Outputs

Output ports usually have A in their name, e.g. PA, QA, RA, SA, TA.
Except that ports in the multi-IO card can be programmed either as outputs or inputs.
All values output on a port can be read back. For example

```
55 PA OUT
PA IN .
```

result is 55
(the dot means print on screen)

When using ports it can be useful to understand the hexadecimal numbering system. To change to hexadecimal enter HEX.
A word X. (X-dot) prints any number in a 4-figure hex field (16 bits) for example

```
HEX
55 PA OUT
PA IN X.    0055
```

Inputs

Input ports usually have B in their name, e.g. PB, QB, RB, SB, TB.
Except that ports in the multi-IO card can be programmed as outputs or inputs and that card also has ports ending in C. For example:
`PB IN .` result is usually 255. However the robot uses the PB port for calibration so you may see a different value.

Standard Outputs and Inputs

	User outputs - 15w D		User inputs - 9w D
1	PA 7	1	PB 6
2	PA 6	2	PB 5
3	PA 5	3	Ovolts
4	PA 4	4	PB 3
5	PA 3	5	+12V
6	PA 2	6	PB 7
7	PA 1 (elec grip)	7	0 volts
8	PA 0 (gripper)	8	PB 4
9	0 volts	9	+12 volts
10	0 volts		
11	+12v		
12	+12v		
13	+12v		
14	+12v		
15	+12v		

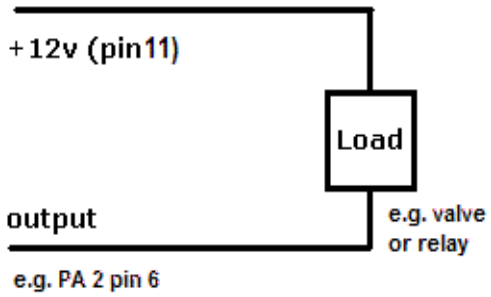
If your controller is configured for 24v then all the above supplies named +12v will be +24v (note that these are unregulated so +12 may be as much as +15 and +24 may be as much as +30)
All following references to +12 are +24 if your controller is configured for 24v I/O.

PA Outputs

The PA port is the primary output port

Turn on/off a 12v relay or lamp or solenoid or valve: connect the -ve side of the device to the PA output, +ve side to 12v (11,12,13,14,15). Must be 12v and less than 0.5 amp.

All the outputs are open collector Darlingtons with the zero volts being the same ground as the controller. You can connect a load e.g. a solenoid or a relay between the output pin and +12v, for example a relay to be operated by PA 2 would connect between pin 6 and pin 11.



The gripper is usually connected to port PA bit 0. Type `GRIP` to close the gripper, `UNGRIP` to open.
You can also enter `PA 0 ON` to close and `PA 0 OFF` to open.

Note: the electric gripper uses PA 0 and PA 1 so ON and OFF can not be used with the electric gripper.

The same philosophy applies to the other output bits, for example suppose you have a pump controlled by PA 2 via a relay. You could enter
`PA 2 ON` and `PA 2 OFF`
Or you could define
```
: PUMP PA 2 ;
```
then `PUMP ON` and `PUMP OFF`
You can incorporate outputs in a definition that also has robot motion, for example let's assume PA 5 means "warning, robot in motion". You could have connected that output to an illuminated legend with that wording.

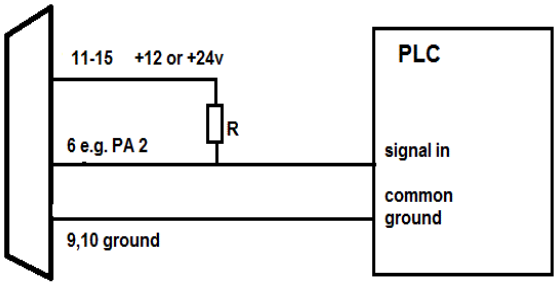
For example

```
: WARNING PA 5 ;
: INITIALIZE
START
WARNING ON
CALIBRATE
HOME
WARNING OFF
;
```

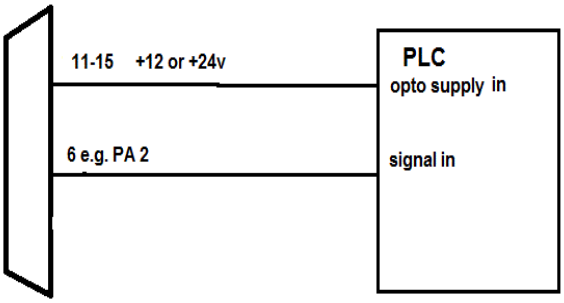
Type `INITIALIZE` or `INITIALISE` to observe that.

Sending an active signal to a PLC

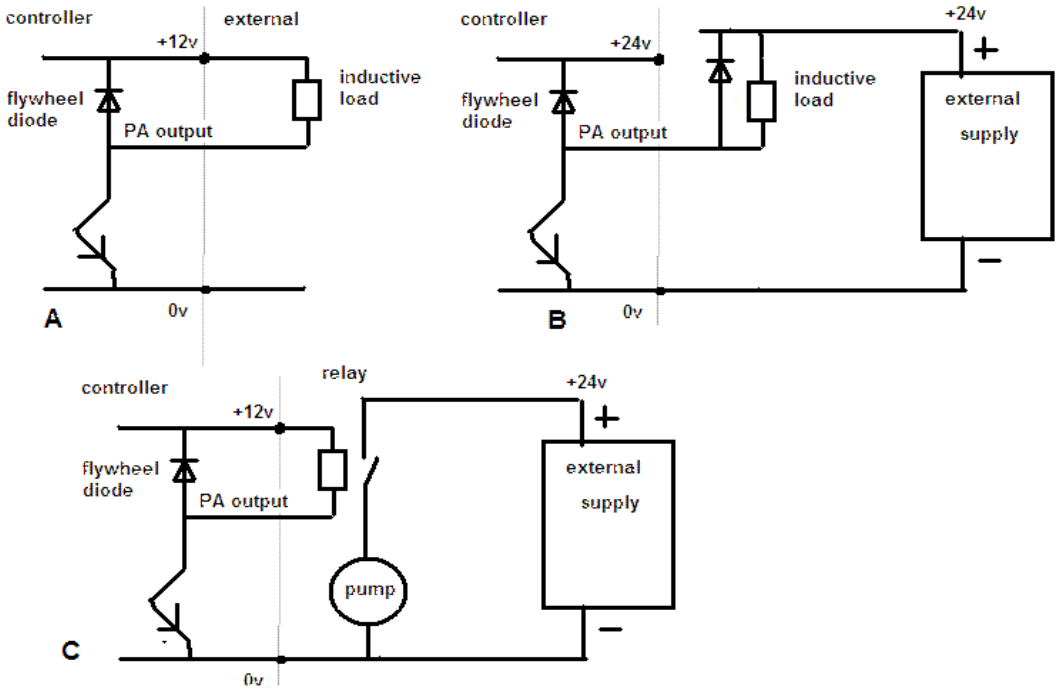
Where the PLC requires a voltage (e.g.24v) to register a signal connect the ground of the controller pins 9,10 to the PLC ground and connect the PA output to the PLC input. Then connect a pullup resistor from the PA output to +12/24v supply on pins 11 to 15.



Most PLCs have opt-couplers. Each opto-coupler input is usually isolated from all the others. In that case connect the +ve side of the input to the controller +12/24v and the -ve side to the desired PA output.



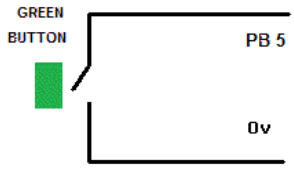
You can also use an external power supply instead of the controller supply. The external must be the same voltage as the controller (12 or 24). If the load is inductive you need an external flywheel diode. Examples:


controller
external
+12v
flywheel diode
PA output
inductive load
0v
A
controller
+24v
flywheel diode
PA output
inductive load
+24v
external supply
0v
B
controller
relay
+12v
+24v
flywheel diode
PA output
external supply
pump
C
0v

PB inputs

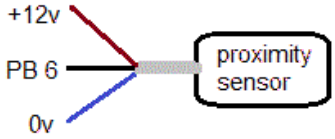
Connecting a relay contact or manual switch or pushbutton.

Connect one side to desired PB input, other side to 0v.



Connecting a proximity detector – PNP

power the detector from +12v (5,9) to brown wire, connect 0v to blue wire.
Connect the black signal wire to desired PB input.



Connecting a proximity detector – NPN

power the detector from +12v (5,9) to brown wire, connect 0v to blue wire.
Connect the black signal wire to desired PB input. Put a 470R resistor from the PB input to 0v.

Connecting a PLC output to controller input

Connect the PLC ground to controller 0v (3,7)
PLCs can have a variety of outputs.
24v current sourcing: when the PLC outputs the voltage is 24v but when off the line is effectively open circuit. Connect a 470R resistor from signal to ground. Connect signal to desired PB via a diode pointing towards the PLC.
12/24v current sinking: Connect signal to desired PB. When off the PLC output is effectively open circuit, the voltage goes high and is read as a '1'. When on the PLC pulls down the current from the controllers internal pullup and is read as a '0'.
5v TTL: Connect signal to desired PB.

The PB port is the primary input port
Bits 0-4 are used by the calibration sensors of the robot, leaving bits 5,6,7 for the user, although some robot inputs may be shared.
Each input has a pullup to +12v. When you read the inputs they should all be ‘1’ unless a robot sensor is sensing.
It is most easily monitored with a command
PP
This continually displays the input in binary e.g.
11111110 (example R12 at HOME position)
11111111 (example R17 at HOME position)
From right to left is ascending value (same as decimal) so bit 0 is furthest right and bit 7 is furthest left. Bits 0,1,2,3,4 are used by the robot for calibration and the 3 furthest left are for the user.
To change an input from 1 to 0 simply ‘short’ it to 0v with a relay or the open collector output of a proximity detector etc. For example connect pin 6 (bit 7) to pin 7 (0v) and you will see
011xxxxx

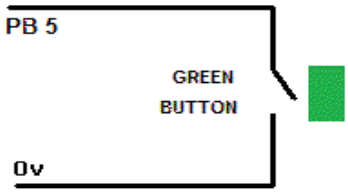
Programming

Words that use these inputs are IN, WAIT and BIT?

BIT? Takes the specified bit and leaves a true or false. A true can be any value but false is 0.

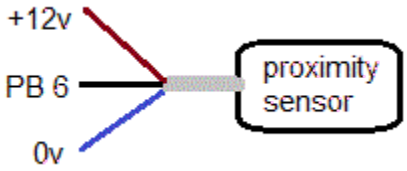
Example use of WAIT

```
: GREEN-BUTTON PB 5 ;
: INITIALIZE
START
GREEN-BUTTON 0 WAIT
CALIBRATE
HOME
;
```



Example use of BIT? (with two PLACEs decided by a sensor input)

```
: TASK
PB 6 BIT? IF
  JIG1
ELSE
  JIG2
THEN
;
```



A thermostat:

```
: SENSOR PB 7 ;
: HEATER PA 7 ;
: HEAT
BEGIN
   SENSOR BIT? IF
     HEATER OFF
   ELSE
     HEATER ON
  THEN
500 MSECS
?TERMINAL UNTIL
HEATER OFF
;
```

16-bit I/O expansion card

This card has 8 bits of opto-isolated and Darlington buffered outputs and 8 bits of opto-isolated inputs.
There is a jumper on the PC card. With the jumper fitted the ports are SA and SB and with the jumper removed the ports are TA and TB.
If you are not sure which one you have here is a quick check:
`HEX 55 SA OUT`
`SA IN X`. result 0055
If the result is 00FF then try TA

The outputs are in 2 separate groups of 4 each with 1A Darlington drivers which pull down to the common ground for each group. The positive supplies must also be brought to the connectors.

The inputs are on a 25 way socket which connects to a 16 way 2 row HE14 connector J4 on the card.

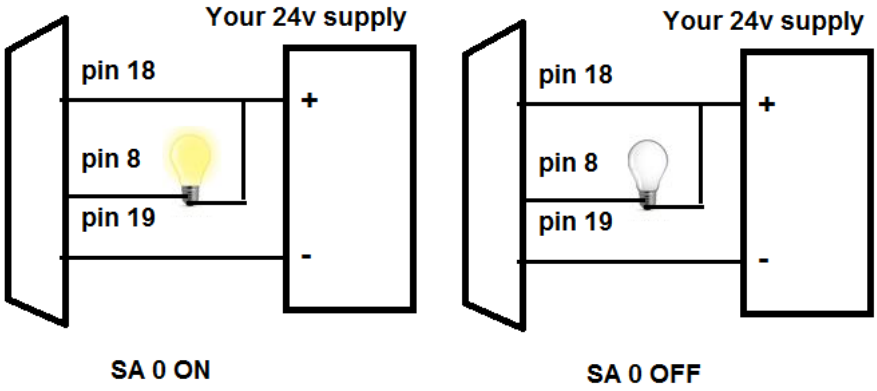
OUTPUTS (SA/TA) **INPUTS (SB/TB)**

25w D skt	Function		25w D plug	Function
1	output 7		1	input 7 neg
2	output 6		2	input 6 neg
3	output 5		3	input 5 neg
4	output 4		4	input 4 neg
5	output 3		5	input 3 neg
6	output 2		6	input 2 neg
7	output 1		7	input 1 neg
8	output 0		8	input 0 neg
14	positive supply for outputs 4,5,6,7		14	input 7 pos
15	common ground for outputs 4,5,6,7		15	input 6 pos
16	common ground for outputs 4,5,6,7		16	input 5 pos
17	common ground for outputs 4,5,6,7		17	input 4 pos
18	positive supply for outputs 0,1,2,3		18	input 3 pos
19	common ground for outputs 0,1,2,3		19	input 2 pos
20	common ground for outputs 0,1,2,3		20	input 1 pos
21	common ground for outputs 0,1,2,3		21	input 0 pos

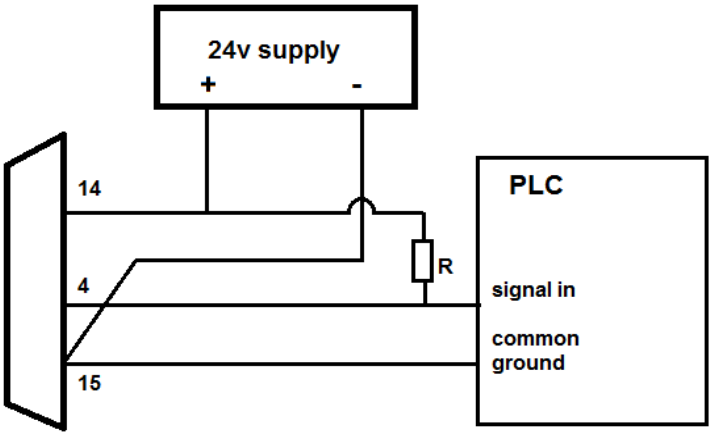
SA/TA Outputs
All the outputs are open collector Darlingtons with their ground returns isolated from the controller. You need a separate external 12 or 24v DC supply. There are two sets of 4 outputs each with its own 0v and +v connections. Therefore you can use two separate supplies if you wish or connect one supply to both sets. Connect the + terminal of your supply to pins 14,18 and the – terminal of your supply to pins 15 (and/or16,17) and 19 (and/or 20,21).

You can connect a load e.g. a solenoid or a relay between the output pin and your +v.

Example: 24v lamp to be operated by SA 0 would connect between pin 8 and 18 (24v).



Example: connection to other logic device or PLC via SA 4.



Depending on the instrument you might need a pullup resistor R, e.g. 4K7

SA 4 ON – sends a 0 to the PLC
SA 4 OFF – sends a 1 to the PLC

SB/TB inputs

The inputs are likewise isolated and require an external supply. You connect your – terminal to one of the negative pins and your load between your + terminal and an output pin. In other words to make an input on SB bit 0 you apply a voltage to pins 8 and 21, pin 8 being the negative and 21 being positive.

The input is most easily monitored with a command similar to PP but PP only shows PB. Instead use

```
SB WATCH
```

This continually displays the input in binary e.g.

11111111

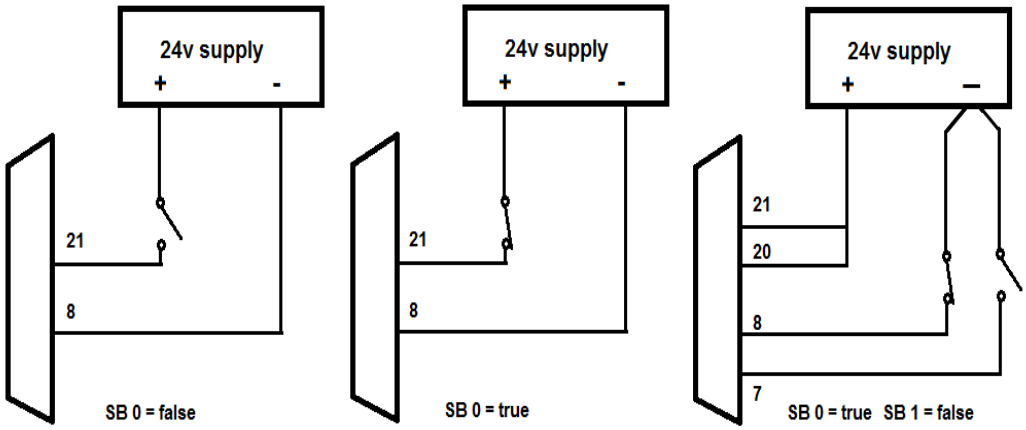
From right to left is ascending value so bit 0 is furthest right and bit 7 is furthest left.

To change an input from 1 to 0 apply a voltage 12-24v between the two pins for that input. For example connect a 24v supply, negative to pin 8, positive to pin 21 and you should see

11111110

All the inputs are independent opto-isolators so you can common up all the + pins if you wish or all the – pins, or use completely independent sources of voltage.

Example: simplest form of inputs – just switch 12 or 24 volts into the inputs. A voltage going into an input turns on the opto-isolator so is read as a 0.




```
SB 0 0 WAIT
```

The system will wait for the switch to close

```
SB 0 1 WAIT
```

The system will wait for the switch to open.

In the third diagram SB WATCH would show

11111110

Operate both the switches and you would see

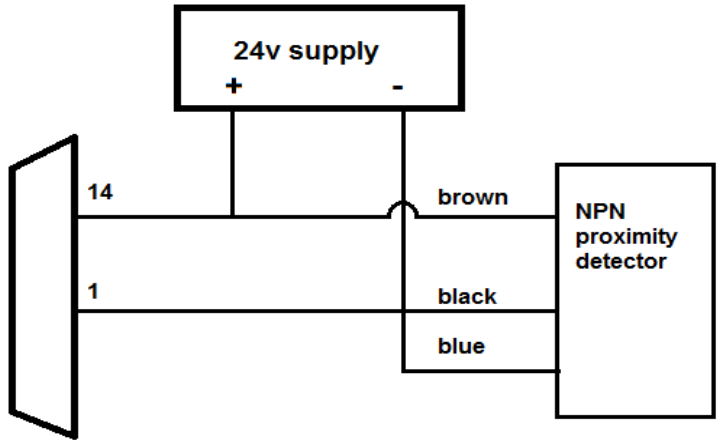
11111101

SB 1 BIT? Leaves true if the switch is closed e.g.

`SB 1 BIT? .` <enter> (remember the dot means print) `0 OK` – means switch is open

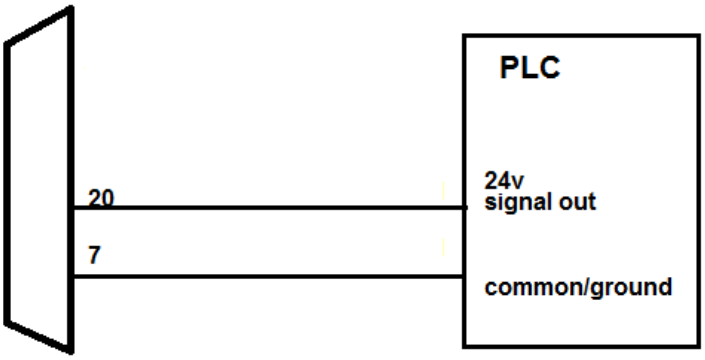
`SB 1 BIT? .` <enter> `2 OK` – non-zero means switch is closed

Example connect an NPN proximity detector



`SB 7 0 WAIT` – wait for detector to detect metal.

Example get a 24v signal from PLC to SB 1



Example decision made on the result of this input:

```
: TASK
SB 1 BIT? IF
    ACCEPT
ELSE
    REJECT
THEN
;
```

ST Robotics

Sharing PB inputs between user and robot sensors –
R17 ONLY.
If you have run out of input lines you can “borrow” the lines used by the robot.

As you can see from the controller manual section 12 inputs PB 3 and PB 4 are available on the user 9w D connector but these are used by the robot for calibration of axes 4 and 5 (the hand).

	Robot inputs - 25w D		User inputs - 9w D
1	Sensor 1 (PB 0)	1	PB 6
2	Sensor 2 (PB 1)	2	PB 5
3	Sensor 3 (PB 2)	3	Ovolts
4	Sensor 4 (PB 3)	4	PB 3
5	Sensor 5 (PB 4)	5	+12V
6		6	PB 7
7		7	0 volts
8		8	PB 4
9		9	+12 volts
21	Sensor 6 (PB 5)		

When an axis calibrates the input goes low and then high, and remains high except when an axis goes past a sensor in normal motion. Therefore if you use an input PB 3 or 4 on the 9wD you must ensure:
1. That your inputs on the 9w D are high (open) before the robot can calibrate
2. That when you are polling PB 3 or 4 that the hand is not in such a position that PB 3 or 4 are made low by chance position against its sensors.

Don’t forget you can check the state of the PB inputs with
`PP`
(press escape to exit PP)

You would be advised to insert the following code in your text file. This redefines CALIBRATE so as to check the shared inputs first:

```
: CALIBRATE
PB 3 BIT? 0=
PB 4 BIT? 0= OR
IF
   .” Shared input prevents calibration “
ELSE
   CALIBRATE
THEN
;
```