G1 X150 Y150 Z30 F18000
G230 X150 Y200 Z30 D18000 F6000 Q-200.0
G220 X150 Y250 Z30 F6000 Q-200
```



Circular interpolation is used when the direction of the end motion changes suddenly.Acceleration and deceleration can also be controlled by starting and ending velocities of circular interpolation.

```
G300 X100 Y0 Z0 R80 F1200
G301 X100 Y100 Z0 F12000
G300 X100 Y200 Z0 R80 F12000
G301 X0 Y200 Z0 F1200
```

The dotted line shown in the following figure is the trajectory after arc interpolation. The deviation from the original trajectory can be controlled by appropriately selecting the radius value of arc interpolation.



Axial Angle interpolation is suitable for the mechanical arm moving in a wide range and at high speed, and the end posture changes greatly. It should be noted that the end posture does not remain fixed in the process of axial Angle interpolation, but will change greatly.

G331 a-5.3 b21.5 c42.0 d-57.55 e155.07 f0.21 i60.0 T1500

The general motion path programming process is to record the complete and accurate path planning points by teaching method first, test the correctness of the running path, and then modify the G code path file by using the text editor of the computer, and adjust the motion track and speed by using the above optimization method to make the motion fast and smooth.

I. **Instruction of Teach pendant**

1.Speed control button, the joystick controls slow movement when normal, and the joystick controls fast movement when pressed

2. Pause/cancel pause

3. Joystick allow/forbid switch, upward -- allow joystick operation, SD card stored program prohibit operation; Down --disable rocker, can run SD card program.

4. Linear motion/axis motion selection switch, up-- axis motion, down-- linear motion.

5. Educator reset button that resets the educator when the user wants to stop a path planner running.

6. Claw opening and closing

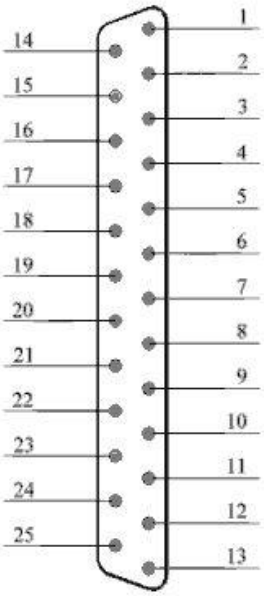
7. Motion control joystick

8. SD card slot for reading motion track program

9. DB25 extended interface.

10. Interface of teaching device and robot

Large rocker and small rocker are linear control devices of internal potentiometer structure, the larger the shaking Angle, the faster the motion



Teach pendant DB2 interface			
1	+3.3V	14	Din_4 *
2		15	Din_5 *
3	pause/resume *	16	Din_6 *
4	Teach pendant reset*	17	Din_7 *
5	N/A	18	Din_8 *
6	Controller reset	19	+5V
7	N/A	20	N/A
8		21	
9		22	
10		23	
11	Din_1 *	24	GND
12	Din_2 *	25	
13	Din_3 *		

*Switching input signal, effective against ground short circuit

Din_1 to Din_8 are 8-channel switch input terminals, corresponding to M codes: M01-M08, M201-M208.

This group of input terminals on the teaching device is used for programming and debugging, without photoelectric isolation, because

users actually use very little, does not have a standard user interface. If the robot arm needs switching input signal in actual operation, please contact our company to purchase photoelectric isolation operation controller, its main function is to enable the manipulator to run offline, o receiving communication instructions from the upper computer to run.

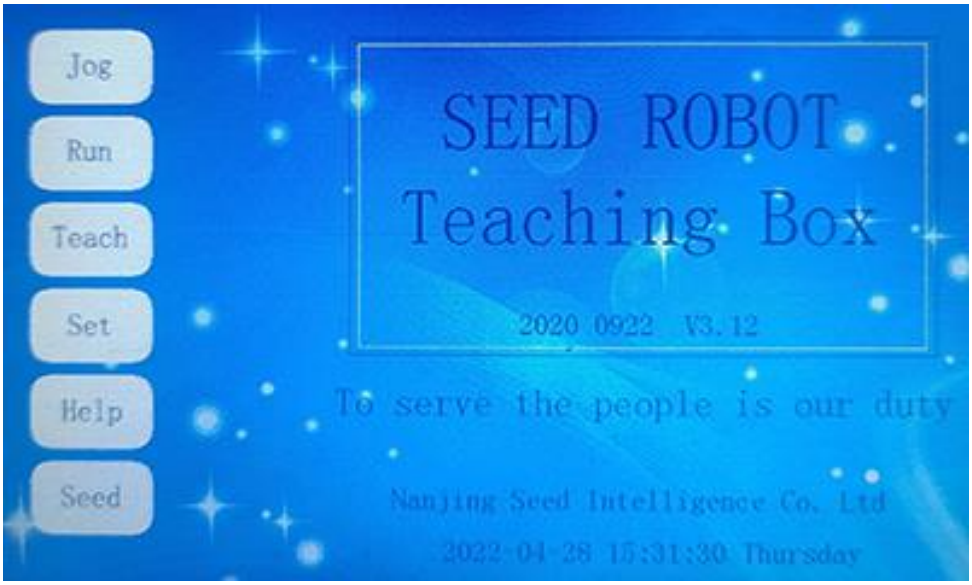
The rocker control direction of the teaching device is consistent with the movement direction of the robot. When holding the teaching device facing the front of the robot arm. The shaking direction is consistent with the movement direction of the robot arm, and the operation in the positive direction is intuitive and not easy to make mistakes.

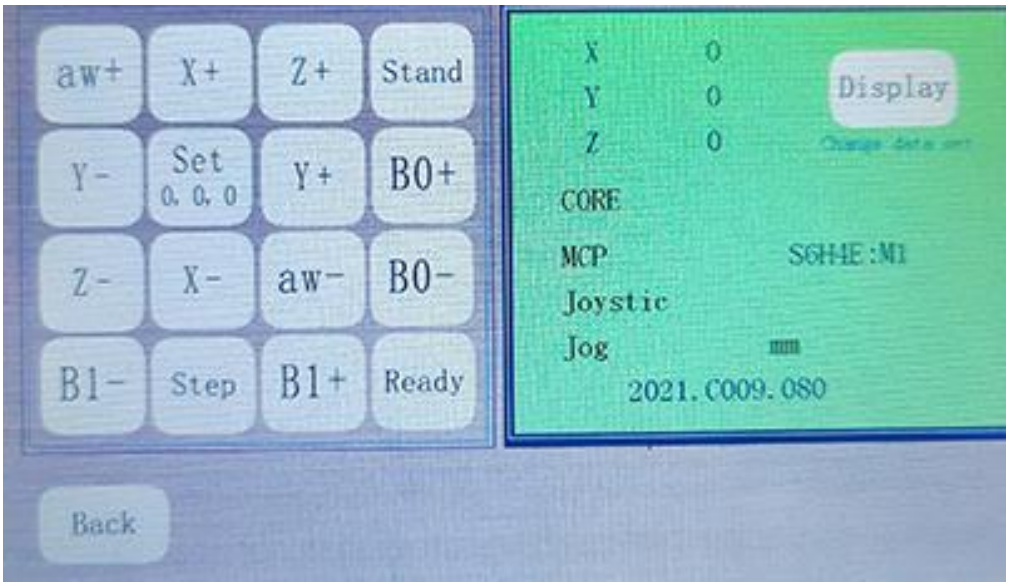
Maintain positive direction instruction programming, if needs precise positioning, users is required to control rocker little tilt movement, the robot can be very slow for precise positioning. After finishing teaching positioning, it is stored as a G code program, which will accurately relocate to the teaching point when running.

The teaching device is mainly designed for programming and debugging. The debugged program can be stored in an SD card and run with the

upper computer adapter (also known as the offline running controller).

Homepage of the teach pendant:





Manual control page by jog

Program running page

The button 001 to 015 of the program run page corresponds to the G code path program of the SD card one by one. For example, click 001 to run the seed000.txt file and click 000 to run the seed000.txt file stored in the SD card. Can support 255 G code files (per SD card)。

Button	SD card	Button	SD card
001	Seed001.txt	009	Seed009.txt
002	Seed002.txt	010	Seed010.txt
003	Seed003.txt	011	Seed011.txt
004	Seed004.txt	012	Seed012.txt
005	Seed005.txt	013	Seed013.txt
006	Seed006.txt	014	Seed014.txt
007	Seed007.txt	015	Seed015.txt
008	Seed008.txt	000	Seed000.txt

If you want to run the seed016.txt to seed255.txt file, you can click seed000. TXT on the right side of the program run page, Enter the file number in the pop-up window and click "Enter", return to the program run page and click the "Run" button below. The robot arm immediately initiates the corresponding action.

Program page

J. Teaching path programming instructions:

Use the rocker to control the robot arm to the appropriate posture and move to the target anchor point, then click the teaching device to record the current anchor point data, a series of positioning data to form a motion path, so that users can quickly achieve complex motion path planning through teaching operation. The operation method is as follows:

Click "Teaching Operation" on the home page of teaching device to enter the teaching page, click "Teaching Permit" to enable other buttons on this page. The three text boxes on the right are empty.

- According to the action you want the robot arm to do at the moment, you choose a G code instruction, and the selected operation instruction name is displayed after "Teach" in the information bar on the right.
- Moving robotic arm to the desired anchor point and pose by using a joystick;
- According to the principle, a speed, radius, or delay is set according to demand.
- Click the "Record" button after the above Settings are completed, the data will be stored in the teaching device, and the G code instruction will be displayed in the bright text box on the right. If you are not satisfied with the current setting at this time, you can adjust the input data or the attitude of the robot arm and click the "Record" button again to rewrite the record.
- If the recording works, you press the ▼button to downlink the text box, leaving the light-colored text box blank, and edit to input the next point.
- After recording a series of point data, you can click ▲and ▼buttons to debug and run the robot arm (need to switch the indicator to

"program" state).Note that certain movements cannot be run in reverse (such as from linear interpolation to rotating axis interpolation) and should be recorded into the SD card test and run. 3D arc interpolation cannot be run in reverse, so the arc interpolation moves in the form of uniform linear interpolation during teaching and debugging, and the motion effect of arc interpolation can be viewed only after it is stored in SD card.

The resulting path is stored on the SD card ROBOT\ seed000. TXT. The file is in text format and can be opened and viewed using your PC's Notepad. The structure mode of the robot arm will be automatically recorded in the file header during teaching operation. Do not change the structure mode of the robot arm in a teaching process (or in a teaching file), that is, motion programming is carried out for a structure mode in a teaching file. If you need mixed mode programming, you can save multiple instruction programs into multiple instruction files, and then merge, edit, and optimize them with a computer text editor.

Click reset on the Settings page to reset the MCP manipulator and automatically calibrate it

K. Run the controller offline

In some applications, the robot only needs to receive the trigger signal and then carry out the corresponding fixed path motion. At this moment

the robot arm does not need a teaching device, nor does it need to be connected to the upper computer, and can use the offline operation controller to receive switching signal, and run the corresponding G code path program stored in the SD card to complete the scheduled function.

There is an SD card slot on the Offline operation controller, and the path files are stored in this SD card. The 4-core aviation socket on the

robotic arm

Is used to connect upper computer, teaching device or offline controller. Before using the offline operation function, each path planning procedure should be debugged with the teaching device to avoid running into obstacles. There are two kinds of input signals. One is waiting for the external state signal, which can provide 8 input signals and The external level continues to run if it meets the condition, and waits if it does not. This set of inputs is configured only for the user who requests it; The second is to trigger the switching signal running the program, the default configuration of 8 lines directly trigger the input end, can trigger the operation of 8 programs.

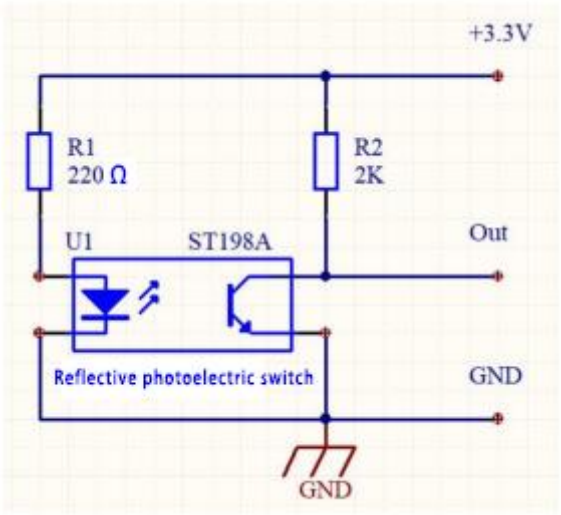
If the user needs more triggers, the 8-line logic controller can trigger 127 programs(optional).

Input signal interface (8-line direct trigger version) :

DB15	Signal	Function
1	1	Low level trigger,After receiving the trigger signal, the robot arm runs the corresponding G code program Signal 1 -> Seed001.txt Signal 2 -> Seed002.txt Signal 3 -> Seed003.txt ... ... Signal 8 -> Seed008.txt
2	2	
3	3	
4	4	
5	5	
6	6	
7	7	
8	8	
9-12	GND	The signal ground,The power negative
13-15	+3.3V	Voltage 3.3V 120mA

The signal line is pulled up inside, and the input signal is triggered on the falling edge to start the operation of the robot. The number of

cycles after each trigger can be set in the upper computer software. The number of cycles ranges from 1-250.Users according to their own working environment design switch position and form, can use mechanical switch, photoelectric switch and so on. This offline controller is not a standard part of the robot, only for users who need it.If users need more trigger interfaces, they can contact the manufacturer for extension.



An example circuit triggered by a photoelectric switch is shown above:

+3.3V connected to pin 15 of DB15 interface,

Out is connected to either pin 1 to 8 of the DB15 interface, or pin 1 to 8 of each pin is connected to a photoelectric switch circuit. The photoelectric switch of each leg triggers the corresponding G code program.

GND Connects to pin 9 of the DB15 port.

Note: this diagram is suitable for reflective photo switches, not for

reflective ones.

1.

Singularity problem of 6-axis robot and description of three operating modes

The high degree of freedom and high flexibility of the 6-axis robot enable it to complete almost all the motion functions in the industrial production line. In theory, the 6-DOF manipulator can perform most of the movements, but there are some singularities that will make the manipulator move abnormally.

The singularity is caused by the inverse kinematics of the robot. When a singularity is encountered, there could be an infinite number of ways to get to the same position of the robot. If the optimal solution is not chosen, assuming one, the robot joint may be ordered to move in an impossible way. The U.S. standard defines a singularity as: "An unpredictable robot motion and velocity caused by the collinear alignment of two or more robot axes.

Six axis robots have three typical singularities, defined in terms of which joint collinearity causes the problem:

1. Wrist singularity - This usually occurs when the robot's two wrist axes (joints 4 and 6) are in a straight line. This could cause those joints to try to rotate 180 degrees instantaneously.

2. Shoulder singularity - this occurs when the axis of the wrist and joint 1 in the center of the robot is aligned. It causes joints 1 and 4 to try to rotate 180 degrees instantaneously. There is another scenario where the first and last joints of the robot (joints 1 and 6) are aligned.

3. Elbow singularity - This occurs when the wrist joint at the center of the robot is in the same plane as joints 2 and 3.The elbow singularity looks like the robot "stretched too far," causing the elbow to get locked in place.

In addition, some singularities are caused by the insufficient motion range of the rotating shaft of the manipulator, which are pinned by themselves in some positions.

Singularities can be avoided by proper attitude adjustment and path planning

If you use the mechanical arm to do a similar action of pouring water from a teapot, the posture will change greatly, and it is easy to encounter singularity. Industrial applications can avoid singularities through path planning to make the manipulator work smoothly. But if you're using a joystick to control a manipulator, singularity is a problem.

The robot arm designed by us is mainly aimed at commercial and family services. Serving tea and pouring water is a common function. Moreover, a few users will completely use the rocker to control the robot arm, so the singularity cannot be avoided through path planning.

For this purpose, we provide three working modes. The traditional 6-axis industrial application is based on the wrist vertical ground for automatic interpolation of attitude transformation, which is called mode 0.The service application is based on the wrist parallel to the ground, the attitude Angle can be set to any specified value, called mode 1, to meet the special movement requirements of a few users, also provides a horizontal wrist mode 2.In mode 2, the attitude Angle is forced on the basis of Mode 1, so the corresponding singularities are also more. Mode 1 has no singularity, so users can use it safely. Mode 0 and Mode 2 are recommended for ordinary users to use with caution. This function is suitable for debugging and programming of robot professionals.

The three modes can be switched at any time. The command to switch to mode 0 is: G501 U3 V100 W0;The command to switch to mode 1 is: G501 U3 V100 W9;The command to switch to mode 2 is: G501 U3 V100 W5.

It is recommended that users specify the working mode of the manipulator with this instruction at the beginning of each G code program. In order to ensure the smooth movement of the manipulator, it is best to follow an axis Angle interpolation instruction after each switching instruction, such as G331 A0.0b-18.0 C79.95D0.0e57.0F0.0i18T1500, so that each axis can be transferred to

the reserved position after mode transformation. The mode selection button can be found on the parameter setting page when using the teaching device, and the mode can be changed by touching. In mode 2, special care should be taken when using the teaching device rocker to control the linear motion of the manipulator, because the manipulator will operate in unexpected ways at some special points due to control logic and singularity.

Special care should be taken when mode 1, mode 2 and mode 3 are mixed programming in the same G code program. An axis Angle interpolation instruction should be followed by the mode conversion instruction to avoid entering singular points in the attitude conversion process of the manipulator .G code multi-mode mixed programming if you encounter difficulties, please contact our technical support.

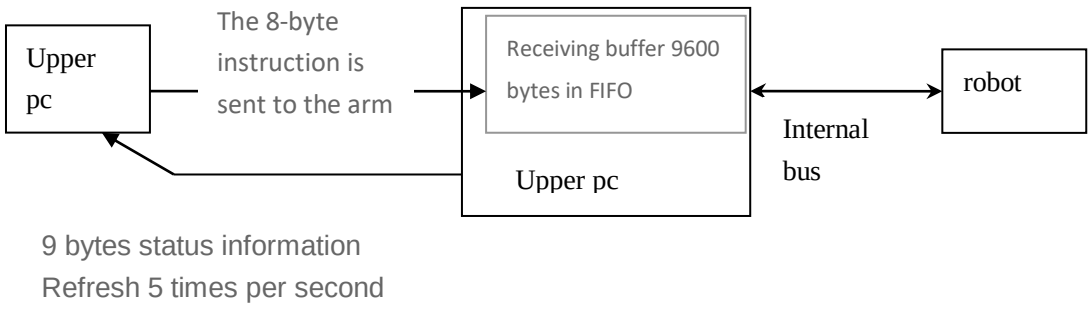
It should be noted that attitude angles B0, B1 and AW in mode 0 and Mode 2 are azimuth angles of the end relative to the manipulator's coordinates, while attitude angles in mode 1 are relative angles of the end corresponding to the forearm. Mode 1 is particularly suitable for applications where frequent, large end angles are adjusted.

L. Upper-computer software

For the convenience of user in-depth development, we provide an upper computer program template, using C++Builder6 programming,

users can quickly change their own upper computer software. User reference program source code can understand the communication protocol, floating point number and 4-byte data conversion protocol, movement instructions, control instructions, manipulator status information, etc. Serial instructions are fixed 48 bytes long, and the connector has a 9600 byte buffer, which can cache 200 motion and control instructions continuously sent by the computer. If the computer sends instructions too fast, no new instructions will be received when the buffer is full, and the instructions already in the buffer will be executed in sequence, first-in, first-out. The robot arm does not reply to every command received, but periodically sends status information to the upper computer. Communication using serial port TTL level, rate 9600bps, can also provide wireless serial version of remote control, and Ethernet version of the connector.

The upper computer software we provide includes all the source code, and the interface design is mainly used for debugging the mechanical arm. After long-term debugging, it runs stably and reliably, and can be provided to users who need reference and test the mechanical arm.This debugger is not commercial software and can be modified by the user. We do not make technical guarantee to host computer software, also do not do maintenance and service.



9 bytes status information
Refresh 5 times per second

M. **Maintenance and troubleshooting**

The structure of mechanical arm is compact and complex, and the control circuit is special. There is no internal electrical parts that users can repair by themselves. If you have control problems, please contact our technical service. Harmonic reducer is a high precision part, too large push and pull, unreasonable collision if exceed its limit force will lead to precision reduction, abnormal sound and even damage scrap.

If the mechanical arm runs in high intensity for a long time, it is necessary to check the loosening of screws every 3 to 6 months. If the screws and synchronous belt are loose, please tighten them.

Problems and solutions	
1	If the arm does not move while being operated with a joystick, it is most likely that: A. The rocker on the teaching device allows/the program to run the switch is in the wrong position and is in the program state.

	B. The navigation plug of the safety switch on the mechanical arm is not properly connected.
2	In the use of rocker control, the remote control rotating shaft movement will automatically stop moving forward after each axis reaches the soft limit point, can be remote control back; When the soft limit is reached in the state of linear remote control, it will automatically retreat a little to exit the soft limit protection state. At this time, the mechanical arm can be remote controlled to retreat, otherwise it will vibrate in the critical region. Normal application should not approach the limit position as far as possible.
3	All six-axis manipulators have singularities, which can be encountered during straight-line maneuvers with joysticks or during path programming tests, turning the manipulator at unpredictable angles. In this case, you need to power off immediately, restart after a few seconds, and continue to use the robot after automatic initialization.
4	If the robot arm does not move when you click the touch screen of the teaching device to run the program, it is most likely that: A, the rocker on the teaching device allows/program operation switch position is not correct, in the rocker state;B. The navigation plug of the safety switch on the mechanical arm is not properly

	connected; C. The SD card is not inserted correctly, or the program of the card is wrong
5	The reset and calibration of the mechanical arm uses a photoelectric switch, which is sensitive to strong light. If direct sunlight will interfere with the reset and calibration process of the mechanical arm, please avoid direct sunlight or strong light.
6	There are three possible reasons for the vibration of the mechanical arm during its operation: A, the base is not firm enough, so that the mechanical arm resonance; B, G code program is not optimized, vibration occurs when the speed or direction of movement changes suddenly; C. The rocker controls the mechanical arm to move to the soft limit state of a certain axis, and the mechanical arm generates vibration reminder.
7	If the long straight line moves into an arc, it indicates that the length of the tool installed by the user on axis 6 is not set. At this time, measure the distance L3 from the terminal anchor point to the rotation center of axis 5, and then set it with the following command: G500 U3 V15 W280.0 (set L3=280.0mm), the setting takes effect after the manipulator is reset.
8	If the electric control claw does not open and close according to

	the program when running G code motion program, it is likely that the control parameter T of the electric control claw is put into the acceleration and deceleration instruction, and the acceleration and deceleration movement instruction does not contain the parameters of the electric control claw. The solution is to add a G1 instruction after the acceleration and deceleration instruction.
9	If the G code program cannot run in a loop, add G100 P2 to the last line of the program
10	If you want to reset the external axis with G code, use this instruction: G501 U4 V6 W0 reset the external axis 1, G501 U4 V6 W1 reset the external axis 2.This instruction cannot be used by a manipulator that is not attached to an external shaft.

Please note that this mechanical arm is a moving machine with certain strength and speed. Although the speed is not very fast, it is not easy to hit others and cause injury. However, do not reach out to touch the moving mechanism during the movement of the mechanical arm to avoid serious injury.

Email: forrestxiao26@gmail.com

Website: seedrobotarm.com