REACH ROBOTICS

REACH BRAVO
INTEGRATION MANUAL

V007

+61 (2) 9519 7651 | info@reachrobotics.com

www.reachrobotics.com

Reach Bravo Integration Manual

Contents

1. Introduction

This manual is designed help users of the Reach Bravo manipulator get familiar with the integration and usage of the system. Additionally, Section 2 describes the necessary safety information and precautions relevant to the setup and operation of the manipulator. For European customers, Section 3 also outlines the applicability of the relevant EC Directives.

Reach Robotics website and Help Centre
Our website, www.reachrobotics.com, holds all our documentation as well as FAQs, knowledge articles, and downloads. You can find some quick links below:

- Datasheets and manuals
- FAQs
- Product theory
- Software downloads

Reach Robotics contacts
If you can't find what you're looking for on our website or Help Centre, please get in touch with Reach Robotics Support at support@reachrobotics.com. You can also get in touch with us at sales@reachrobotics.com (for all sales enquiries), or info@reachrobotics.com (for any other enquiries).

Feedback
If anything in our manuals, FAQs or knowledge articles is out-of-date, poorly explained, or erroneous, please don't hesitate to let us know. We always appreciate the opportunity to improve our documentation for the benefit of all users.

2. Safety Information

These instructions contain notes that you must follow for your own personal safety and to avoid injury and damage to property. They are highlighted by warning triangles and are shown as follows according to the level of danger.

2.1. Hazard classification

DANGER	Denotes a hazard with a **high** degree of risk that will result in death or serious injury if not mitigated or avoided.
WARNING	Denotes a hazard with a **medium** degree of risk that may result in death or serious injury, or serious damage to the product, if not mitigated or avoided.
CAUTION	Denotes a hazard with a **low** degree of risk that may result in moderate to minor injury, or damage to the product, if not mitigated or avoided.
INFO	Denotes important information about a product or procedure.

2.2. Target Group

The activities described in this manual must only be carried out by technicians with the following qualifications:

- Training in the installation and commissioning of electrical devices (qualified electrician as defined in EN 50110-1: a person with technical training, knowledge and experience sufficient to allow them to recognise and avoid the risks that might be posed by electricity)
- Extensive knowledge in the fields of electrical engineering and drive technology
- Training in electrical and mechanical hazards and the local safety requirements
- Knowledge of the relevant standards and directives
- Knowledge and observance of this document and all the safety instructions

Any employee who does not have the relevant training must be given appropriate training and instruction. The instruction is to be given by authorised personnel with the appropriate training.

2.3. Personal safety

This section describes the necessary safety information and precautions relevant to the setup and operation of the Reach Bravo manipulator system. To ensure correct and safe use of Reach Robotics manipulators, carefully read this section and make yourself well acquainted with the contents. Follow any warnings and cautions included. In conjunction with this manual, it is important that the users have knowledge of safety considerations and make correct judgments on safety procedures during operation.

Reach Bravo manipulators are highly dexterous, electromechanical devices that can move with a high degree of freedom. Failure to take necessary safety measures or mishandling due to not following the instructions in this section may result in damage to the robot or injury to personnel.

DANGER

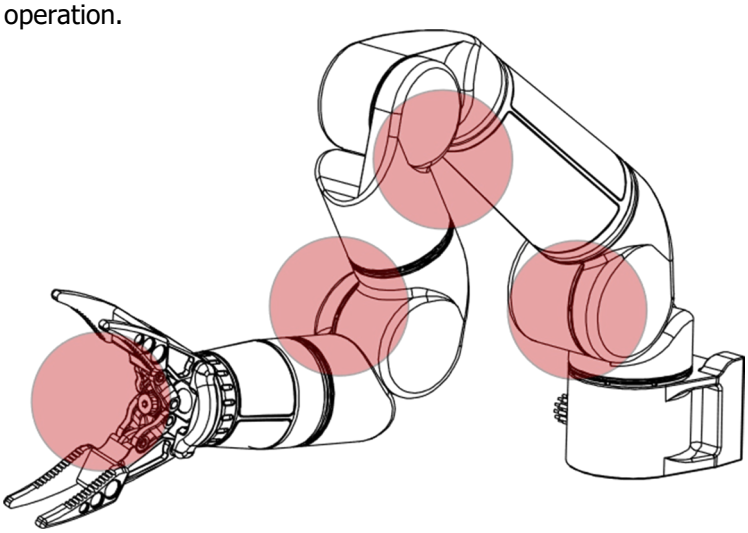
The Bravo has the potential to emit a powerful magnetic field which can pose a fatal risk to personnel with passive or active implants such as pacemakers, defibrillators, insulin pumps, etc. Personal with these life support devices must not place the device within 10 mm of the outer shell of the manipulator. This distance has been determined through empirical measurements that found the magnetic field was less than 0.5 mT (5 Gauss) when a sensor was placed further than 10 mm from the shell surface.

WARNING

Do not attempt to open the joints of the Bravo to access any part of the motors or electronics. This will void your warranty and poses a serious health risk due to crushing or electrical shock. It also risks damaging internal components, which will require repair at the Reach Robotics facility.

WARNING

The Reach Bravo presents multiple crush and/or cut hazards: in the jaws or end-effector, and at any point where two limbs can compress together. When cutter jaws are installed, the operator must ensure that the working area of the manipulator is clear prior to operation.



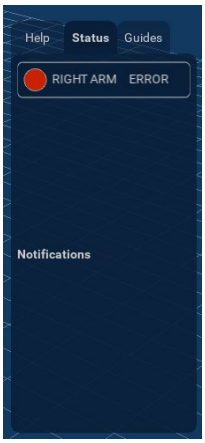
CAUTION

When bench-testing or operating the Bravo in a human environment, it is strongly recommended that the following safety procedures are adhered to:

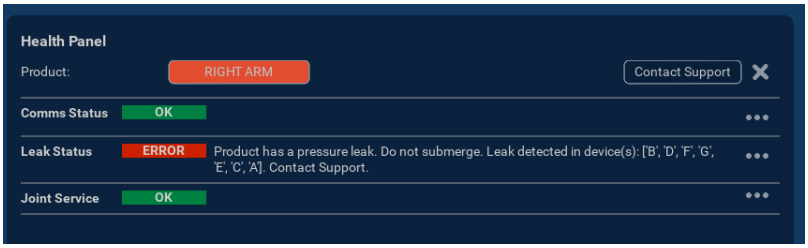
- Install and operate the unit below head height
- Wear safety goggles when installing or working closely to the manipulator
- Include an easily accessible E-stop button in the power circuit
- Avoid physical interaction with the end-effector or limbs to prevent crush and/or cut hazards
- Install barriers/signage to prevent untrained personnel from entering the manipulator workspace
- Implement stop, speed and separation monitoring and torque limiting to reduce the risk of human contact and injury

2.4. Product safety

2.4.1. Leak detection



If there is a breach in the vacuum, an error will be thrown and the Status tab in the Help menu of Reach Control will open. To view more details of the error, click on the product button. This will open the health panel.



Click the ellipsis […] to view more details if required.

2.4.2. Obstacle setup

Obstacles can be defined within the manipulator workspace to avoid collision between the Bravo and other equipment. The manipulator arrives with a "floor" obstacle installed to avoid collision with the bench/test platform. Care should be taken to ensure that any obstacles configured are defined correctly to cover all potential collision points.

2.4.3. Physical installation

Prior to operation, ensure that the manipulator is firmly secured using the supplied mounting kit, or an alternative solution with the appropriate specifications.

When the manipulator is under load, ensure that the mounting surface is sufficiently stable to avoid unbalancing.

2.4.4. Operating environment

The Reach Bravo is intended for in-water operation. The system is designed and tested as partially completed machinery to be integrated into a complete underwater robotic system. It is possible to use this system in ambient laboratory conditions, however, it should be noted that radiated emissions from this product may not comply with limits imposed by local authorities. See Section 3 for more information regarding compliance.

Operating and storage temperature

The manipulator system is specified for operation between 5°C- 35°C and storage between -10°C-80°C.

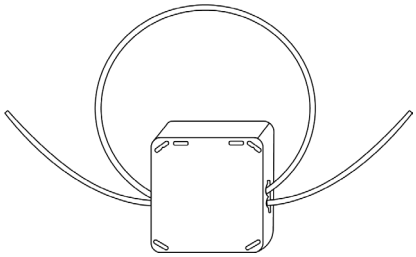
Water Pressure
The Reach Bravo is depth-rated to operate at the equivalent of 450 MSW (Metres below Sea Level).

Explosive environments
Reach Bravo manipulators are not designed to meet explosion-proof specifications. Do not use the robot and controller in environments containing inflammable gas, gasoline, or solvent. Explosions or fire may otherwise result.

Harmful substances
Reach Bravo manipulators are not designed to operate in areas in which harmful substances as defined in EN 60721 may be encountered, such as oils, acids, gases, vapours or dusts.

2.4.5. Electromagnetic Compatibility (EMC)

To ensure your product conforms to EMC directives, you must evaluate your finished product (entire system) and take necessary countermeasures. One consideration for meeting the above standard is the installation of a ferrite core on the cable connected to the manipulator. Emissions will vary depending on length and design of this cable. Reduction of emissions can be achieved by placing the ferrite bead as shown:



Reach Robotics has had success with the Wurth Elektronik Clamp-On Ferrites (P/N 74272251, 74272221) and the TDK Power Line Filter (P/N B84112G0000B080).

WARNING

Integrators must take care to install any filters in the **correct orientation**. Failure to do so may cause open/short circuits and pose a **fire hazard**. Read all relevant third-party user manuals to ensure safe operation.

2.4.6. Power Circuit and System Integration

The manipulator is not sold with a complete, stand-alone power supply circuit and associated control and safety systems. Instead, the manipulator should be integrated into an overall system power supply that includes the appropriate Protective Bonding Circuit and ancillary equipment according to EN60204-1. This circuit should include the appropriate current limiting, circuit break and/or fusing system to prevent inadvertent touch voltages.
Components that should be considered by the system integrator to fully comply with certain electronic equipment safety standards (e.g. EN60204-1) include:

- Supply disconnecting device
- Emergency stop
- Residual Current Device (RCD)
- Integration of a Protected Extra-Low Voltage (PELV) circuit where required
- Over-current Protection mechanism
- Protective Bonding Circuit (PBC) design
- Protective interlocks
- Indicator Lights and Labelling
- Any additional control inputs required

For bench level testing, it is strongly recommended to use a controlled power supply with a current limiting circuit and/or a Residual Current Device (RCD) mechanism. See Section 8 for bench test instructions.

3. Compliance with EC Directives

According to 2006-42-EC - Machinery directive, the Reach Bravo manipulator system is not, by itself, a complete robot system. Instead, the Reach Bravo manipulator is a component of a larger system which comprises additional power, safety, and control devices. As such, the Reach Bravo conforms to the applicable EC Directives within the scope of this framework. The customer who incorporates the Reach Bravo manipulator system into the customer's final system, which will be shipped to or used in the European region, should verify that the overall system conforms to the EC Directives.

3.1. CE marking

As the Reach Bravo does not constitute a complete robot system, it does not comprehensively meet the requirements allowing for a CE Marking. Therefore, no CE Marking is affixed to Reach Robotics products in accordance with the requirements of 2006/42/EC Machinery directive.

Note: Differences between the Reach Bravo series products (robots and controllers) and robot systems.
The Reach Robotics Bravo manipulator system (both the manipulator and controllers) are components of a full robot system and therefore do not constitute a robot system. It does not include the additional equipment (power regulation, power interface, emergency stop, etc) required for a full system, according to the "Robot System" definition in Clause 3.2.20 of the EN775:1992 standard. Example systems that should be integrated for a complete system are listed at Section 2.4.6.

3.2. Applicable directives and standards

The applicable directives and standards are available in the *Reach Bravo – declaration of incorporation of partial machinery*. As per 2006-42-EC, this document is available on request.

Under this assessment, several prescribed procedures of the harmonized standards have been omitted given the appropriate justification as described below.

- As specified in Section 2.4.4, the Reach Bravo system is rated for in-water use and lab environments only. EN61000-6-3:2007 ELECTROMAGNETIC COMPATIBILITY (EMC) radiated emissions procedure has been omitted due to the high attenuation of radiated EM waves in an underwater environment. Reach Robotics PTY LTD deems radiated emissions not relevant for this product. The arm is classed as Partly Completed Machinery to be integrated onto a host underwater drone system; full compliance testing is to be carried out on the fully completed system.
- EN61000-6-2:2016 Electromagnetic compatibility (EMC) immunity procedures have been omitted due to precautions in place for system installation and commissioning. The integration onto the host underwater drone system must be performed while the arm is powered off in a warehouse environment (wood or concrete floors; no active humidity control). Additionally, the commissioning and installation period is expected to be far shorter than the total lifetime of the device (minimal human contact). Reach Robotics assess that arcing due to charge build up on metallic surfaces of the underwater drone, or a discharge being coupled onto the surface of the device from nearby transient event, is a low likelihood, low severity event in the final end-application. As such Reach Robotics deems ESD discharge not relevant for this product.

3.3. Installation of external safety circuits

To comply with EC directives, customers using the Reach Bravo manipulator must always build and install their own external safety circuits after selecting product components (safety relays, etc.) according to performance levels and safety categories required by the customer equipment.

3.4. Use of the supplied RS232/485-to-USB Break-Out-Board

The Reach Bravo is commonly supplied with an external Printed Circuit Board (PCB) for interfacing between a USB Serial Device and the manipulator. This device does not form a core part of the manipulator system and is included as an optional setup item only. To conform with the EC directives, this device should not be used, or should be built into a compliant system.

3.5. Cautions regarding official language of EU countries

Only English which is the official language of the EU is utilised in the manuals, warning labels and operator interface for the Reach Bravo manipulator.

4. Product overview

The Reach Bravo is an advanced electric manipulator system designed for subsea use that opens a new set of compact inspection and intervention opportunities for militaries, service providers, researchers, and other operators. Please discuss your requirements with our Sales team prior to purchase to ensure that the Reach Bravo is the correct manipulator for you.

The Bravo is a modular robot, available in configurations ranging from a single-function rotate actuator up to a 7-function manipulator. Multiple tooling options are available from Reach Robotics, though the manipulator also features an end-effector interface that can accept custom tooling.

It can be controlled using a Reach Robotics Master Arm, a Gamepad or SpaceMouse, or commands sent using the RR Software Development Kit (SDK). For more information, please see the appropriate manuals for each control method.

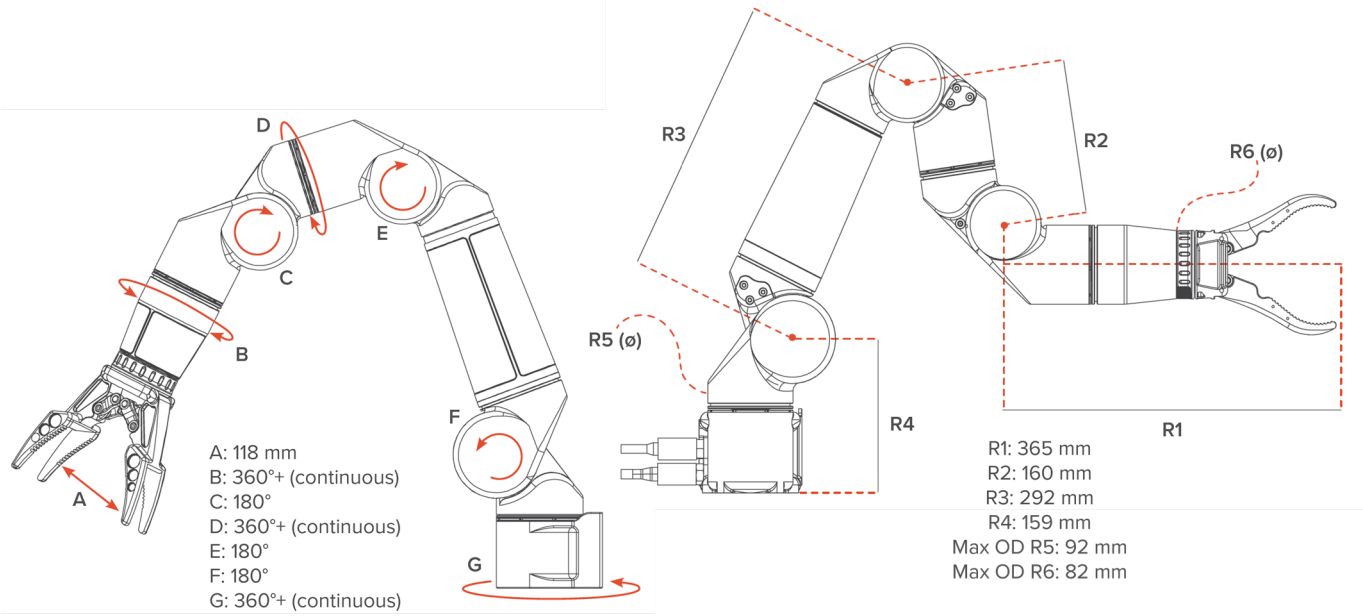
5. Specifications

5.1. Mechanical

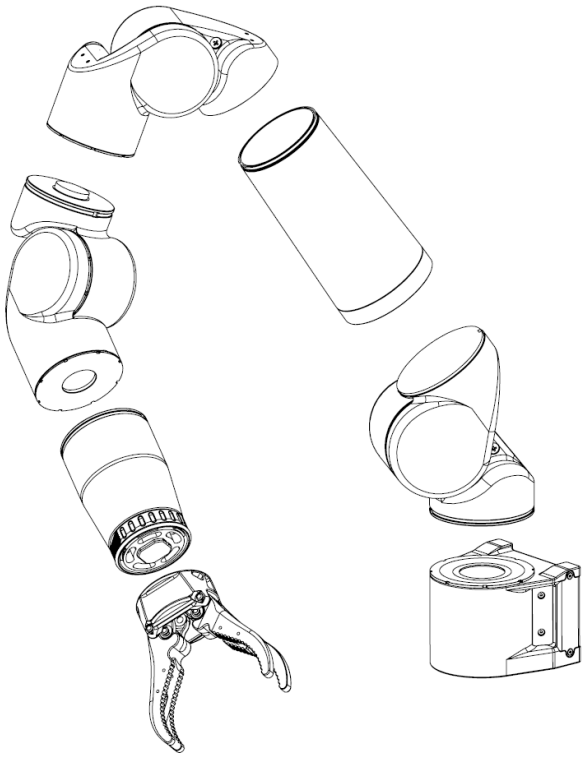
	Bravo 7	Bravo 5	Bravo 3	Bravo 2
Functions	7	5	3	2
Degrees-of-freedom	6	4	2	1
Full extension reach	900 mm	750 mm	410 mm	320 mm (static)
Dynamic full-extension lift	10 kg	12 kg	15 kg	N/A
Max axial load	100 kg		200 kg	
Base joint torque	110 Nm		50 Nm	N/A
Wrist torque	20 Nm			
Grabber closing force	80 kg (800 N)			
Weight (in air)	9.5 kg	7.5 kg	4.0 kg	2.8 kg
Weight (in water)	4.5 kg	4.0 kg	2.6 kg	1.6 kg
Joint speed (24-48V)	45 – 80 °/s			
End-effector repeatability	<1 cm		N/A	

All specifications are for Bravo V010 and higher. Please contact Reach Robotics Support for older version specifications.

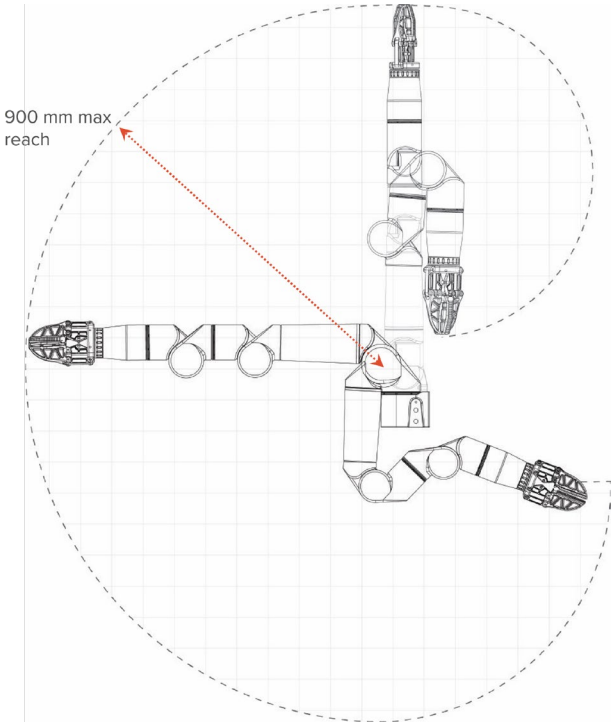
5.1.1. Bravo 7



Bravo 7 – dimensions and rotational capacity

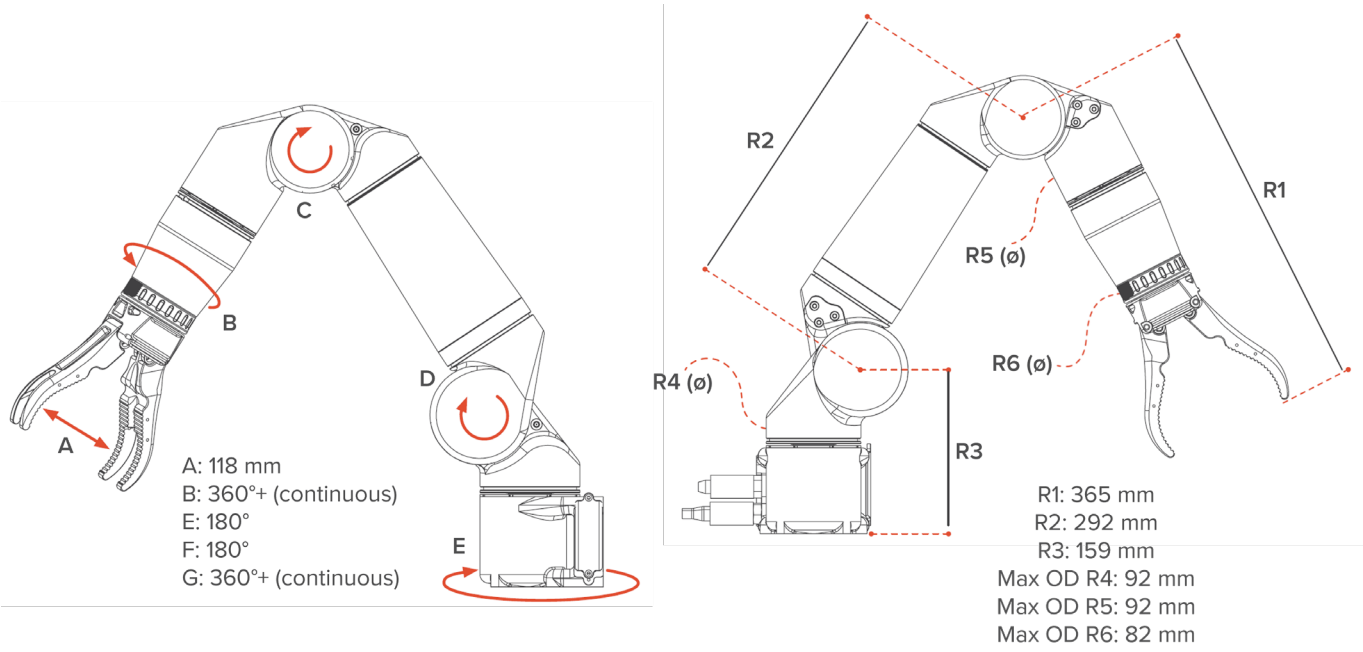


Bravo 7 – module breakdown

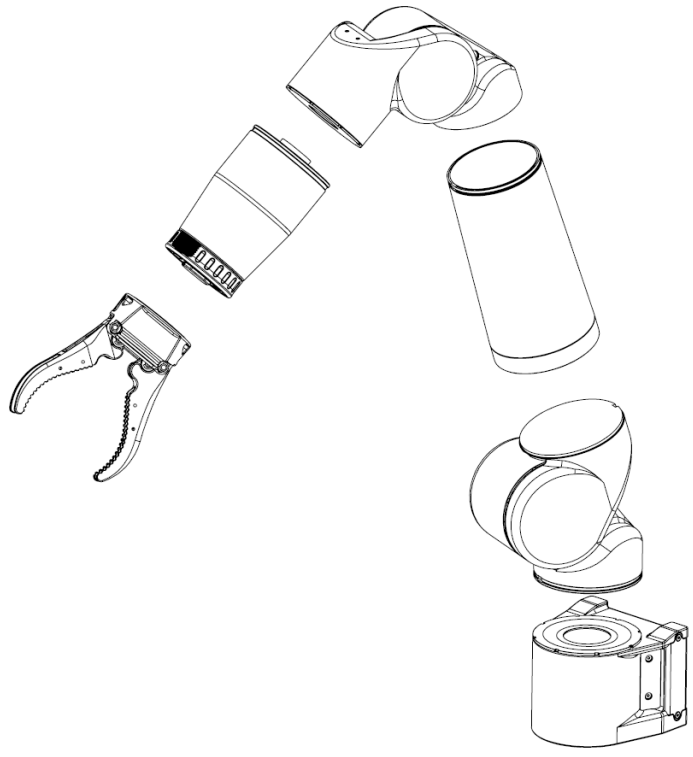


Bravo 7 – range of motion side view

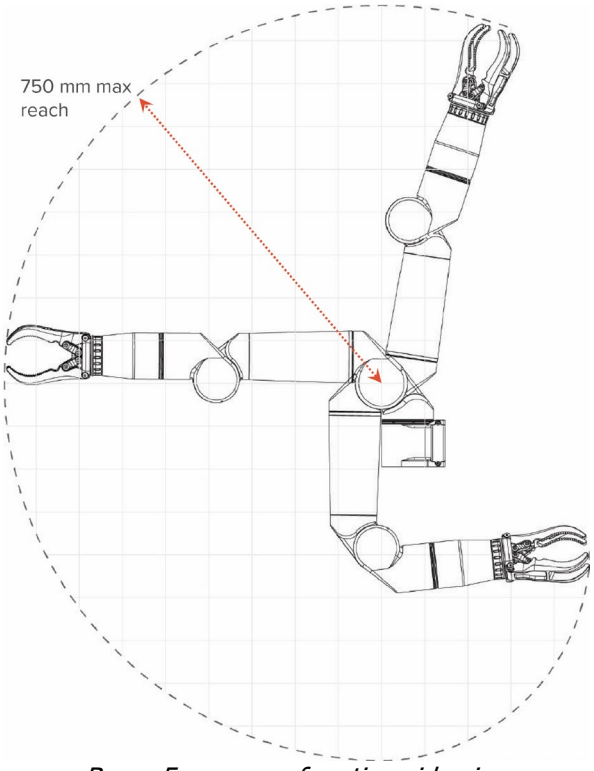
5.1.2. Bravo 5



Bravo 5 – dimensions and rotational capacity

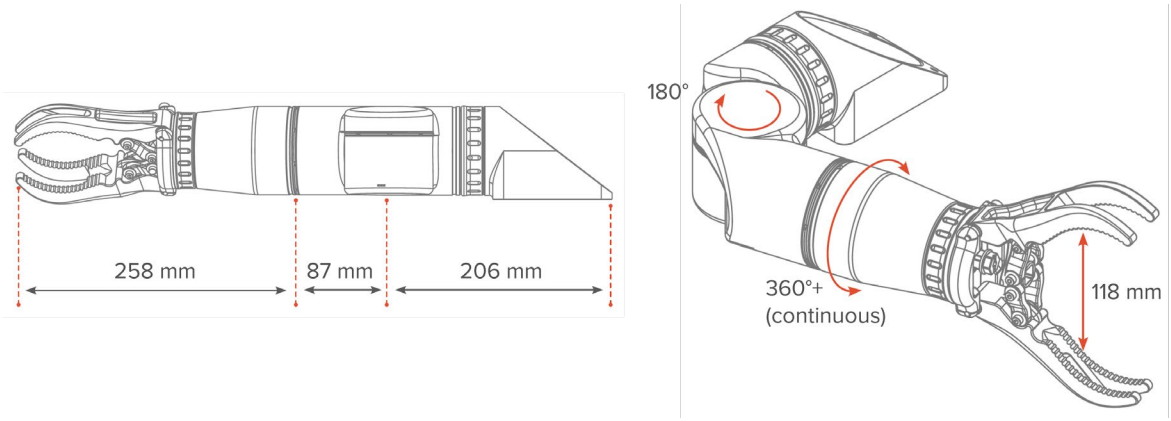


Bravo 5 – module breakdown

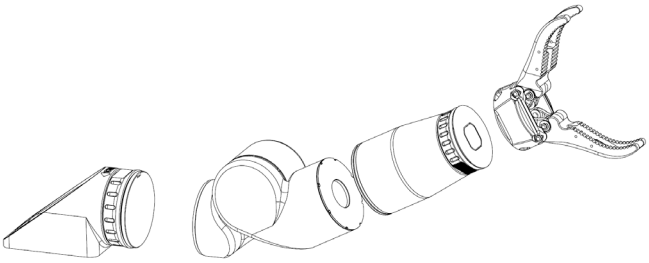


Bravo 5 – range of motion side view

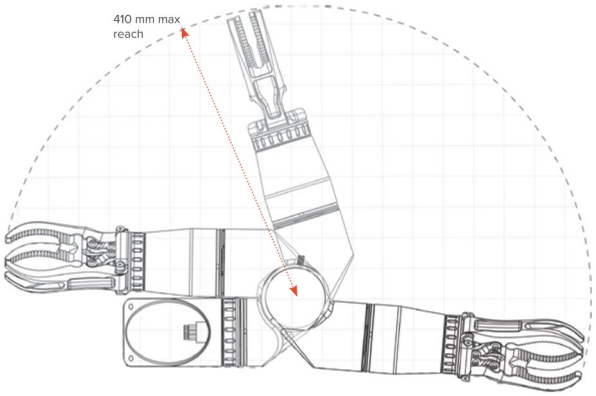
5.1.3. Bravo 3



Bravo 3 – dimensions and rotational capacity

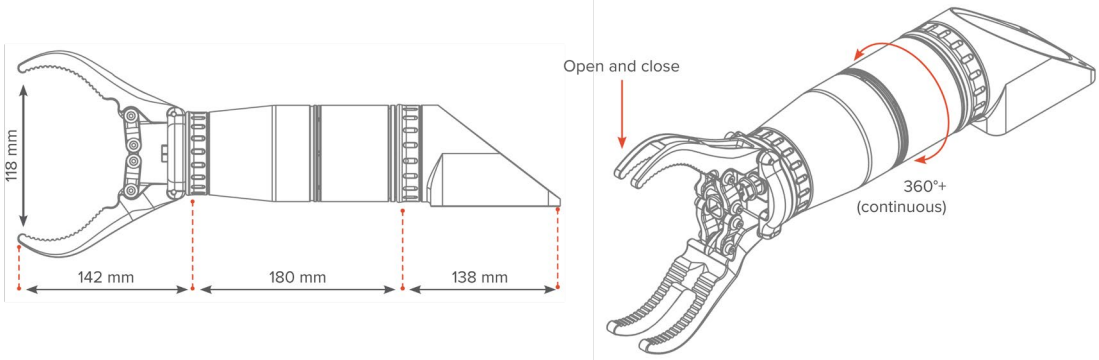


Bravo 3 – module breakdown

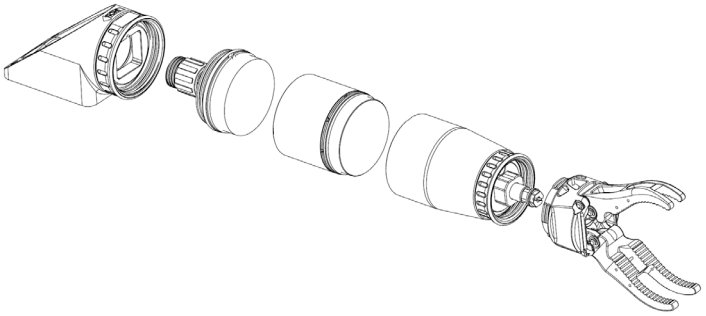


Bravo 3 – range of motion side view

5.1.4. Bravo 2



Bravo 2 – dimensions and rotational capacity



Bravo 2 – module breakdown

5.2. Environmental

	All Bravo manipulators
Operating temperature range	5-35°C
Storage temperature range	-10-80°C
Depth rating	450 MSW
Housing material	Hard Anodised AL7075

5.3. Electrical

	Bravo 7	Bravo 5	Bravo 3	Bravo 2
Input voltage	20-48 V DC			
Power draw (nominal with 10 kg load)	400 W	200 W	100 W	75 W
Power draw (max with 10 kg load)	500 W	300 W	200 W	150 W

INFO

For systems with strict power requirements, the velocity can be limited to reduce power draw. Please contact Support for assistance.

5.4. Communication

	Bravo 7	Bravo 5	Bravo 3	Bravo 2
Processor	NVIDIA TX2		N/A	
Interface low-level protocol	Ethernet, RS485, RS232			
Proprietary communication protocol	Reach Robotics Reach System Communication Protocol*			

**Please contact Reach Robotics Sales for access to the Reach System Communication Protocol documentation.*

5.5. Kinematic, dynamic, DH parameters, and other properties

For more detailed information to assist with research and low-level control/autonomy applications, please contact Reach Robotics regarding our Reach System Research Data Pack.

6. Interfacing and Integration

This section covers the mechanical and electrical requirements for integrating the Reach Bravo into a full system. Please contact Support if you require 3D CAD files or any additional information to assist with integration.

CAUTION

To comply with EMC immunity procedures, the integration of the Reach Bravo into the host underwater drone system must be performed while the arm is powered off in a warehouse environment (wood or concrete floors; no active humidity control). When integrated, the arm should only be operated underwater to avoid interference due to radiated emissions.

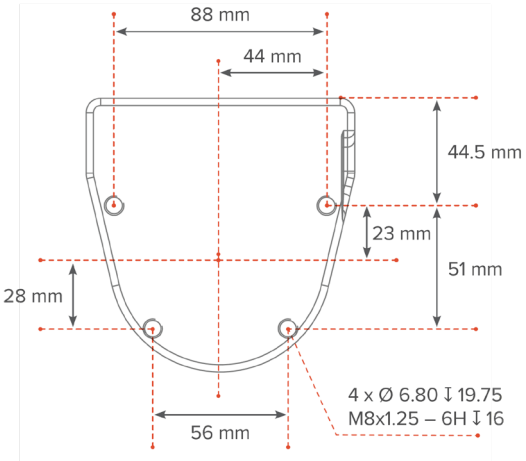
INFO

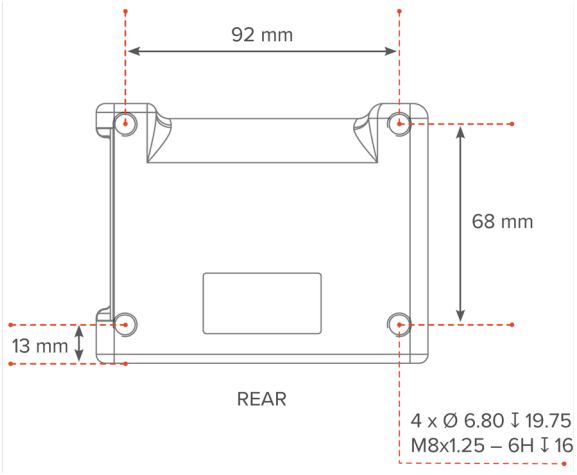
Since the Reach Bravo is designated as partially completed equipment, the integrator must ensure that the integration of the manipulator into a complete robotics system complies with local regulations and standards. Please refer to Sections 2 and 3 for more information.

6.1. Bravo 7/Bravo 5

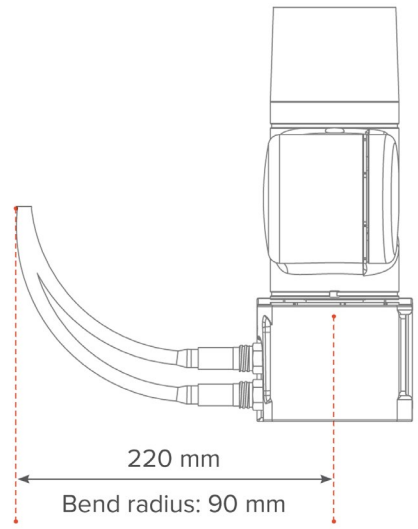
6.1.1. Mechanical

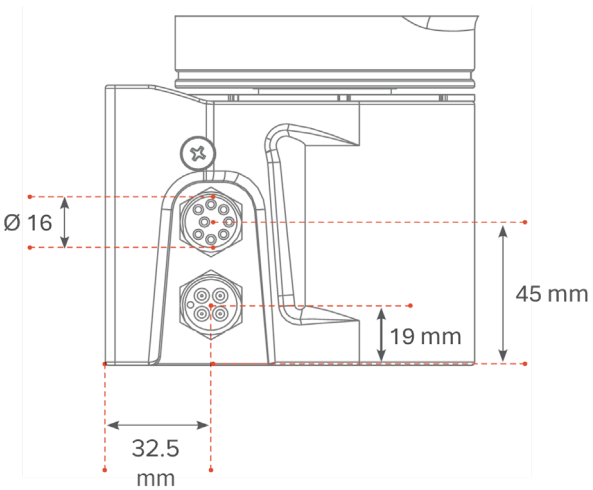
Manipulator base integration





Connector clearance





6.1.2. Electrical

CAUTION

The Bravo experiences a high **inrush current** that can trigger over-voltage protection in certain power supplies. This is due to the components used in the arm to prevent backdrive damage and arm drop under load.

If you find that the Bravo does not power on correctly when applying power, it is recommended to implement a soft start with a slew rate of ~0.5V/ms.

INFO

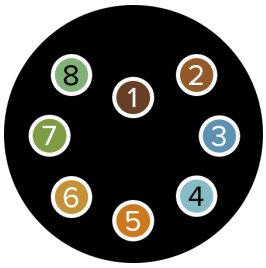
TX in the tables below refers to **data to the vehicle**.
RX in the tables below refers to **data from the vehicle**.

Bulkhead power connector (MCBH4M)

Pin #	Description	Colour
1	GND	Black
2	PWR	White
3	PWR	Red
4	GND	Green

Interface cable (supplied): MCIL4F (MC inline, 4C female to unterminated ends, 100cm)

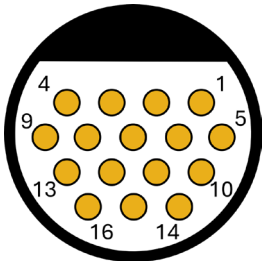
Bulkhead communication connector (MCBH8ME)



Pin #	Description	Colour	Pairs
1	RS485 A	Brown	Twisted pair
2	RS485 B	Light brown	
3	RS232 TX	Blue	Twisted pair
4	RS232 RX	Light blue	
5	ETH RX-	Orange	Twisted pair
6	ETH RX+	Light orange	
7	ETH TX-	Green	Twisted pair
8	ETH TX+	Light green	

Interface cable (supplied): MCIL8FE10 (MC ethernet inline, 8C female to unterminated ends, 100cm)

Accessory port connector (MCP16WD)



Pin #	Description
1	RX-
2	CAN L
3	CAN H
4	TX-
5	RX+
6	GND
7	GND
8	GND

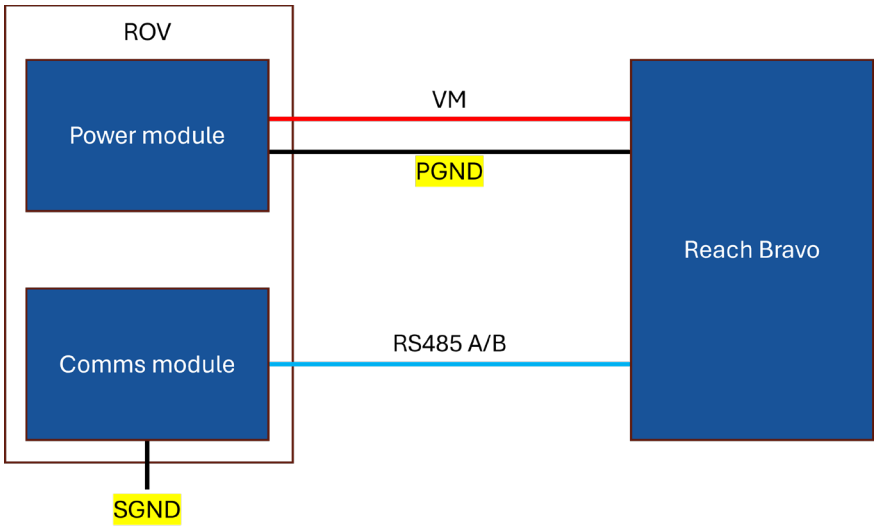
Pin #	Description
9	TX+
10	GND
11	PWR
12	PWR
13	GND
14	PWR
15	PWR
16	PWR

The Bravo 5 and 7 include an accessory port connector on the "elbow" joint to provide power and comms to either a Bravo Wrist Camera or Bravo Accessory Port (see Section 9).

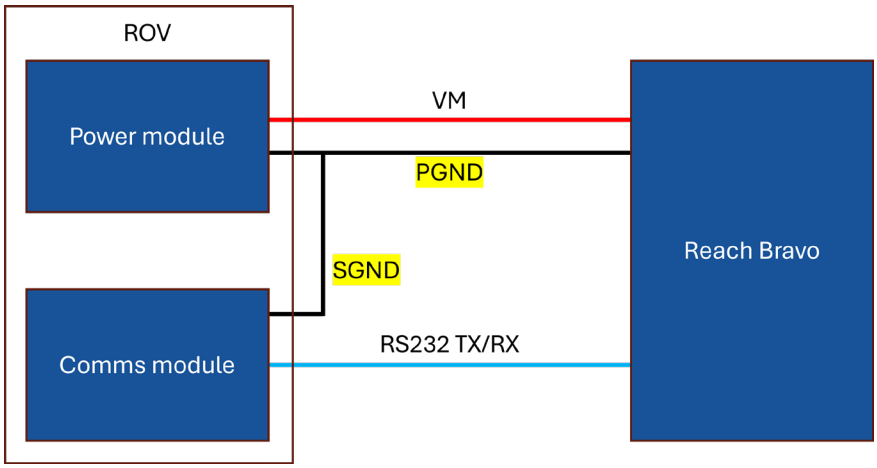
Grounding when using serial comms

Ensure that the Reach Bravo is grounded correctly when using serial communications to avoid a ground loop, which can introduce interference or damage the device. This is detailed in the diagram below, using a Remotely Operated Vehicle (ROV) power and comms module as an example.

- When using **RS485**, ensure that PGND and SGND in the diagram below have a **maximum voltage difference of ±7V**.



- When using **RS232**, ensure that PGND and SGND in the diagram below are **tied directly together**.



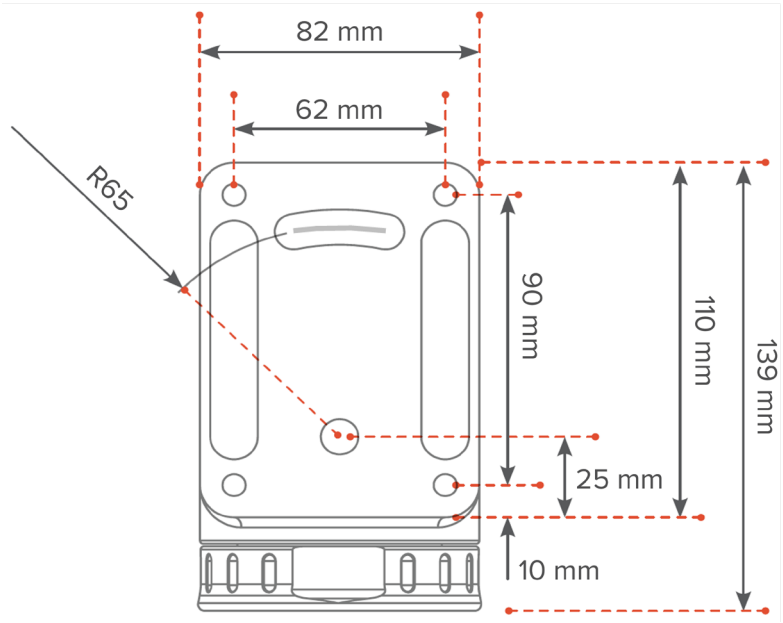
If you have any questions, please contact Reach Robotics Support.

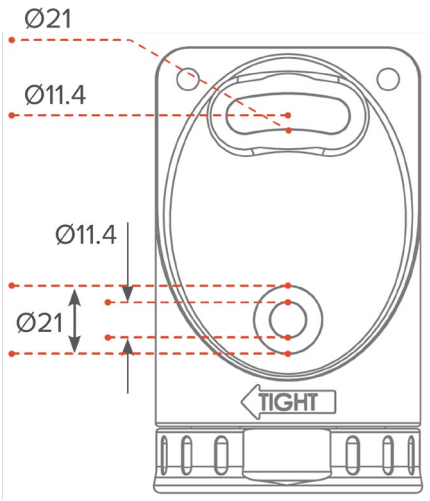
6.2. Bravo 3/Bravo 2

6.2.1. Mechanical

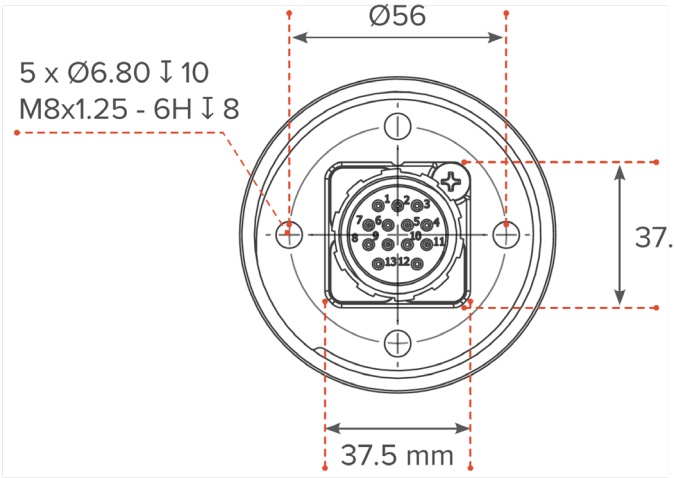
Manipulator base integration

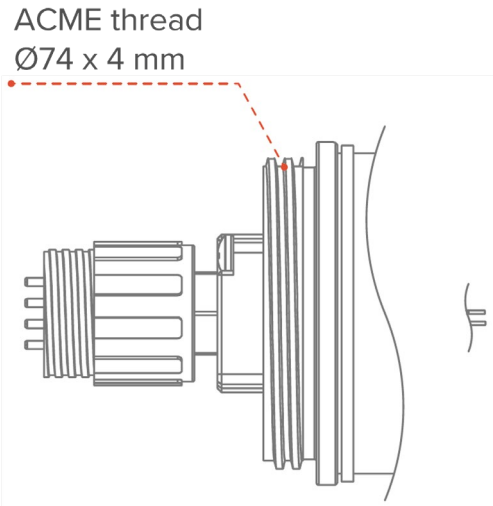
Option 1: Reach Bravo mounting kit





Option 2: Direct backplate integration



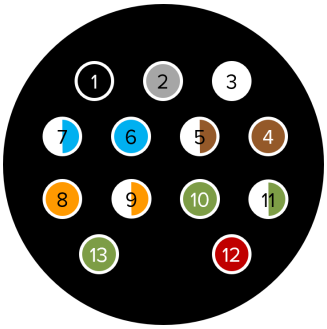


6.2.2. Electrical

INFO

TX in the tables below refers to **data to the vehicle**.
RX in the tables below refers to **data from the vehicle**.

Bulkhead power and comms connector (DBH13M)



Pin #	Description	Colour	Pairs
1	GND	Black	
2	NC	(Screen)	
3	PWR	White	
4	RS485 A	Brown	Twisted pair
5	RS485 B	Brown/white	
6	RS232 TX	Blue	Twisted pair
7	RS232 RX	Blue/white	
8	ETH RX-	Orange	Twisted pair
9	ETH RX+	Orange/white	
10	ETH TX-	Green	Twisted pair
11	ETH TX+	Green/white	
12	PWR	Red	
13	GND	Green	

Interface cable (supplied): DIL13F (MC ethernet inline, 13C female to unterminated ends, 100cm)

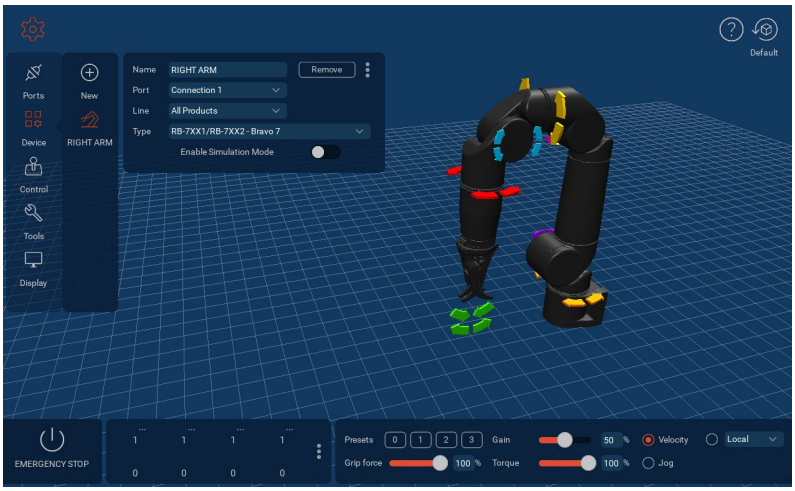
7. Control options

The Reach Bravo can use serial (RS232 and RS485) or Ethernet for comms, and is commanded either through the Reach Control software, with a physical hand-held controller, or by a custom-built program.

7.1. Reach Control software

Reach Control provides a graphical means to control each joint of the connected manipulator(s) in position or velocity mode. Each purchase of a Reach Robotics manipulator comes with the Lite version of Reach Control, while the Pro version is available as an upgrade option.

The full Reach Control manual can be download from our website.



7.2. Hand-held controllers

7.2.1. Master Arm

The Reach Robotics Master Arm system is a topside controller that maps the human operator control inputs to the movement of the manipulator's joints in a corresponding manner. In this way, the Master Arm controller allows the manipulator to "mimic" the movement of the operator.

Master Arm for 7-function Reach manipulators RM-7201

Master Arm for 5-function Reach manipulators RM-5201

The full Master Arm manual can be download from our website.

7.2.2. Gamepad

A simple HID gamepad (Reach Robotics supplied or BYO) can be used in conjunction with Reach Control. The gamepad control inputs can be customised and mapped to the different functions and joints of the manipulator. The gamepad can be used to control the manipulator in joint velocity, or end-effector Cartesian (XYZ) mode. Please contact Support for access to the Gamepad Mapping Manual.

7.2.3. SpaceMouse

For controlling the manipulator in end-effector Cartesian (XYZ) mode, a SpaceMouse can also be used. This translates 3D motion on the controller into kinematic control of the manipulator end-effector relative to its current position. Please contact Support for access to the SpaceMouse Mapping Manual.

7.3. Custom-built programs

Reach Robotics can provide a Software Development Kit and Communication Protocol to aid in creating custom software for communicating with Reach products. Please contact our Sales team for more details.

8. Bench setup and acceptance test

CAUTION

The bench setup and acceptance test are not regarded as an "integration", and as such does not account for EMC directive standards. Please refer to Sections 2, 3 and 6 for more information.

CAUTION

The provided power supply and E-stop are intended for bench testing only and should not be used in the full integrated system. The power supply provides 260 W and thus is not suitable for intensive usage.

8.1. Bench setup

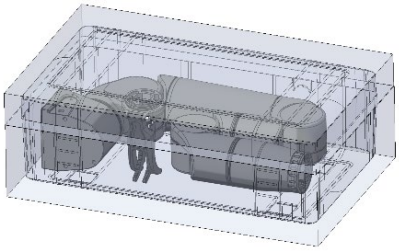
8.1.1. Mechanical interfacing

This section outlines the basic setup and testing procedure users should complete to ensure their arm is fully operational. The following example is demonstrated with a Bravo 7. If you experience any issues in following these steps, please contact Reach Robotics for technical support.

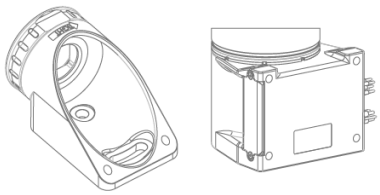
Materials required:

- Reach Bravo manipulator
- Power and comms cable(s)
- Reach Breakout Board
- Power supply
- USB or Ethernet cable
- PC with Reach Control
- 4 x M8 bolts
- 5 mm Allen key
- Marine grease

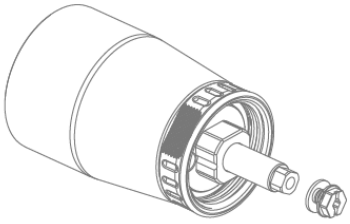
1. Unpack all Bravo components from the flight case and verify that you have all required parts.



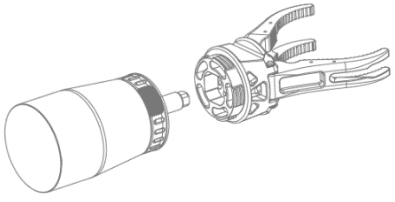
2. Use the provide 4 x M8 bolts to fix the Bravo base in position onto your mounting surface. Sections 6.1.1 and 6.2.1 provide the mounting interface dimensions for the Bravo 7/5 and Bravo 3/2 respectively.



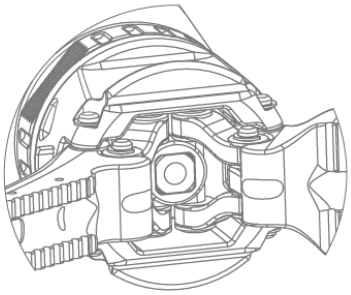
3. Using the 5 mm Allen key, remove the screw and washer from the end-effector pushrod.



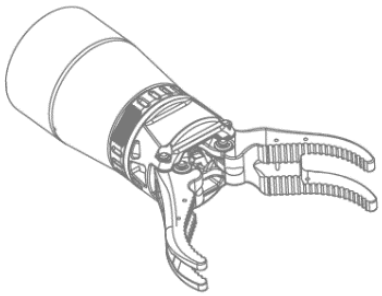
4. Fit your chosen jaws onto the arm, ensuring the dowel pin is correctly aligned. Apply marine grease to the thread at the base of the jaws.



5. Ensure central sheath is fitted over the pushrod. You can rotate the pushrod by hand if necessary.



6. Screw the collar on the end-effector interface to tighten. Fasten the screw in the centre of the jaws with the 5 mm Allen key to secure (with a torque of ~3 Nm).



7. Ensure the included power and communication cable(s) are securely connected to the Reach Breakout Board (BOB).

8. Plug the power and communication cable(s) into the base of the arm.

9. Connect the power supply to the BOB. Plug the other end into a wall socket and turn on. Ensure the red E-stop button is released and a red LED is lit in the centre.

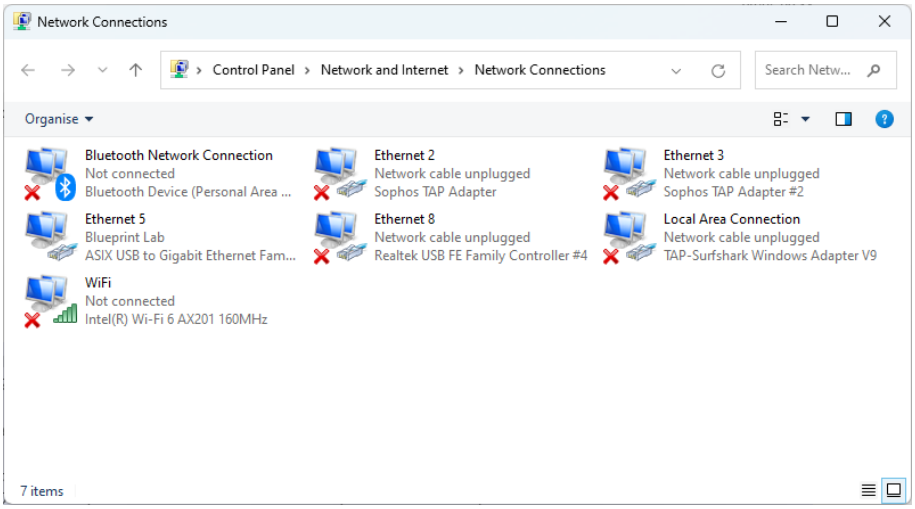
10. Use an Ethernet or microUSB cable to connect the BOB to your PC.

8.1.2. Communication setup

Ethernet comms

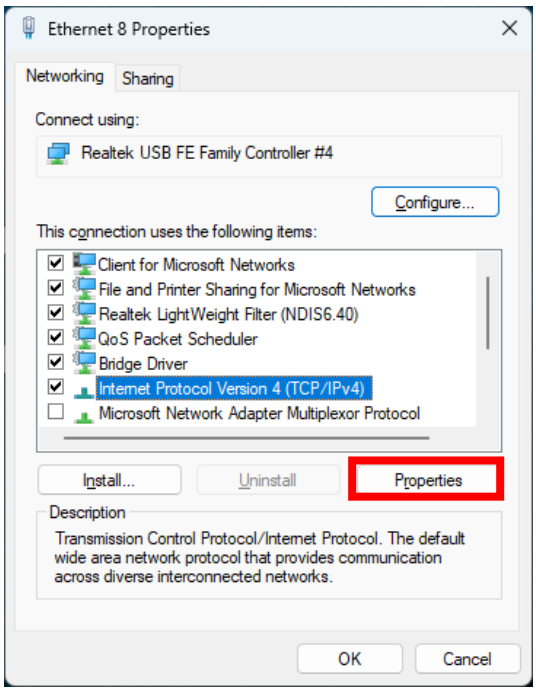
For Ethernet communication with the Bravo, you must configure the Ethernet connection to the PC before attempting to connect through Reach Control.

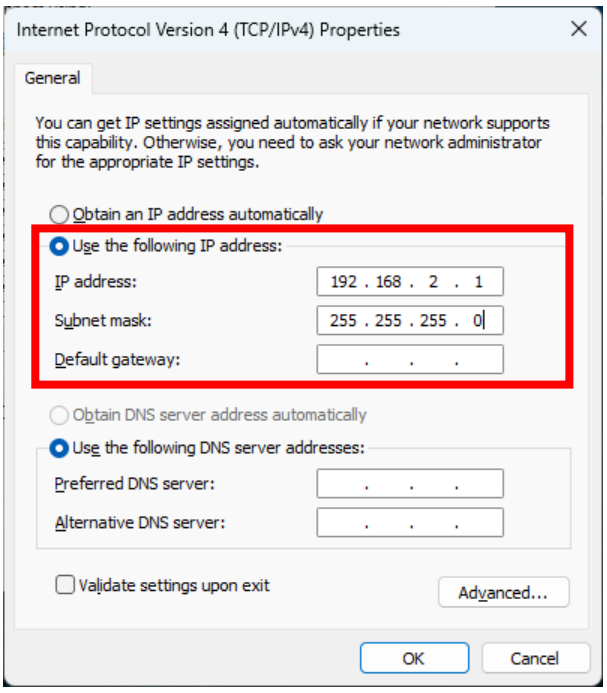
1. On your Windows PC, go to Start > Control Panel > Network and Internet > Network and Sharing Centre > Change Adapter Settings.



2. Double-click the Ethernet connection to the Reach Bravo arm. To check if you have the correct Ethernet connection, unplug and re-plug the cable. The connection should disappear and reappear.

3. Highlight "Internet Protocol Version 4 (TCP/IPv4)" and click "Properties". Select "Use the following IP address", then set the IP address to **192.168.2.1** and the subnet mask to **255.255.255.0**.





4. Click "OK", then close all windows.

Serial comms

There are no initial setup requirements for serial communication with the Bravo.

Reach Control

1. Install Reach Control from the provided .exe file. If you don't have access to Reach Control, download the Lite version from our website, or contact Sales to ask about access to the Pro version.

2. Open the software and go to Settings (cog icon) > Ports > Add. Click the new port and give it a suitable name (default: "Connection 1").

    a. Ethernet comms:
    - Select **UDP** as the communication method
    - Set the IP address to **192.168.2.3** (192.168.2.4 for Bravo 2/3)
    - Set the port to **6789**
    - Select **Full Duplex**

    b. Serial comms:
    - Select correct COM port
    - Select **Full Duplex** for RS232 comms
    - Select **Half Duplex** for RS485 comms

INFO

The Reach Bravo operating system can take up to **60 seconds** to come online when powered on.

2. Go to Settings > Device and select the existing RIGHT ARM device (add a new device if one doesn't already exist).

3. Select the port just created, then select the correct product line and type. If the Bravo has been set up correctly, the 3D model in the background will update to reflect the physical position of the manipulator.

4. Navigate the 3D model with the following mouse operations:
   - Rotate view – left-click and drag
   - Translate view – right-click and drag
   - Zoom – scroll wheel

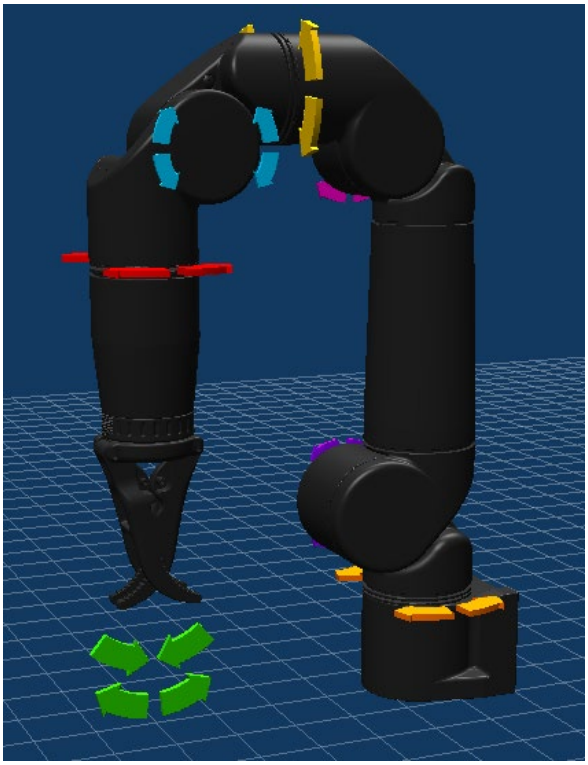
8.2. Acceptance test

8.2.1. Range of motion test

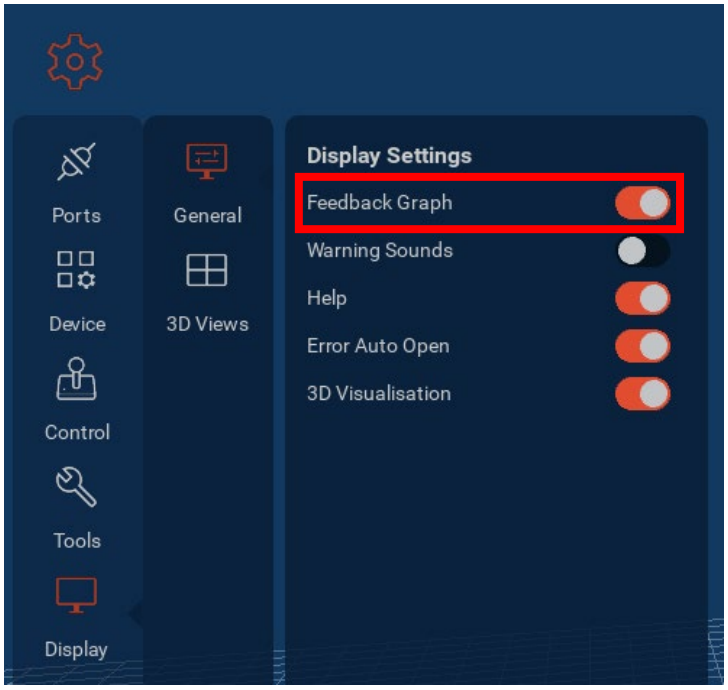
WARNING

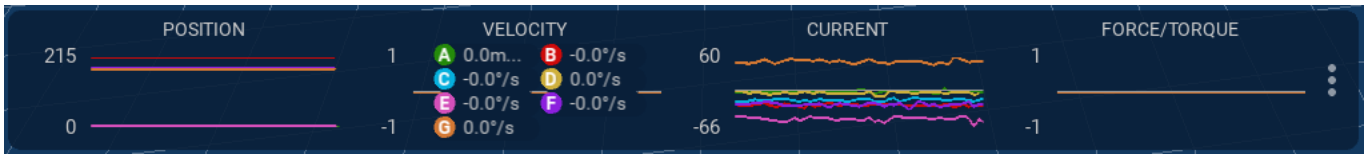
Before carrying out the acceptance test, ensure the Bravo is **securely mounted** and clear of all **potential obstacles** within its range of motion.

1. On the control panel in the bottom right of Reach Control, select "Velocity". Directional arrows will appear on the 3D model.



2. Go to Settings > Display > General > Feedback Graph. The monitoring panel will open at the bottom of the screen. Clicking on any of the graphs will bring up the numeric values for each joint.

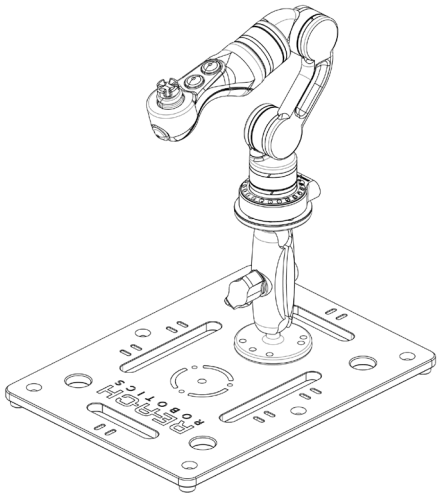




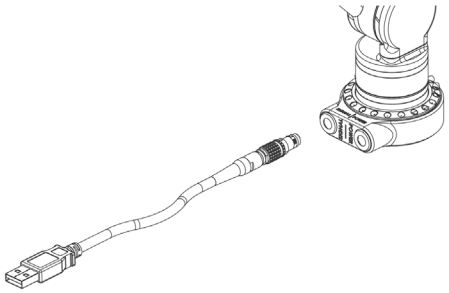
3. **Making sure it is safe to do so**, use the directional arrows on the 3D model of the arm to move each joint for a few seconds in each direction. Ensure the movement is as expected and corresponds with the control input.

8.2.2. Master Arm test (if applicable)

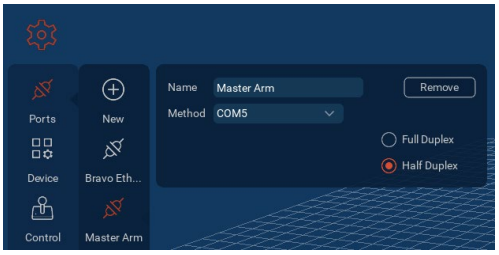
1. Secure the Master Arm mount to the metal stand provided, then attach the Master Arm to the mount using the ¼-20 UNC camera tripod thread in the base.



2. Connect the Master Arm to the PC using the USB cable. Once powered, the buttons on the handle will flash blue.

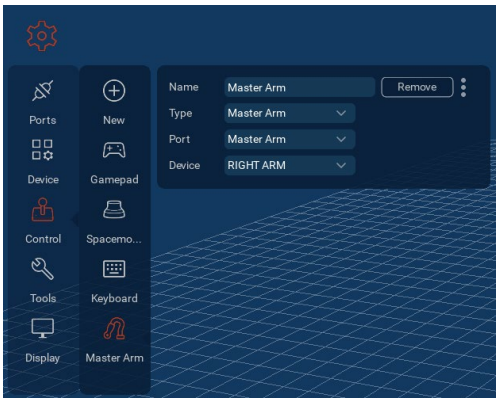


3. In Reach Control, go to Settings > Ports > Add. Click the new port and give it a suitable name. Select the correct COM port and ensure Half Duplex is selected.

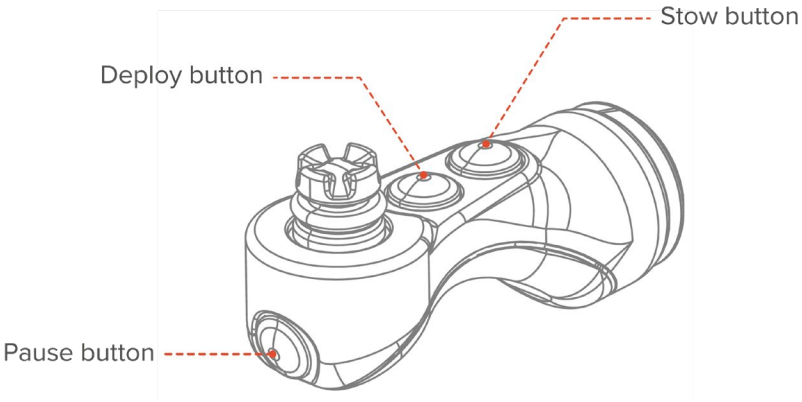


4. Go to Settings > Control and select the existing Master Arm controller (add a new controller if one doesn't already exist).

5. Select the correct product type and the port just created, then select the device you wish to control with the Master Arm.



6. The Master Arm is now ready to control the slave manipulator. **Making sure it is safe to do so**, press the Master Arm pause button to activate the Master Arm. The flashing blue lights will become solid. Double press the pause button to deactivate.



7. Move each Master Arm joint through its full range of motion. Check that:
    a. The corresponding joint on the slave arm responds
    b. The joint moves in the correct direction
    c. The motion of slave to master is a 1:1 ratio
    d. The motion is smooth and complete

8. Press and hold the stow button to ensure the arm stows completely. Release the button to stop the movement. Repeat for the deploy button.

9. Whilst moving the arm, press and hold the pause button, ensuring the arm stops responding while the button is held down. Releasing the button will engage movement again.

This completes the acceptance test for the Bravo and Master Arm.

9. Bravo accessories

The datasheets and manuals for all Bravo accessories can be downloaded from our website.

9.1. Wrist camera (RB-1057)

The Bravo wrist camera is a 2MP IP camera that connects to the accessory port connector in Joint C of the Bravo 5 and 7 to provide a video feed of the end-effector area for the Bravo operator. The Bravo must be connected via Ethernet for the wrist camera to connect, and we recommend having a connection bandwidth of 100 Mbps or higher.

CAUTION

When you remove the cap from the Joint C accessory port connector, ensure you either replace it or install a wrist camera/accessory port. Leaving the accessory port connector open to the air can result in loss of vacuum from Joint C.

9.2. Accessory port (RB-1006)

The accessory port allows integration of third-party instruments (e.g. probes and cameras) onto the Bravo. It provides an 8-pin female connector (MCBH8F) with 12-24 VDC of power and communications over either 100Mbps Ethernet or RS485.

9.3. Bravo hub (RB-1080)

The Reach Bravo Hub allows communication with multiple third-party payloads including sensors, probes, tethers and numerous Bravo-class manipulators from a single source. Comprising a network switch and RS-485 link, the hub provides up to four ethernet and power connections to Bravo manipulators and accessories.

9.4. Payload interface (RB-1054)

The Payload Interface add-on allows attachment of external sensors and tools to Reach Bravo manipulators. Replacing the jaws at the end-effector, the plate design makes it easy for developers to securely integrate their own payloads to the manipulator system.

10. Manipulator maintenance

Preventative maintenance is strongly recommended to keep your manipulator functioning as intended and to avoid unscheduled downtime and expensive repairs. Follow the steps in this section to prolong the life of your manipulator.

It is also recommended to conduct a regular Acceptance Test (Section 8.2) to check all joints for abnormal behaviour.

10.1. General manipulator care

Reach Robotics manipulators are intended for use in water or air. Other fluids may have an adverse effect on the materials used in their production.

Cleaning

- Manipulators should be cleaned thoroughly after every deployment, dry or wet.
- After immersion in salt-water, wash manipulators in fresh water to prevent salt deposits and corrosion.
- Remove all debris from the manipulator, focusing particularly on joint closures and jaws to preserve sealing surfaces.
- Do not use harsh chemicals to clean any Reach Robotics manipulators.

Connector care

- Keep connectors covered with provided bulkhead protectors at all times when not in use.
- Regularly check connector pins for signs of damage or corrosion.
- Ensure female connectors are free of debris – flush with compressed air if necessary.
- Apply silicon grease to both male and female connectors prior to every mating – ensure female connector sockets are greased to 1/10-1/3 of socket depth.

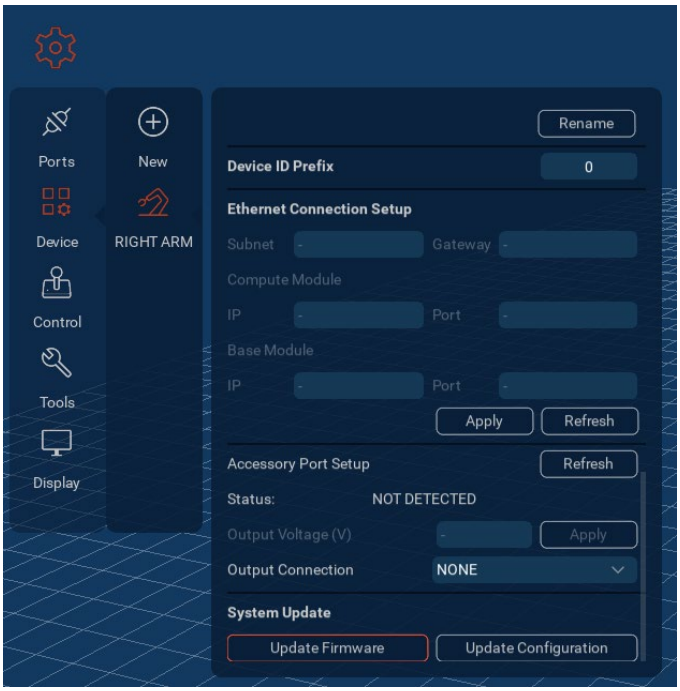
Cable care

- Avoid exceeding the bend radii given in Section 6.
- When de-mating connectors, pull the connector rather than the cable to remove it.
- Consider strain relief methods if using externally powered tools at the end-effector of the manipulator.

10.2. Firmware updates

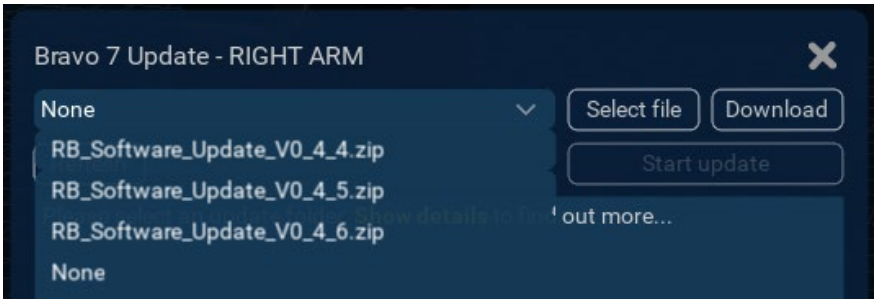
We recommend regularly checking for firmware updates using Reach Control to gain access to upgrades and bug fixes.

With the manipulator is connected via Ethernet, go to Settings > Device > RIGHT ARM, click the ellipsis […] in the top right corner to expand the panel, then scroll down to "Update Firmware".

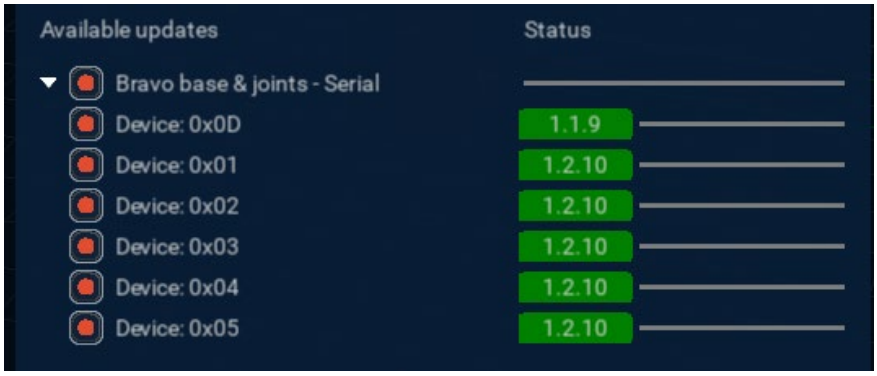


There are three ways to update the firmware from the panel that opens:

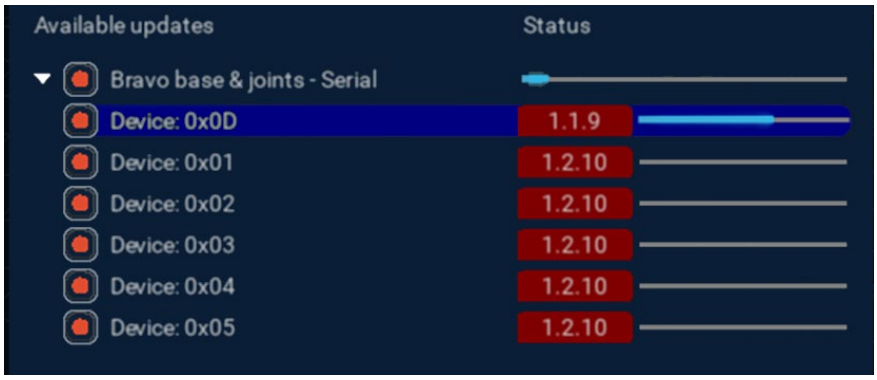
1. Click "Download" to retrieve the latest software from the Reach Robotics server. Your PC must be connected to the internet.
2. Click "Select file" to choose a .zip file containing the firmware you want to upload.
3. Select an existing .zip file from the drop-down menu.



Once you have selected the correct firmware file, ensure that all the joints are selected under the available updates.



Click "Start update". **Do not disconnect the Bravo during the update.** The joints will now update one-by-one.



When all the joints have updated and you get a success message, you can close the Firmware Update panel.

10.2.1. Firmware update errors

When updating the firmware, you may encounter the following errors:

Error/warning message	Solution
Error: Connections of type […] are not supported.	The device port has not been selected. Check that the connection is secure and try again.
Error: Bad zip file.	The .zip file selected is empty or corrupted. Download again or contact Support for assistance.
Error: Unable to get software version from device 0x1, 0x2, 0x3, 0x4,…	Check that the device is powered. If the device is powered correctly, contact Support for assistance.
Error: Unable to Update. Select **Refresh** to try again.	The update cannot go through. Click Refresh to try again. If unsuccessful, contact Support.
Warning: No valid software files found.	The .zip file selected doesn't have valid software files inside it. Check that the file is complete and uncorrupted.

10.3. Changing IP address

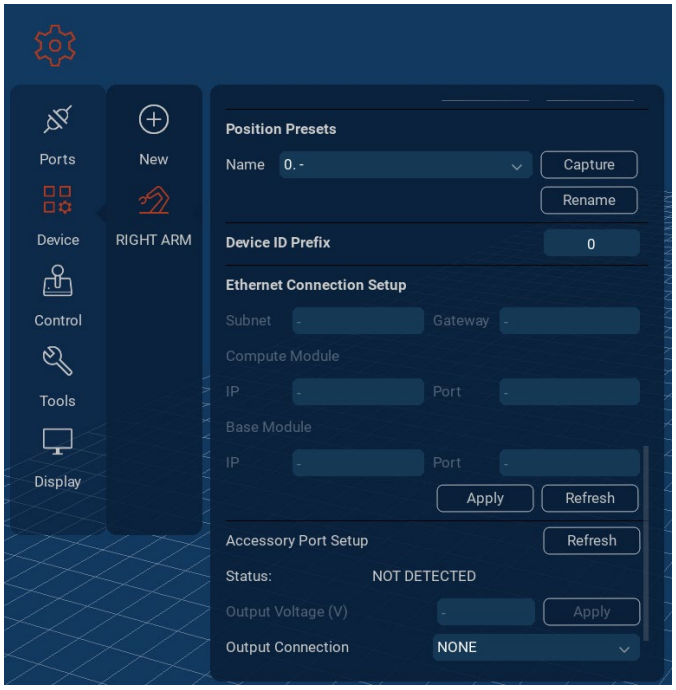
You can change the IP address of the Bravo manipulator to integrate it into an existing Ethernet system.

Connect the Bravo over serial comms to Reach Control. Go to Settings (cog icon) > Device > RIGHT ARM. Click the ellipsis [...] in the top right corner of the device panel, then scroll down to **Ethernet Connection Setup**. Change the IP address, port, subnet and gateway as required. Powercycle the unit to apply the new settings, then connect over Ethernet using the new details.

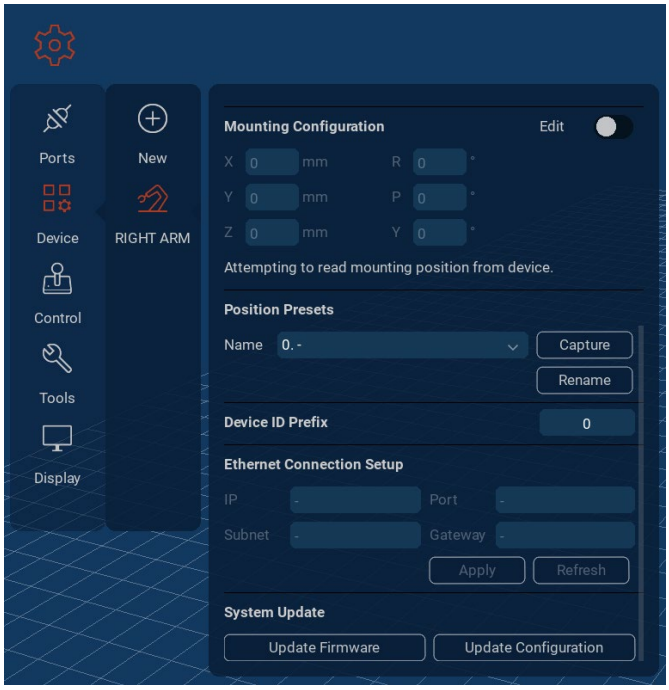
INFO

The Bravo 5 and 7 variants have two IP addresses over which they can be connected, while the Bravo 2 and 3 variants have one.

Bravo 5/7 defaults: 192.168.2.3 Compute, 192.168.2.4 Base
Bravo 2/3 default: 192.168.2.4 Base



Change IP address for Bravo 5/7



Change IP address for Bravo 2/3

10.4. Replacing joints

The Reach Bravo has been designed so users can replace joints in the field if they suspect a fault with a particular part of the arm. This reduces downtime by avoiding a full RMA procedure (see Section 10.6).

The Bravo Servicing and Spares kits can be purchased by contacting our Sales team, and a full instruction manual will be provided alongside.

10.5. Servicing

Subsea electric manipulators contain several drivetrain mechanisms which require servicing to preserve their performance and value. Like cars, if servicing is ignored, wear and tear can lead to unexpected field failures, downtime, and more expensive repairs.

Reach Robotics recommends you service your Reach Bravo manipulator after 10,000 joint revolutions or 2 years, whichever comes first. Joint revolutions are the number of times a joint has travelled 360° around its axis. If you

have a Bravo manipulator that was manufactured from April 2022 onwards, you can check the number of joint revolutions via the Health Panel in the Reach Control software (V3.4.3 onwards). For Bravo products manufactured prior to April 2022, a self-assessment will need to be made based on your history of usage.

Please see this article on our Help Centre for more information, including what a service involves and current lead times.

10.6. Repairs

If your Reach Robotics equipment becomes damaged or faulty, it may need to be returned to Reach Robotics for investigation and repair under a Return Merchandise Authorisation (RMA). Only a Reach Robotics engineer may authorise a return to our factory; the requirement may be determined through a phone call, email, or video call/remote access to the unit. If you suspect that an RMA may be required, please contact Reach Robotics Support.

10.6.1. RMA process

The RMA process will cover the following steps:

1. Reach Robotics Support will request details of the issue to determine whether a return is necessary.
2. If so, an RMA Number (RMAXXXX-YYMMDD) will be issued to you, and the Reach Robotics engineer will request shipping details so we can organise a pickup of the equipment. **Do not send the equipment prior to being issued an RMA Number.**
3. The equipment will be shipped to Reach Robotics Headquarters in Sydney, Australia (see Note 4).
4. Our Production team will conduct an initial investigation on the unit, based on the information provided. This will take an estimated 1-2 weeks. Any delays due to the complexity of the problem will be communicated to you.
5. After the initial investigation, Reach Robotics Support will contact you with the findings of our Production team. If the unit is not under warranty, a quote for the repair work and shipping costs will be included. If the unit is under warranty, you will be notified, and the repairs will be carried out free of charge.
6. To authorise a non-warranty repair, send a PO for the work to Reach Robotics Support (see Note 3). Once this is received, the repair work will start, and our Accounts team will send an invoice to you.
7. Typical repair times vary post-investigation, and the exact length of time required for the repair will depend on the product being repaired, the complexity of the repair, and the availability of spare parts.
8. Any delays to the expected shipping date will be communicated to you. Priority service may be possible; please discuss this with your usual Reach Robotics Sales Engineer.
9. When the repair is completed, our Warehouse Manager will organise returning shipping and contact you with a ship date and tracking information (see Note 4).

10.6.2. Additional Notes

1. Standard Warranty of 1-year from date received is provided on all new Reach Robotics Products.
2. There is no warranty extension for units following an RMA unless extended warranty has been purchased prior to the RMA being raised.
3. If the nature of the repair is such that you feel it is uneconomical to carry out the work, a discount on a new unit may be possible; please discuss this with your usual Reach Robotics Sales Engineer. This remains at Reach Robotics' discretion, and no discount is guaranteed.
4. All RMAs are shipped CPT. Any insurance desired by the customer is the customer's responsibility and Reach Robotics can take no responsibility for shipment losses.

11. Declaration of incorporation

EU DECLARATION OF INCORPORATION OF PARTIALLY COMPLETED MACHINERY

The Manufacturer: Reach Robotics PTY LTD of 3 Queen St, Glebe, NSW 2037, Australia,
And,
Authorised Person: Kyle McLean of 3 Queen St, Glebe, NSW 2037, Australia,
Hereby declare that a declaration of incorporation has been issued for the following partially completed machinery:
Product Description: Subsea robotic manipulator
Product Code: RB-XXXX including RB-7204, RB-7203, RB-7202, RB-7201, RB-7003, RB-5202, RB-5201, RB-3001, RB-2130, RB-1100
Product Name: Reach Bravo
Product Versions: Up to and including V012

This partially completed machinery is in conformity with the following directives and standards:

2001/95/EC – General Product Safety

2011/65/EU – Restriction of the use of certain hazardous substances (RoHS)

2006/42/EC – Machinery (MD)

EN ISO12100:2015

The relevant technical documentation is compiled in accordance with part B of Annex VII of 2006/42/EC and in response to a reasoned request by the market surveillance authorities, relevant information on the partly completed machinery shall be provided.

This declaration of incorporation of partially completed machinery is issued under the exclusive responsibility of the manufacturer and is provided with the understanding that the partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of all required directives.

Reach Robotics PTY LTD
Kyle McLean
Sydney Australia
06 June 2024

12. Revision history

Version	Date	Author	Notes
V001	26/05/2020	Anders Ridley-Smith	Initial version
V002	25/08/2020	James Spinks	Inclusion of Bravo 2 and 3 Electrical diagrams Setup and integration information Acceptance testing
V003	15/04/2021	James Spinks	Bravo 2/3 module breakdown and mounting kit diagrams Stainless steel jaws added Servicing schedule and Support program
V004	03/08/2022	James Spinks Ethan Grenot	Integrated Bravo V010 changes Updated formatting
V005	23/08/2023	James Spinks Ellie Best	Branding/diagram/software updates Serial connection details Master Arm acceptance tests
V006	27/06/2024	Ellie Best Kyle McLean	Layout change Updated safety information Reach Control V3 screenshot updates Servicing schedule update Manipulator maintenance Additional information regarding EU compliance Information merged from existing Reach Bravo Safety Manual Added page numbering for user reference
V007	24/07/2024	Kyle McLean Ellie Best	Clarification of risk from magnetic fields How to change IP address