Model HT-91108
Microplate Orbital Shaker
with USB Data Control

Product Manual

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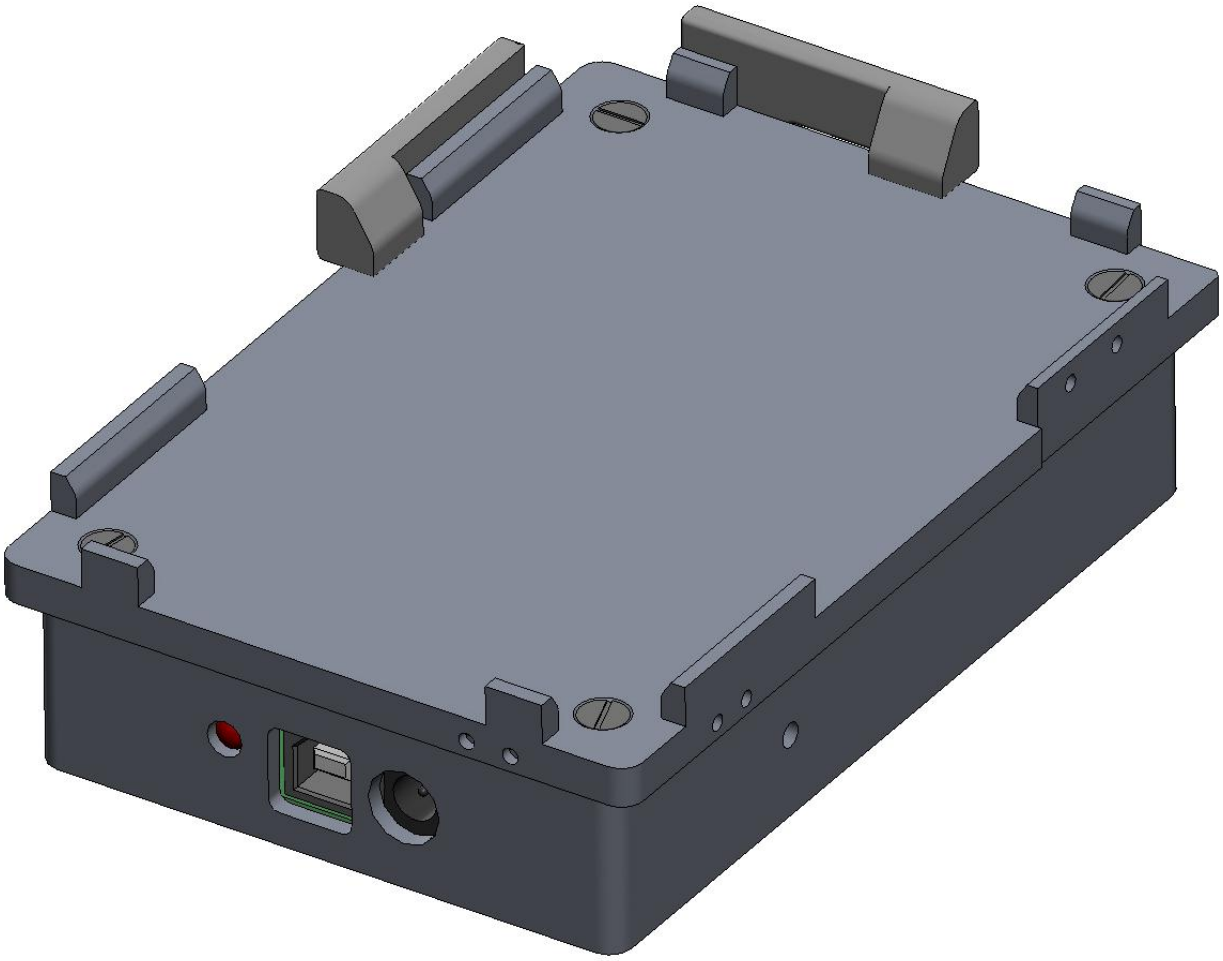


Description

Congratulations on your purchase of Big Bear Automation's Microplate Orbital Shaker. This precision laboratory instrument will provide years of reliable operation for you. The HT-91108 Microplate Orbital Shaker with USB control is designed to provide an orbital shaking motion for a single microplate, keeping liquids either gently stirred or fully mixed and in suspension. Its thin profile and same footprint dimensions as a standard well-plate makes it ideal for use on robotic deck plates wherever you might set a microplate.

The Shaker uses it's own built-in microcontroller and USB transceiver to supply you with intelligent program control of all Shaker features.

HT-91108 Microplate Orbital Shaker with USB Control

Features

- Rotationally shakes a single microplate.
- Table corrected speed range of 60 to 3570 RPM.
- 0.5, 1 or 2 mm orbital motion. Small enough not to spill liquids at high speed.
- Full and rich ASCII command set, with sample VB6 PC interface.
- Low stirring speed to ultra-vigorous vortex speeds for viscous liquids.
- 24 VDC power for safe and easy integration with other automation.
- Cold running motor allows continuous operation, weeks at a time.
- Small number of precision components for extreme reliability over years of use.
- Precise home positioning every time.
- Spring clips secure microplate; easy on and off for robots or people.
- Base is same size as microplate & fits onto robotic decks.

Specifications

Orbital Motion	1 mm diameter, circular shape, constant everywhere on well plate. 0.5 and 2 mm orbital motions optional.
Speed	60 RPM to 3570 RPM, programmable. Resolution 14 RPM. Acceleration/deceleration in range of 0-10 seconds.
Power Required	24 VDC, 180 mA. 100-240 VAC 50-60Hz power adapter included. DC power receptacle on end of unit.
USB Port	USB 1.0/2.0 compatible. Supplied Windows driver makes the USB port look like an serial Com port, with identical specs as HT-91100 shaker. 6 foot USB cable supplied.
Base Dimension	3.350" (85mm) width, 5.030" (127.8mm) length
Microplate Platform Dimension	3.650" (92.7mm) width, 5.300" (134.6mm) length, centered on top of base. Secures a single 96 or 384 micro well plate with SBS footprint.
Height	1.215" (30.9mm) height from bottom of rubber feet to top surface of shaker table platform. 1.775" (45.1mm) height from bottom of rubber feet to the top surface of a standard well plate. 0.995" (25.3mm) from bottom of rubber feet to bottom of shaker platform.
Weight	1.351 pounds (612.8 g)
Operating Temperature	0° F to 120° F (-17.5° C to 49.0° C), non-condensing, RH to 90%
LED Indicator	Tricolor LED, green when at commanded velocity, yellow during acceleration or deceleration, red during home finding, on end of unit.
Serialization	Each unit has unique electronic serial number.
Control	8752 family microcontroller, 8-bit DA converter for speed control. 3-phase brushless servomotor drive, retroreflective optical sensor for shaft position and home index.
Material	Aluminum, nickel plated, stainless steel hardware, white polypropylene clips. Hi-phosphor nickel plating available.
Warranty	Two year limited replacement warranty.
Certifications	CE certified for laboratory equipment, RoHS compliant.
EAN Codes	EAN 0700371289553: HT-91108-0.5 EAN 0700371289560: HT-91108-1 EAN 0700371289577: HT-91108-2

Set-up Instructions

Included in your boxed package:

- HT-91108 Microplate Orbital Shaker
- 100-240 VAC 50-60 Hz Power Adapter with power cord and cable
- 6 foot USB cable, male A to male B connectors.
- Yellow USB drive with this manual in pdf format, PC interface program, VB6 sample source code.
- Red USB drive with Virtual Com Port driver.

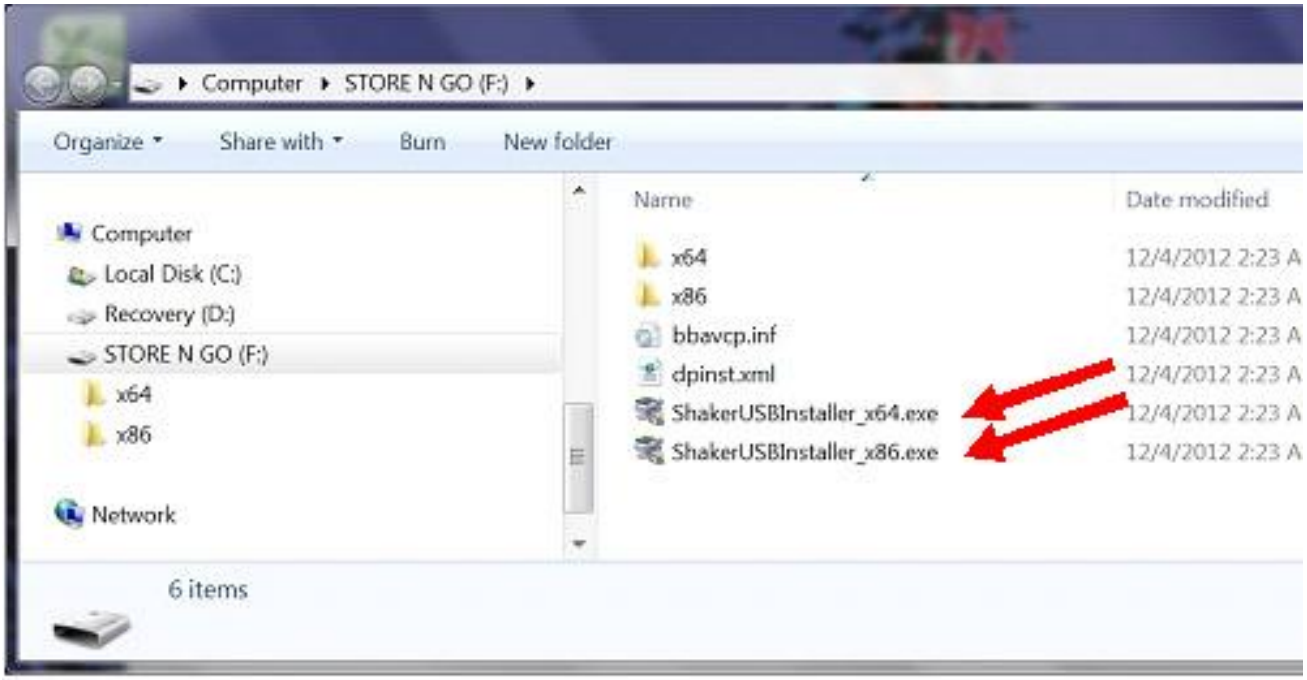
Installing USB Virtual Com Port Driver

To interface this shaker with a PC or a Windows based operating system, you must install a USB virtual Com Port driver. This driver is included with your package and is a file on the red USB drive in the red plastic baggie. The file is a driver that allows the shaker's USB port to act as a virtual serial Com port.

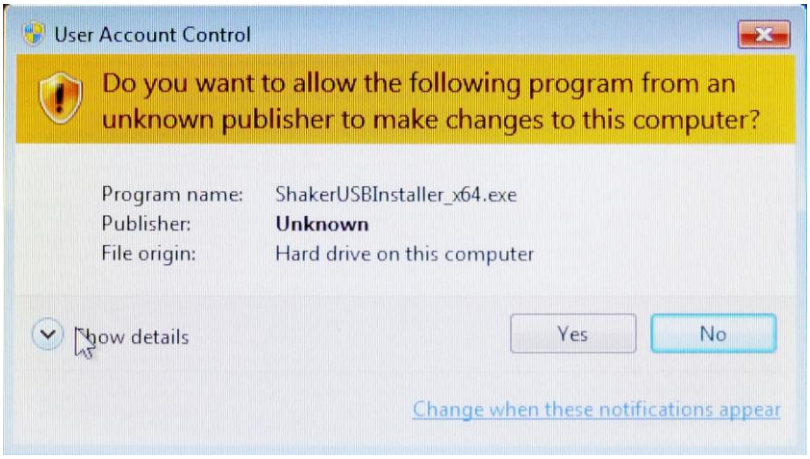
In simplest instructional terms, plug in the red colored USB drive, navigate to the files on this drive, and then choose the *ShakerUSBInstaller_x64.exe* for PCs with 64 bit processors, or choose the *ShakerUSBInstaller_x86.exe* for older PCs with 32 bit processors. Follow the instructions and allow the driver software to install, and you are done. You can plug in and use the shaker in just a few moments.

Detailed instructions follow for each step needed to install:

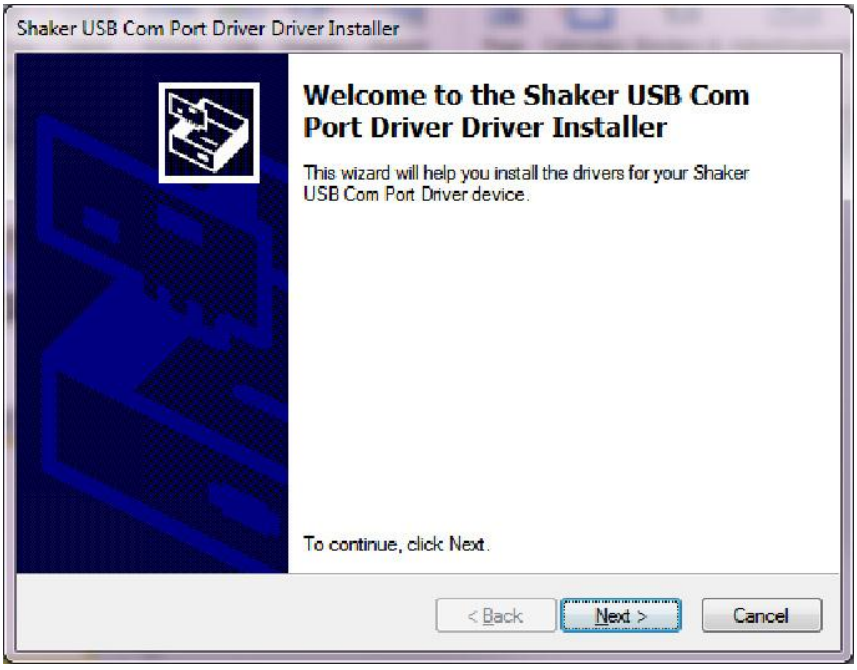
Insert the red USB drive into your computer. Generally, a window will pop up to allow you to open the files on the device. Open the device files, or navigate to the USB drive, and look for the two .exe files.



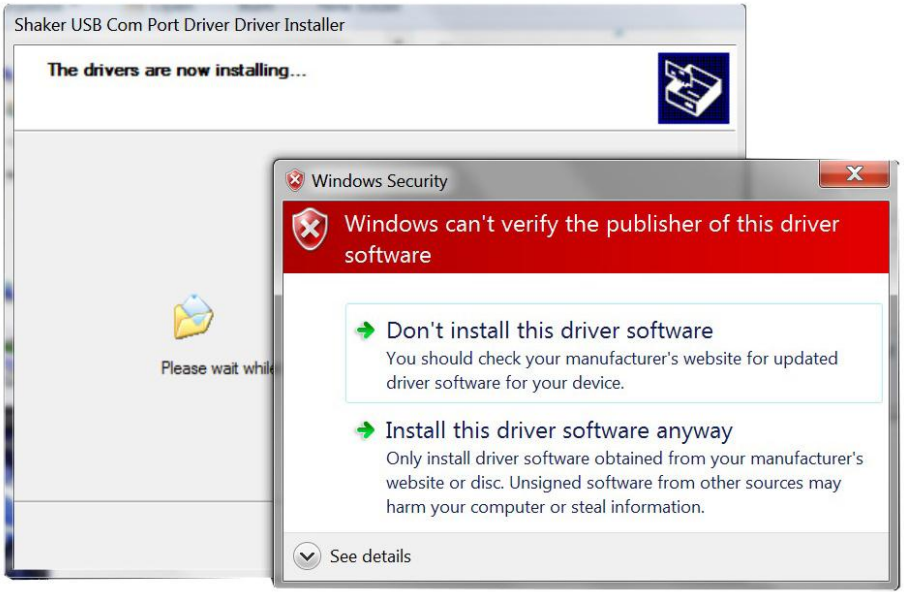
If you have a newer PC with a 64-bit operating system, then choose the file ***ShakerUSBInstaller_64.exe***, and execute it by clicking it twice. If you have a slightly older PC with a 32-bit operating system, then choose the file ***ShakerUSBInstaller_86.exe***, and execute it by clicking it twice.



You may see this pop-up message window, press ***Yes*** to continue.



Press ***Next*** to continue after the welcome screen for this driver installation.



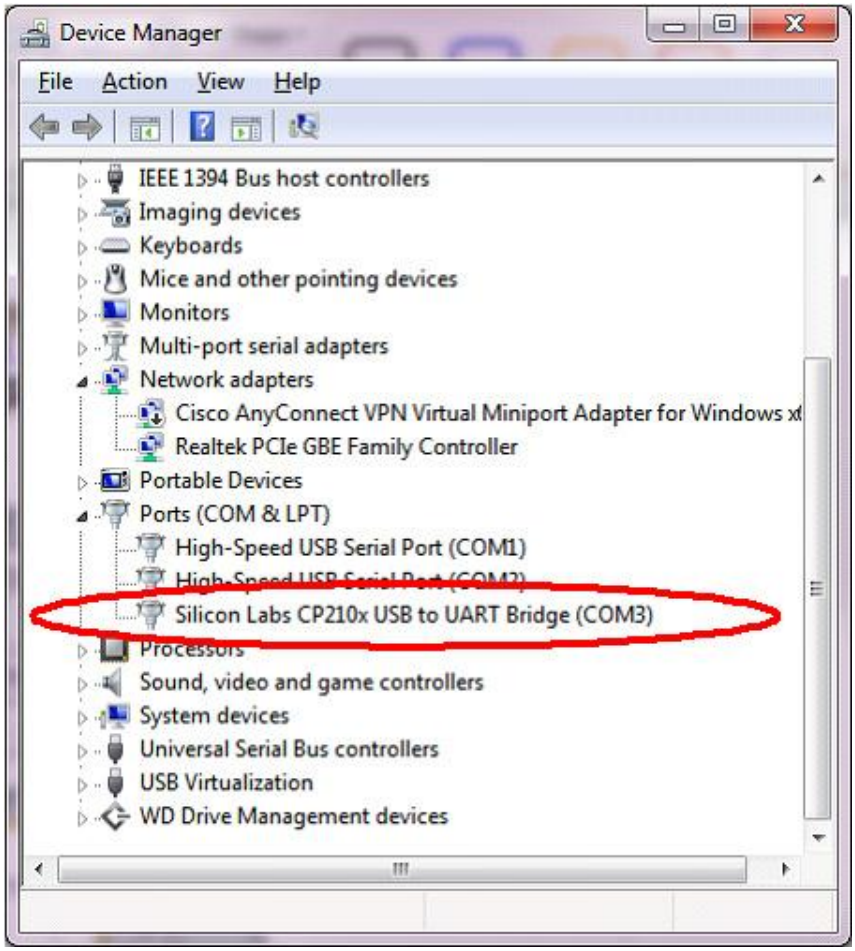
Again, continue installation by pressing the selection ***Install this driver software anyway***.

Press the ***Finish*** button to complete installation of the driver.

The driver is now completely installed. Plug in the USB cable to the shaker now. There will be a moment while the software driver installs, and then the shaker is ready to be used.

What just happened? The shaker uses an IC on its printed circuit board that links to the USB standard. This chip is a Silicon Labs 2102 device. The driver you just installed allows the computer to access this USB channel as if it were a much simpler RS232 serial port. This is called a Virtual Com Port, where the Com Port is not an actual hardware port, but instead a software driver access to the USB channel. The shaker can now be accessed as if it were a serial port. Many programs on PCs can easily access a Com Port to control the shaker now, including the Shaker Interface application, which you can load from the other yellow USB drive in your shaker package. That app allows you to control the shaker and all of its most basic functions so you can debug it quickly when integrating to your own equipment.

When looking at the Device Manager reporting, you will find the new shaker USB port listed as a *Silicon Labs CP210x USB to UART Bridge (COMx),* where the x value was just assigned automatically by your PC.



Plug-In the Shaker

Unwrap the Shaker and place flat onto a hard surface. Connect the 24 VDC power plug from the power adapter firmly into the power receptacle hole on the end of the shaker. Connect the USB cable into the end of the shaker fully. Plug in the other end to any spare USB port on your PC. Finally, plug the power adapter into any AC outlet.

Ensure the status LED on the end of the Shaker blinks rapidly through red, yellow and then a stable green color.

You are now ready for interfacing to your Shaker with the PC.

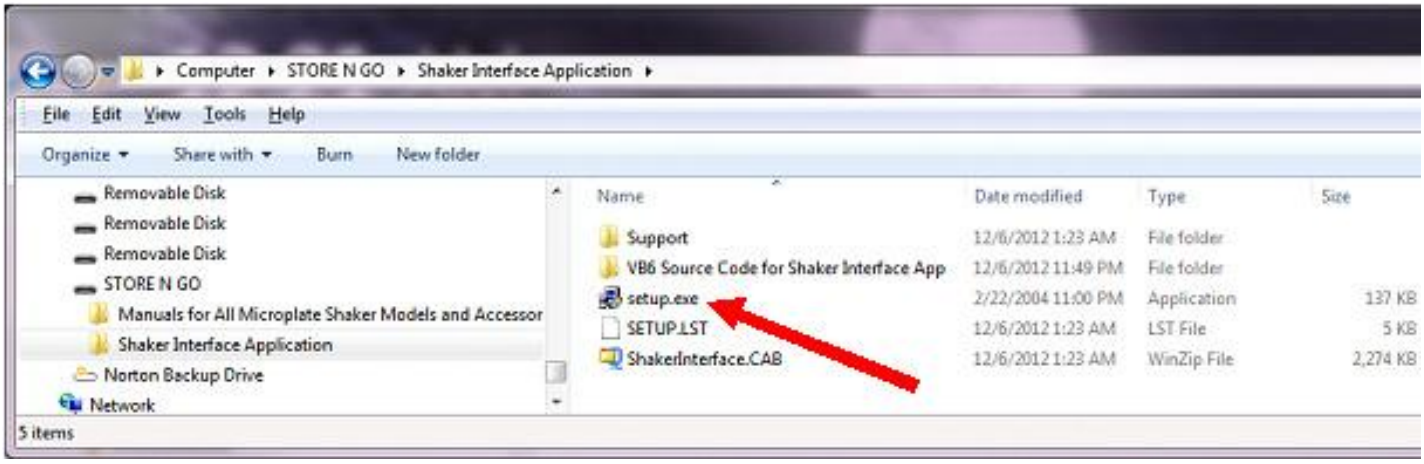
Set-up the PC Shaker Interface Program

Included with your package for the HT-91108 Shaker is a test program for interfacing the Shaker with a PC. It allows you to test all of the features available on your new shaker with a simple-to-use interface Window. All of the VB6 source code is also included on a separate sub-directory, so you may use portions of it in your own programming interfaces.

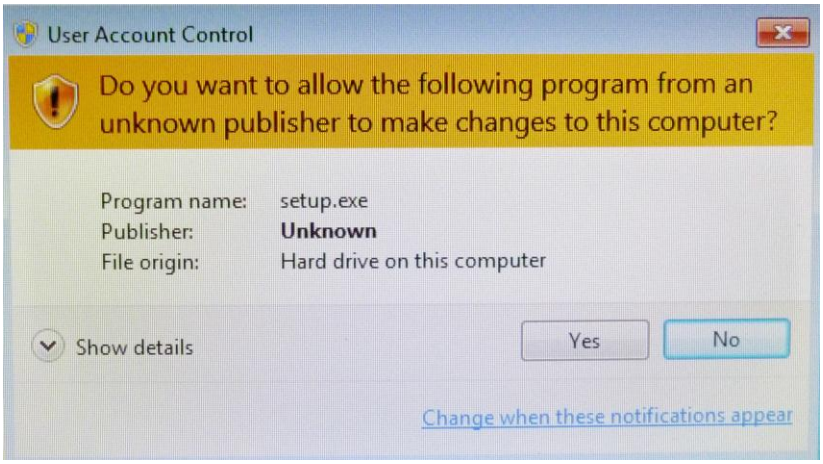
To set-up the program, simply plug in the yellow (or green) USB drive into any spare USB port on your PC. Navigate to the USB drive's root files. Double click the setup.exe file to execute it, and follow the instructions to install it.

Detailed installation instructions follow:

Insert the yellow (or green) USB drive into your computer. Generally, a window will pop up to allow you to open the files on the device. Open the device files, or navigate to the USB drive, and look for the sub-directory named ***Shaker Interface Application***. Double click on that directory name to open it up. Now look for the ***setup.exe*** file, and double click to execute it.

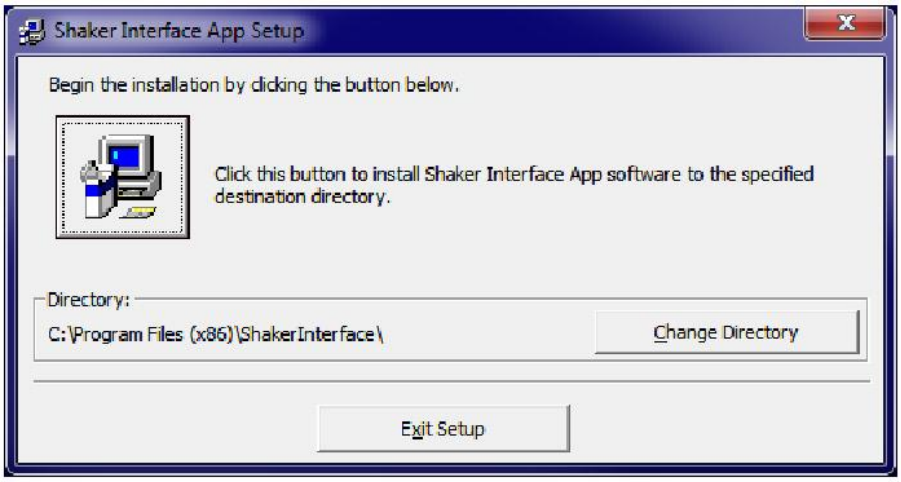


What the sub-directory listing looks like where the ***setup.exe*** file can be found.

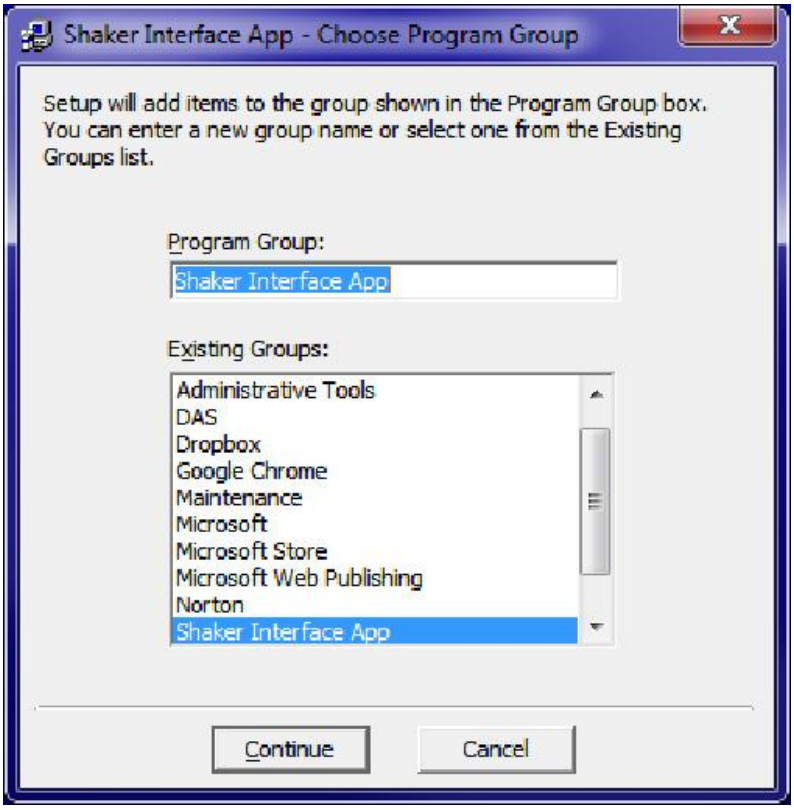


You may see this notice, press the ***Yes*** button to continue.

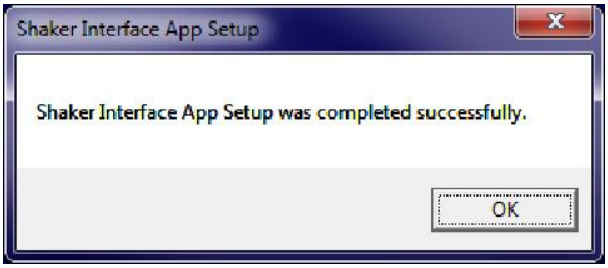
Now the App setup screen starts, press the ***OK*** button to continue.



Press the large square button to setup the app with normal defaults.



Press the ***Continue*** button for normal app setup defaults.



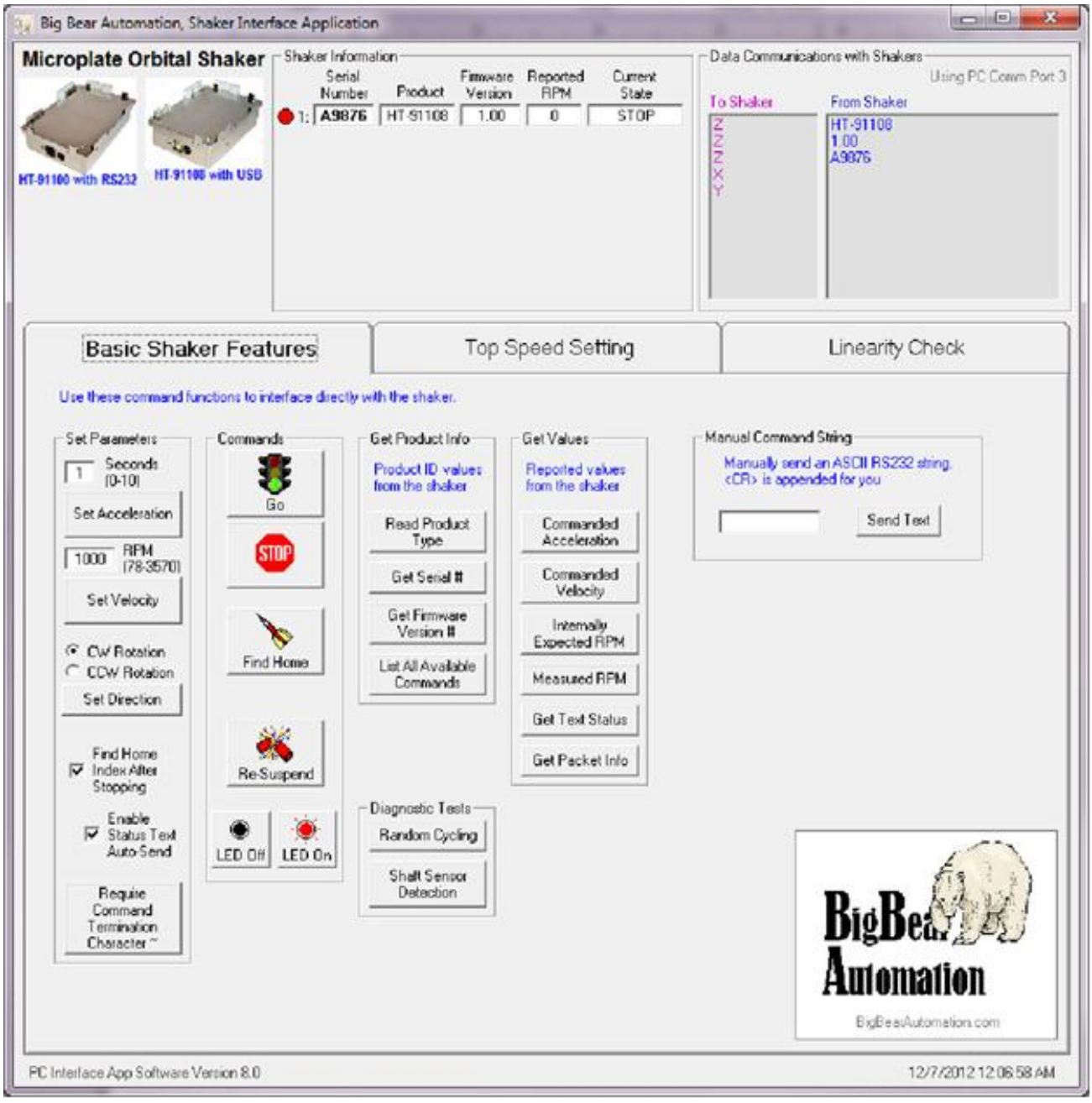
All done, the app was installed successfully. Press ***OK*** to finish.

Once loaded onto your computer, navigate to the Program Group now on your computer called *Shaker Interface App*, and execute the program called ***Shaker Interface App***.

First, you must select whether you have just a single shaker connected to a single PC port, or you are connecting a USB shaker. If so, select the top radio button.

If you have multiple shakers configured in a daisy-chain mode connected to a single serial port, choose the bottom radio button.

The program will now automatically scan all of your PC's serial ports (or virtual serial Com ports using USB channels). This automated process runs through all of the accessible ports on your PC and attempts to establish communication with the Shaker. If it finds a shaker, it will automatically assign that Com port to the Shaker, and the rest of the interface program's features will be enabled. The basic information about the shaker is acquired automatically, such as the serial number and firmware revision number.



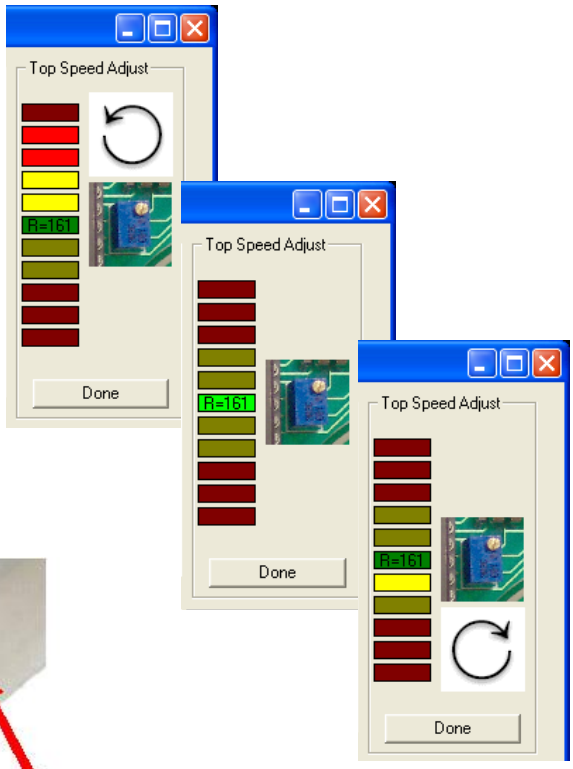
If it did not automatically find the Shaker, the available com ports on your PC will be displayed in black, and the unavailable ports, or those ports not present on your PC, will be displayed in grayed-out color. You may reconfigure your PC if necessary and try again.

After a serial port has been located that detects the presence of a shaker, all of the menus will be visible..

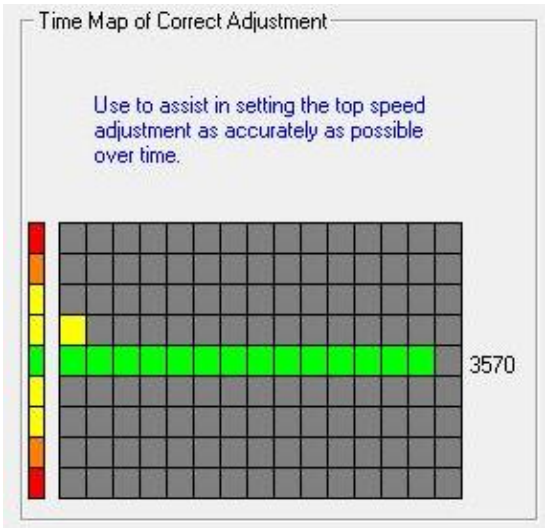
Most of the features of the Shaker interfacing is accessible on this program window. You can read in details of the Shaker values. The interface program provides a real-time display of the incoming communications text from the Shaker. You can monitor the Shaker's responses to your data queries there.

As a simple example of operation, in the *Set Parameters* frame, fill in the number of *Seconds* in the text box acceleration and press the ***Set Acceleration*** button to send it to the Shaker, do the same for the *RPM* you want to achieve and press the ***Set Velocity*** button, then simply press the ***Go*** button in the *Motion Commands* frame. The Shaker will start ramping up to the desired velocity. You'll notice the status text strings being sent from the Shaker as it ramps up and finally reaches speed. Press the ***Stop*** button and the Shaker decelerates at the same rate back to zero, and a homing action will occur very quickly afterwards to complete the cycle.

Another feature present on the test program is the factory adjustment for the top speed of the Shaker. The Shaker is specified at 3570 RPM for the highest speed, and this is adjusted and calibrated at the factory at a potentiometer on the microcontroller's printed circuit card inside the Shaker unit. By clicking the ***Set Top RPM*** button of the test program under *Diagnostic Tests*, anther frame pops up displaying the adjustments required as the Shaker runs at its top speed. If the speed is too high or too low, a small rotation picture shows which way the potentiometer must be adjusted. The correct speed calibration will show only the green bar lit. It is normal to have some small amount of data bounce about this exact speed. Press the ***Stop*** button or the ***Done*** button when you are finished, and the Shaker will decelerate back to a stop.



To access the top speed adjustment, remove the tiny set screw on the side of the shaker, as described in the picture above. Use a small jeweler's screwdriver to access the potentiometer directly behind the opening.



Additionally, there is time-map graph showing the percentage of successful top speed readings. It allows you to make adjustments and ensure they are stable over time.

Interfacing to the Shaker Using Serial Communications

Interfacing with the Shaker uses the serial communication ports available on almost all PCs, or over the virtual Com Port installed using a USB channel, which makes the USB channel act like a Com Port.

Communication protocol with the Shaker over the USB Virtual Com Port is 9600 baud rate, 1 stop bit, no parity bits and no hardware flow control. Using the HT-91108 USB shaker and its associated Virtual Com Port, you do not have any responsibilities for correct hardware wiring or any RS232 serial signal lines.

We have designed the Shaker programming interface to be as simple as possible, using single character commands attached directly to any data you send. Most data coming from the Shaker is completely automatic, and you may optionally turn off automated status strings if it interferes with your code that accepts incoming serial data.

Summary of Serial Communication Commands

Axx	Set acceleration value in range 0 to 10 seconds.
B	Immediate, uncontrolled brake action.
C	Disable finding of shaft home feature.
D	Disable motor driver, motor will free coast to a stop.
E	Enable the finding of home feature after the motor stops (default).
F	Find the home sensor.
G	Go, start the motor, using set velocity and acceleration.
Hxx	Set acceleration in range 0-10 for Cycle 1.
Ixxxx	Set velocity in RPM for Cycle 1, range 60-3570.
Jxxxxx	Set time, in seconds, that Cycle 1 lasts, range 0-30,000.
Kxx	Set acceleration in range 0-10 for Cycle 2.
Lxxxx	Set velocity in RPM for Cycle 2, range 0-3570.
Mxxxxx	Set time, in seconds, that Cycle 2 lasts, range 0-30,000.
N	Begin continuous cycling between the two speeds set in Cycle 1 and 2.
O	Enable status text automatically sent over serial data after a change (default).
P	Disable status text sent automatically, nothing is sent.
S	Stop the motor using deceleration values, then find home if okay to use.
T	Test the reflective optical sensor that finds the home index mark.
Vxxxx	Set the velocity for the next motion, in range 60 to 3570 RPM.
+	CW rotation motion (default).
-	CCW rotation motion.
U	Enter daisy-chain mode and re-order multiple shakers.
@	Preface character for daisy-chain addressing.
(	Turn off and disable usage of the LED indicator on the side of the shaker.
)	Turn on and enable the LED indicator.
!	Re-suspension protocol, breaks up stubborn sediment.
~	Request a response for every command sent.

Summary of Serial Communication Requests

?	Request this list in its entirety, with the descriptions listed here per command..
?A	Shaker responds with A=xx, the currently set acceleration value, 0-10.
?V	Shaker responds with V=xxxx, currently set velocity, range 0-3570 RPM.
?R	Shaker responds with R=xxxx, measured RPM of the motor shaft.
Q	Request text status, unit responds with RAMP+-, RUN, STOP, BUZZ.
?W	Shaker responds with W=xxxx, internal commanded current velocity.
X	Shaker responds with the firmware version of the microprocessor, x.xx.
Y	Shaker responds with the serial number of the unit, A1234 (xxxxx).
Z	Shaker responds with model number, HT-91108.
$	Responds with a high speed data packet of status, commanded and measured RPM.

Serial Communication Rules

Common serial communication rules that the shaker uses are:

- Characters "**=**" (Equal Sign), " " (Space) and the **Linefeed** character are ignored by the shaker unit. Therefore, the command that you send "**V=100**" is the same as "**V100**".

- All commands or data request strings sent to the shaker must be terminated by a **<CR>**, Carriage Return, decimal value 12, hexadecimal value 0xD.

- Since the **<LF>**, Linefeed character, decimal value 10, hexadecimal value 0xA, is ignored, you may safely send a **<LF><CR>** command termination at the end of every string line if you are using a PC port testing program such as HyperTerminal.

- After the shaker sends out all data, it terminates the string with a single **<CR>**, Carriage Return.

- Only data request type of commands initiate the shaker to send data. For all other commands, the shaker does not send a response. You can request the shaker to always respond with the special mode command "**~"**.

- If the shaker receives an unknown data request, it responds with "**?:**", followed by the command values that you sent, followed by a <CR>.

- If you do not terminate a command string with a <CR>, subsequent strings will accumulate in the shaker. If the shaker receives a command string longer than 20 characters, or if the accumulated buffer reaches 20 characters, the shaker responds immediately at the 20th character with "**?;**", followed by the current command string buffer, followed by a <CR>.

- All commands you send the shaker and data sent from the shaker will be upper case characters only. Lower case characters will not be recognized.

- The shaker accepts and responds to serial commands at any time, even while executing another command or motion. Therefore, you may request information on current velocity at any time, or you can even request a new acceleration and velocity motion to be executed before the last has ended. A Stop command can be sent at any time and will be executed immediately.

- After you power up the shaker, all values are internally defaulted. If you wish certain features disabled, you must resend these commands to perform these actions before you use the shaker in your application.

- You may send values with leading zeros if your programming is easier to accommodate. For example, the command "**V=0500**" is the same as a command of "**V500**".

Overview of Shaker Control Features

There are a number of features that can be commanded, as well as options that can be enabled or disabled. Some basic features are:

***Basic speed, start and stop commands*:** Set the RPM you want to achieve by setting the **Vxxxx** command to any value in the range 0 to 3570. Use **Axx** to set the number of seconds to reach that velocity in range 0-10, then begin the shaking motion to that velocity with the **G** go command. When you want to stop the shaking, send an **S** command to stop.

Alternating speeds mode: In the alternating speed mode, you set the acceleration, velocity and dwell time for speed number 1, set the same conditions for speed number 2, then start the shaker. It works on its own, alternating between these two speeds indefinitely. For speed 1, use **Hxx** for acceleration, **Ixxxx** for RPM velocity value, and **Jxxxxx** for the number of dwell seconds, in range 0-30,000, that the shaker stays at this speed. For the alternate speed 2, use **Kxx** for acceleration, **Lxxxx** for speed 2 velocity, and **Mxxxxx** for the dwell time. Start this mode using the **N** command. Use **S** for stopping normally, using the most recently set acceleration value for ramping down to zero velocity.

Timed speed mode: Use this mode to set a velocity **Ixxxx**, an acceleration **Jxx**, and a total amount of dwell time **Jxxxxx** in seconds that this speed runs. You must specifically set the velocity value of the alternating mode's speed 2 value of **Lxxxx** to 0, as in "**L=0**". Then start the timed dwell time with the **N** command. The shaker will ramp up to whatever speed value you have set, then it will wait at that speed for the amount of seconds you have specified. After this dwell time is reached, the shaker decelerates and finally stops automatically. You may also terminate the dwell time and shaking at anytime by stopping the unit with the **S** command.

Precision home search: The shaker uses an optical retroreflective sensor to watch for an index mark on the spinning motor shaft that runs the shaker table. When it finds this index mark, it immediately brakes the unit at a very specific position each time this feature activates, within only a few rotational degrees each time (within 0.01mm of X-Y shaker table position). The speed of the home search is preprogrammed. It can occur at least once every revolution. By default, the home searching is on, or you may enable it with the **E** Command. When enabled, the home search occurs after every stop **S** command, after the shaker has decelerated to a stop. It adds about 0.75 seconds to the completion of the stop function. You can force the home feature to activate, if it is enabled, with the **F** command. You can disable this feature with the **C** command.

LED indicator: The tricolor LED on the end of the shaker units indicates current status. A green light indicates that the shaker is at a constant velocity value or is at rest. A yellow lamp indicates the shaker is transitioning or ramping between velocity values. A red lamp occurs when the shaker is searching for its home position. You can turn off the LED usage with the **(** command, and turn it back on with a **)** command.

Shaker status requests: There are a number of methods of retrieving the status of the shaker. By default, the shaker automatically sends out over the serial line a string value of "**RUN**" and a

<CR> if the shaker has achieved a stable velocity. If sends out "**STOP**" after the shaker has reached zero velocity and a home search is completed. It sends out "**RAMP+**" if the unit is in the process of accelerating to a new higher RPM, or it sends out "**RAMP-**" when decelerating to a lower RPM or stopping. When the shaker is executing the re-suspension protocol feature, the shaker sends out "**BUZZ**".

You can disable this default text sending condition by sending the **P** command, and the shaker will not send out these string commands at all. You can turn it back on using the **O** command. The text status can also be queried at any time by sending the **Q** data request command, and the shaker will send out one of these status strings immediately, even if the automatic text status is disabled.

You can request the current acceleration value the shaker will use by sending the "**?A**" data request, and the shaker responds with "**A=xx**", Use "**?V**" for the commanded velocity "**V=xxxx**" you have requested that the shaker achieve. Use "**?W**" to get a value of "**W=xxxx**", which is the value of the real-time internally commanded velocity that the shaker is achieving at that moment, and this value will change up or down as the shaker decelerates and accelerates.

Shaking orbital direction: By default, the shaker orbits clockwise (CW). To change the shaker to orbit counter clock wise (CCW) use the "**-**" command. To set it back to use CW motion, use the "**+**" command.

Product and unit information: Send the "**Z**" command to get the product model number of the shaker, currently "**HT-91108**". Use "**X**" to receive the software version in the microcontroller inside the shaker unit, such as "**1.00**". Use the "**Y**" command to get the unique factory programmed serial number of this unit, 5 characters always, such as "**A1234**".

Command List, Alphabetically

Axx

Set acceleration value in range 0 to 10 seconds.

The acceleration of a motion can be set by this command. The range is whole numbers of 0 through 10, and is the number of seconds requested for the shaker to go from its current velocity to the new velocity. If you set this value greater than 10, it will be clipped to the top acceleration of 10 RPM. If there are errors in the value you send with this command, such as non-numeric characters, the value is set to the top acceleration value of 10. This value is stored in the shaker unit and is used at the next Go or Stop command. If you do not set the value of the acceleration, the default value used is 5 seconds. The deceleration of a motion also uses this acceleration value. Typically, the shaker will need at least 0.5 second to reach top speed from a stopped condition, so if you set the acceleration to a value of 0, it will still take just a bit more than a quarter second or more to reach top speed.

B

Uncontrolled brake action.

Used only for hardware troubleshooting purposes. It provides for an instant and immediate braking action of the motor controller. There is no deceleration, no home finding or any other useful function at this time. It will probably throw liquid contents off the microplate. Send a **G** go command again to release the motor and resume normal operations.

C

Disable home search feature.

By default, the shaker uses the home feature searching after coming to a stop from shaking. You can turn off this feature using this **C** command. Although the stopping function total time may be decreased by about 0.5 seconds, the shaker table will eventually stop in any random orbital position. See command **E** to turn this feature back on.

D

Disable motor driver.

Used only for hardware troubleshooting purposes. It provides for an immediate decoupling of the motor driver from the shaker table. It results in uncontrolled short-term deceleration. There is no controlled deceleration, no home finding or any other useful function at this time. Send a **G** go command again to engage the motor and resume normal operations.

E

Enable home search feature.

By default, the shaker uses the home feature searching after coming to a stop from shaking. If it had been turned off with the **C** command earlier, you can enable this default feature again with this **E** command.

F

Force the home search feature.

Use this command to force the home search feature function immediately. Homing works by braking the unit for 0.25 seconds, then spinning the shaft at 200 RPM until the motor index mark is seen twice using a retro-reflective optical sensor, and then braking again. The LED status indicator is red during this function. If the status text is enabled, the shaker will send the "**STOP**" string after the home search is performed. If the home feature has been disabled using the **C** command, this command will be ignored completely.

G

Go command, starts the shaker.

Once the shaker receives the **G** command, the shaker uses the values you have set in the acceleration and velocity commands, or the defaults if not yet set, to calculate the amount of RPM change per millisecond, then begin the acceleration or deceleration to reach this new velocity. If the status text is enabled, the shaker will immediately send the "**RAMP+**" string if the unit must accelerate, or "**RAMP-**" string if decelerating. You may send the **G** command anytime to begin shaking at a new velocity. For example, if the unit is accelerating up to 1000 RPM over 10 seconds, and half way through this time period you reset the velocity value to 500 and then send the **G** go command, the shaker will recalculate ramping from the point it is currently at to go to the 500 RPM value. If you send the **G** command without changing the velocity value, the velocity will not change, and the status string will be "**RAMP**". See the **S** stop command also.

Hxx

Set acceleration in range 0-10 for Cycle 1.

Sets the acceleration of the speed number 1 cycle when using the alternating speed mode, or the acceleration for the timed mode. See command **N** for a full description of these modes.

Ixxxx

Set velocity in RPM for Cycle 1, range 60-3570.

Sets the velocity of the speed number 1 cycle when using the alternating speed mode, or the acceleration for the timed mode. See command **N** for a full description of these modes.

Jxxxxx

Set time, in seconds, that Cycle 1 lasts, range 0-30,000.

Sets the dwell time of cycle 1 when using the alternating speed mode, or the acceleration for the timed mode. Value range is 0-30,000 seconds, which is a maximum of 500 minutes, or 8.33 hours. Do not put commas in the string value you send to the shaker. See command **N** for a full description of these modes.

Kxx

Set acceleration in range 0-10 for Cycle 2.

Sets the acceleration of the speed number 2 cycle when using the alternating speed mode, or the acceleration for the timed mode. See command **N** for a full description of these modes.

Lxxxx

Set velocity in RPM for Cycle 2, range 60-3570; 0 if timed mode.

Sets the velocity of the speed number 2 cycle when using the alternating speed mode. If you want to use a timed mode, setting the value of **L0** tells the shaker to use a timed mode for cycle 1 only, then it stops automatically after cycle 1 dwell time completes. See command **N** for a full description of these modes.

Mxxxxx

Set time, in seconds, that Cycle 2 lasts, range 0-30,000.

Sets the dwell time of cycle 2 when using the alternating speed mode, or the acceleration for the timed mode. Value range is 0-30,000 seconds, which is a maximum of 500 minutes, or 8.33 hours. Do not put commas in the string value you send to the shaker. See command **N** for a full description of these modes.

N

Begin continuous cycling mode between the two speeds set in Cycle 1 and 2; or begin timed mode.

Begins immediate execution of the alternating cycle mode, using values previously programmed into the shaker using commands **H**, **I**, **J**, **K**, **L**, and **M**. In operation, this mode accelerates up to the speed programmed in cycle 1, then dwells at this speed for a period of time. Then the shaker ramps to the cycle 2 speed using cycle 2 acceleration, and dwells another period of time for cycle 2. This process then repeats indefinitely, until you send a **S** stop command, acceptable at any time. Use this feature to stir microplate contents gently for a long period of time, then burst mix for a short period of time, then repeat. There is also a timed mode feature. You select this mode by setting the cycle 2 velocity value to 0, as in **L0**. You do not need to set the other two parameters of cycle 2 (commands **K** and **M**). The value of **L0** tells the shaker to ignore the alternating cycle mode and perform a single timed cycle mode function. It executes the values of cycle 1 to the RPM value, then dwells for the amount of time set in cycle 1. After this dwell time, the shaker simply decelerates to a stop by itself. During these continuous alternating cycles or timed mode transitions, the text status output will be sent if it is enabled.

O

Enable status text automatically sent over serial communication after a change (default).

This is the default mode of the shaker sending textual status to the host computer. The possible strings that can be sent are **RUN**, **RAMP**, **RAMP+**, **RAMP-**, **STOP** and **BUZZ**. The string **RUN** occurs when the shaker reaches intended velocity. **RAMP**, **RAMP+** and **RAMP-** indicate acceleration or deceleration initiation. **STOP** occurs after the unit stops and a home search completes, if enabled. **BUZZ** occurs when the re-suspension protocol feature mode is started. These strings are sent out automatically. They are terminated with a **<CR>**. See commands **P** and **Q** also.

P

Disable status text sent automatically, nothing is sent.

Disables the automatic sending of text status strings during shaker operation. No status data strings are sent at all after this **P** command is received. See command **O** also.

S

Stop the motor using deceleration values, then find home if okay to use.

Send the **S** command at any time to stop the shaker from whatever it is doing. It always uses the current acceleration value as the deceleration value to ramp down to a zero velocity. After reaching zero, the home search feature is activated, if it is enabled. The **S** command also resets the alternate cycling modes, and terminates and resets the timed mode.

T

Test the reflective optical sensor that finds the home index mark.

Begins a diagnostic test that continually runs to check the operation of the retro-reflective optical sensor. The motor shaft slowly rotates, and the sensor is monitored detecting the home index mark. When the index mark is not present, the LED is green. When the index mark is visible, the LED turns RED. If all is well, the LED alternates between green and red every shaker table orbit. Use the **S** stop command to terminate the test.

U

Enter daisy-chain multiple shakers mode and re-order addresses.

Changes operating mode immediately to the daisy-chained multiple shakers on a single serial line. Also re-orders all shakers on the chain with discreet addresses. Returns a **Ux** at the completion with x indicating how many shakers are present on the chain. See separate manual section discussing daisy chain mode.

Vxxxx

Set the velocity for the next motion, in range 60 to 3570 RPM

The velocity of a motion can be set by this command. The range is whole numbers of 0 through 3570, and is the number of seconds requested for the shaker to go from its current velocity to the new velocity. In actual usage, the shaker will not go below 60 RPM, so values less than 60 RPM and greater than 0 RPM will still result in a 60 RPM speed. If you set this value greater than 3570, it will be clipped to the top speed of 3570 RPM. If there are errors in the value you send with this command, such as non-numeric characters, the value is set to the top speed value of 3570. This value is stored in the shaker unit and is used at the next **G** go command. If you do not set the value of the velocity after powering on the unit, the default value used is 500 RPM.

X

Shaker responds with the firmware software version of the microprocessor, x.xx.

The shaker responds to this data request command **X** with a four character code corresponding to the firmware software version of the C code in the microcontroller inside the shaker. Typical response is "**1.00**".

Y

Shaker responds with the serial number of the unit, A1234 (xxxxx).

There is a unique serial number programmed into each shaker unit's microcontroller. Use this data request command **Y** to access this information. It is always 5 characters. Sample response is "**A1234**".

Z

Shaker responds with model number, HT-91108.

The data request command **Z** returns the shaker's product model number, current sample is "**HT-91108**".

+

CW rotation motion (default).

Normally by default the shaker orbits in a clockwise direction. If the shaker had been placed in a counter clockwise (CCW) orbiting motion, this command "**+**" will set the unit back to a clockwise (CW) orbit.

-

CCW rotation motion.

You can change the orbital direction motion of the shaker table from the default of clockwise (CW) to a counter clockwise (CCW) motion by sending the "**-**" command. Note that you can send either the "**+**" or "**-**" command at anytime, even while the shaker is in motion. It is even a valid protocol option to inject extra energy into a microplate well while the shaker is at full speed.

(

Turn off and disable usage of the LED.

After power-on default, the LED indicator at the end of the shaker enclosure is used to indicate status. It is a tri-color, red, yellow and green lamp. By sending the "**(**" command, the LED is turned off and is not used again. Use this command to turn off any light at the shaker, for those shaking protocols requiring darkness.

)

Turn on and enable usage of the LED.

Reverses the "**(**" command and re-enables usage of the LED. The LED resumes whatever state it would normally show at this instant.

! or !xxx

Initiate the re-suspension protocol feature.

This feature works by using the currently set velocity to begin spinning the motor in the clockwise direction for 400 msec. After this, the motor is instantly reversed to a counter clockwise motion, at the same pre-set velocity for another 400 msec. This cycle of aggressive energy dispersion in the wells repeats for 20 times. You may also elect to add in a value after the **"!"** command, and the shaker will buzz for the number of cycles you have designated, replacing the default 20 cycles. If you do not specify a value for the xxx, the shaker defaults to 20 buzz cycles. It allows you to tailor the amount of energy injected into the well by changing the preset velocity. Set-up this velocity ahead of the buzz command by using the **"V"** command with a high value for maximum injection of energy into the wells. The buzz function serves to break up and re-suspend stubborn packed particles or material in the bottom of the wells. If the status text is enabled, the shaker will immediately send the "**BUZZ**" string. After completion, the shaker will respond with a "**STOP**" string. The LED indicator is yellow during this feature activation.

~

Put shaker into a mode to always respond to all commands.

Normally, after power-up default, the shaker does not respond to any command that does not expect a response. For example, setting the velocity with a "**V1000**" command does not elicit any further response from the shaker. This response mode is an alternative to always have the shaker respond to every command sent. In our example, after setting the velocity, the shaker will respond with a "**~**" (tilde) character, followed by the normal **<CR>**. All commands get a response of "**~**", unless it is a query command that expects a typical response, such as when requesting the firmware version. In that case, the firmware version string will be returned, and the "**~**" character will not be returned. Use this mode to ensure that every command you send to the shaker has been acknowledged and received.

In daisy chain mode, the "**~**" response request allows you to send off a command to a particular shaker, and wait for the "**,~**" response (note the comma preface for all daisy chain responses) back at your PC before sending on the next command. Use this instead of waiting for a particular inter-command delay period, so you can send commands as fast as they are acknowledged at the string of shakers. To initiate this mode in daisy chain, do not preface it with any "@" character or the shaker address. This command, once initiated with simply sending the

"**~**" command to the set of daisy chained shakers, ripples through all the shakers on the daisy chain by itself, and all of the shakers will be in this response mode thereafter. If you are going to use this mode in daisy chain mode, send this "**~**" command after you have successfully sent the "**U**" command.

Once you send the "**~**" command, it may not be revoked, and can only be reset to an off condition by a power-off reset.

?

Shaker responds with all available serial commands.

This data request command **?** instructs the shaker to send out the entire summary list of all possible commands and requests, along with their descriptions. Not active in daisy-chain mode.

?A

Shaker responds with A=xx, the currently set acceleration value, 0-10.

This data request command **?A** requests the current acceleration value set in the shaker. This value will have been set by you with the **Axx** command earlier. If the value was not set previously, the default value inside the shaker is 5. The shaker sends out the string "**A=xx**", where xx is in the range 0-10.

?V

Shaker responds with V=xxxx, currently set velocity, range 0-3570 RPM.

This data request command **?V** requests the current velocity value set in the shaker. This value will have been set by you with the **Vxxxx** command earlier. If the value was not set previously, the default value is 500. The shaker sends out the string "**V=xxxx**", where xxxx is in the range 0-3570.

?R

Shaker responds with R=xxxx, measured speed of the motor shaft.

This data request command **?R** requests the current measured velocity value of the spinning motor shaft. The value is a raw program variable and does not correspond to actual RPM engineering units. The value returned requires further math manipulation to correspond to actual RPM values. This variable is intended for factory usage only. One example of the use of this variable is the fact that at 3570 RPM, or the top specified speed of the shaker, the value returned will be 161, and the printed circuit card potentiometer can easily be adjusted and calibrated to match this speed. Returned values are in the range 50-8000.

To convert the returned value to an actual RPM figure, use the following formula:

RPM=(1 / (ReturnedValue * 0.000049913)) * 30

Q

Request text status, unit responds with RAMP, RUN, STOP, BUZZ.

This data request command **Q** queries the shaker for an immediate textual status. The possible strings that can be sent are **RUN**, **RAMP**, **RAMP+**, **RAMP-**, and **STOP**. The string **RUN** is sent if the velocity of the shaker is currently over 0 RPM and stable. **RAMP**, **RAMP+** and **RAMP-** indicate acceleration or deceleration phases. **STOP** is sent if the shaker is currently stopped. **BUZZ** occurs for the re-suspension feature. By default, these text commands are sent out automatically when one of these conditions occurs. And that automatic sending of status strings can be disabled using the **P** command. However, the **Q** data request command always returns a string value, even if the automatic sending of strings is disabled. See commands **O** and **P** also.

?W

Shaker responds with W=xxxx, internal commanded current velocity.

This data request command **?W** requests the current internal real-time commanded velocity value in the shaker. This value is computed by the shaker microcontroller while acceleration and deceleration occurs. You may query the shaker to see what the current RPM value the shaker is trying to achieve at that moment in time. In contrast to the **?V** data request, which responds with the velocity value you had set for this orbital motion, **?W** returns the changing value of the shaker motion, as it ramps up and down. When the shaker velocity reaches the speed you have set in **Vxxxx**, the data request commands **?W** and **?V** will return the exact same value. The response is "**W=xxxx**" where xxxx corresponds to the range of 0-3570.

$

Shaker responds with a high speed data packet

During final testing, the shakers undergo a reliability testing procedure where they are continuously queried at high speed for their status, their expected RPM, and their actual measured RPM. You can fire this command to any shaker, even on a daisy chain, as fast as the shaker responds. The shakier responds with 11 characters, example "**10100000997**". Typical response time is 25 msec.

The first character is an ASCII value in the range of '**0**' to '@', representing a status condition value of 0 through 16. Typically, a value of 0 indicates a stopped condition, a 1 indicates running, a 4 or 5 indicates a ramping state, and a value of 11 is for the re-suspension mode state.

The next five characters comprise the expected RPM value that is being calculated by the shaker for that moment. For instance, if the shaker is commanded to reach 1000 RPM over a 10 second period, this value will change every few moments to the RPM value that the motor should be following for that instant along the upwards velocity linear ramp. In a range of xxxxx RPM, examples are: "**00250**", "**01450**", "**03500**".

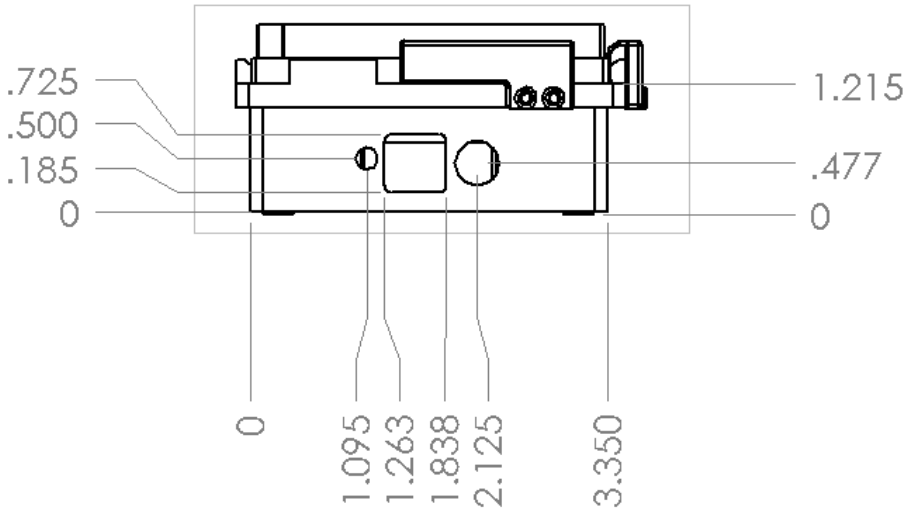
The last 5 characters are the measured value in the range of "**00050**" to "**08000**" corresponding to the internally measured speed of the motor shaft at this moment in time. This value is the same as is received with the **?R** command request, and needs further math manipulation for it to correspond to a proper recognized engineering value.

This command can be useful to carefully and accurately track the current orbital speed of the shaker, to ensure the shaker is linear in its operation, and to watch for a specific motion state. Also, a shaker always responds to this command, so subsequent commands sent to a daisy chained set of shakers can occur again as soon as you receive this $ response, ensuring you are requesting data as fast as the daisy chain allows. The shaker always responds immediately to this command, regardless of current operating state.

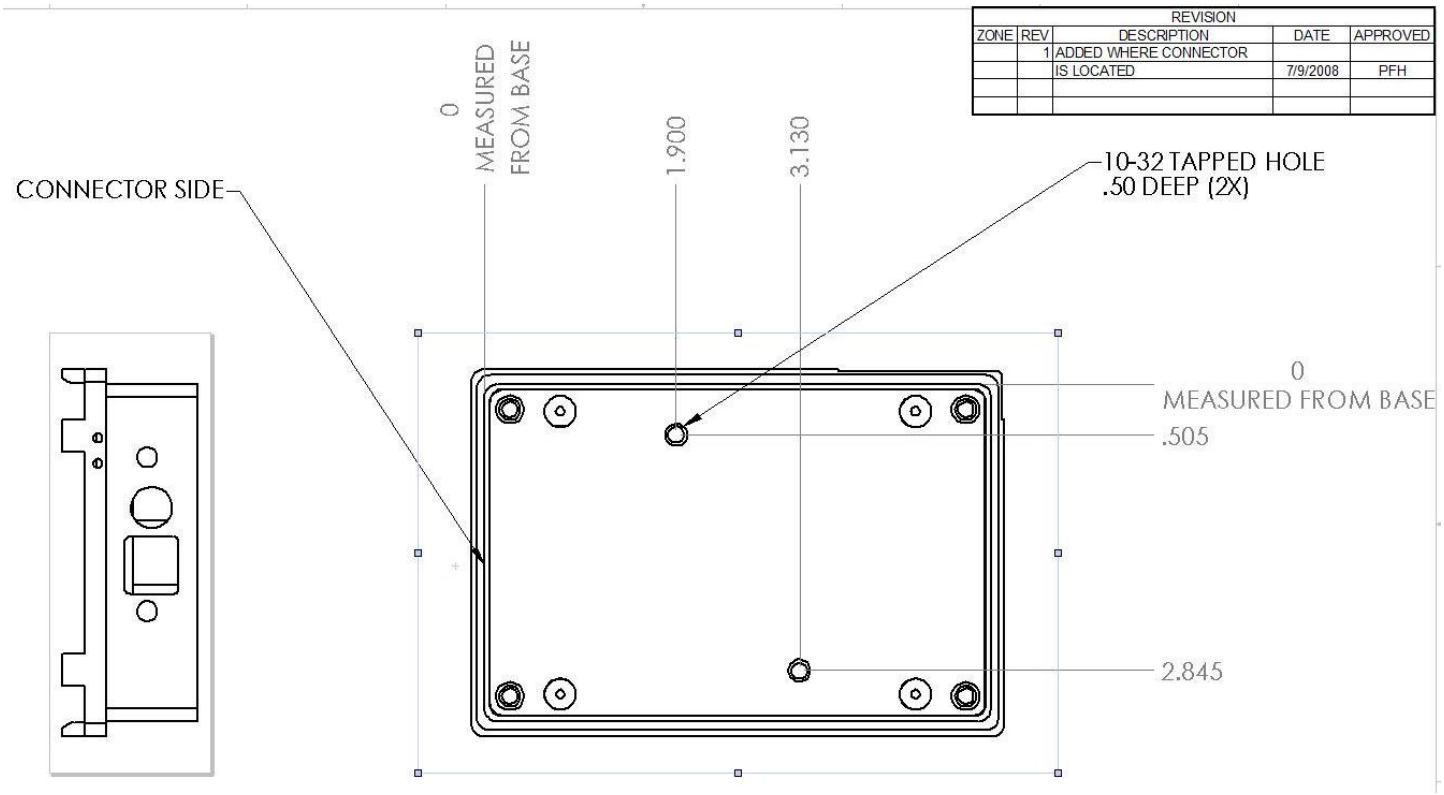
Each shaker is shipped with a certification sheet after being run through a series of tests to validate proper operation for homing and velocity performance at various speeds. All shakers are life tested for at least 12 hours before running this certification test.

```
CERTIFICATION for HT-91100-1 Microplate Orbital Shaker
Serial Number: A2250
Firmware version: 4.71
Customer:  CUSTOMER X     Reference PO: X123456
Verfied serial number label is on the bottom.
Verfied feet are installed.
Verfied 2 clips are installed.
Run-in Life Testing time was: 12 Hours
Test started: 05/02/2009 7:04:08 PM    Ended: 5/2/2009 7:10:47 PM

Find Home Times:  1.621  1.627  1.629  1.637  1.637   PASS

Top Speed Distribution     Under RPM:21%   Exact 3570RPM:79%   Over RPM:0%

 200 RPM Speed Test  207  207  208  207  208
                      Deltas: Worst:4.00%  Best:3.50%  Mean:3.70%   PASS
 500 RPM Speed Test  496  497  495  495  495
                      Deltas: Worst:1.00%  Best:0.60%  Mean:0.88%   PASS
1000 RPM Speed Test  981  981  983  983  981
                      Deltas: Worst:1.90%  Best:1.70%  Mean:1.82%   PASS
1500 RPM Speed Test  1497  1493  1493  1493  1493
                      Deltas: Worst:0.47%  Best:0.20%  Mean:0.41%   PASS
2000 RPM Speed Test  1985  1985  1991  1985  1985
                      Deltas: Worst:0.75%  Best:0.45%  Mean:0.69%   PASS
2500 RPM Speed Test  2485  2485  2485  2485  2495
                      Deltas: Worst:0.60%  Best:0.20%  Mean:0.52%   PASS
3000 RPM Speed Test  3001  3001  3001  3001  3001
                      Deltas: Worst:0.03%  Best:0.03%  Mean:0.03%   PASS
3500 RPM Speed Test  3490  3490  3490  3490  3490
                      Deltas: Worst:0.29%  Best:0.29%  Mean:0.29%   PASS


Certified using Software Version 5.51
Manufactured by Big Bear Automation, Inc., Santa Clara, CA   USA
http://www.BigBearAutomation.com
```

Dimensions of Shaker Unit Connectors

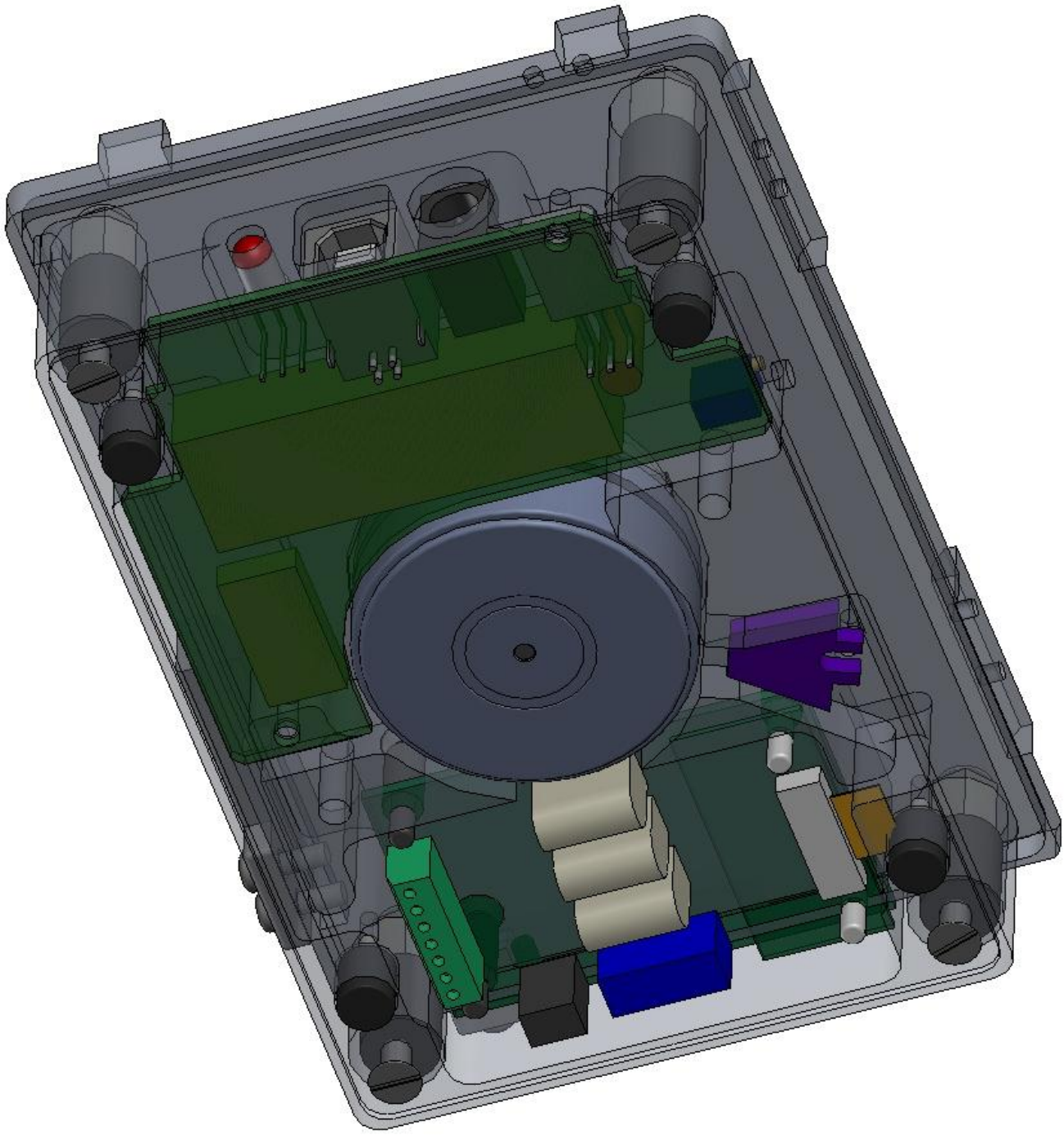


Dimensions of Shaker Mounting Holes

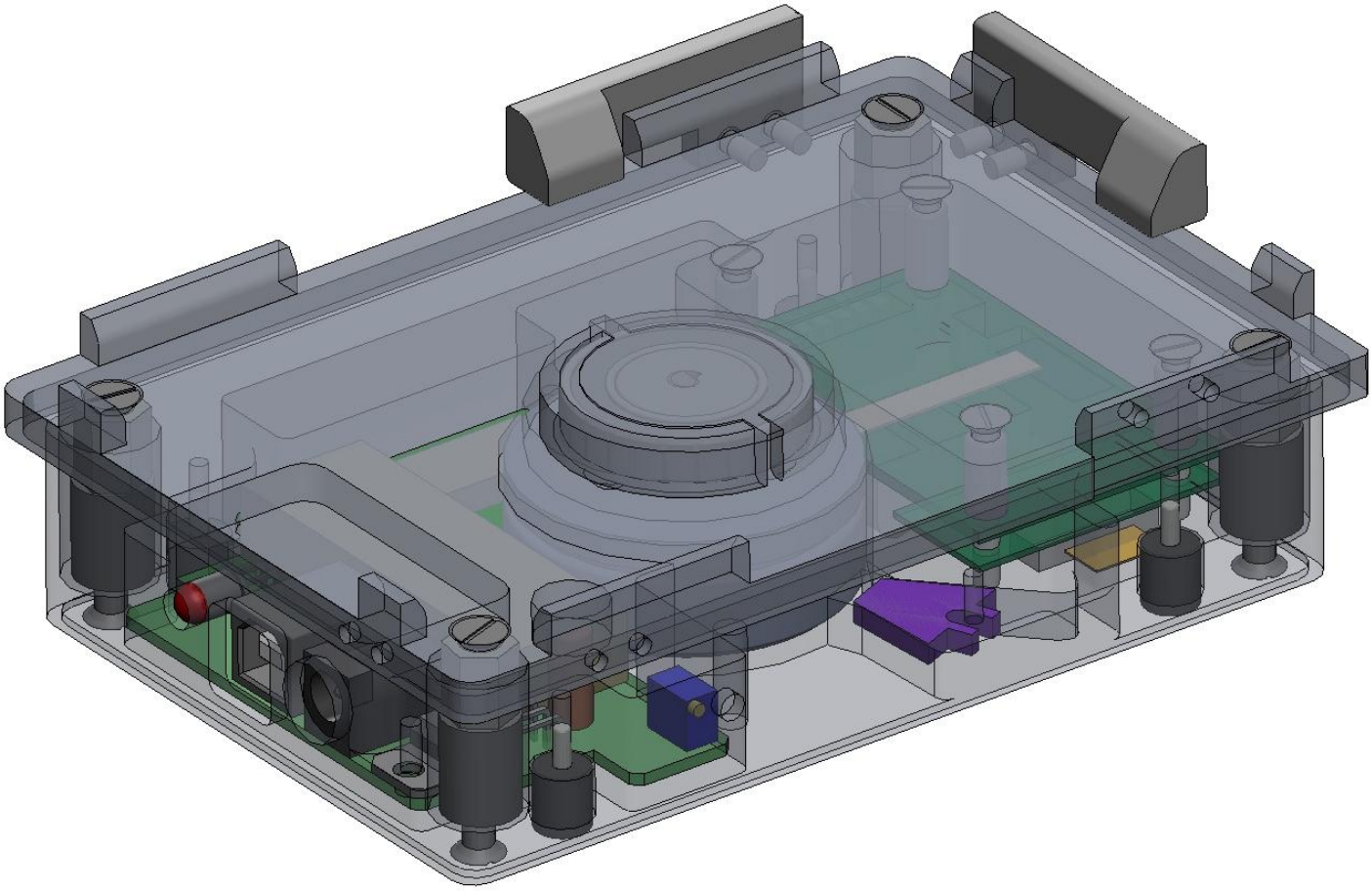


Bottom of shaker

Various Views



View of Internal Microcontroller Printed Circuit Board



Top View of Shaker

Bottom View of Shaker