Model HT-91100
Microplate Orbital Shaker
with RS-232 Data Control

Product Manual

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Microcontroller firmware upgrade list:
1.00: Original release
2.00: Add daisy chain capability for up to 50 shakers
3.00: Correction lookup table to linearize speed settings
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-91100 Microplate Orbital Shaker with RS-232 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 its own built-in microcontroller and RS-232 transceiver to supply you with intelligent program control of all Shaker features.
Features

- Rotationally shakes a single microplate.
- 1 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.
- Daisy-chain configuration allows one serial port to control over 35 shakers.

Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbital Motion</td>
<td>1 mm diameter, circular shape, constant everywhere on well plate</td>
</tr>
<tr>
<td>Speed</td>
<td>75 RPM to 3570 RPM, programmable. Resolution 14 RPM. Acceleration/deceleration in range of 0-10 seconds.</td>
</tr>
<tr>
<td>Power Required</td>
<td>24 VDC, 180 mA, 100-240 VAC 50-60Hz power adapter included. DC power receptacle on end of unit.</td>
</tr>
<tr>
<td>RS-232 Port</td>
<td>9600, 8, 1, no hardware data control. ASCII text characters with &lt;CR&gt; for end of line. RJ-11 connection on end of unit. Standard RJ-11 telephone cable, 6 foot, included. RJ-11 to 9 pin D-type and 25-pin D-type PC serial interface connectors supplied.</td>
</tr>
<tr>
<td>Base Dimension</td>
<td>3.350&quot; (85mm) width, 5.030&quot; (127.8mm) length</td>
</tr>
<tr>
<td>Microplate Platform Dimension</td>
<td>3.650&quot; (92.7mm) width, 5.300&quot; (134.6mm) length, centered on top of base. Secures a single 96 or 384 micro well plate with SBS footprint.</td>
</tr>
<tr>
<td>Height</td>
<td>1.215&quot; (30.9mm) height from bottom of rubber feet to top surface of shaker table platform. 1.775&quot; (45.1mm) height from bottom of rubber feet to the top surface of a standard well plate. 0.995&quot; (25.3mm) from bottom of rubber feet to bottom of shaker platform.</td>
</tr>
<tr>
<td>Weight</td>
<td>1.48 pounds (671 g)</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>0° F to 120° F (-17.5° C to 49.0° C), non-condensing, RH to 90%</td>
</tr>
<tr>
<td>LED Indicator</td>
<td>Tricolor LED, green when at commanded velocity, yellow during acceleration or deceleration, red during home finding, on end of unit.</td>
</tr>
<tr>
<td>Serialization</td>
<td>Each unit has unique electronic serial number.</td>
</tr>
<tr>
<td>Control</td>
<td>Intel 8752 microcontroller, 8-bit DA converter for speed control. 3-phase brushless servomotor drive, retroreflective optical sensor for shaft position and home index.</td>
</tr>
<tr>
<td>Material</td>
<td>Aluminum, nickel plated, stainless steel hardware, white polyethylene clips.</td>
</tr>
<tr>
<td>Warranty</td>
<td>Two year limited replacement warranty.</td>
</tr>
</tbody>
</table>
Set-up Instructions

Included in your package is:

- HT-91100 Microplate Orbital Shaker
- 100-240 VAC 50-60 Hz Power Adapter with cables
- Straight-thru RJ-11 telephone cable, 6 feet.
- 9-pin D-type to RJ-11 connector module
- 25-pin D-type to RJ-11 connector module
- CDROM with this manual in pdf format, PC interface program, VB6 sample source code.

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 RJ-11 telephone cable into the end of the shaker until it snaps into the Shaker’s data port. Connect the other end of the RJ-11 telephone cable into either the 9-pin or the 25-pin D-type to RJ-11 interface connector module. The type you use is dependent on the serial interface connector you have available on your PC.

(Important Note: If you want to extend the distance to the Shaker from your PC, you may use a longer telephone cable. However, always use a straight thru RJ-11 telephone cable. Never use a crossover type of cable.)

Plug in the D-type to RJ-11 connector module into any available serial communications port on your PC. Finally, plug the power adapter into any AC outlet.

Ensure the status LED on the end of the Shaker turns green.

You are now ready for interfacing to your Shaker with the PC.
Set-up PC Interface Program

Included with your package for the HT-9100 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 source code is also included, so you may use portions of it in your own programming interfaces.

To set-up the program, simply load the CDROM into your PC and it will start the setup program automatically. If it does not begin, start the setup.exe manually by double-clicking that file on the CD.

Once loaded onto your computer, navigate to the Program Group now on your computer called OrbitalShaker, and execute the program called HT9100TestV2. Your computer will bring up a Window that looks like this:

![Image of the setup program window]

First, you must select whether you have just a single shaker connected to a single PC serial port. 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.
Next, you will need to assign a PC serial communication port to the Shaker you have plugged into your
PC. The easiest method is to simply click the button in the test program called **Auto-Find Shakers**. This
automated process runs through all of the serial ports on your PC and attempts to establish
communication with the Shaker. If it finds a Shaker on a serial port, it will automatically assign that com
port to the Shaker, and the rest of the test program’s features will be enabled.

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 manually choose an available port at any time by simply pressing the selection next to that com
port description.

Once the **Auto-Find Shakers** feature has successfully found a Shaker, it’s serial number will be
displayed on the com port assigned to it. If you have multiple daisy-chained shakers, the display will read
"Ux", where x is the number of shakers on the chain.

After a serial port has been located that detects the presence of a shaker, all of the menus will be visible.
There will be two separate menu selections based on if the configuration is a single shaker or daisy-
chained multiple shakers.
Most of the features of the Shaker interfacing is accessible on this program window. You can read in-detail all of the Shaker features in the following sections.

The test program provides a real-time display of the incoming RS-232 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 finally occur very quickly.
When you have selected the multiple shakers in a daisy chain configuration mode and the serial port with the shakers has been found, you will see this window. In the upper left portion of the screen is blue lettering showing Daisy-Chained Multiple Shakers. To the right of the photo image of the shaker is the selection frame for specifying which shaker in the chain is to be controlled with the rest of the menu. Use the arrow buttons to increase or decrease the shaker to be controlled. The designation range is ‘1’-‘9’, then ‘A’ through ‘Z’.

Once you select a shaker on the chain, you can control just that shaker completely using the rest of the menu. You can then select another shaker, and send a different set of commands just to that shaker. In this manner, you can independently control all of the shakers on the chain.

In daisy-chain mode, there is a ‘,’ (comma) character that precedes all incoming data (see separate section for this discussion), and this comma is stripped off here to display all of the other characters in the Incoming TS232 Text box.

As another note, only for the daisy-chained mode, the Auto-Find Shakers button only works the very first time that the shakers are initialized, and once the shakers have entered this mode, they must all be powered down and up again before searching on another serial port.
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, another 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.

On the CDROM you will also find this manual under the filename HT91100Manual.pdf. All of the source code in MS Visual Basic 6 is also under a subdirectory called SourceCode.
Interfacing to the Shaker Using RS-232

Interfacing with the Shaker uses the serial communication ports available on almost all PCs. The interface hardware on your PC is usually a 9-pin D-type connector or a 25-pin D-type connector. We have supplied you connector modules for both types of connectors.

In the event you are using an industrial computer with multiple serial ports, any available serial port can be used. The test program works through the first eight standard serial ports on a PC. Beyond that, you will need to write your own code to interface serially with the Shaker.

Communication protocol with the Shaker is 9600 baud rate, 1 stop bit, no parity bits and no hardware flow control. Only three lines are used, TxD, RxD and ground. The shaker uses its own RS-232 transceiver chip to generate the proper RS-232 signal levels.

### Shaker Signal Connections on the D-Type Connector

<table>
<thead>
<tr>
<th>Signal Description</th>
<th>Signal</th>
<th>9-pin D-type</th>
<th>25-pin D-type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitted Data</td>
<td>TxD</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Received Data</td>
<td>RxD</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Signal Ground</td>
<td>Ground</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

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 RS-232 data.
Summary of RS-232 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.
Lxxxxx 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 RS232 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.

Summary of RS-232 Data Requests

?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 speed of the motor shaft.
Q    Request text status, unit responds with RAMP, RUN, STOP.
?W   Shaker responds with W=xxxx, internal commanded current velocity.
X    Shaker responds with the software 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-91100.
RS-232 Communication Rules

Common RS-232 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.

- 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 characters will not be recognized.

- The shaker accepts and responds to RS-232 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 \texttt{Vxxxx} command to any value in the range 0 to 3570. Use \texttt{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 \texttt{G} go command. When you want to stop the shaking, send an \texttt{S} command 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 \texttt{Hxx} for acceleration, \texttt{Ixxxx} for RPM velocity value, and \texttt{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 \texttt{Kxx} for acceleration, \texttt{Lxxxx} for speed 2 velocity, and \texttt{Mxxxxx} for the dwell time. Start this mode using the \texttt{N} command. Use \texttt{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 \texttt{Ixxxx}, an acceleration \texttt{Jxx}, and a total amount of dwell time \texttt{Jxxxxx} in seconds that this speed runs. You must specifically set the velocity value of the alternating mode’s speed 2 value of \texttt{Lxxxx} to 0, as in “\texttt{L=0}”. Then start the timed dwell time with the \texttt{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 \texttt{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 \texttt{E} Command. When enabled, the home search occurs after every stop \texttt{S} command, after the shaker has decelerated to a stop. It adds about 0.5 seconds to the completion of the stop function. You can force the home feature to activate, if it is enabled, with the \texttt{F} command. You can disable this feature with the \texttt{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.

**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 “\texttt{RUN}” and a \texttt{<CR>} if the shaker has achieved a stable velocity. If sends out “\texttt{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. You can disable this default 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-91100”. 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 1 second to reach top speed from a stopped velocity, so if you set the acceleration to a value of 0, it will still take 1 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 250 RPM until the motor index mark is seen using a retro-reflective optical sensor, usually within one revolution, 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 RS232 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-, and STOP. 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. 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 software version of the microprocessor, x.xx.

The shaker responds to this data request command X with a four character code corresponding to the 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-91100.

The data request command Z returns the shaker’s product model number, current sample is “HT-91100”.

+
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.

@ 
Preface character when addressing individual shakers when in the daisy-chain mode.

Send this character, followed by a numeric (1-9) or ASCII (A-Z) character, then followed by the command you wish to execute at that shaker. As an example, the serial string “@8Y” queries shaker number 8 in the daisy-chain for it’s serial number.
?A  
Shaker responds with A=xx, the currently set acceleration value, 0-10.

This data request command ?A returns 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 returns 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 returns 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. 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 174, and the printed circuit card potentiometer can easily be adjusted and calibrated to match this speed while watching the returned value over multiple queries. Returned values are in the range 100-10000. You can convert to RPM using the following formula, where X is the value returned by the ?R command:

\[
\text{RPM} = \frac{30}{X \cdot 0.00048295}
\]

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

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. 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.
Daisy Chain Mode

The shaker unit can be configured for operating in a daisy-chained, individually addressable, single serial port mode. This mode allows many shakers to share a single serial port on your PC. This configuration requires that the cable D-type connector modules at the end of each RJ-11 shaker interconnect cables be connected together in a manner where the serial output from one shaker connects to the serial input of the next shaker, and on and on. Up to 50 shakers can be connected together in this configuration, and the mode will also work with only one shaker.

Since there are only three wires used in the communications for these shakers, it is easy to assemble a cable or connector box for the daisy-chaining configuration. Certainly our factory can arrange for any required hardware to perform this function for you.

To enter this mode, send the command ‘U’ to the single shaker serial line. This should be the very first command sent to the shakers after powering up the units. The first shaker in the daisy-chain will assign itself the address of value ‘1’, then send on the re-order command to the next shaker. That next shaker will then assign itself an address value of ‘2’ and then send on the command. At the end of the chain, you will receive back at the original serial port the string data ‘Ux’, where the ‘x’ is the last address designation of the last shaker on the chain. As an example, if there are 4 shakers on one serial line, the response string back at your PC will be ‘U4’. The shakers automatically assign themselves the next character in the chain, so if there are 8 shakers connected, they will assign themselves the addresses of ‘1’ through ‘8’. If there
are more than 9 shakers on the chain, the tenth shaker will have the address ‘A’. Subsequent
shakers will continue to use the rest of the ASCII character set such as ‘B’ through ‘Z’. You can
even have more shakers on the chain and they will be addressed starting with the next ASCII
character ‘[’.

After entering this mode by sending the ‘U’ command, you will be required to preface any
command with the address of the shaker you wish to talk to. You must use the ‘@’ character,
followed by the address character for that shaker, followed by the command you wish to
execute at that shaker. For example, to query shaker number 8 for its serial number, send the
string value ‘@8Y’ followed by the normal <CR> for all message strings. To stop shaking the
12th shaker on the chain, send the string value ‘@CS’ (‘C’ is the address designation for the 12th
unit). To set the velocity value for shaker 3 send the string ‘@3V=1000’. Once you send the ‘U’
command, it will not be recognized again until the next time the shakers are all powered-up.

All data responses from all shakers coming back to your PC’s serial port receive line will be
prefaced with the ‘,’ (comma) character while in this daisy-chain mode. For example, the typical
response when not in daisy-chain mode to a query for a product ID command such as ‘Z’ would
be ‘HT-91100’. When in daisy chain mode, this same query will result in the data string ‘,HT-
91100’. Your software should strip any comma as the first received character when querying
any shaker while in daisy-chain mode.

Daisy chain mode is not reversible. All shakers will revert back to the original default mode
when powered-off, thus the need for resending the ‘U’ command at every power up. All of the
normal commands sent to the shaker without the ‘@x’ address preface will be ignored
completely when in daisy chain mode.

Finally, while in daisy chain mode, the shaker feature that automatically reports textual status of
shaking, such as ‘RUN’, ‘RAMP’ or ‘STOP’, will not work, and that data is not automatically
sent. Instead, you will need to poll or query an individual shaker for that data using the ‘Q’
command. For example, to stop a shaker on a chain, send the command ‘@5S’, then begin to
continuously query that shaker with the command ‘@5Q’. You will receive the data ‘,RAMP-
while shaker number 5 decelerates, and when finally stopped you will receive the data string
’,STOP’. Again, note that each string received is prefaced with the ‘,’ (comma) character, and
can be stripped as you receive it.

In general, each shaker microcontroller is able to handle a new communication stream every 8-
15 milliseconds. We recommend that there is a 20 msec delay between every command sent
down the daisy chain serial line to be completely error free. If more than two or three command
strings get sent out without delays, there is a probability that the RS232 buffers at the first
shaker will overrun and data may be corrupted. The shaker’s control software is configured to
accept and pass on any command in real-time, even while it is handling its own shaking
operation. If you send a request for a query type of command, such as a ‘@6Y’, you should wait
for the response before sending on another command or request. This will allow the serial chain
to pass on the result from that one addressed shaker, so you can match that result to the query
you have just sent.
The daisy chain feature is only available on shakers with a software version of 2.00 or later.
Dimensions of Shaker Unit Connectors
Various Views

Bottom View of Shaker, Panel Removed

Internal Top View of Shaker
View of Internal Microcontroller Printed Circuit Board

Close-up Internal View of End of Unit
Exploded View of Shaker Components