WaveVortex 10 Electrode Rotator Calibration

1. Required Tools

Gather the following tools prior to beginning the calibration:

- Digital laser tachometer (included in the MSR Rotation Rate Calibration Kit, AKMSRCAL)
- Potentiometer adjustment tool (included in the MSR Rotation Rate Calibration Kit, AKMSRCAL)
- Traceable, digital voltmeter (can use a potentiostat on site if not available)
- Traceable DC voltage source (at least $0-5\,V$) (can use a potentiostat on site if not available)
- Phillips-head screwdriver (included in the WaveVortex 10 Maintenance Toolkit, AK01WV10TK1)
- 2x small wires for use with WaveVortex 10 Electrode Rotator external I/O connector

2. Calibration Procedure

STOP:

Ensure the Brush contacts have been adequately worn prior to calibration. Run the WaveVortex 10 Rotator, without an electrode tip installed, at 3200 *RPM* for at least 2 hours prior to calibration.

1. Record the serial number of the motor head and the control unit (see Figure 2-1). Any WaveVortex 10 motor head can be calibrated to any WaveVortex 10 control unit; however, matching serial numbers on both components indicate the original, calibrated state of the WaveVortex 10.

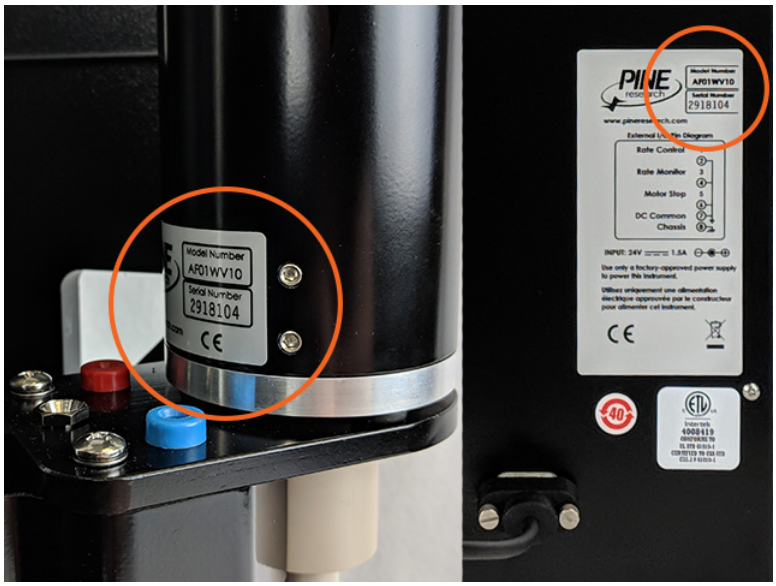

Figure 2-1. Motor Head and Control Unit Labels with Serial Numbers Circled

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2. Remove the back panel of the WaveVortex 10 control unit. Use the smaller Phillips-head screwdriver included in the WaveVortex 10 Maintenance Toolkit (AK01WV10TK1) to remove six screws (see Figure 2-2). Gently rest the cover on the bench (note: the connector and a grounding wire prevent the panel from being separated).

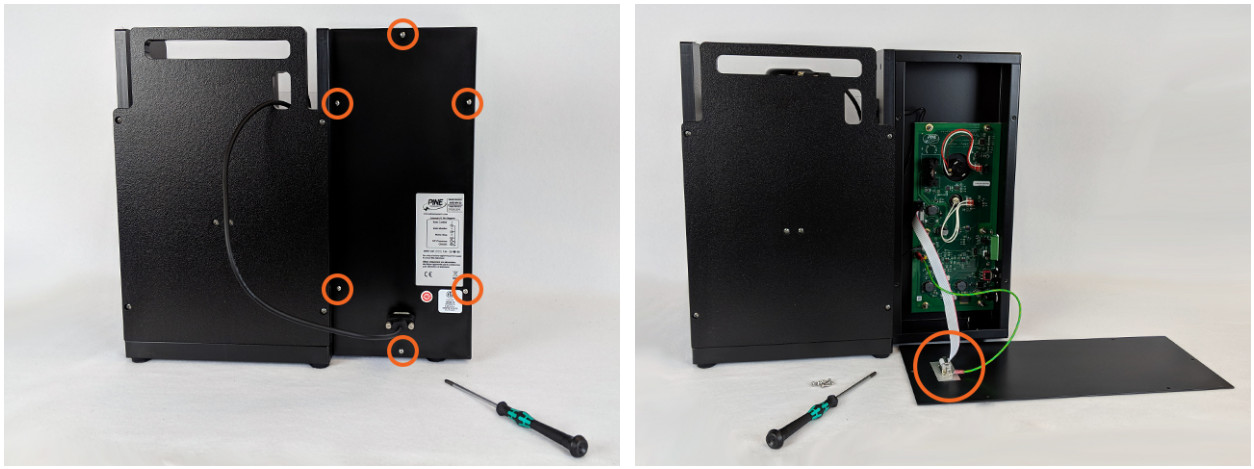

Figure 2-2. Six Screws Secure the Back Panel of the Control Unit

3. Find and locate the J3 jumper on the circuit board (middle right). There are three jumper positions, which control the RPM/voltage conversion ratio. By default, the jumper is located in the middle, which corresponds to the 1 *RPM/mV* setting (see Figure 2-3).

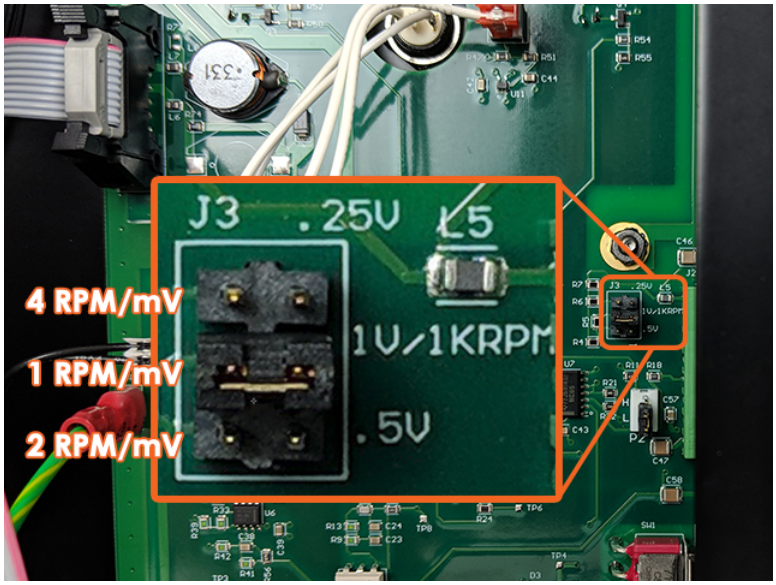

Figure 2-3. J3 Jumper on Control Unit Circuit Board Selects Rotation to Voltage Ratio

4. Locate the R43 trim potentiometer on the circuit board (lower left). Notice that after initial production facility calibration, adhesive is applied to the screw to prevent it from accidentally rotating and altering calibration. During subsequent calibration, the adhesive must be broken to adjust the trim screw setting on the potentiometer (see Figure 2-4). The blade on the

potentiometer adjustment tool seats into the screw of this trim potentiometer, which is turned during calibration to make adjustments.

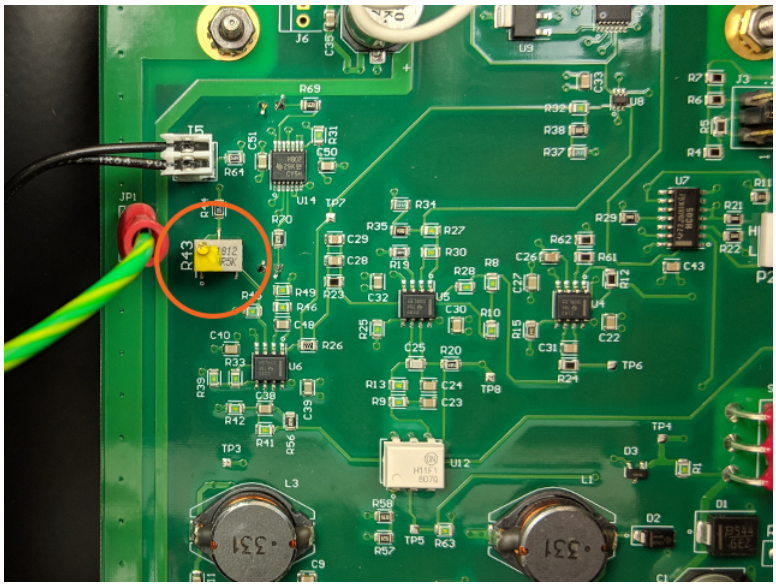

Figure 2-4. R43 Trim Potentiometer for Calibration (with Yellow Adhesive Shown)

5. Raise the clear enclosure and lower the motor unit to its lowest position on the support beam, tightening the height adjustment knob when finished. Attach a small (1/8" *or* 3.2 *mm*) strip of reflective tape to the rotating shaft (see Figure 2-5). The reflective tape is included in the MSR Rotation Rate Calibration Kit (AKMSRCAL). Lower the enclosure to the closed position, ensuring the "Enclosure" LED on the control unit is not illuminated.

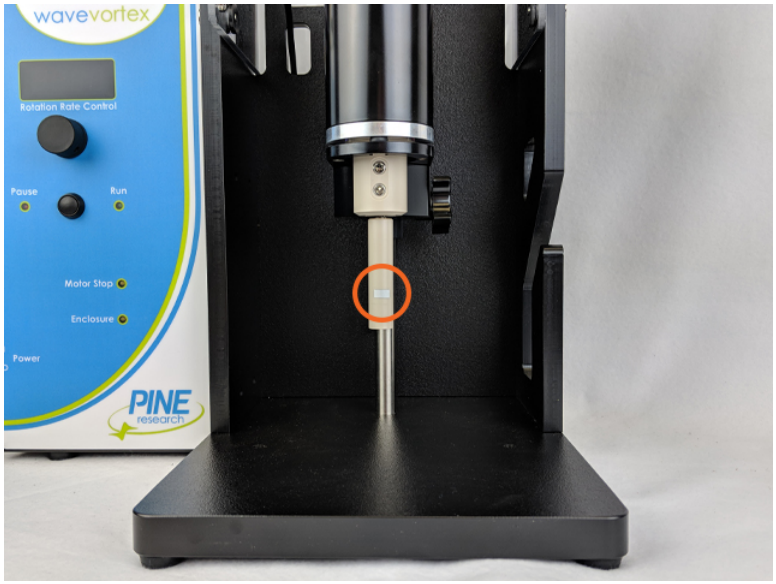

Figure 2-5. WaveVortex 10 Shaft with Reflective Tape Applied

6. Ensure the control cable is installed, connecting the motor head with the control unit connector on the back panel.
7. Connect the power supply to the WaveVortex 10 and turn the power switch to the on position. After a brief pause, the Rotation Rate LED will indicate the last used rotation rate. The "Pause" LED will illuminate upon initial power on.

WARNING: Laster Radiation.

Many optical tachometers use a laser beam as a light source. Do not look directly at the laser beam. Do not point the laser beam into the eye.

8. Set the rotation rate to 1600 *RPM* by turning the Rotation Rate Control knob.
9. Obtain the hand-held laser tachometer (included with AKMSRCAL). Rest the tapered orange end of the tachometer against the outside enclosure wall, Press the "TEST" button on the tachometer and view the position of its measurement by watching the red laser beam on the shaft. The red beam must strike the shaft at the point where the reflective tape is applied to the rotating shaft when measuring rotation rate.

Figure 2-6. Positioning of the Handheld Tachometer and its Beam Hitting the Rotating Shaft

10. Press the button on the WaveVortex 10 front panel, switching the system from "Pause" to "Run." The shaft will rotate at the specified rate and the "Run" LED will illuminate.
11. Use the handheld tachometer to measure the actual rotation rate of the shaft. Compare the value on the handheld tachometer to the blue LED display on the front panel of the WaveVortex 10 rotator.
12. Use the potentiometer adjustment tool to turn the trim potentiometer screw located at position R43 of the control unit circuit board (see Figure 2-7). Doing so will adjust the blue LED display of the WaveVortex 10 rotation rate.
13. Repeat the rotation rate measurement with the handheld tachometer.

14. Continue adjusting the trim potentiometer and taking tachometer measurements until the blue LED reads within ± 1 *RPM* of the reading on the handheld tachometer.
15. Calibration is now complete. Following calibration, a secondary set of verifications will ensure the input and output from the WaveVortex are also calibrated (see Section 3. Verification Procedure).

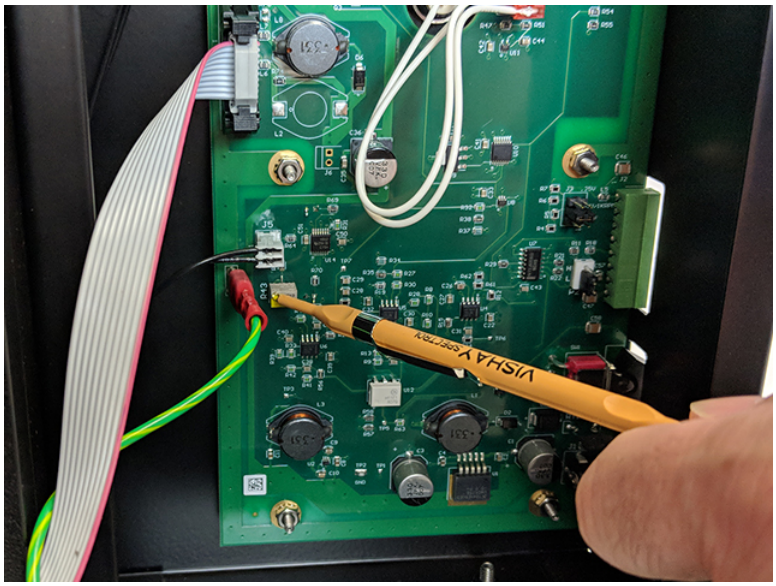

Figure 2-7. Adjustment of the Trim Potentiometer Screw to Calibrate the Rotation Rate

3. Verification Procedure

Following calibration (see Section 2. Calibration Procedure), verify the input to, and output from, the WaveVortex 10 Electrode Rotator.

3.1 Verification of Output Signal

The 8-position I/O connector on the side of the WaveVortex 10 control panel provides access to monitor the rotation rate as a voltage signal. The back of the WaveVortex 10 shows a label that indicates the function of each of the eight positions (see Figure 3-1).

When the WaveVortex 10 is in the "Run" state, the actual rotation rate measured by the rotator's tachometer is displayed on the front panel. The actual rotation rate can also be monitored using a signal presented at port #3 on the External I/O Port (see Figure 3-1). A traceable voltmeter, oscilloscope, or other recording device like a potentiostat can monitor the potential difference between pin #3 (Rate Monitor) and pin #4 (DC Common), and the observed signal is proportional to the rotation rate.

The ratio for this output signal is 2 *RPM/mV*. These measurements allow verification of the WaveVortex 10 calibration at various rotation rates.

1. Prepare the WaveVortex 10 by connecting it to its power supply, adjusting the power switch to the on position, applying a piece of reflective tape to the shaft (see Figure 2-5), and lowering the enclosure.
2. Connect the voltage measuring device to the WaveVortex 8-port I/O connector.
3. Identify the positions to which you will connect the voltage measuring device. Install a short lead wire into the 8-slot connector by inserting a wire and tightening the screw to hold the wire in place (see Figure 3-2).

Figure 3-1. Side Connector I/O Label

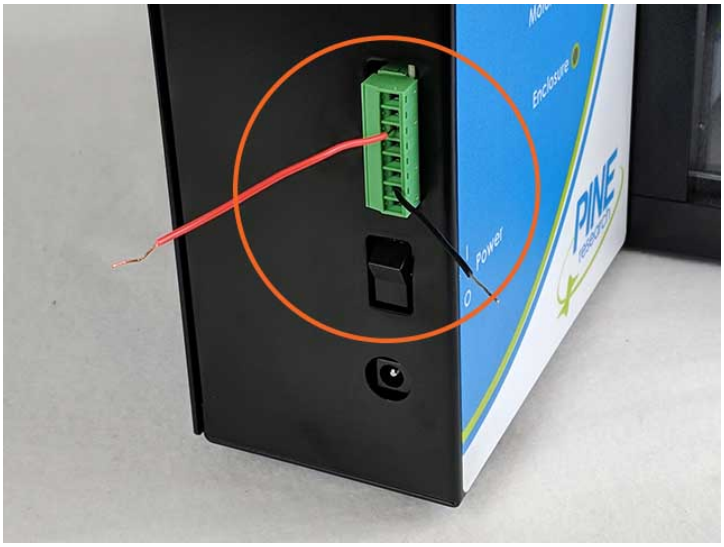

Figure 3-2. Lead Wires Connect to Various Positions on the 8-Port Connector

4. Connect the voltage-carrying lead (typically red lead for a digital voltmeter, or the Working/Working Sense leads of a potentiostat) to the wire at position 3 of the 8-port connector. Connect the ground/common lead (typically black lead for digital voltmeter, or the Counter/Reference leads of a potentiostat) to any of the DC common positions of the 8-port connector (positions 2, 4, 6, or 7) (see Figure 3-1 and Figure 3-3).
5. Enable the voltage-measuring system to make continuous recordings (set voltmeter to measure potential, or perform a long Open Circuit Potential experiment with a Pine Research potentiostat).
6. With the WaveVortex "Pause" LED illuminated, select the desired rotation rate. During calibration and verification in the production facility, our technical team measures the voltage reading at several rotation rates (see Table 3-1).

7. Enable rotation by pressing the center button. The "Run" LED will illuminate.
8. As with calibration, monitor the rotation rate with a handheld tachometer by focusing the laser on the reflective target on the rotating shaft.
9. Record the stable handheld tachometer reading and output voltage. Remember, the output voltage is always in ratio to rotation rate by 2 RPM/mV.
10. Repeat steps 4 – 7 for each rotation rate (see Table 3-1).

Figure 3-3. Calibration Verification by Measuring Output Voltage with a Voltmeter (Left) and Potentiostat (Right)

Blue LED Display Reading (RPM)	Expected Rotation Rate (RPM)	Tachometer Reading (RPM)	Output Signal (V)
100	100 ± 2.0		
200	200 ± 2.0		
500	500 ± 5.0		
1000	1000 ± 10.0		
2000	2000 ± 20.0		
5000	5000 ± 50.0		
8000	8000 ± 80.0		

Table 3-1. WaveVortex 10 Output Signal Verification

If the voltage recording device does not log data, be sure to manually write down the potential value during each rotation rate test. The displayed rotation rate on the blue LED is proportional to a set ratio, found by the simple calculation, which follows.

$$Output\ Signal\ (mV) \times \left(\frac{2\ RPM}{mV}\right) = Rotation\ Rate\ (RPM)$$

If using a potentiostat and open circuit potential to monitor the rotation rates, the output voltage will be recorded and can be measured after a sequence of rotation rates. A typical OCP experiment response has been provided, from which the voltage can be found using tools in our AfterMath software (see Figure 3-4).

INFO:

For a good calibration, the Tachometer Reading will be equal to the Expected Rotation Rate (within the stated tolerance). The Output Signal multiplied by the 2 *RPM/mV* ratio is the actual rotation rate and should also be equal to the Tachometer Reading (within the stated tolerance).

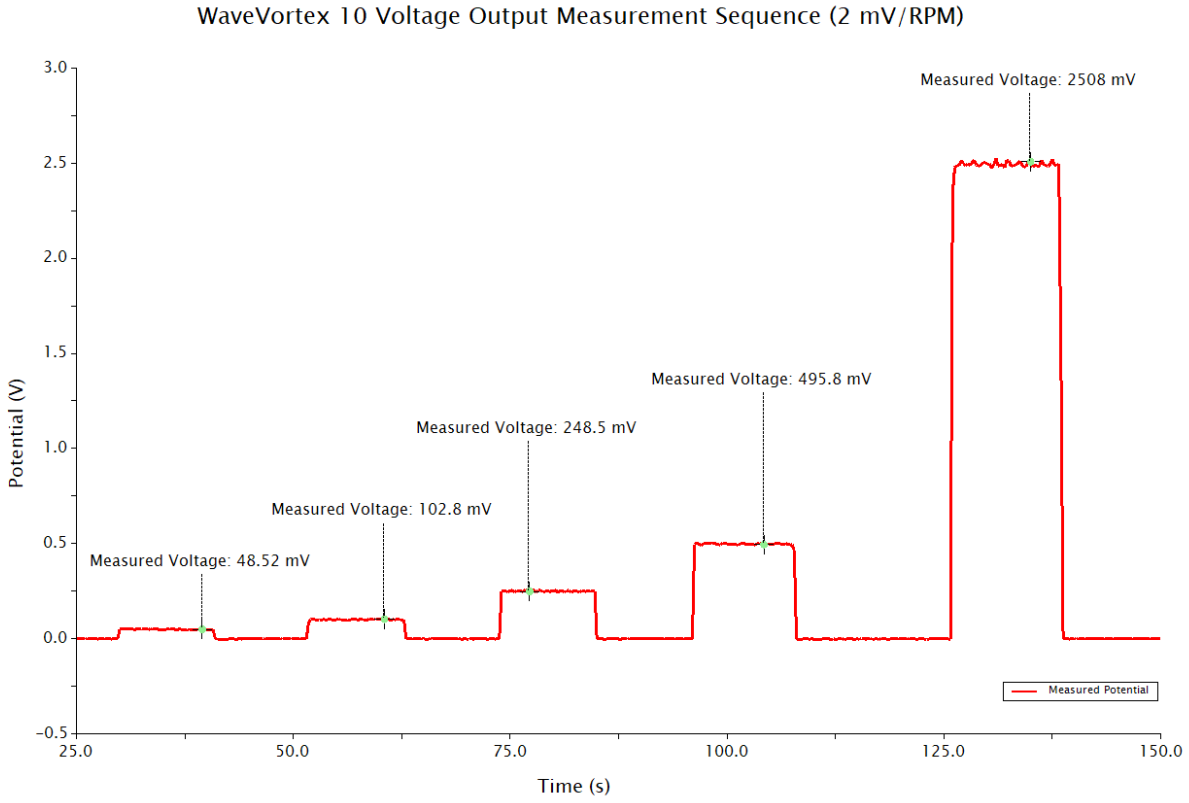

Figure 3-4. AfterMath Open Circuit Potential Measurement at the Rate Monitor I/O port of a WaveVortex 10

3.2 Verification of Input Signal

Many potentiostats can provide a signal to control the rotation rate while simultaneously performing electrochemical measurements. Such automated control of the rotator is made possible when the potentiostat outputs an analog voltage signal to the WaveVortex 10 rotator. This $0 - 10\ V$ signal and DC common connect to the Rate Control (port 1) and DC common (ports 2, 4, 6, or 7) on the 8-port External I/O Port connector on the WaveVortex 10. A special cable (part number AKCABLE7-03) available for Pine Research potentiostats also carries a digital control signal from the potentiostat to port 5 (motor stop) on the 8-port External I/O Port connector on the WaveVortex 10. When a Pine Research potentiostat is connected to the WaveVortex 10 rotator with this special cable, the signal ensures that

when an experiment is not performing, there is absolutely no movement (or residual rotation) of the shaft.

The observed rotation rate is proportional to the input signal based on the setting of the J3 jumper (see Figure 2-3). The standard control ratio is 1 RPM/mV. Therefore, the displayed rotation rate on the blue LED is proportional to a voltage by the simple calculation, which follows.

$$Input\ Signal\ (mV) \times \left(\frac{1\ RPM}{mV}\right) = Rotation\ Rate\ (RPM)$$

To verify calibration with an input signal (analogous to using the Pine Research potentiostat rotator control connection), use a traceable DC voltage supply to deliver a signal voltage to the appropriate ports on the WaveVortex 10 External I/O connector. In production, Pine Research uses a traceable DC voltage supply; however, in the field a potentiostat can supply the signal in its place.

1. Prepare the WaveVortex 10 by connecting it to its power supply, adjusting the power switch to the on position, applying a piece of reflective tape to the shaft (see Figure 2-5), and lowering the enclosure.
2. Connect the DC voltage supply device to the WaveVortex 8-port I/O connector.
3. Identify the positions to which you will connect the DC voltage supply device. Install a short wire into the 8-slot connector by inserting the wire and tightening the screw to hold it in place (see Figure 3-2).
4. Connect the voltage signal lead (typically red lead for a DC voltage supply, or the Working/Working Sense leads of a potentiostat) to a wire at position 1 of the 8-port connector. Connect the ground/common lead (typically black lead for digital voltmeter, or the Counter/Reference leads of a potentiostat) to any of the DC common positions of the 8-port connector (positions 2, 4, 6, or 7) (see Figure 3-1).
5. Enable the DC Power supply to continuously supply a specified voltage signal (set supply to apply a potential for 15 s, or when using a potentiostat, setup a bulk electrolysis experiment (controlled potential) to run continuously for 15 s).
6. With the WaveVortex "Pause" LED illuminated, adjust the rotation rate to zero (turn knob left until it stops). During calibration and verification in the production facility, our technical team applies a series of voltages to interrogate the calibration at several rotation rates (see Table 3-1).
7. Enable rotation by pressing the center button. The "Run" LED will illuminate, but there should not be any noticeable shaft rotation as the system is set to 0 RPM.
8. Apply the desired input signal (see Table 3-2). Record the stable handheld tachometer reading and Blue LED Rotation Rate display reading. Remember, the input ratio is set at the production facility to 1 RPM/mV (see Figure 2-3).
9. Repeat steps 4 –6 for each input signal (see Table 3-1).

Input Signal (V)	Expected Rotation Rate (RPM)	Tachometer Reading (RPM)	Blue LED Display Reading (RPM)
0.100	100 ± 2.0		
0.200	200 ± 2.0		
0.500	500 ± 5.0		
1.000	1000 ± 10.0		
5.000	5000 ± 20.0		

Table 3-2. WaveVortex 10 Input Signal Verification

INFO:

For a good calibration, the Tachometer Reading will be equal to the Expected Rotation Rate (within the stated tolerance) and to the Blue LED Display Reading as a function of the applied input signal.

4. Finalization

After completing calibration and verification tasks, turn the WaveVortex 10 power switch to the off position and disconnect the power supply. Remove the reflective target from the shaft. Use the screwdriver to secure the back panel to the rear of the control unit. Make final notations in a calibration record, as appropriate.

5. Support

After reviewing the content of this user guide, please contact Pine Research Instrumentation should you have any issues or questions with regard to the use of the instrument, accessories, or software. Contact us anytime by the methods provided below.

Online

Our website has a contact form which allows technical support requests to be sent directly to Pine Research. Visit www.pineresearch.com/contact.

E-mail

Send an email to pinewire@pineresearch.com. This is the general sales email, and our team will ensure your email is routed to the most appropriate technical support staff available. Our goal is to respond to emails within 24 hours of receipt.

Phone

Our offices are located in Durham, NC in the eastern US time zone. We are available by phone Monday through Friday from 9 AM EST to 5 PM EST. You can reach a live person by calling +1 (919) 782-8320.

WaveVortex 10 Electrode Rotator Calibration

Serial Number	Certification Technician
Tachometer Make, Model, and SN	Tachometer Calibration Date
Voltmeter Make, Model, and SN	Voltmeter Calibration Date

Control Unit Display and Output Signal Verification

Blue LED Display Reading (RPM)	Expected Rotation Rate (RPM)	Tachometer Reading (RPM)	Output Signal (V)
100	100 ± 2.0		
200	200 ± 2.0		
500	500 ± 5.0		
1000	1000 ± 10.0		
2000	2000 ± 20.0		
5000	5000 ± 50.0		
8000	8000 ± 80.0		

Control Unit Input Signal Verification

Input Signal (V)	Expected Rotation Rate (RPM)	Tachometer Reading (RPM)	Blue LED Display Reading (RPM)
0.100	100 ± 2.0		
0.200	200 ± 2.0		
0.500	500 ± 5.0		
1.000	1000 ± 10.0		
5.000	5000 ± 20.0		

- The rotation rate for this unit is certified to be within ±1% of the displayed value on the control unit from 200 – 8000 *RPM* and ±2 counts of the displayed value from 100 – 200 *RPM*.
- This calibration is valid only for the control unit and motor unit whose serial numbers match as specified above. The control unit and motor unit must be calibrated together.

- Each rotating electrode type used with this rotator has a unique maximum rotation rate.
- Never exceed the maximum rotation rate for a given rotating electrode type.
- Use extreme caution when rotating electrodes > 2000 *RPM*.
- Always put the enclosure window in lower position before rotating an electrode.