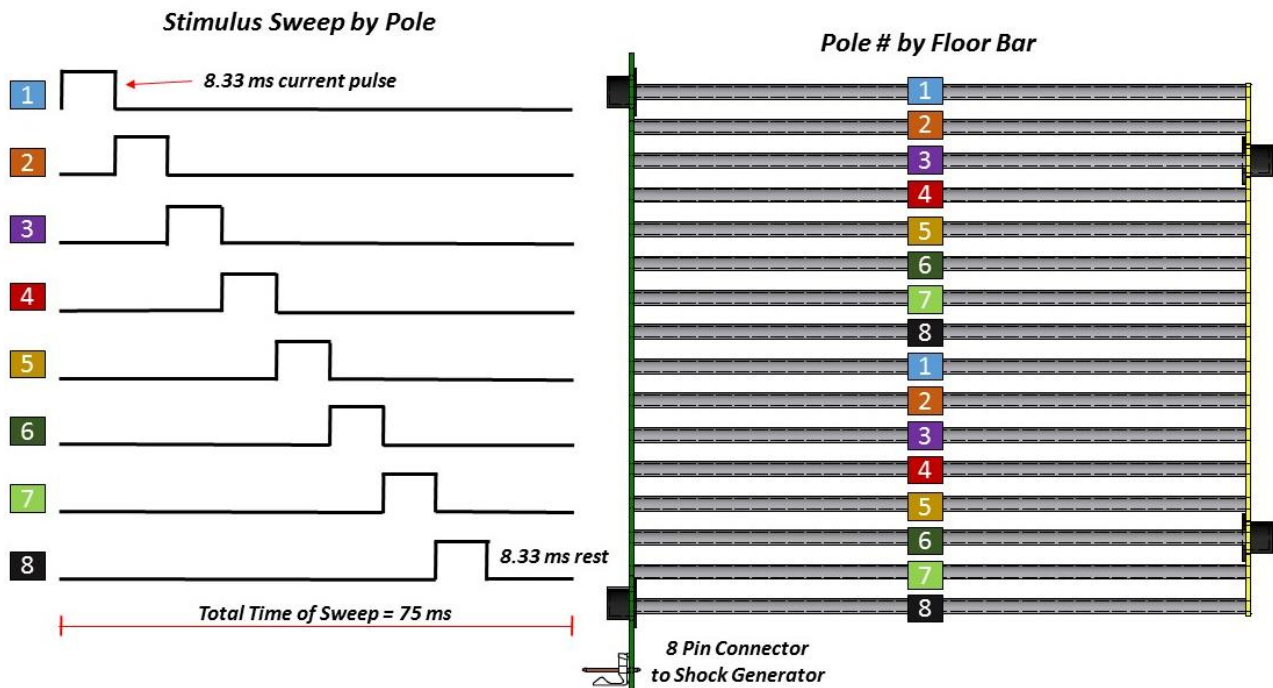


Model H13-15 Precision Shock Generator Scrambled, 8-Pole Output Mode

Application Notes. The H13-15 manual shock generator provides two operational modes – 2-pole and 8-pole – set by a toggle switch on the back panel of the unit. For shock grid applications the 8-pole mode is employed. In this mode the unit functions as a scanner distributing the stimulation across 8 output lines to produce a scrambled, square-wave shock.

The connection to the Habitest test cage shock floors divides these 8 output lines into two sets of parallel bars as shown below. Scrambling the shock in this manner prevents the animal from avoiding the aversive stimulus by positioning itself across bars in the floor that share the same pole connection. No current will flow across bars that are connected to the same pole. In the case of a 2-pole shock floor, where the current is only alternated across every other bar, the subject could learn to stand on bars sharing the same pole and, in turn, never receive the stimulus. This is not a possibility with the 8-pole, scrambled shock mode as shock avoidance would require the animal to balance on bars that are 9 positions apart without making contact along any other point in the floor.



Verification of the Shock Output. The value configured using the shock generator’s meter in Set/Test mode corresponds to the **peak** current delivered for each stimulus pulse.

Certain considerations are required when verifying the performance of the shock generator given that the output is a pulsing current. External measurement of the peak current requires two of the poles to be bridged by a resistor of a known value (10 kOhm suggested) and a device designed to read an alternating signal such as an **RMS** voltmeter or oscilloscope. In the case of the RMS voltmeter, the device must be set to measure AC voltage. The reading then must be converted from RMS to peak current through additional calculations. The relationship for the 8 pole output is:

$$\text{Peak Current (mA)} = \left(\frac{V(\text{volts})}{R(\text{kOhm})} \right) \div \sqrt{2/9}$$

The testing procedure is simplified through the use of an A13-16 model Shock Level Tester, which provides a 10 kOhm impedance and convenient alligator clips to connect to two bars of the shock floor. This device provides two outputs for use with a voltmeter and/or an oscilloscope.



A13-16 Shock Level Tester

The voltmeter connection is a rectified DC output. More specifically, the internal circuitry of this connection converts the pulsed output of the shock generator to a constant voltage signal that is proportional to the peak current of the stimulation. This connection can be used with any standard (non-RMS or RMS voltmeter).

The voltmeter output will be consistent with Ohms Law

$$\text{Peak Current (mA)} = \frac{V(\text{volts})}{R(\text{kOhm})}$$

where the internal resistance load used is 10 kOhms. Because this output circuit contains diodes and filtering, the voltmeter output will be slightly lower than predicted. A table of expected output voltages with given input currents is provided below.

Set Current (mA)	Voltmeter Value (V)
0.5	4-5
1	9-10
2	18-19
3	28-29
5	50-51

In order to meet the requirements of more rigorous verification, the second output provided is for connection to an oscilloscope. This output will follow Ohms law precisely. The maximum amplitude of the output pulse will be exactly equal to Ohms Law.

H13-15 Working Procedure with A13-16 Shock Level Tester. The following sequence of steps is suggested before experimental procedures to verify the shock intensity.

Hardware Required:

- + Voltmeter
- + A13-16 Shock Level Tester

- 1) Power the shock generator by flipping the switch where the power cord plugs into the unit. The red Power LED will light on the front of the unit.
- 2) Check that the unit is set to 8 pole operation for scrambled shock output. This setting is controlled by a toggle switch on the back panel of the unit above the 8-pin shock output connector.
- 3) Check that one end of the rainbow ribbon cable is connected to the 8-pin shock output connector on the back of the shock generator and that the opposite end is securely connected to the 8-pin connector located at the front of the shock floor.
- 4) On the front panel of the shock generator choose the appropriate meter range for the desired stimulus intensity.

*In the “Lo” setting the values along the upper scale of the meter display are in effect. The Lo setting allows for stimulus intensities between **0.05 – 0.5 mA**.*

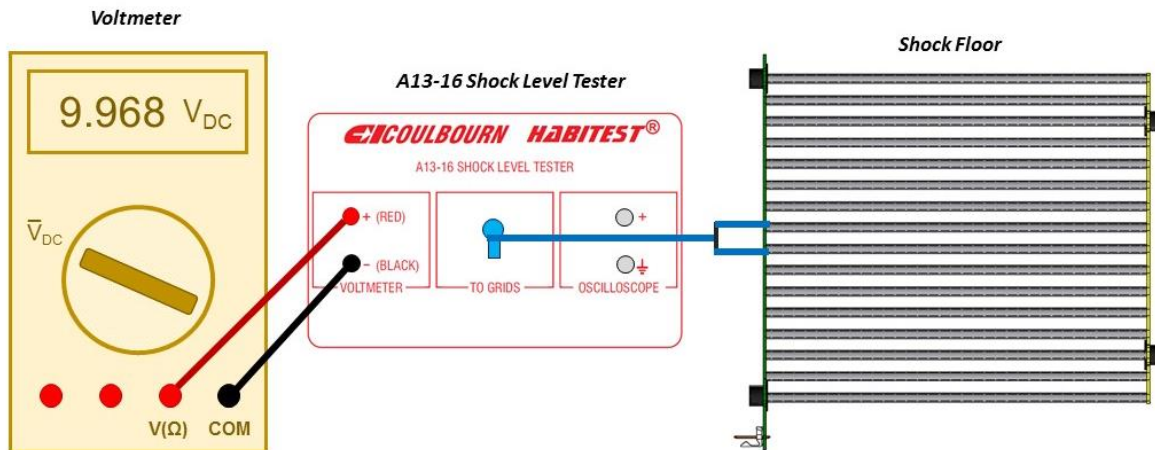
*In the “High” setting the values along the bottom scale of the meter display are in effect. The High setting is used for stimulus intensities ranging between **0.5 – 3 mA**.*

- 5) Set the shock generator to Set/Test mode. Hold down the Operate lever to manual trigger the shock through the internal calibration unit. The shock will not be routed to the floor when in Set/Test mode. While holding the Operate lever down, turn the Manual/Set Shock knob to adjust the current shown on the meter to the desired intensity.
- 6) Release the Operate lever and switch the unit from Set/Test to Subject Mode.
- 7) With nothing touching the shock floor, trigger the shock generator again manually by pressing the Operate lever on the front panel of the unit. The Subject LED should flash when triggered. The meter needle will respond but should indicate very little current flow. As there is nothing on the shock floor to connect the electrified bars there should be no path for current to flow. If significant current is measured on the meter ensure that the shock floor is clean.
- 8) Release the Operate lever keeping the unit in Subject Mode.
- 9) Connect the alligator clip cable assembly from the center jack on the A13-16 Shock Level Tester to two adjacent bars in the shock floor. Note that every 8th bar is electrically connected (1 + 9, 2 + 10, 3 + 11, etc). Measurements across connected bars will not, and should not, show current flow.
- 10) Connect the cable leads from the voltmeter to the COM and V(Ω) inputs.
- 11) Set your voltmeter to read DC volts and plug the red probe in the A13-16 jack labeled Voltmeter “+” and plug the black probe in the A13-16 jack labeled Voltmeter “-”. DC volts is indicated by a V with straight solid and dotted lines.
- 12) Trigger the shock generator again manually by pressing the Operate lever on the front panel of the unit. The Subject LED should flash when triggered. While the shock is triggered, the reading of the voltmeter should be **SLIGHTLY LESS than 10x** the value of the current amplitude setting. See the table below.

Current Amplitude in Set/Test Mode (mA)	Value Measured by Voltmeter (V)
0.5	4-5
1	9-10
2	18-19
3	28-29
5	50-51

Also note the reading on the shock generator meter. The needle on the meter will now show current flow; however the value shown will be less than the set current. This is because the meter is reading the average current flow through the system, while the set current indicates the amplitude of each shock pulse. The average current flow is based on the set current and the number of contacted electrified bars.

Connections for Shock Output Test



- 13) Release the Operate lever keeping the unit in Subject Mode.
- 14) Lift the Operate lever into the Remote position. The shock generator is now ready for computer operation.
- 15) Before placing the animals in the chambers, run a brief test protocol that activates the shock generators. (If the animals are in the vicinity of the chambers please do not include any auditory or visual stimuli in the dummy protocol). When the shock generators are triggered the Subject LED will flash. For any stations that do not respond to the protocol check that the Operation mode is set to Remote and that Shock Routing is set to Subject.

H13-15 Working Procedure with Voltmeter and Resistor. The following sequence of steps is suggested before experimental procedures to verify the shock intensity when using a voltmeter and resistor.

Hardware Required:

- + True RMS Voltmeter
- + 10 kOhm Resistor
- + Alligator Clips for Voltmeter Leads (Suggested)

- 1) Power the shock generator by flipping the switch where the power cord plugs into the unit. The red Power LED will light on the front of the unit.
- 2) Check that the unit is set to 8 pole operation for scrambled shock output. This setting is controlled by a toggle switch on the back panel of the unit above the 8-pin shock output connector.
- 3) Check that one end of the rainbow ribbon cable is connected to the 8-pin shock output connector on the back of the shock generator and that the opposite end is securely connected to the 8-pin connector located at the front of the shock floor.
- 4) On the front panel of the shock generator choose the appropriate meter range for the desired stimulus intensity.

In the "Lo" setting the values along the upper scale of the meter display are in effect. The Lo setting allows for stimulus intensities between 0.05 – 0.5 mA.

In the "High" setting the values along the bottom scale of the meter display are in effect. The High setting is used for stimulus intensities ranging between 0.5 – 3 mA.

- 5) Set the shock generator to Set/Test mode. Hold down the Operate lever to manual trigger the shock through the internal calibration unit. The shock will not be routed to the floor when in Set/Test mode. While holding the Operate lever down, turn the Manual/Set Shock knob to adjust the current shown on the meter to the desired intensity.
- 6) Release the Operate lever and switch the unit from Set/Test to Subject Mode.
- 7) With nothing touching the shock floor, trigger the shock generator again manually by pressing the Operate lever on the front panel of the unit. The Subject LED should flash when triggered. The meter needle will respond but should indicate very little current flow. As there is nothing on the shock floor to connect the electrified bars there should be no path for current to flow. If significant current is measured on the meter ensure that the shock floor is clean.
- 8) Release the Operate lever keeping the unit in Subject Mode.
- 9) Connect two adjacent bars on the shock floor with the 10kOhm resistor. Note that every 8th bar is electrically connected (1 + 9, 2 + 10, 3 + 11, etc). Measurements across connected bars will not, and should not, show current flow.
- 10) Connect the voltmeter leads to the COM and V(Ω) inputs of the voltmeter.
- 11) Slip the alligator clip connectors on the opposite end of the voltmeter leads.
- 12) Connect the voltmeter to the grid floor by clamping the alligator clips on the two bars bridged by the resistor.
- 13) Set your voltmeter to read resistance. The display should read close to 10,000 Ohms. If it does not, adjust the resistor connection across the bars.

14) Set your voltmeter to read AC voltage. The symbol for AC voltage is a V with a tilde:



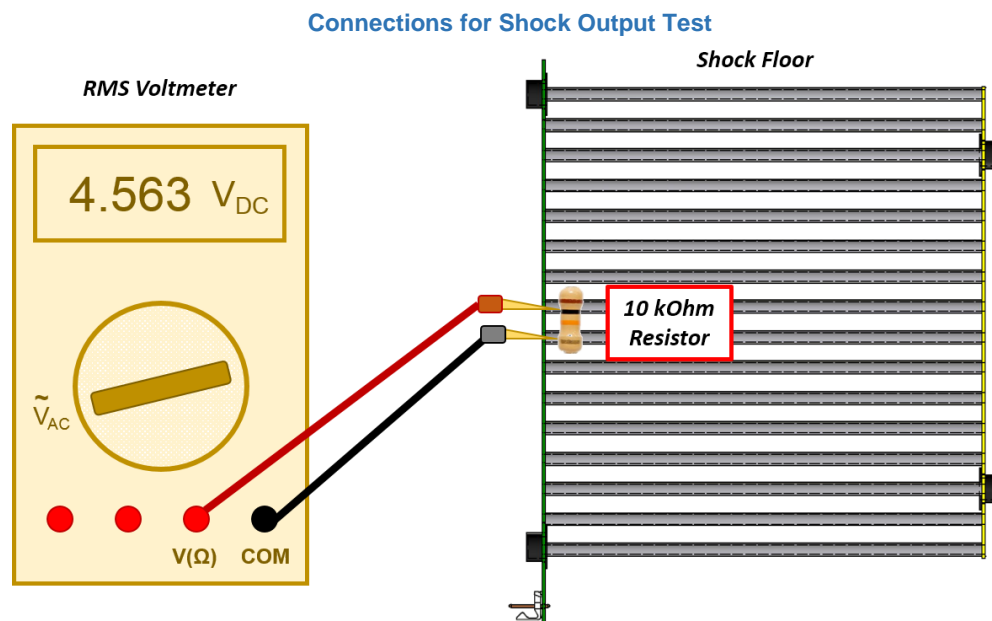
15) Trigger the shock generator again manually by pressing the Operate lever on the front panel of the unit. The Subject LED should flash when triggered. While the shock is triggered, the voltmeter will display the RMS voltage measured. This value can be used to calculate the shock intensity using the following relationship:

$$\text{Peak Current (mA)} = \left(\frac{V(\text{volts})}{10} \right) \div \sqrt{2/9}$$

In more simple terms, the voltmeter reading will be **about 5x** the peak current. The table below provides some example values using the RMS calculation.

Current Amplitude in Set/Test Mode (mA)	Value Measured by Voltmeter (V)
0.5	2.4
1	4.7
2	9.4
3	14.1
5	23.6

Also note the reading on the shock generator meter. The needle on the meter will now show current flow; however the value shown will be less than the set current. This is because the meter is reading the average current flow through the system, while the set current indicates the amplitude of each shock pulse. The average current flow is based on the set current and the number of contacted electrified bars.



16) Release the Operate lever keeping the unit in Subject Mode.

17) Lift the Operate lever into the Remote position. The shock generator is now ready for computer operation.

18) Before placing the animals in the chambers, run a brief test protocol that activates the shock generators. (If the animals are in the vicinity of the chambers please do not include any auditory or visual stimuli in the dummy protocol). When the shock generators are triggered the Subject LED will flash. For any stations that do not respond to the protocol check that the Operation mode is set to Remote and that Shock Routing is set to Subject.