PLUG-AND-PLAY E50 | P/N: 81401665-A2/-A4

Pole shoes required for operation

The PLUG-AND-PLAY E50 (PPe50) from Magswitch boasts a quick set-up process, high breakaway forces, and more mounting interfaces as part of the latest generation of Magswitch E-Tools.

These electrically actuated magnetic grippers are great for use in fixtures, in material handling, and as end-of-arm tools. They are operated directly from a standard I/O block.

Custom pole shoe geometry is available upon request for the handling of non-flat or irregularly shaped surfaces.

With part-present sensing and a magnet that won't let go if power is lost, the Magswitch PLUG-AND-PLAY electric line of automation tools changes the way things are done!

General Specifications[1]

Maximum Breakaway Force	2577 N	579.3 lbf	262.8 kgf
Maximum Shear Force	588 N	132.3 lbf	60.0 kgf
Minimum De-Stack Thickness		0.35 in	9.0 mm
Net Tool Weight		7.5 lbs	3.4 kg
Supply Voltage			24 V DC
Peak Current Draw			2 A @ 24 V DC
Connector Type	Male M12 – 5 Pin – A-coded Male M12 – 4 Pin – A-coded Male M12 – 3 Pin – A-coded		
Mounting Options	TOP: Ø6-M8-Ø6 NAAMS pattern (x2) TOP: M8-Ø6-M8 pattern (x4) SIDE: Ø6-M8-Ø6 NAAMS pattern (x2)		

Version Information

There are two versions of this tool: -A2 and -A4.
The version indicates which pin is used to actuate the tool ON. Note the version printed on the black top cap of the tool and see the tables on pages 8 and 9 for detailed pinout information.

Version -A2 (See page 8 for details)
Connector A

Pin	Function
A1	No connection
A2	**De-Actuate** command
A3	Actuator ground
A4	**Actuate** command
A5	Earth ground

Version -A4 (See page 9 for details)
Connector A

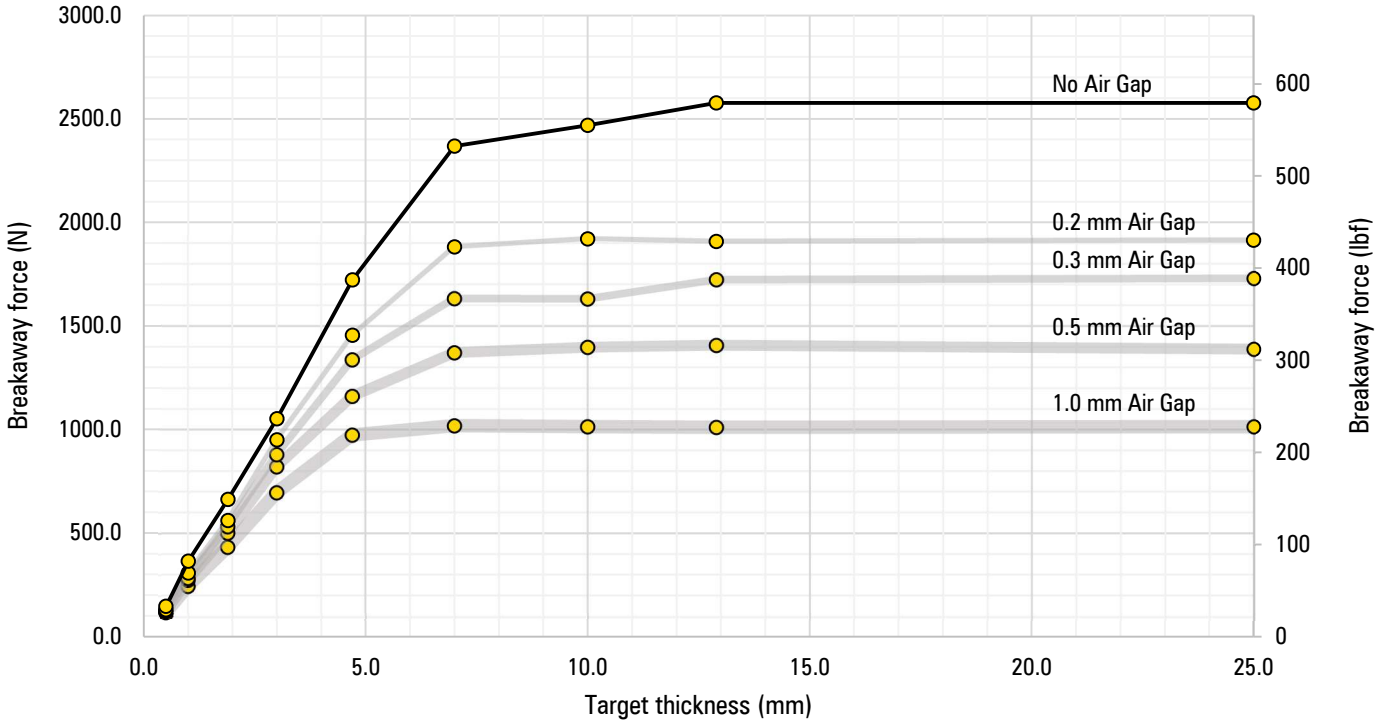
Pin	Function
A1	Actuator power supply
A2	**Actuate** command
A3	Actuator ground
A4	**De-Actuate** command
A5	Earth ground

Magnet Strength[1]

Table 1: Breakaway Strength with Different Target Thicknesses

Target Thickness	mm	0.5	1	1.9	3	4.7	7	10	12.9	25
	inches	*0.020*	*0.039*	*0.075*	*0.118*	*0.185*	*0.276*	*0.394*	*0.508*	*0.984*
Hold Force	N	146	363	662	1052	1723	2368	2469	2576	2577
	lbf	*32.8*	*81.6*	*148.9*	*236.5*	*387.3*	*532.3*	*555.0*	*579.2*	*579.3*

Figure 1: Breakaway Strength with Different Air Gaps



[1] Footnotes:

- **The forces listed in this document represent ideal maximums and may not accurately reflect the actual forces achievable in a customer's specific application due to variations in materials or process conditions.**
- **Review and understand the warnings section on page 3 before operating the tool.**

- Breakaway forces were determined in laboratory environment on a 200mm x 200mm sheet of SAE1018 Steel with surface roughness of 63 microinches with standard pole shoes.
- Breakaway forces in Table 1 were determined using standard pole shoes on clean, flat surfaces with no air gaps between the pole shoes and the target material. Any variation from this ideal scenario will decrease breakaway forces.

Warnings

Review and understand all warnings before operating the tool.

Contact and consult Magswitch engineering at +1(303) 468.0662 if you have any questions or concerns about your application or the tool's operation.

The breakaway and shear forces listed in this document are not safe lifting forces. Designers must account for the safety factor. Safe working loads must account for additional forces placed on the magnet and part when in motion or out of balance.

- The forces listed in this document represent ideal maximums and may not accurately reflect the actual forces achievable in a customer's specific application due to variations in materials or process conditions.
- The following conditions affect the tool's strength and impact the safe handling and transport of target materials:
  - Motion of the magnet (e.g. fast movements, emergency stops, and steep carrying angles)
  - Debris or contamination on the target surface
  - Air gaps between the magnet and target materials
  - Wear and damage to the tool's pole shoes
  - Target material thickness
  - Target material shape
  - Target material alloy
  - Pole shoe design
- To safely use the tool:

Do not actuate the magnet off-target except during calibration (Page 6).
Actuation of the magnet off-target may create hazardous conditions where body parts could get trapped between the tool and ferromagnetic material.

  - Only use non-magnetic stainless steel or aluminum mounting hardware.
  - Always use pole shoes. If your pole shoes include dowel pins, always operate with dowel pins installed.
  - The COG of the material being lifted should be centered on the magnet to reduce pry.
  - Ensure all surfaces are clean and free of debris for maximum magnetic hold force. Any air gaps will reduce the magnet's hold force.
  - The north and south pole shoes of the magnet must make full contact with the target at time of actuation.
  - Do not expose the magnet to temperatures above 80^0C (176^0F). High temperatures will permanently degrade the magnet and may result in an unsafe condition.
  - Consult Magswitch engineering for custom pole shoes if working with irregular target surfaces
- To prolong the life of the tool:
  - Always use armor in bin picking operations
  - Do not actuate the magnet off-target except during calibration (Page 6). Actuation of the magnet off-target will lead to increased wear on the magnet's internal actuation mechanisms.
- Always perform testing before deployment

LED Color Codes

Function/State	Blue LED State	Green LED State	Red LED State	White LED State
No power	Off	Off	Off	Off
Tool awaiting first command	Flashing	Flashing	Off	Off
Magnet actuated (ON) with a part present	Off	Solid	Off	Off
Magnet actuated (ON) with no part present ⚠ **This is a dangerous condition. Ensure that no body parts get trapped between the tool and ferromagnetic material.**	Off	Off	Solid	Off
Magnet de-actuated (OFF)	Off	Off	Off	Solid
Tool in Calibration - Step 6 (Page 6)	Flashing	Off	Flashing	Off
Tool in Calibration - Step 7 (Page 6)	Flashing	Off	Off	Flashing
Tool in Calibration - Step 9 (Page 6)	Off	Flashing	Off	Off
Tool in Calibration - Step 11 (Page 6)	Off	Off	Off	Flashing
Magnet error (See Troubleshooting below for details)	Off	Off	Flashing	Off

Troubleshooting

Magnet Error	# of Red Flashes	Troubleshooting Steps
Magnet sensor error	3	▸ Powercycle tool ▸ Recalibrate tool (Page 6)
Magnet actuator error	4	▸ Powercycle tool
Homing error	7	▸ Powercycle tool
Voltage dropout error	8	▸ Do not pulse inputs (See graphs on pages 8 and 9) ▸ De-actuate the magnet to reset
Tool turns on or off unexpectedly		▸ Check version of device on top cap (-A2 or -A4) and make sure you are using the corresponding pinout (Page 8 for -A2 and page 9 for -A4) ▸ Check the cables are connected correctly (Pages 8 and 9) ▸ Check the pinout (Pages 8 and 9)
Tool does not change state when expected		▸ Confirm only one actuation signal (A2 or A4) is high at a time. ▸ Set both A2 and A4 LOW then try resending command. ▸ Check the cables are connected correctly (Pages 8 and 9).

Start-Up Sequence

- **Every time a PPe is powered ON, follow the start-up steps below.**
  - These steps must be done on initial power-up or after a power outage, they are NOT calibration steps.
- **The tool comes calibrated to the installed standard pole shoes.**
  - If custom pole shoes are used, the tool will need to be re-calibrated before the first cycle (See page 6).

1. Make sure pole shoes are installed.
2. Connect all cables. Connectors A and C are required for operation, but connector B is only required for part presence sensing.
3. Power the tool **ON**. Depending on your IO block, command state, and target state, the tool will display one of the stable light codes below.

The tool may flash other colors briefly before entering a stable state.

Stable Light Code	Meaning	Next Step
Groups of 3 short **BLUE** flashes followed by 1 long **RED** flash	**Magnet:** ON **De-Actuate Magnet Command:** LOW **Actuate Magnet Command:** LOW	Send actuate magnet command to tool: • For version -A2, set A2 HIGH and A4 LOW • For version -A4, set A4 HIGH and A2 LOW Once the tool shows solid **RED** (if off-target) or solid **GREEN** (if on-target), it is ready for use.
Groups of 3 short **BLUE** flashes	**Magnet:** OFF **De-Actuate Magnet Command:** LOW **Actuate Magnet Command:** LOW	Send de-actuate magnet command to tool: • For version -A2, set A2 LOW and A4 HIGH • For version -A4, set A4 LOW and A2 HIGH Once the tool shows solid **WHITE**, it is ready for use.
Solid **RED**	**Magnet:** Actuated ON and positioned off-target **De-Actuate Magnet Command:** LOW **Actuate Magnet Command:** HIGH	Send actuate magnet command to tool: • For version -A2, set A2 HIGH and A4 LOW • For version -A4, set A4 HIGH and A2 LOW Once the tool shows solid **RED** (if off-target) or solid **GREEN** (if on-target), it is ready for use.
Solid **GREEN**	**Magnet:** Actuated ON and positioned on-target **De-Actuate Magnet Command:** LOW **Actuate Magnet Command:** HIGH	
Solid **WHITE**	**Magnet:** OFF **De-Actuate Magnet Command:** HIGH **Actuate Magnet Command:** LOW	Tool is ready for use.
Flashing **GREEN** and **BLUE**	**Magnet:** Unknown **De-Actuate Magnet Command:** Unknown **Actuate Magnet Command:** Unknown	If tool is on-target, actuate magnet ON: • For version -A2, set A2 HIGH and A4 LOW • For version -A4, set A4 HIGH and A2 LOW Once the tool shows solid **RED**, it is ready for use. If the **GREEN** and **BLUE** flashing persists, check cable connections. If tool is off-target, actuate magnet OFF: • For version -A2, set A2 LOW and A4 HIGH • For version -A4, set A4 LOW and A2 HIGH Once the tool shows solid **WHITE**, it is ready for use. If the **GREEN** and **BLUE** flashing persists, check cable connections.
Flashing **BLUE** and **RED** or Flashing **BLUE** and **WHITE**	**Magnet:** OFF and in calibration state **De-Actuate Magnet Command:** HIGH **Actuate Magnet Command:** HIGH	Wait for the tool to start flashing **BLUE** and **RED**, then set both A2 and A4 commands LOW. When light turns solid **WHITE**, send de-actuate magnet command to tool: • For version -A2, set A2 LOW and A4 HIGH • For version -A4, set A4 LOW and A2 HIGH Once command is sent, tool is ready for use.

4. If the light codes do not match the states listed in the table above, check your wiring using the tables on pages 8 and 9. Make sure you are using the table for the correct tool version (-A2 vs -A4).

Calibration

- **Calibration only needs to be performed ONCE when a new set of pole shoes is installed.**
  - Each PPe tool is **pre-calibrated** to the standard pole shoe kit installed from factory.
  - Perform calibration only after installing pole shoes different from the standard pole shoes.
- **For basic tool start-up sequence, see page 5.**
  - Every time power is cycled, follow the simple start-up instructions are on page 5; re-calibration is not necessary

Calibration is the ONLY time the tool should be actuated off-target.
Actuation of the magnet off-target may create hazardous conditions where body parts could get trapped between the tool and ferromagnetic material.

Calibration Step	LED Color
1. De-actuate the magnet	**WHITE**
2. Unplug all cables and power down the tool	
3. Remove current pole shoes and attach desired pole shoes to the tool (See page 10)	
4. Connect all cables and power up the tool	
5. Set de-actuate command HIGH a. For version -A2 set A4 HIGH (See page 8 for details) b. For version -A4 set A2 HIGH (See page 9 for details)	**WHITE**
6. Set actuate command HIGH while keeping de-actuate command HIGH a. For version -A2 set A2 HIGH b. For version -A4 set A4 HIGH	Flashes **RED** and **BLUE** for 15 sec
7. The tool will flash RED and BLUE for 15 sec then it will change to flashing WHITE and BLUE	Flashes **WHITE** and **BLUE**
8. **IMMEDIATELY after the tool starts flashing WHITE and BLUE**, set BOTH the actuate and de-actuate commands LOW. a. A2 and A4 LOW for both versions of the tool (See pages 8 and 9 for details) b. After the WHITE and BLUE flashing sequence starts, you have **10 sec** to set A2 and A4 low or the calibration will not start. If the calibration does not start, go back to step 6.	
9. The tool will flash GREEN. If you do not see a flashing GREEN light, return to step 6.	Flashes **GREEN**
10. Ensure the magnet is away from ferromagnetic material	
11. Actuate magnet ON and wait until it flashes WHITE approximately 15 seconds and then turns solid RED. 1. For version -A2 set A2 HIGH 2. For version -A4 set A4 HIGH	Flashes **WHITE** ~15s then turns solid **RED**
12. Once the light turns solid RED, the magnet is actuated on and the tool is calibrated **In this state, the magnet is active and off-target. Ensure that the tool is far away from ferromagnetic material and that no body parts get trapped between the tool and ferromagnetic material.**	**RED**
13. Set actuate pin LOW and de-actuate pin HIGH to de-actuate the magnet a. For version -A2 set A2 LOW and A4 HIGH b. For version -A4 set A4 LOW and A2 HIGH	**WHITE**
14. Test the calibration by actuating magnet on your target material. The tool will detect part present for targets greater than 0.3mm thick.	**GREEN** - Magnet ON, Part present detected **RED** - Magnet ON, NO part present detected

Electrical Characteristics

Recommended Operating Conditions

Parameter		Min	Max	Unit
Supply voltage	A1, C1	21.6	26.4	V
Digital input high voltage threshold	A2, A4	11	26.4	V
Digital input max current	A2, A4	NA	2000 for PNP 100 for NPN	mA
Digital input timing threshold	A2, A4	See graphs on pages 8 and 9		
Operating free-air temperature range		-10	60	C
Storage free-air temperature range		-25	80	C
Relative humidity (non-condensing)		0	95	%

Electrical Characteristics

@ 25 ^{0}C , V_{DD} = 24 V

Parameter		Max	Unit
Current draw	A2, A4 (PNP supply and logic) A1 (NPN supply) A2, A4 (NPN logic) C1 (Supply)	2 2 15 100	A A mA mA
Start-up time	Time from power on until ready to operate	1	s
Actuate on time	On target (25mm thick, no air gap) Off target	700 900	ms ms
Actuate off time	On target (25mm thick, no air gap) Off target	375 375	ms ms

Connector Pin Configuration

Version -A2

- **Connectors A and C are required for operation.**
  - Connector B is only required for part presence sensing.
- **Do NOT pulse actuate and de-actuate commands.**
  - A voltage dropout error will be generated if these inputs are pulsed. (See troubleshooting on page 4)
  - See digital input timing graph below.

Connector A (Input for **PNP** operation)

Pin	Function
A1	No connection
A2	Actuate command Set High to actuate magnet (2A max) **Do not pulse**, continuous actuation needed
A3	Actuator ground
A4	De-actuate command Set High to de-actuate magnet (2A max) **Do not pulse**, continuous actuation needed
A5	Earth ground

Connector A (Input for **NPN** operation)

Pin	Function
A1	Actuator power supply
A2	Actuate command Set High to actuate magnet (100mA max) **Do not pulse**, continuous actuation needed
A3	Actuator ground
A4	De-actuate command Set High to de-actuate magnet (100mA max) **Do not pulse**, continuous actuation needed
A5	Earth ground

Connector B (Output)

Pin	Function
B1	Not connected
B3	Not connected
B4	Part present status Part present = High No part present = Low (Magnet must be actuated for part presence)

Connector C (Output)

Pin	Function
C1	Logic power supply
C2	Magnet on status Magnet on = High
C3	Logic ground
C4	Magnet off status Magnet off = High

Figure 2: Digital Input Timing (Version -A2)

Do NOT switch A2 or A4 until corresponding magnet status is reached

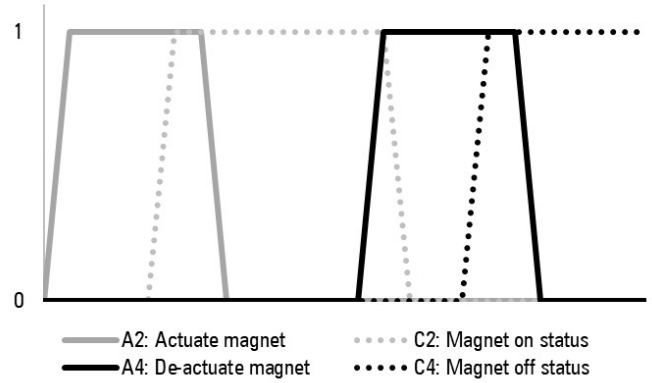
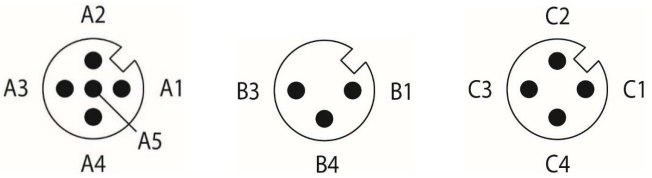


Figure 3: Pin locations



SConnector Pin Configuration

Version -A4

- **Connectors A and C are required for operation.**
  - Connector B is only required for part presence sensing.
- **Do NOT pulse actuate and de-actuate commands.**
  - A voltage dropout error will be generated if these inputs are pulsed. (See troubleshooting on page 4)
  - See digital input timing graph below.

Connector A (Input for **PNP** operation)

Pin	Function
A1	No connection
A2	De-Actuate command Set High to de-actuate magnet (2A max) **Do not pulse**, continuous actuation needed
A3	Actuator ground
A4	Actuate command Set High to actuate magnet (2A max) **Do not pulse**, continuous actuation needed
A5	Earth ground

Connector A (Input for **NPN** operation)

Pin	Function
A1	Actuator power supply
A2	De-Actuate command Set High to de-actuate magnet (100mA max) **Do not pulse**, continuous actuation needed
A3	Actuator ground
A4	Actuate command Set High to actuate magnet (100mA max) **Do not pulse**, continuous actuation needed
A5	Earth ground

Connector B (Output)

Pin	Function
B1	Not connected
B3	Not connected
B4	Part present status Part present = High No part present = Low (Magnet must be actuated for part presence)

Connector C (Output)

Pin	Function
C1	Logic power supply
C2	Magnet on status Magnet on = High
C3	Logic ground
C4	Magnet off status Magnet off = High

Figure 4: Digital Input Timing (Version -A4)

Do NOT switch A2 or A4 until corresponding magnet status is reached

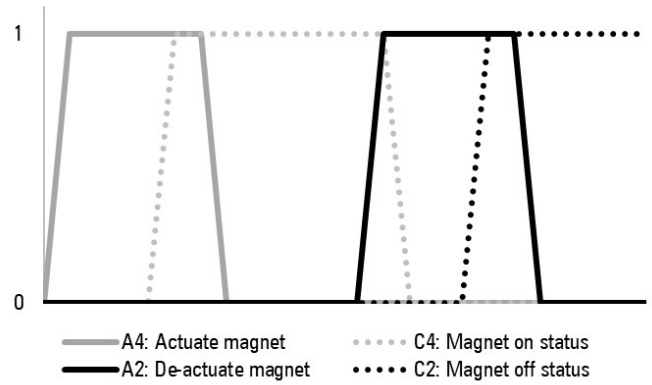
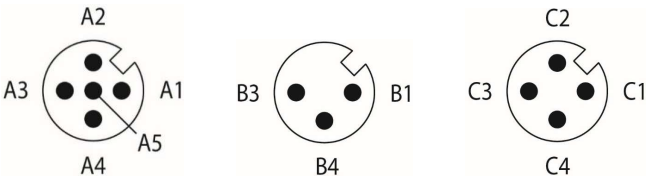


Figure 5: Pin locations



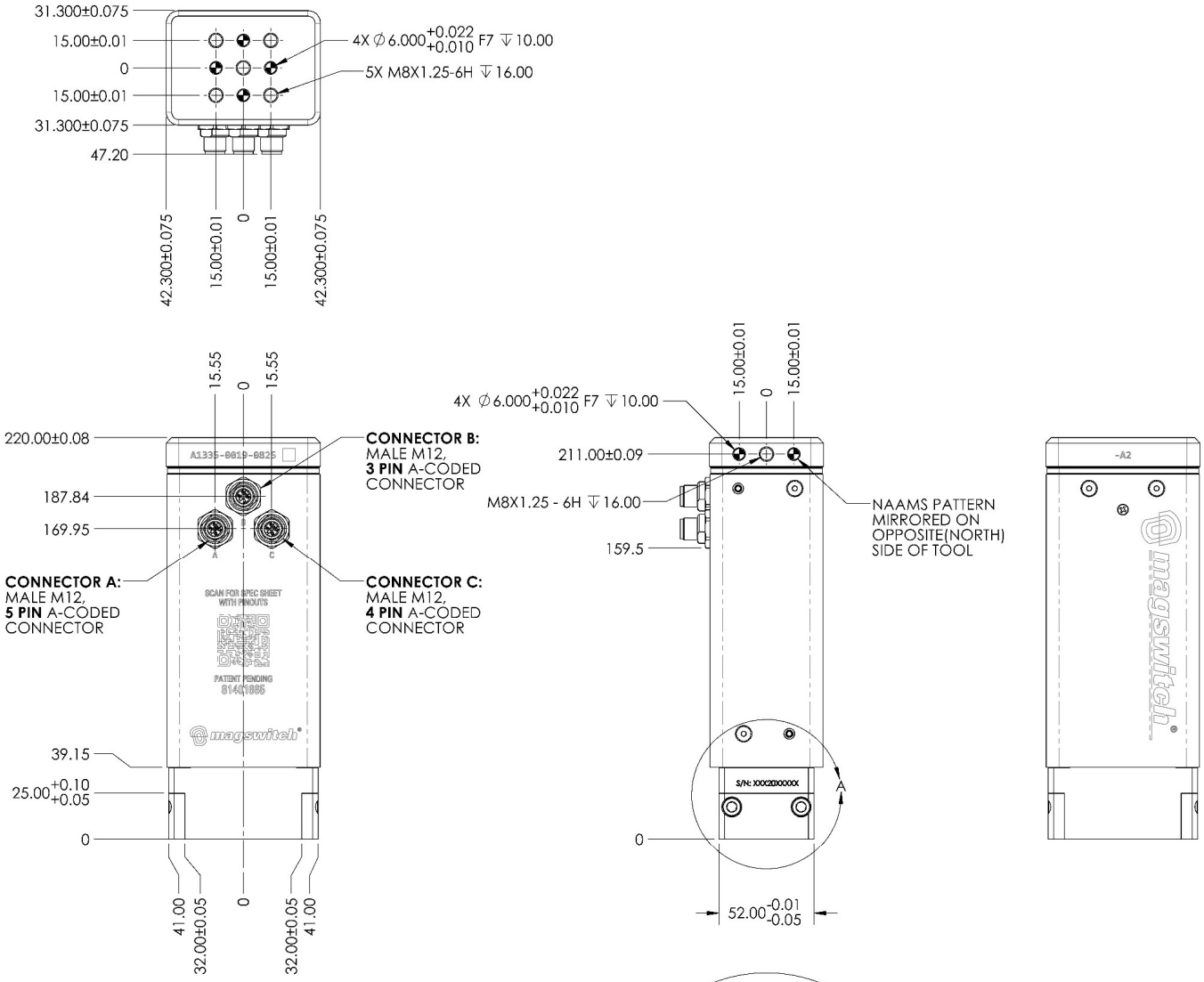
Accessories Available

Standard pole shoes	
E50 Standard Flat Pole Shoe Kit (Included)	8800837
E50 Standard Step Under Thin Optimized Pole Shoe Kit	88001555
E50 Standard Pin Clamp Pole Shoe Kit	88002020
Armor	
E50 Armor Kit, Standard Bin Picking	88001419
Armor-ready pole shoes	
E50 Flat Pole Shoe Kit, Armor Ready	88001420
E50 Thin Optimized Pole Shoe Kit, Armor Ready	88001587
E50 V-Cut 135deg Pole Shoe Kit, Armor Ready	88001421
E50 V-Cut 155deg Pole Shoe Kit, Armor Ready	88001422
Compliance	
E50 Compliance Device Kit, Top Mounted	88001628
Mounting	
EOAT Wrist Adapter ISO 80 (UR30)	88002022
EOAT Wrist Adapter ISO 125/160	88002023
Magnet Mount and Riser Does not include robot interface	88002021

Pole Shoe Installation

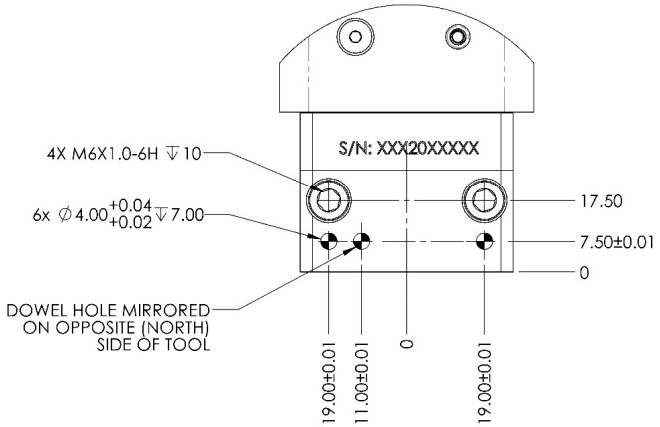
1. Remove any pole shoes currently installed on the sides of the tool.
2. Ensure dowel and fastener holes are clean. Confirm the side surfaces of the magnet housing are flat and smooth.
3. Align dowel pins with housing bores and apply light pressure to seat poles flush against housing.
4. Apply Loctite 222 to fastener threads and install 4x M6 socket head cap screws.
5. Torque all screws to 11.5Nm (8.5 ft-lbf). There should be no visible gap between the pole shoes and the magnet housing.

Tool Dimensions



DETAIL A IS SHOWN WITHOUT POLE SHOES

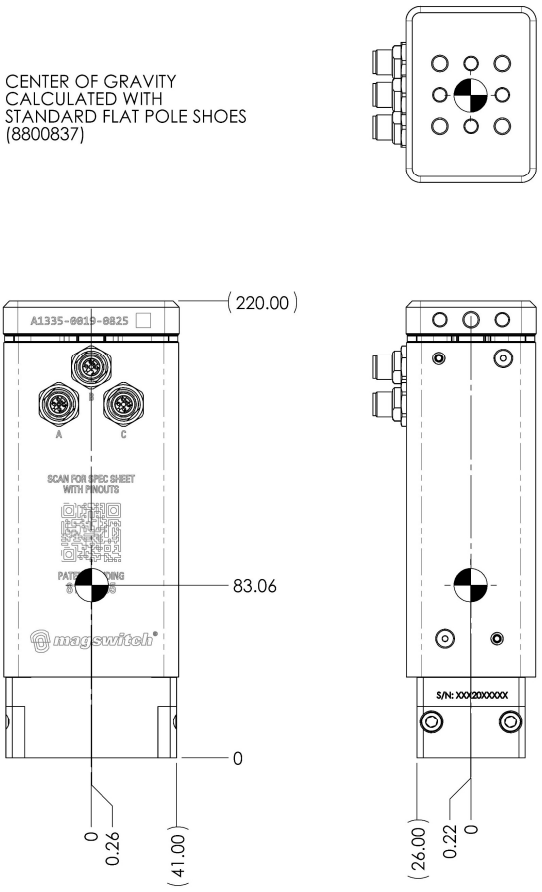
- POLE SHOES ARE REQUIRED FOR OPERATION.
- IF YOUR POLE SHOES INCLUDE DOWEL PINS, ALWAYS OPERATE WITH DOWEL PINS INSTALLED.



DETAIL A
Drawn with Pole Shoes Removed

Center of Mass

CENTER OF GRAVITY
CALCULATED WITH
STANDARD FLAT POLE SHOES
(8800837)



Patents

Patents Pending