

REACH **BRAVO** _____

INTEGRATION MANUAL

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*Note: Jump to **Section 6: Bench Setup and Acceptance Test** for instructions on how to setup your manipulator.*

1 SAFETY INFORMATION

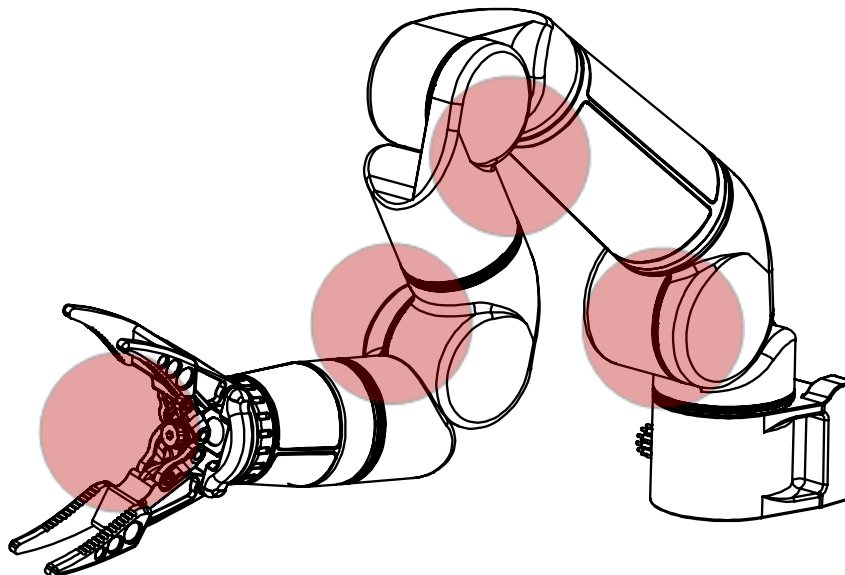
This section describes the necessary safety information and precautions relevant to the setup and operation of the Reach Bravo manipulator system. To ensure correct and safe use of Blueprint Lab manipulators, carefully read this section and make yourself well acquainted with the contents. Follow any 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 technical supplement may result in damage to the robot or injury to personnel.

1.1 CRUSH POINTS AND COLLISION HAZARDS



Crush hazards exist on the Reach Bravo in locations where two limbs can compress together as well as in the jaws of the grabber stage of the manipulator. It is important that the operator ensures the working area of the manipulator is clear prior to operation.



1.2 SHOCK HAZARD



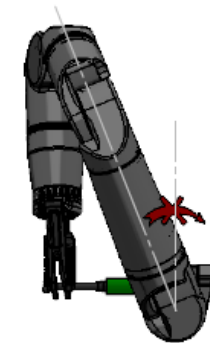
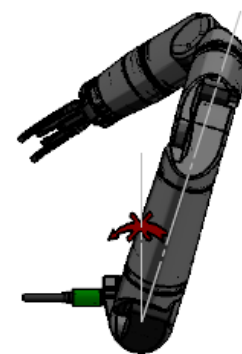
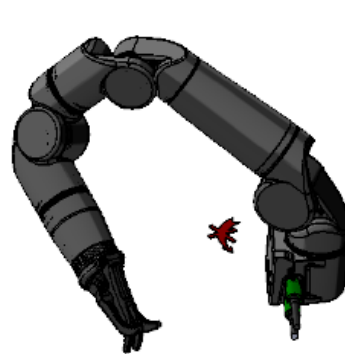
There should be no attempt made to remove the external housing of the manipulator to expose the internal circuitry. Doing so could cause injury or fatality by electrical shock.

1.3 BACKDRIVABILITY WARNING

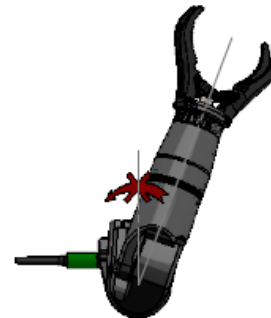
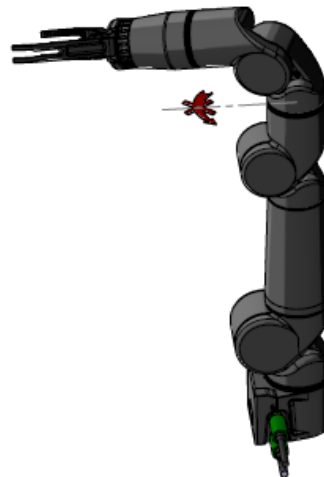
Axes G and D (see diagram below) use a software limits to ensure they do not rotate beyond their described Range of Motion. When power is off, this software limit is inactive allowing the joint to be rotated past its limit.

When the arm is powered on, it does not know it has been rotated past its limit and will continue as normal. This can cause damage to the joint.

Do not backdrive The G axis
beyond its limit!!



Do not backdrive The D axis
beyond its limit!!



1.4 LEAK DETECTION

All Reach Bravo products have an internal vacuum pulled inside the modules of the manipulator. This vacuum is monitoring by an internal Leak Detection System. If there is a breach in the vacuum, this message will appear in the help menu of Reach Control.



It is important that users do not remove any of the internal screws of the port, at the risk of releasing the modules vacuum.

1.5 SERVICING SCHEDULE

Blueprint Lab have a recommended servicing schedule for manipulator products of 1 year or 200 operational hours, whichever occurs first. Adhering to this servicing schedule ensures Blueprint Lab manipulators maintain their performance within the operational specification and reduced the risk of failure in the field.

1.5.1 BRAVO SERVICING OVERVIEW

System Item Procedure Description

<u>System</u>	<u>Item</u>	<u>Procedure Description</u>
<i>Subassembly Mechanical</i>	O-rings	Replace
	Gears	Clean and re-lubricate
	Keyway systems	Check backlash and tune
	Crimps, connectors and wire harness	Visually Inspect
	Internal Fasteners	Replace and apply Loctite
<i>Subassembly Electrical</i>	Motors	Check output torque
	Electrical Board	Check indicators and functionality
	Encoders	Visually Inspect and recalibrate if required.
	Encoder boards	Check indicators and functionality
<i>Subassembly Software</i>	Software Revision	Upgrade to latest software
	Configuration Settings	Check and update if required
	Kinematics	Check and update if required
<i>Whole</i>	Anodising	Visually Inspect
	External fasteners	Replace
	Quality Control	Perform Outgoing quality control and provide

Any additional rectification work required will be assessed and quoted during the servicing process.

1.6 OBSTACLE SETUP

Ensure that the manipulator is setup correctly using the bench test and platform integration procedures shown elsewhere in this manual. In particular, care should be taken to ensure that permanent obstacles in the workspace are correctly defined to avoid collision between the manipulator and other equipment. The manipulator arrives with a 'floor' obstacle installed to avoid collision with the bench/test platform.

1.7 EMERGENCY STOP

It is strongly recommended that an ESTOP button is included in the power circuit when bench level testing the manipulator. Additionally, a digital ESTOP is included in the Reach Control software.

1.8 ELECTRICAL INSTALLATION

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.

1.9 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.

1.10 OPERATING ENVIRONMENT

1.10.1 OPERATING AND STORAGE TEMPERATURE

The manipulator system is specified for use from -10°C to 40°C (operating) and up to 80°C storage.

1.10.2 PRESSURE

The Reach Bravo is Depth Rated to operate at the equivalent of 300MSW.

1.10.3 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.

2 PRODUCT OVERVIEW

The Reach Bravo is an advanced electric manipulator system that opens a new set of compact inspection and intervention opportunities for militaries, service providers, researchers, and other operators.

Designed originally for the harsh subsea environment, and with an operating depth of 300m, the Reach Bravo is also suitable for austere out-of-water applications.

With a highly modular design, the Reach Bravo is available in configurations ranging from a single-function grabber (linear) or rotate actuator up to the seven-function Bravo 7. The Reach Bravo range is a one-stop-shop for multiplying the manipulation capability of your inspection class vehicle or other platform.

MAIN PRODUCT FEATURES

- Master Arm Enabled
- 300m Depth Rated
- All-Electric, Zero Oil
- Accessory Port for Camera, Lights, and other Sensors/Tools
- Embedded NVIDIA TX2 (5/7F Only) for Real-Time Perception and Control
- Adjustable Grab Force
- On-board Kinematics
- Workspace Obstacles
- Collision Protection
- One-click deploy/stow position

2.1 AVAILABLE CONFIGURATIONS



Bravo 7 – Seven-Function Manipulator
RB-7001



Bravo 5 – Five-Function Manipulator
RB-5001



Bravo 3 – Three-Function Manipulator
RB-3001



Bravo 2 – Two-Function Manipulator
RB-2001

2.2 END-EFFECTOR OPTIONS

Wide Quad Jaws
RB-1025



Interlocking Quad Jaws (Stainless Steel option)
RB-1041 (RB-1055)



Parallel Jaws
RB-1034



Cutter
RB-1031

Image Not Available

2.3 RELATED PRODUCTS AND ACCESSORIES

See respective manuals of related products for details.

Master Arms
RM-5201 and RM-7201



Reach Control Pro
RC-2000



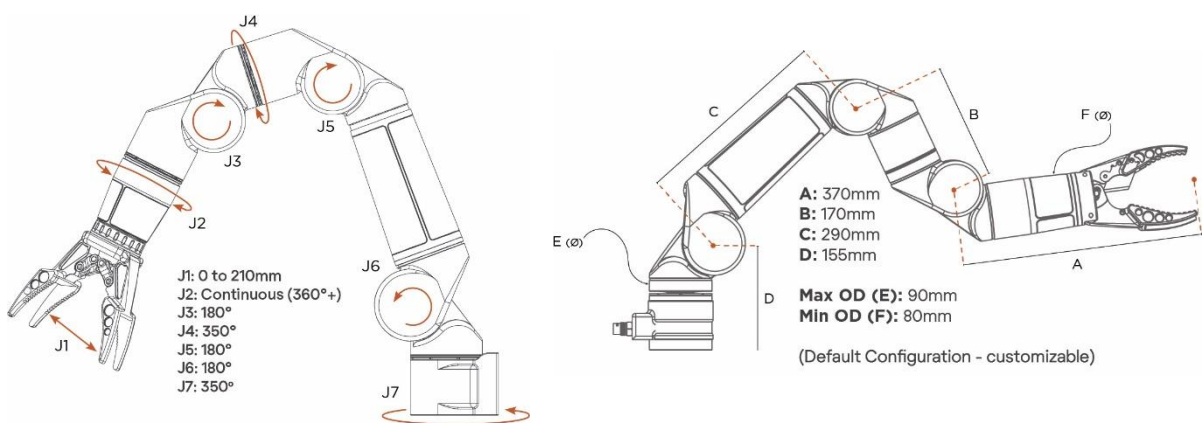
3 SPECIFICATIONS

3.1 MECHANICAL

	Bravo 7	Bravo 5	Bravo 3	Bravo 2
Functions	7	5	3	2
Degrees-of-Freedom	6	4	2	1
Full-Extension Reach	900mm	750mm	410mm	320mm <i>(static)</i>
Dynamic Full-Extension Lift	10kg	12kg	15kg	N/A
Base Joint Torque	110Nm		50Nm	N/A
Max Dynamic Lift	15kg	20kg		N/A
Max Axial Load	100kg			200kg
Wrist Torque	20Nm			
Linear/Grabber Force	1000N			
Weight (in Air)	9kg	7.5kg	3.8Kg	2.7Kg
Weight (in Water)	4.5kg	4kg	2.6kg	1.6kg
Joint Speed (24-48V)	45 - 80 deg/s			
End-effector Repeatability	<1cm			N/A

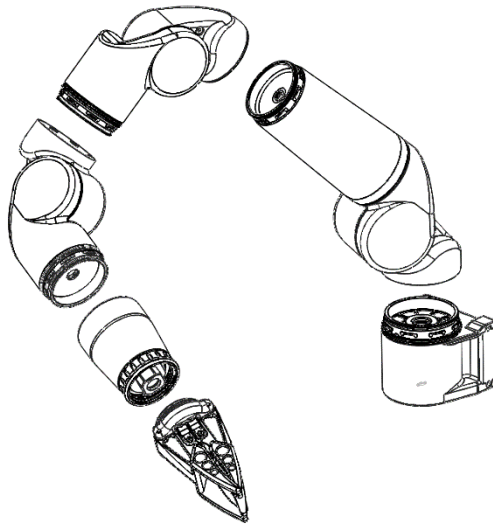
3.2 DIMENSIONS, MODULES AND RANGE OF MOTION

3.2.1 BRAVO 7

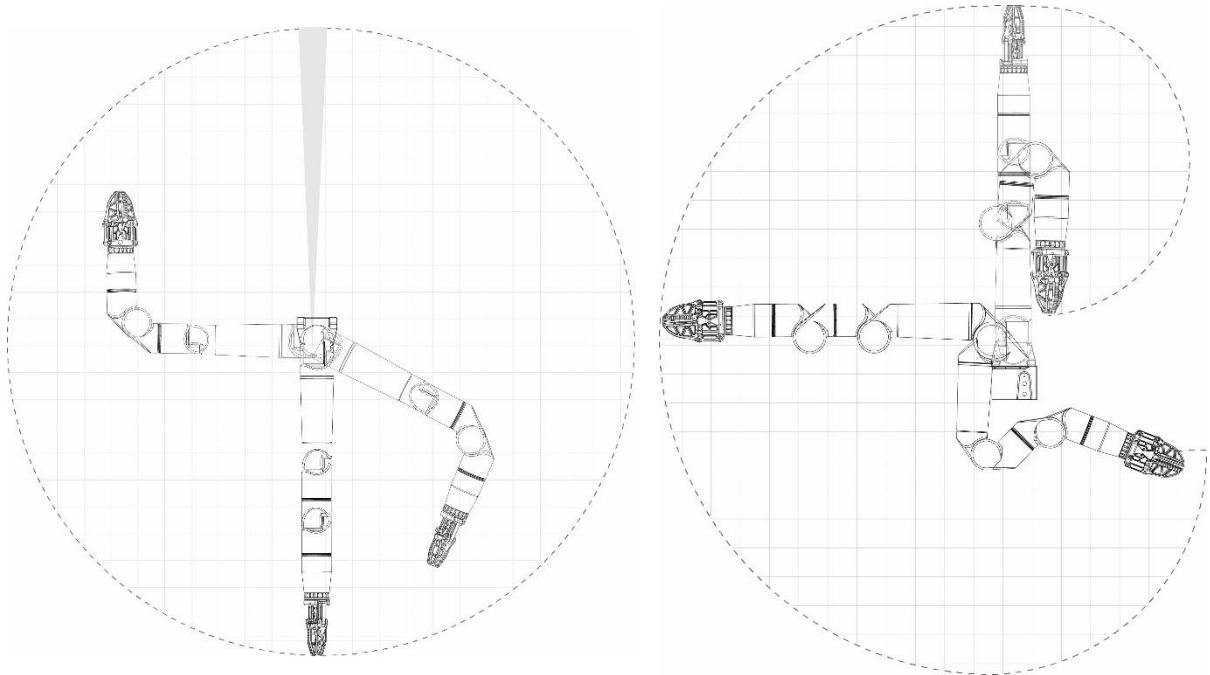


Bravo 7 – Dimensions and rotational capacity.

Note: Base joint is software limited to 359° (not continuous).

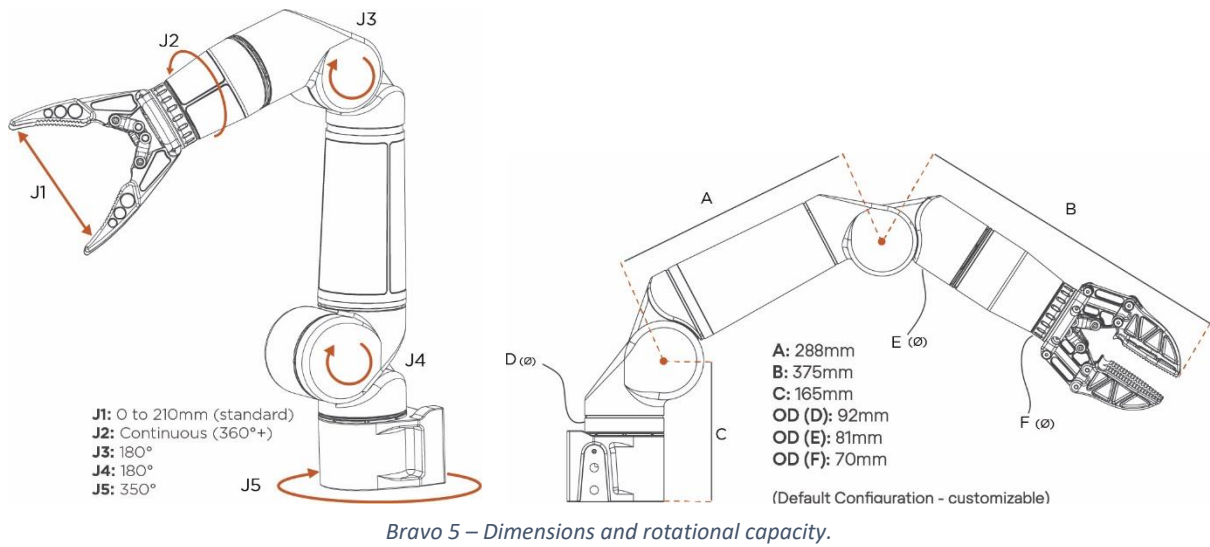


Bravo 7 – Module breakdown.

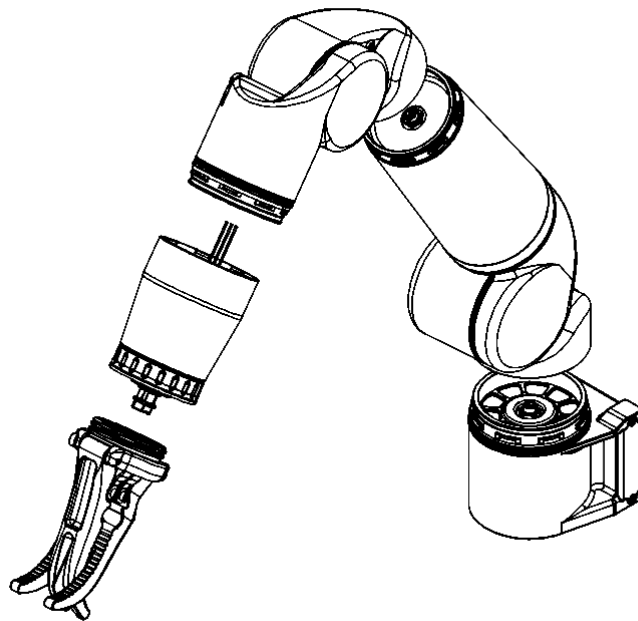


Bravo 7 – Range of Motion top view (left) and side view (right).

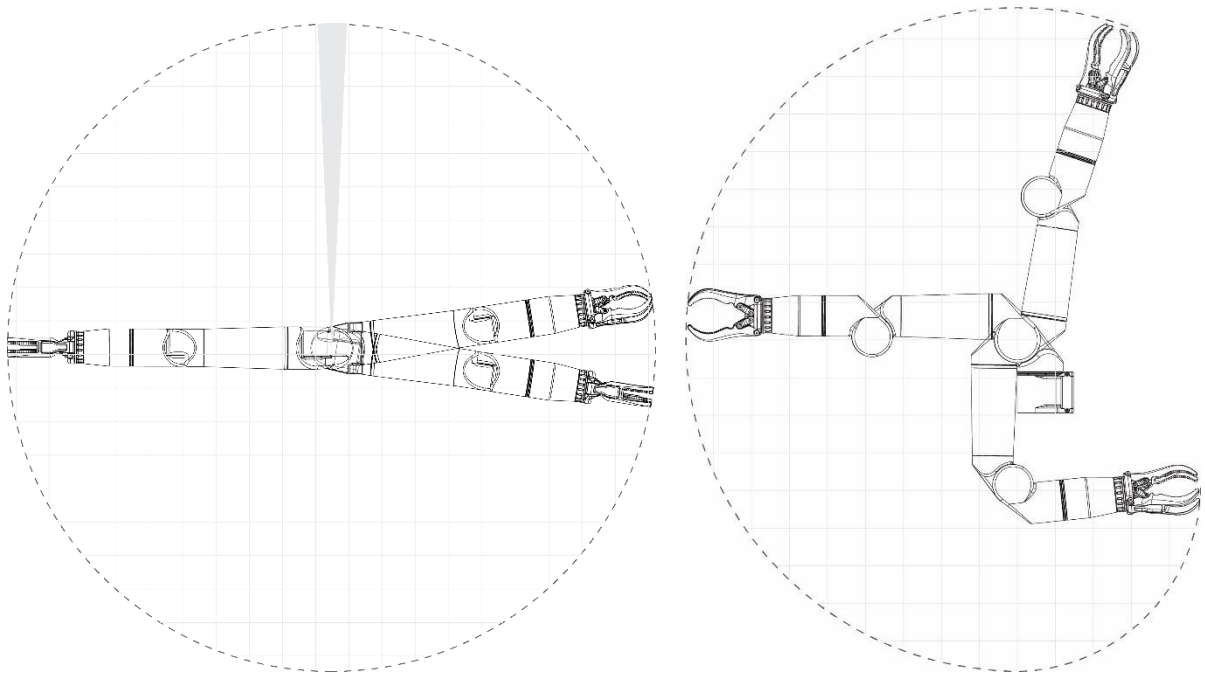
3.2.2 BRAVO 5



Note: Base joint is software limited to 359° (not continuous).

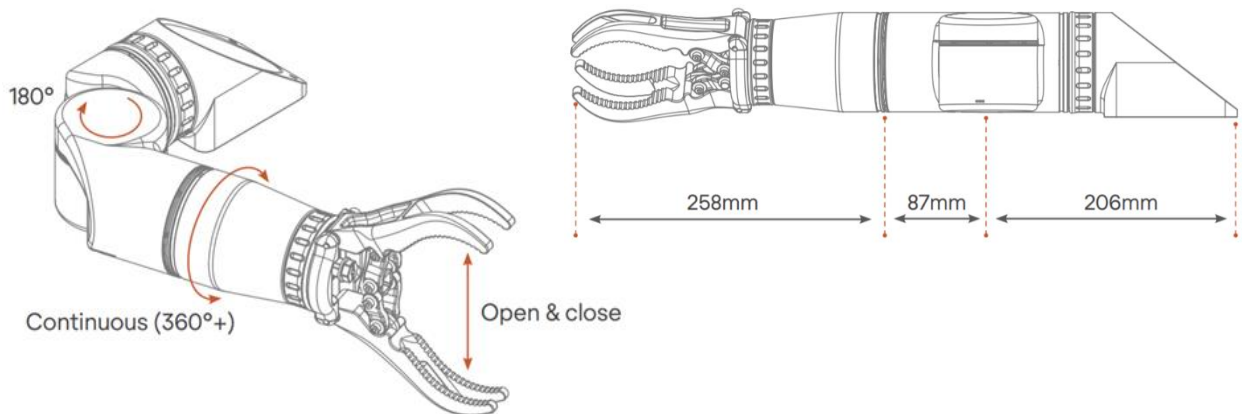


Bravo 5 module breakdown.

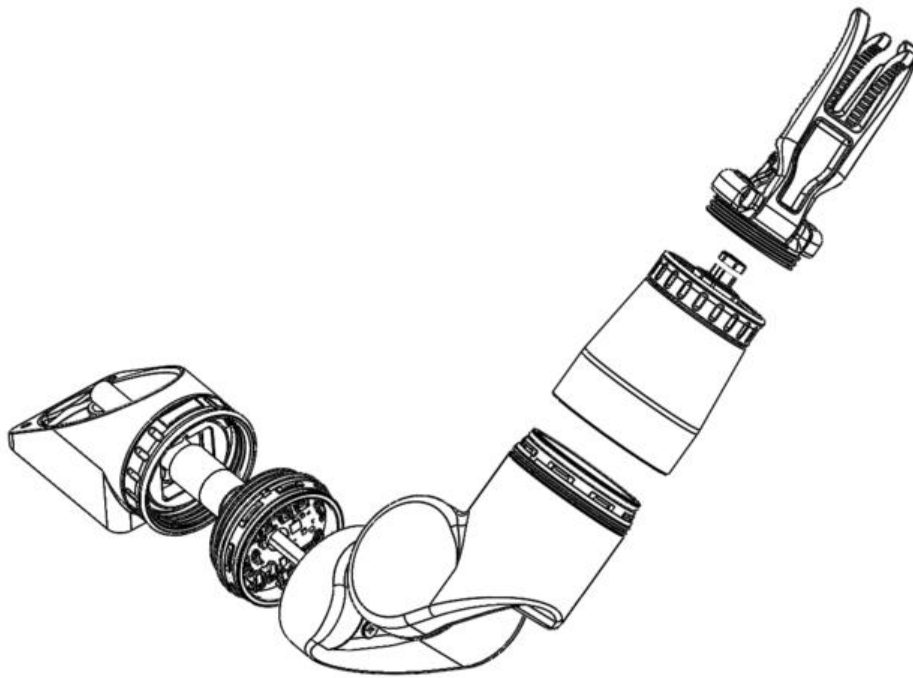


Bravo 5 – Range of motion top view (left) and side view (right).

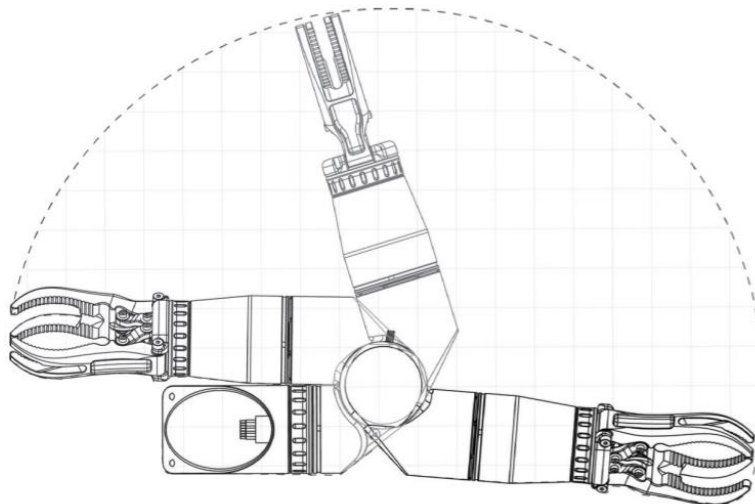
3.2.3 BRAVO 3



Bravo 3 – Dimensions and rotational capacity

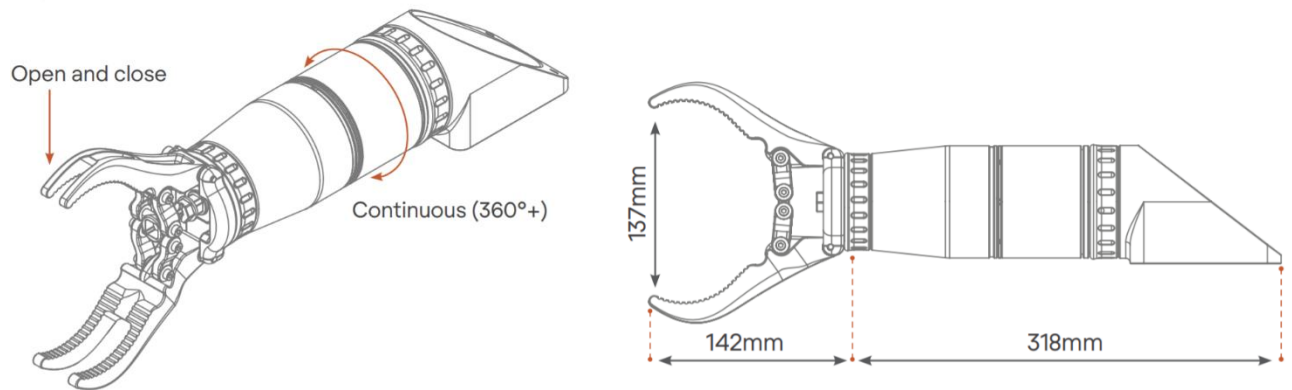


Bravo 3 – Module breakdown

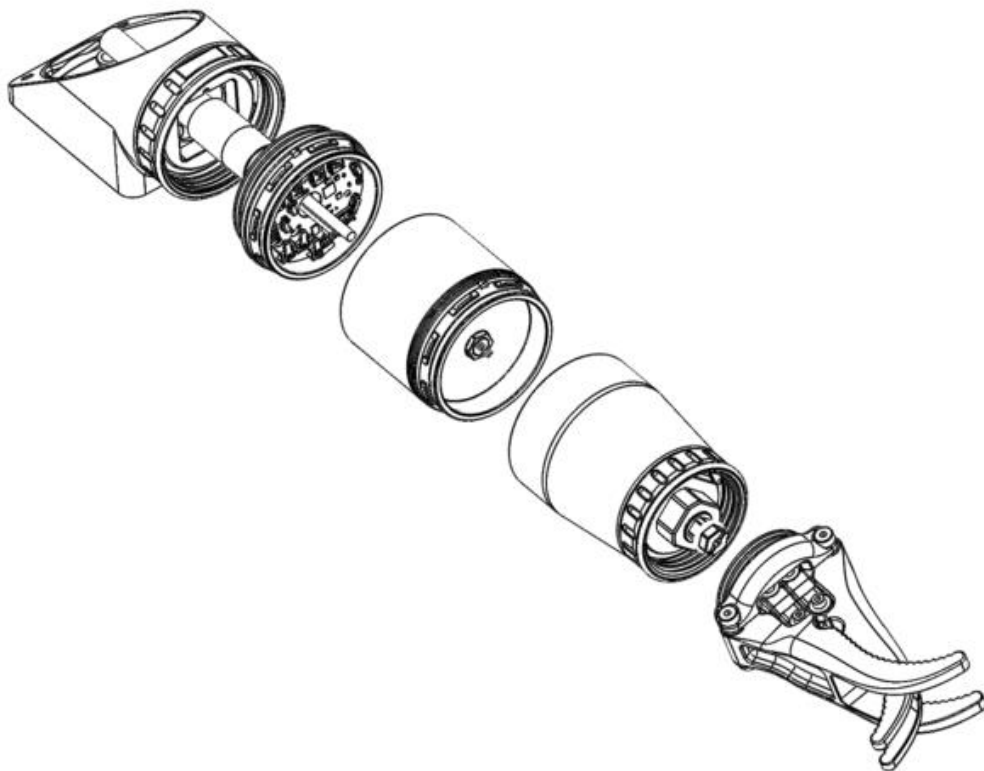


Bravo 3 – Range of motion of the Bravo 3 (top view)

3.2.4 BRAVO 2



Bravo 2 – Dimensions and rotational capabilities.



Bravo 2 – Module breakdown

Note; Bravo 2 Range of Motion is limited to the continuous rotate joint only.

3.3 ENVIRONMENTAL

Operating Temperature Range	-10°C to 35°C
Storage Temperature Range	-10°C to 70°C
Depth Rating	300MSW
Housing Material	Hard Anodized AL6061

3.4 ELECTRICAL AND COMMUNICATION

3.4.1 POWER INTERFACE

	Bravo 7	Bravo 5	Bravo 3	Bravo 2
Input Voltage	20-48V	20-48V	24-48V	24-48V
Power Draw (Nominal with 10kg)	200W	200W	60W	60W
Power Draw (Max with 10kg)	300W	300W	150W	N/A

3.4.2 COMMUNICATION INTERFACE

Processor	NVIDIA TX2
Interface Low-level Protocol	Ethernet, RS485, and RS232 (<i>for units shipped Dec 20 onwards</i>)
Proprietary Communication Protocol	Blueprint Lab Reach System Communication Protocol Document (<i>BPL-RCPD</i>)

3.5 KINEMATIC, DYNAMIC, DH PARAMETERS, AND OTHER PROPERTIES

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

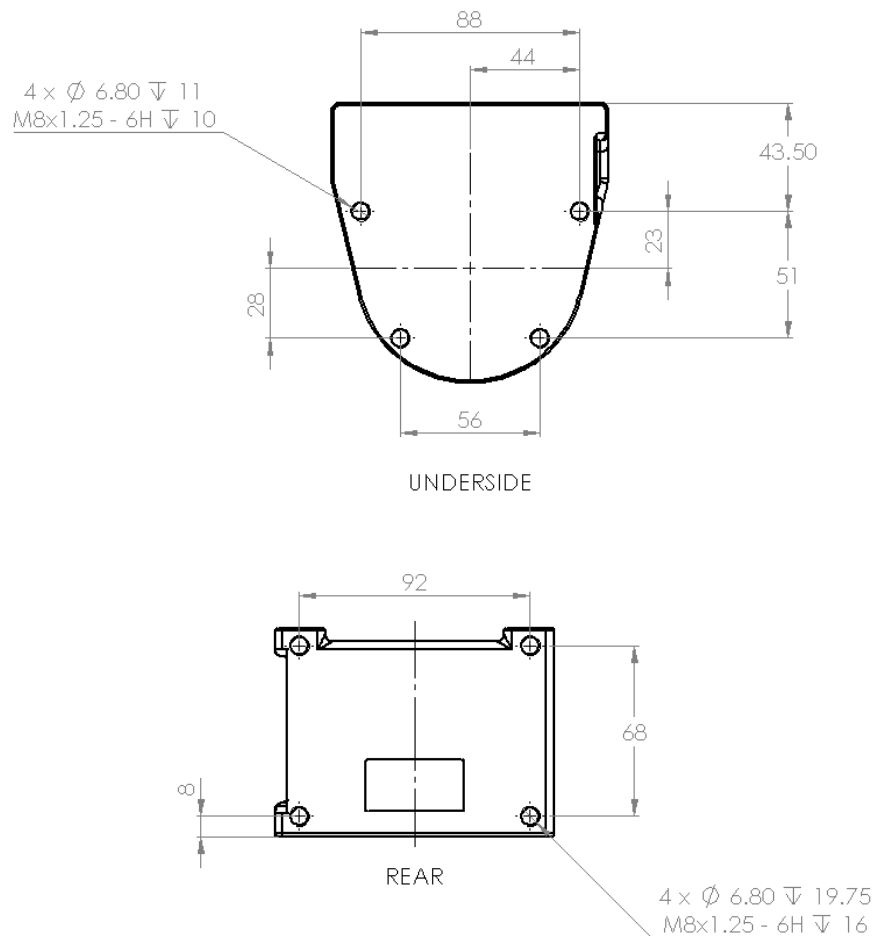
4 INTERFACING AND INTEGRATION

Note: 3D CAD files for our manipulators are available upon request to assist with integration.

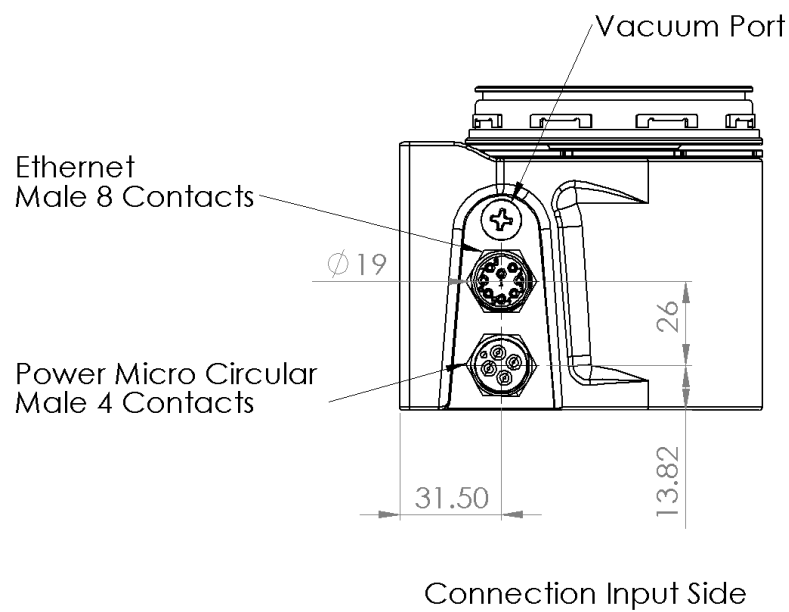
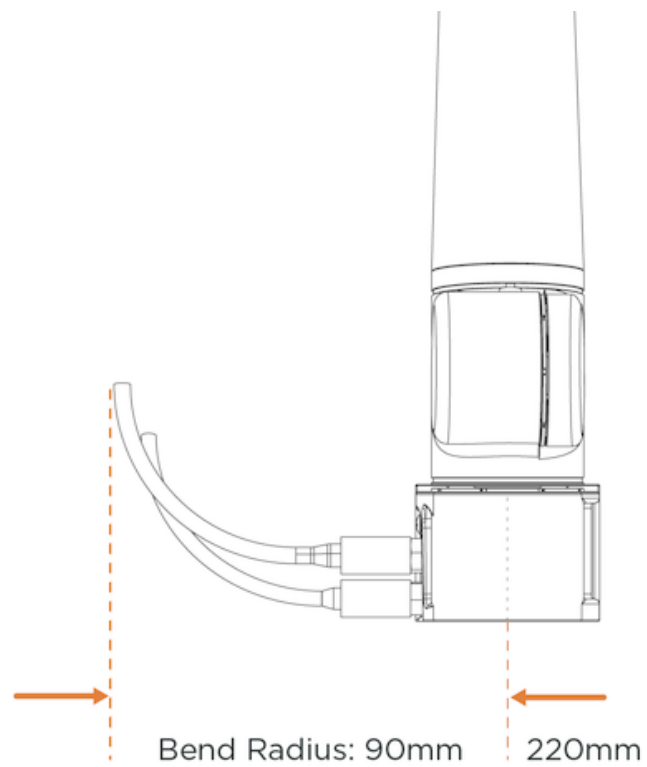
4.1 BRAVO 5 / BRAVO 7

4.1.1 MECHANICAL

MANIPULATOR BASE INTEGRATION



CONNECTOR CLEARANCE



4.1.2 ELECTRICAL

POWER CONNECTOR - DWTEK MCBH4M

Bulkhead Connector Receptacle

Male Face View



Pins	Description	Colour
1	GND	Black
2	POWER	White
3	POWER	Red
4	GND	Green

Interface Cable (Supplied)

MCIL4F - MC Inline, 4C Female to unterminated ends (100cm)

COMMUNICATION CONNECTOR – DWTEK MCBH8ME

Bulkhead Connector Receptacle

Male Face View



1-2 Brown, Light brown * 5-6 Orange, Light orange *
3-4 Blue, Light blue * 7-8 Green, Light green *
* Twisted pairs

Pins	Description	Colour
1	RS485 A	Brown
2	RS485 B	Light brown
3	RS232 TX (data to vehicle)	Blue
4	RS232 RX (data from vehicle)	Light blue
5	ETH RX-	Orange
6	ETH RX+	Light orange
7	ETH TX-	Green
8	ETH TX+	Light green

Interface Cable (Supplied)

MCIL8FE10 - MC Ethernet Inline, 8C Female to unterminated ends (100cm).

4.1.3 COMMUNICATION PROTOCOL

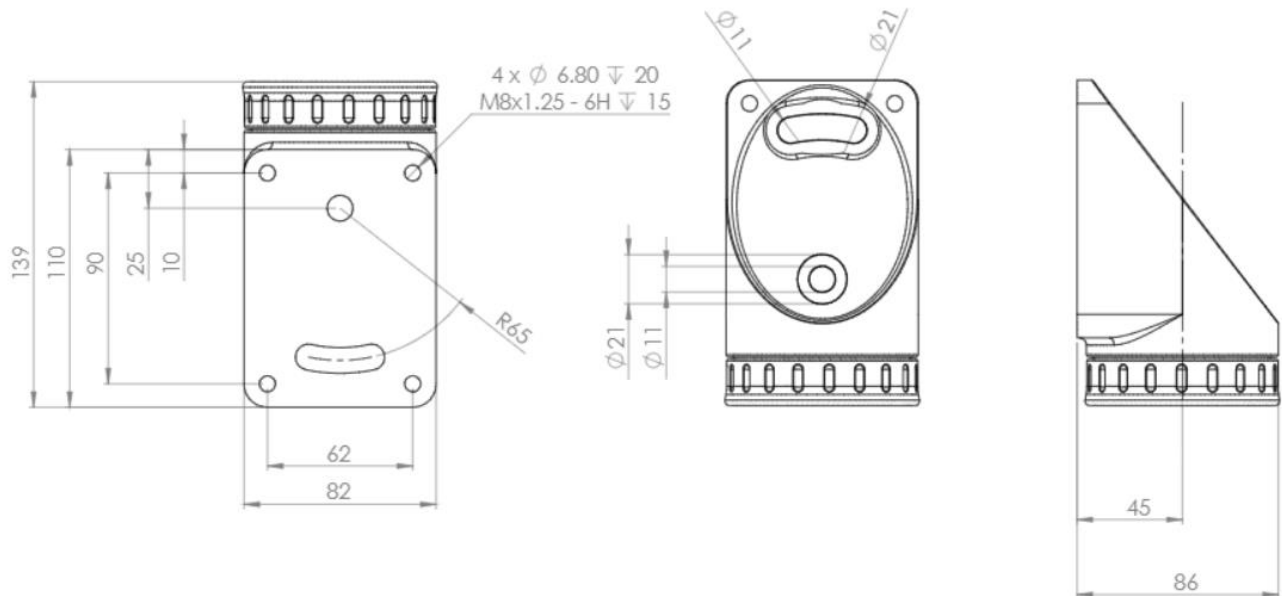
Full details of the communication protocol are found in the Reach Communication Protocol Document (*BPL-RCPD*) (*Contact Blueprint Lab for further details*).

4.2 BRAVO 2 / BRAVO 3

4.2.1 MECHANICAL

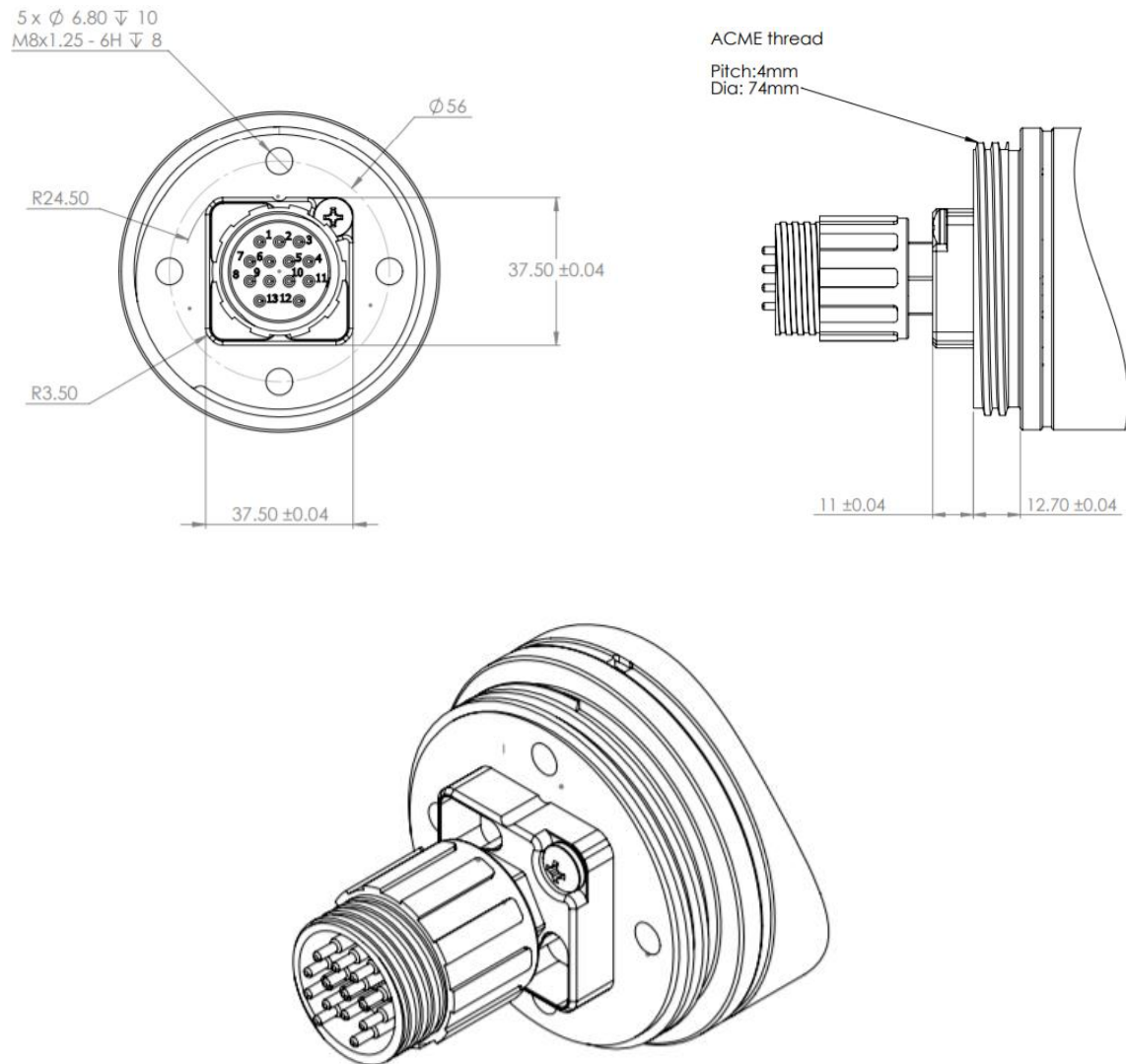
MANIPULATOR BASE INTEGRATION

Option 1 – Reach Bravo Mounting Kit



Bravo 2 and 3 Mounting Kit Technical Drawings

Option 2 – Direct Backplate Integration



Bravo 2/3 backplate technical drawing.

4.2.2 ELECTRICAL

COMMUNICATION AND POWER CONNECTOR – DIL13F DBH13M

Bulkhead Connector Receptacle

Male Face View



Inline cable colour code

- 1: Black
- 2: Screen (orange wire on bulkhead)
- 3: White
- *4-5: Brown, Brown/white
- *6-7: Blue, Blue/white
- *8-9: Orange, Orange/white
- *10-11: Green, Green/white
- 12: Red
- 13: Green

* Twisted pairs

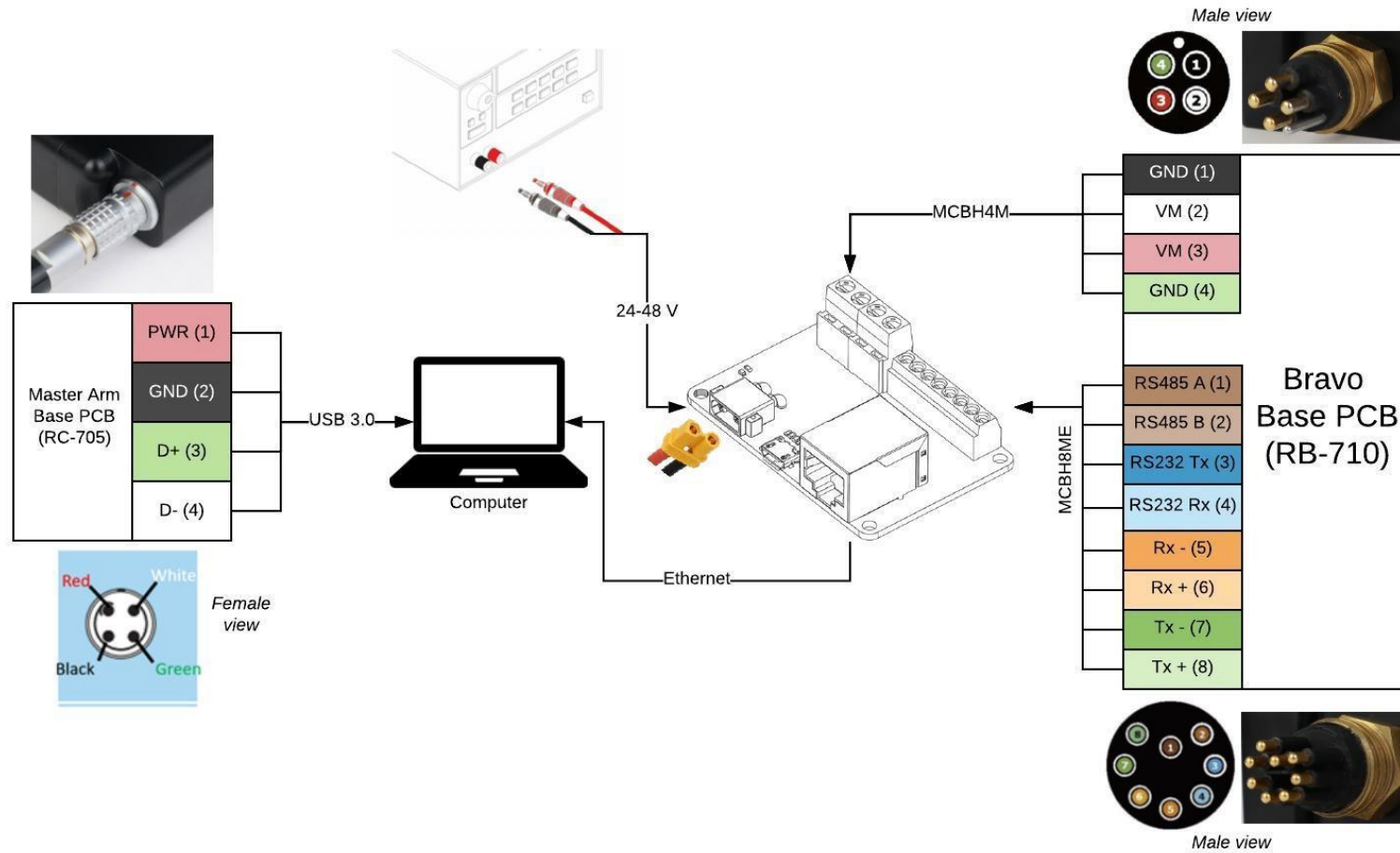
Pins	Description	Colour
1	GND	Black
2	NC	Screen (orange wire on Bulkhead)
3	VM	White
4	RS485 A	Brown
5	RS485 B	Brown/White
6	RS232 TX (data to vehicle)	Blue
7	RS232 RX (data from vehicle)	Blue/White
8	ETH RX-	Orange
9	ETH RX+	Orange/White
10	ETH TX-	Green
11	ETH TX+	Green/White
12	VM	Red
13	GND	Green

Interface Cable (Supplied)

DIL13F - MC Ethernet Inline, 13C Female to unterminated ends (100cm).

4.3 INTEGRATION ELECTRICAL DIAGRAM

The diagram below shows the basic electrical integration of a Bravo 7/5 and Master Arm controller, to a computer. Note that this is the same setup that is described in *Bench Setup and Acceptance Test* section of this manual.



5 CONTROL OPTIONS

Reach Bravo manipulators can be controlled by using the Reach Control Graphical User Interface, an external input such as a Gamepad or Blueprint Lab Master Arm, or by implementing the Reach Control Communication Protocol for custom control setups.

5.1 REACH CONTROL

Reach Control is available in two packages, Reach Control Lite (RC-1000) and Reach Control Pro (RC-2000). A comparison of these packages are as follows:

Feature	RC Lite	RC Pro
Communication over TCP/IP, serial, or UDP	Yes	Yes
Diagnostics and status monitoring	Yes	Yes
Customisable limits of position, velocity, and force	Yes	Yes
Basic Kinematics for Obstacle Avoidance	Yes	Yes
Workspace Obstacle Avoidance	Yes	Yes
Number of Obstacles	1	8
Advanced Kinematics Engine	Yes	Yes
Cartesian (XYZ) End-Effector Control	No	Yes
Eye-Ball Control (move arm with respect to tool/sensor orientation)	No	Yes
Crack and Feature Measurement Tool	No	Yes
Data Logging Tool	No	Yes
Custom Probe Configuration	No	Yes
End-Effector Tool Configuration	No	Yes
Position Presets	2	4

Reach Control (Lite and Pro) provides a graphical means to control each joint of the manipulator in position, velocity, or open loop mode. Reach Control Pro provides a further option to operate the arm in Cartesian (XYZ) mode using the manipulators kinematics engine. Every purchase of a Reach Bravo manipulator comes with an installation of Reach Control Lite included. Reach Control Pro (RC-2000) is available as an upgrade option.

In-depth instructions are included within the Reach Control software interface explaining the function of each feature.

5.2 EXTERNAL INPUTS

5.2.1 GAMEPAD

A simple HID gamepad (Blueprint Lab 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.



5.2.2 MASTER ARM

The Blueprint Lab 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.

The following Master Arm products are available:

Master Arm for Seven-Function
Reach Manipulators
RM-7201

Master Arm for Five-Function Reach
Manipulators
RM-5201



Further detail on the operation of the Master Arm system is available in the separate Master Arm Operators Manual from Blueprint Lab.

5.3 LOW-LEVEL CONTROL IMPLEMENTATION

For users who wish to implement their own control systems such as OEMs or autonomous systems researchers, interfacing is possible via the Reach Communication Protocol Document (*BPL-RCPD*).

6 BENCH SETUP AND ACCEPTANCE TEST

6.1 BENCH SETUP

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.*

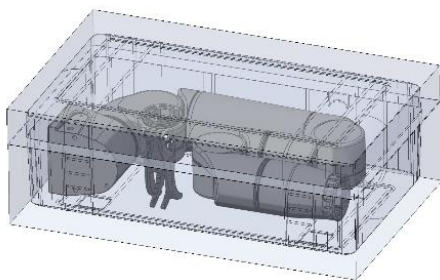
If you experience any issues in following these steps, please contact Blueprint Lab for technical support via info@blueprintlab.com.

You will need:

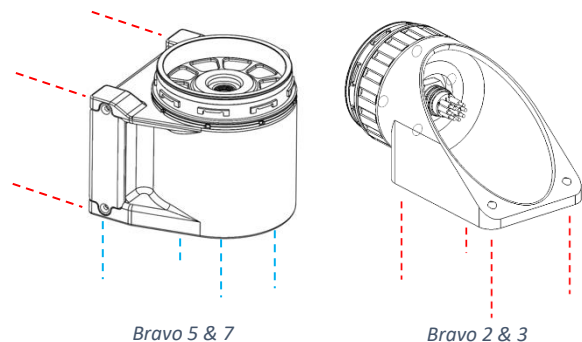
- ✓ Bravo Product
- ✓ Reach Control
- ✓ Wall Power Outlet
- ✓ Computer or Laptop with ethernet port (or ethernet-to-USB adaptor)

6.1.1 PHYSICAL INTERFACING

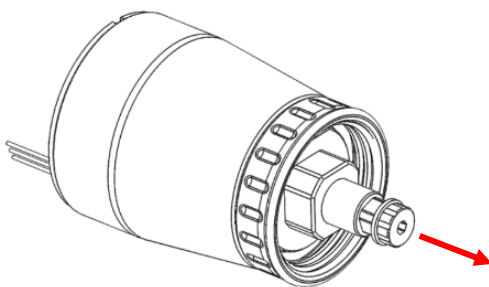
- 1) Unpack all Bravo components from case.



- 2) Use the provided 4xM8 bolts to fix the Bravo base in position onto your mounting surface. *Section 4.1.1* provides the mounting interface dimensions.



- 3) Using the 3/16 In. Allen Key, remove the screw and washer from the end effector pushrod.



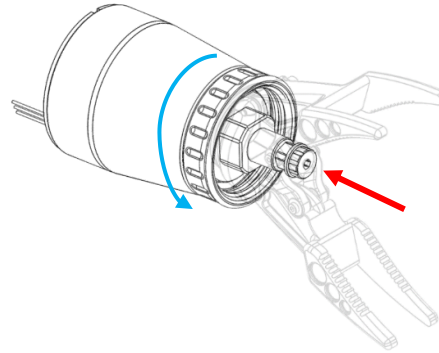
- 4) Connect the end effector onto the arm.



- 5) Ensure sheath is slid over pushrod. Rotate pushrod if needed.



- 6) Screw the **collar** to tighten. Fasten the **screw** with the 3/16 In. Allen key to secure.



- 7) Ensure the included power and communications cables are securely connected to the Breakout Board (BoB).



- 8) Plug the power and communications cables into the arm.



- 1) Connect the power supply to the BoB. Plug the other end into a wall socket. Turn on.



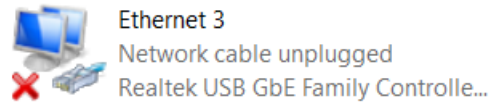
- 2) Use an ethernet cable to connect the BoB to your computer.



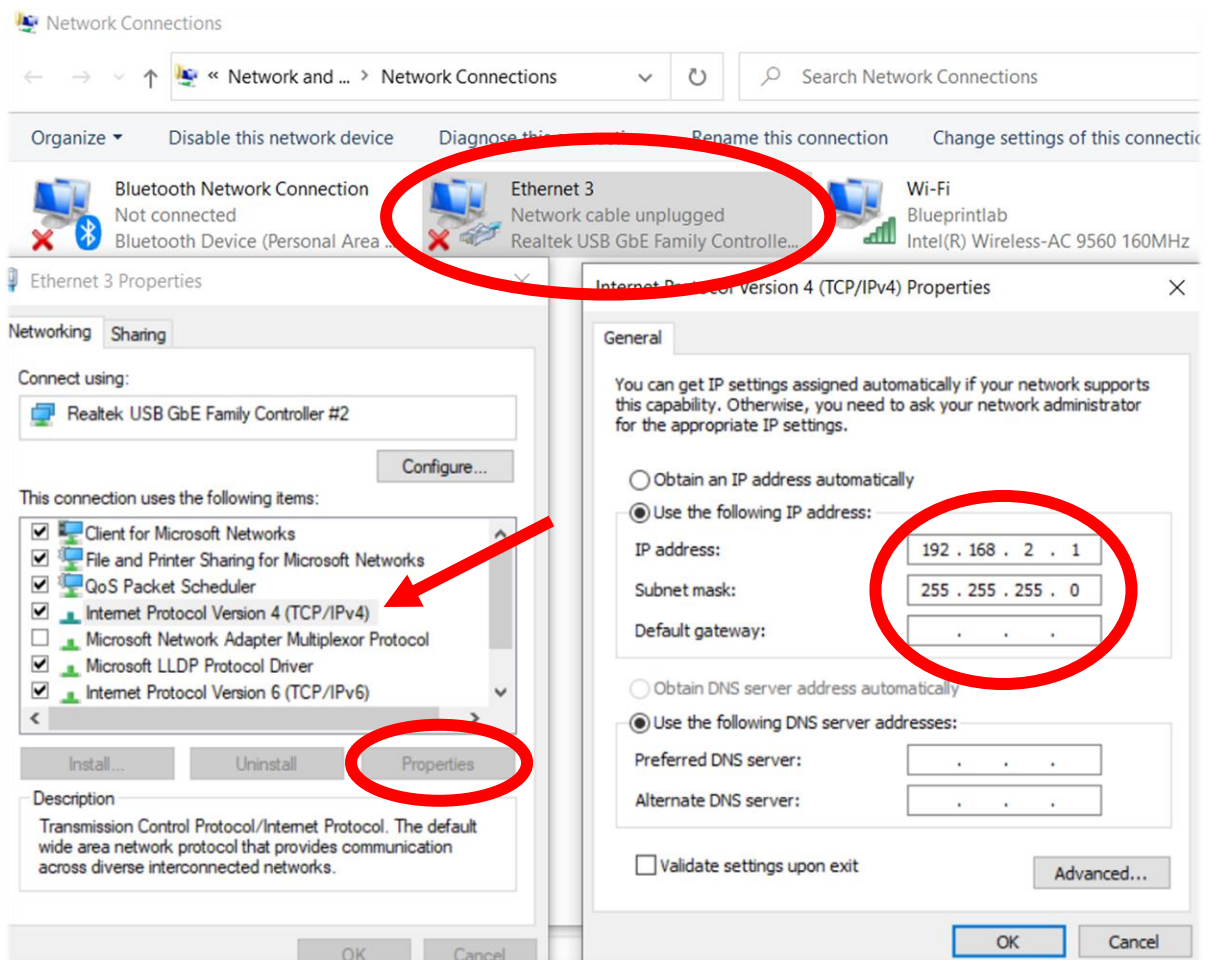
This completes the mechanical setup procedure.

6.1.2 COMMUNICATION SETUP

- 1) On your Windows computer, press START > type "Settings" > Network and Internet > Ethernet > Change Adaptor Options.
- 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 correct connection should disappear and reappear.*



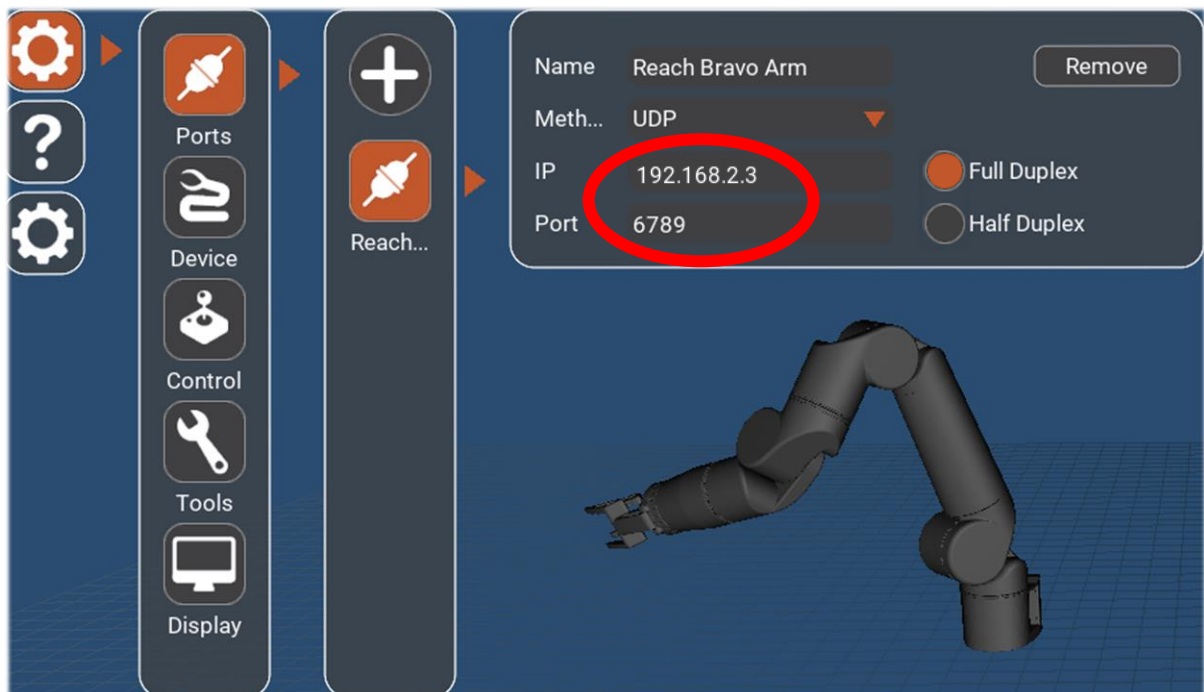
- 3) Click 'Properties'.
- 4) Highlight 'Internet Protocol Version 4 (TCP/IPv4)' > 'Properties'. Set the IP Address to 192.168.2.1 and Subnet Mask to 255.255.255.0. Click Ok and Close all windows.



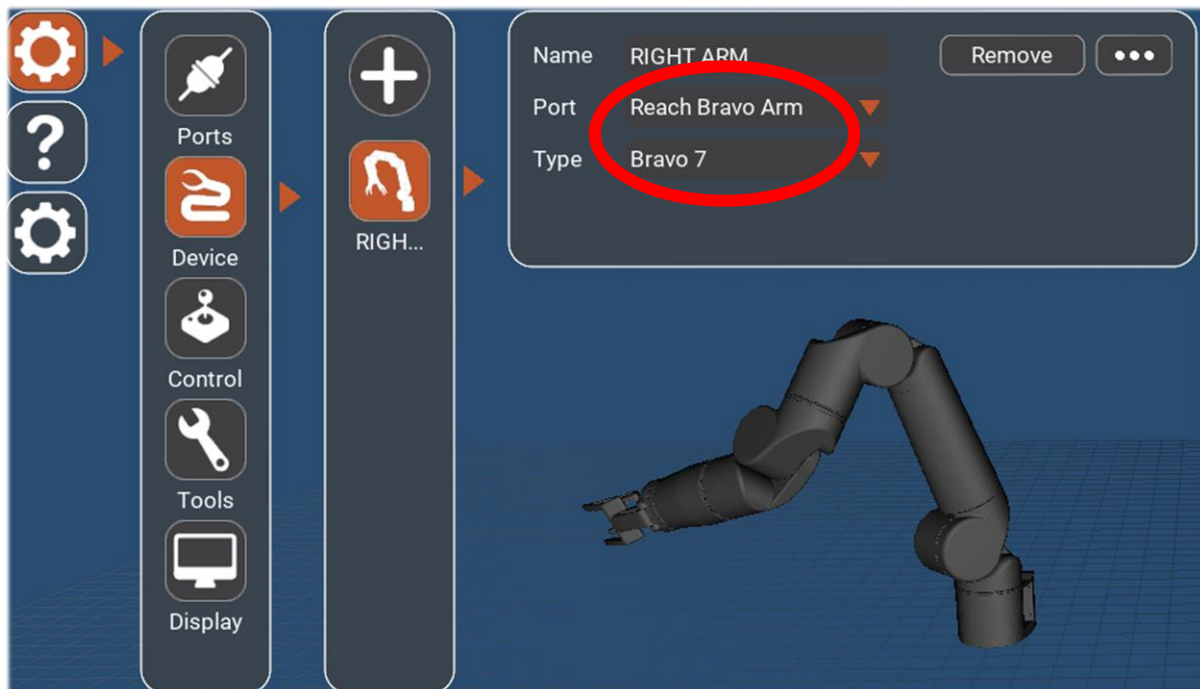
6.1.3 REACH CONTROL

Reach Control will be provided to you digitally via email as well as on a USB within the Hard Carry Case.

- 1) Install Reach Control.
- 2) Open Reach Control > Settings (Cog Icon) > Ports > Add.
Click the new Port. Name your device. Select UDP as the communication method. Set the:
 - a. IP to 192.168.2.3
 - b. Port to 6789
 - c. Ensure Full-Duplex is selected



- 3) Click Settings (Cog Icon) > Device
Select the existing device (or click add if none exist). Select the name of the port just created. Select the type of manipulator.



- 4) If the Bravo is setup correctly, the 3D model in the background will update to reflect the physical position of the manipulator.
- 5) If the jaws do match the 3D model, you may wish to re-orient them physically to match now. See *6.1.1 Physical Interfacing* for details.
- 6) Navigate the 3D model with the following mouse operations:
- Rotate View – Left mouse + Drag
 - Translate View – Right mouse + Drag
 - Zoom – Scroll wheel
- 7) The Device is now connected. Continue to *6.2 Acceptance Test*.

6.2 ACCEPTANCE TEST

6.2.1 RANGE OF MOTION TEST

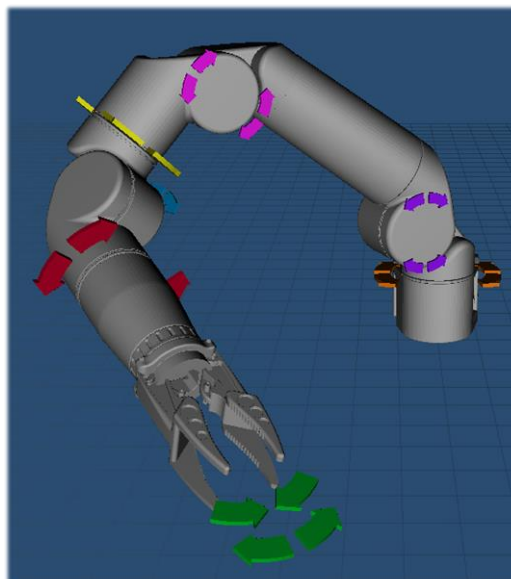
- 1) On the control panel in the bottom right of Reach Control, click the velocity button. Directional arrows will appear on the 3D model.



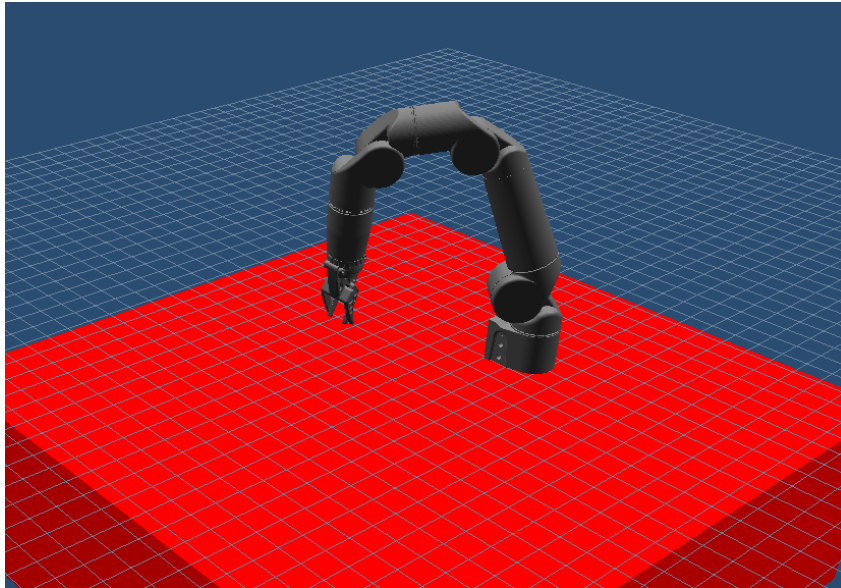
- 2) Click Settings (Cog Icon) > Display > Feedback. The monitoring panel will open at the bottom of the screen. *Clicking on any of the graphs will bring up the numeric values for each joint.*



- 3) **Making sure it is safe to do so**, use the directional arrows in the 3D model of the arm to rotate each joint.



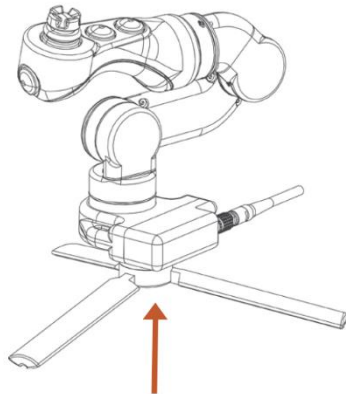
- 4) All Bravo products are shipped with a virtual obstacle to prevent collision with the 'floor' under the base of the manipulator.



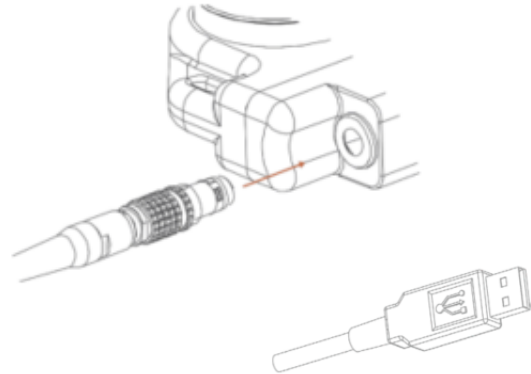
- 5) Move each joint for a few seconds in each direction. Ensure movement is as expected and corresponds with control input.

6.2.2 MASTER ARM TEST (IF APPLICABLE)

- 1) Set up the Master Arm with the stand provided.



- 2) Connect Master Arm to the computer via USB.



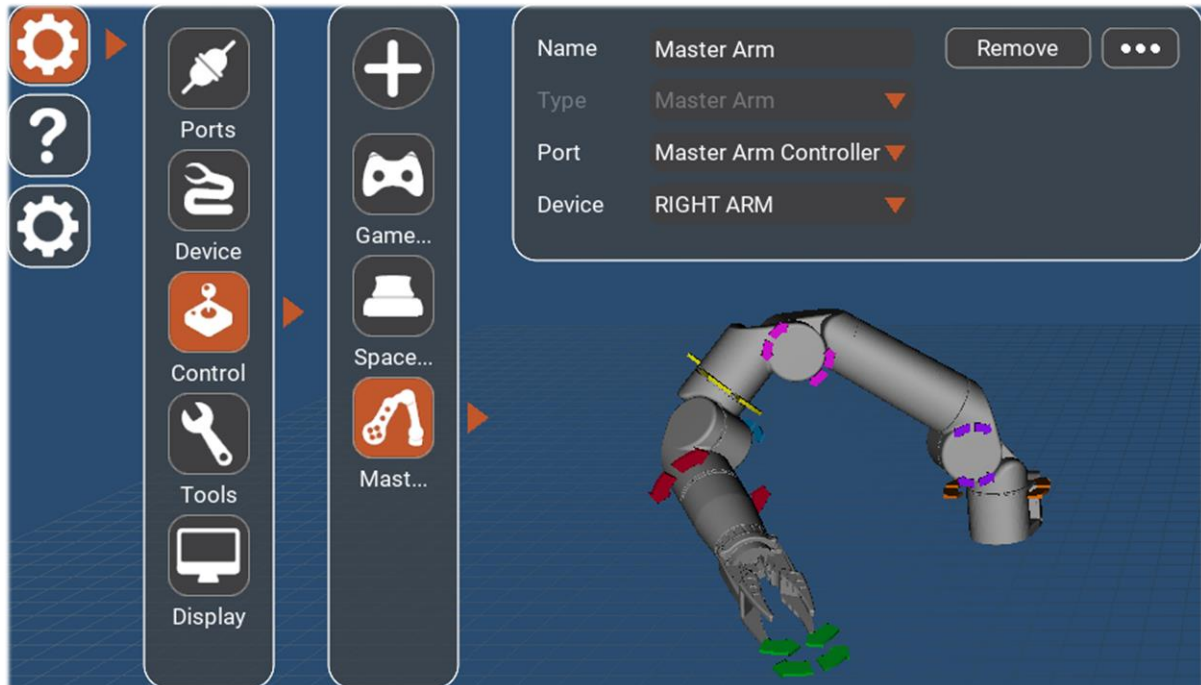
- 3) Once powered, the Master Arm buttons will flash blue.
- 4) Open Reach Control, Settings (Cog Icon) > Ports > Add.
Assign the new port a Name and select the comm port the Master Arm is communicating on. Ensure half duplex is selected.



- 5) Settings (Cog Icon) > Control.

If there is no Master Arm option underneath Spacemouse, click Add.

Assign the new Control port a name. Set 'Port' to the name of your Master Arm port. Set 'Device' to the name of the Slave arm you wish to control.



- 6) The Master Arm is now ready to control the slave manipulator.

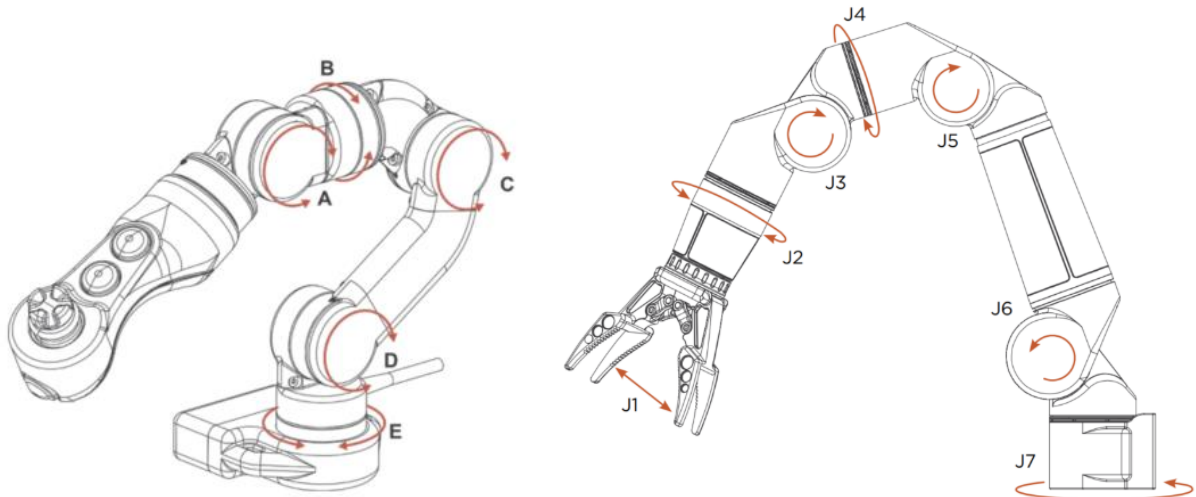
Making sure it is safe to do so, press the Master Arm Pause Button to activate the Master Arm. Blue lights should become solid.

Double tap the Pause Button to deactivate.

- 7) Move each Master Arm joint through its full range of motion. *Note: J1 and J2 are controllable from the Master Arm Joystick.*

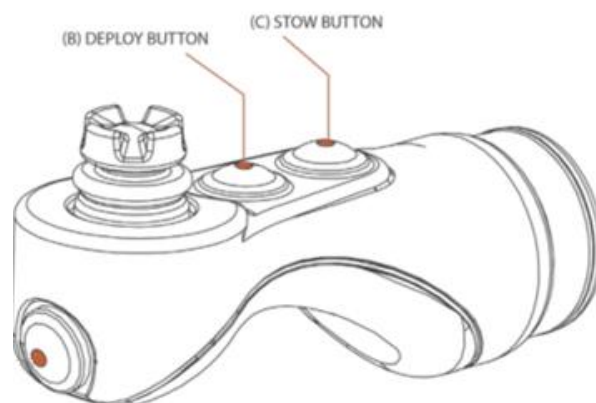
Check that:

- The corresponding joint on the slave arm responds.
- The joint moves in the correct direction.
- The motion of slave to master is a 1-to-1 ratio.
- The motion is smooth and complete.



- 8) Press and hold the stow button, ensure the arms 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 whilst the button is held down. Releasing the button will engage movement again.

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

7 Recommended Servicing Schedule

The Reach Bravo system is recommended for an OEM Servicing every one (1) year or 200 operational hours, whichever occurs first. Blueprint Lab offer a capped price service with each new Reach Bravo system. The coverage period of the capped price service program is for a period of two (2) years, or 200 operational hours, whichever occurs first. For details on the Blueprint Lab Service Program please contact Blueprint Lab.

8 Blueprint Lab Support Program

Blueprint Lab's Support Program provides you with the technical support you require to get your project up-and-running quickly. With three-tiered Support Plans, After-Sales Care, and Priority Servicing, rest assured that your manipulator needs are covered – even in the trickiest of times.

SUPPORT PLANS	CUSTOMER RENTAL POOL
<div>Gold +++ <i>BLSP-SP-BRONZE</i><ul style="list-style-type: none">Your own full system spare located and maintained in your regionRent your system spare at short noticePriority access to customer rental pool for important projectsIntegration SupportVirtual TrainingPriority Technical SupportOEM-Lead Upgrades and MaintenanceCapped Price Service Guaranteed</div>	<div>The Customer Rental Pool (Gold and Silver Support Plans only) is designed to provide a means to mitigate the risk of field failure for existing customers bidding on and conducting important projects.<ul style="list-style-type: none">Reduce risk on critically important projectsPlan rental costs into your projects to quantify risk reduction as part of Operational Expenditure</div>
<div>Silver ++ <i>BLSP-SP-SILVER</i><ul style="list-style-type: none">Priority access to customer rental pool for important projectsIntegration SupportVirtual TrainingPriority Technical SupportOEM-Lead Upgrades and MaintenanceCapped Price Service Guaranteed</div>	<div>EXTENDED WARRANTY AND CARE PLAN <i>BLSP-EW</i><p>An additional year of full manufacturer's warranty coverage for extra product assurance and peace of mind. Includes a one (1) year OEM-level service.</p></div>
<div>Bronze + <i>BLSP-SP-BRONZE</i><ul style="list-style-type: none">Integration SupportVirtual TrainingPriority Technical SupportOEM-Lead Upgrades and MaintenanceCapped Price Service Guaranteed</div>	<div>STAND ALONE OPTIONS AND ADD-ONS<div>Integration Support <i>BLSP-ISP</i><p>Dedicated integration to fast-track your system development, taking your custom requirements into account.</p></div><div>Virtual Training <i>BLSP-VTP</i><p>Dedicated training to quickly familiarise you and your team with your manipulator, fast tracking your operational training.</p></div><div>Priority Technical Support <i>BLSP-PTS</i><p>Dedicated video call same or next business day for any issue as well as unlimited annual support tickets.</p></div></div>

Email sales@blueprintlab.com to inquire further about the right plan and options for you.

9 REVISION HISTORY

Rev	Name	Date	Change
V1.0	Anders	26 May 20	First Version
V2.0	James	25 Aug 20	Inclusion of Bravo 2 & 3. Electrical Diagrams. Setup and Integration information. Acceptance Testing.
V3.0	James	Jan 2021	Bravo 2/3 Module breakdowns and Mounting kit diagrams. SS jaws added. Servicing schedule and Support Program.