H-111A Starter Kit
Student Workbook
H-WB111A

Hands-On
Vehicle Electrical-Electronics
Troubleshooting Training Program

Supplement Training To
"The" (60 Lesson Home-Study)
Vehicle Electronics Training Course
www.training.veejer.com

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(1) Snap the boards together and squeeze the connector C700 till it snaps together to lock the boards. It is not necessary to use the small screws in the C700 connector to keep the two boards locked together. The locking screws can be removed from the connector.

(2) Notice the electronic circuit components between the Red and Black terminal posts are now mounted on the underside of the Power Board in the revised H-PCB01/02A. These components form the voltage regulator circuit and are not part of the troubleshooting program. Do not allow any metallic object to make contact with the components on the underside (copper) side of the PCB when powered up.
Introduction
The vehicle service industry needs technicians trained in electrical-electronics troubleshooting. We call this highly trained technician a VEHICLE ELECTRONIC TECHNICIAN, or V.E.T. They are vehicle service technicians who can hands-on troubleshoot vehicle electrical-electronic systems with test equipment using the same methods as electronics technicians have done in the worldwide electronics industry for over 90 years.

It is one thing to discuss how open connections, voltage drops and shorts-to-ground affect circuits and discuss how to troubleshoot those problems on paper. But it's different when live circuits are used to actually experience those problems and effectively troubleshoot with repetitious hands-on practice.

Students perform hands-on troubleshooting at home, in the shop or technical school to develop troubleshooting skill and become hands-on vehicle circuit troubleshooters using this training program.

"The" Hands-On Program contains several circuit board training kits. Students begin "The" Hands-On Program with The Starter Kit, H-111A, containing the first two modules we refer to as "PCBs" (printed circuit boards). The Starter Kit, H-111A, covers essential troubleshooting technique with the Lamp Board (H-PCB02A) connected to the Power Board (H-PCB01A).

This is followed by Part Number H-113, "Troubleshooting DC Motor Circuits" with a specially designed DC Motor Troubleshooting Trainer circuit board, H-PCB03, containing a brushless DC motor. It has 37 DC Motor circuit troubleshooting exercises.

Part Number H-115, "Troubleshooting Relay Circuits" uses the Relay Circuit Troubleshooting Trainer, H-PCB05. The relay is operated and studied as a fuel pump relay circuit to add realism to 75 relay troubleshooting exercises.

Part Number H-116, "Wire Harness Troubleshooting" covers electrical system troubleshooting with all the circuit boards connected together to create a Mini-Electrical-System, or "M.E.S." for short. The M.E.S. contains over 104 electrical systems problems.


Prerequisite for "The" Hands-On Program
There are no specific prerequisites to study The Starter Kit, H-111A, however it is recommended that the first 25 lessons of "The" Vehicle Electronics (60 Lesson) Training Course" has been reviewed since they compliment circuit explanations in "The" 60 Lesson Course with more detailed information.

Goals and Objectives
The primary goal of "The" Hands-On Program is to develop skill in troubleshooting vehicle electrical and electronic systems with hands-on practice. A student of "The" Hands-On Program who applies what is learned can begin to successfully troubleshoot electrical and electronic problems on vehicles after only a few hours of study. Changing parts to troubleshoot electrical problems becomes a thing of the past.

"The" Hands-On Program can be studied at home by self-study, or in a study group setting where students share the circuit boards and have their own workbook, or in a tech-school classroom led by a teacher. Technicians can take turns sharing the same circuit boards using their own student workbook.

What This Program Offers
"The" Hands-On Program's begins by reading this student workbook H-WB111A. The Starter Kit introduces the principles of vehicle electrical and electronic systems troubleshooting techniques with live circuits using real world circuit problems. The Starter Kit, H-111A, contains a DC voltage power supply, H-PS01.

Please use caution with the H-PS01 DO NOT ALLOW THE POWER SUPPLY WIRE TIPS TO EVER "SHORT" TOGETHER WHILE THE POWER SUPPLY IS PLUGGED IN. ALWAYS CONNECT THE RED AND BLACK WIRES TO THE RED AND BLACK POSTS ON THE POWER BOARD BEFORE PLUGGING THE POWER SUPPLY INTO A WALL SOCKET OR POWER STRIP. ALWAYS FIRST UNPLUG THE POWER SUPPLY BEFORE DISCONNECTING THE RED AND BLACK WIRES FROM THE POSTS.

Two PCBs are included for measuring voltage, resistance and current while troubleshooting circuit problems. The Power Board H-PCB01A and Lamp Board, H-PCB02A. mimic an actual live vehicle circuit. Voltage and resistance readings are in the same range as found in actual vehicle circuits to add realism to the program. Students use their own DMM.

Later on in the program a circuit fault is inserted on the bottom of properly functioning circuit boards to create an electrical problem such as an OPEN, a Voltage drop (abbr. Vd) or a shorted load or short to ground.

Students troubleshoot the live circuit boards from the top of the PCBs, to find the problem using troubleshooting techniques covered in the workbook which would be exactly the same if the circuit were on an actual vehicle.
Notice:
The original home-study manual H-SM01/02A and school version S-SM01/02A are replaced with this new updated version H-WB111A.

The PCBs are designed and laid out to represent complete vehicle circuits so live measurements can be taken with a DMM and live readings analyzed. The circuits are not complex in design so that students can focus on developing troubleshooting technique and skill with simple circuits. These troubleshooting techniques can then be employed on more complex circuits without additional training.

A "CONFIDENTIAL" Instructor Guide, H-IG111A (abbr. I/G) is included with complete instructions to insert faults to set up troubleshooting problems and contains all the step-by-step answers to study exercises and troubleshooting problems. If this is being studied in a classroom only the instructor has access to the Instructor Guide.

To maximize the benefits of this training program and develop professional troubleshooting skill, technicians should NOT look at the answers to a problem before troubleshooting a problem. Advance knowledge of a fault dilutes the troubleshooting lesson to be learned from that exercise.

If you are working on "The" Hands-On Program by yourself at home or in the shop, find someone to insert the faults for you for each problem number to achieve best results. While it may be necessary to insert problems for yourself in a self-study setting, it is not an ideal situation. We recommend you show another person how to insert circuit faults for you. In a classroom the instructor will insert problems.

Students can progress at their own pace and find that after only a couple of hours of study that the troubleshooting principles learned can be immediately applied in the shop on vehicles with electrical or electronic problems even before all of the 32 troubleshooting problems are completed.

How To Begin

Begin "The" Hands-On Program by reading through the first 39 or so pages in this student workbook Part Number H-WB111A, and do the initial exercises in preparation for the 32 problems.

Start troubleshooting problems by inserting a "fault," in the PCBs as explained in the Instructor Guide. Write down your troubleshooting steps and DMM readings in your student workbook until you know exactly what is wrong with each circuit problem. Be careful to write down your answers under the problem number you are troubleshooting at that time. In other words, if you are troubleshooting problem number 4 do not record your answers under problem number 3 in the work book. Compare your answers with the answers in the Instructor Guide for each problem. If in a classroom setting the Instructor will review each problem. Students should not read the answers to a problem before troubleshooting a circuit problem.

Troubleshoot one problem at a time and follow them in numerical order for the first go around. Later you may troubleshoot any problem in any order for more practice. Keep track of your troubleshooting progress using the Student Troubleshooting Record on the last page of this student workbook.

Tips Using "The" Hands-On Troubleshooting Training Program

(1) STUDENTS SHOULD NOT LOOK AT THE BOTTOM OF THE PCBs PRIOR TO TROUBLESHOOTING A PROBLEM SINCE THE CIRCUIT FAULT MIGHT BE SEEN. DISCOVERING A CIRCUIT FAULT BY OBSERVATION WILL SPOIL THE BENEFIT TO BE GAINED FROM THAT PROBLEM. DON'T EVEN PEEK!

(2) A student should have his own Student work book to keep notes, complete reading assignment exercises and record test steps and results in the troubleshooting problems. Failure to record troubleshooting test results and personal notes will make it impossible to evaluate troubleshooting success later.

(3) Do not insert more than one fault at a time in the PCBs. Follow the instructions for inserting each troubleshooting problem so the fault is correctly inserted. In the classroom the Instructor will insert the problems.

(4) Faults should be removed from the PCBs after finding the problem unless someone is going to troubleshoot the same problem immediately after you. AVOID CONFUSION! Any fault left in a PCB will affect the circuit when a second fault is installed causing false readings and confusion.

(5) "Scan the top and bottom" of the PCBs to verify that no parts are missing on the top of the PCBs before inserting a fault. Scanning the top of the PCBs is covered in this student workbook. Scanning the bottom of the PCBs is covered in the Instructor Guide. Do both to properly prepare the PCBs for inserting faults.

The first circuit covered in the Starter Kit, H-111A, is called the Power Board, H-PCB01A, to which the second circuit, the Lamp Board, H-PCB02A, is connected. A complete but simple lamp circuit is created by connecting (snapping) the two boards together at connector C700.

A simple circuit of a lamp is used first to introduce the technician or student to essential troubleshooting skills needed for any circuit on any vehicle.
If a technician understands how to troubleshoot a simple lamp circuit he/she can use the same skills to troubleshoot any circuit whether it is an electrical or electronic circuit, simple series circuit, parallel circuit or compound circuit.

All electrical and electronic circuits operate on the same electrical laws. By studying these electrical laws with hands-on exercises and use them in troubleshooting a simple lamp circuit, it is easier to learn more complex troubleshooting procedures as you progress through your career.

Resistor Bag—Lamp Circuit H-RB01/02A

The Resistor Bag—Lamp Circuit contains an assortment 1/4 watt fixed resistors of different ohmic values for inserting faults into the PCBs. These fixed resistors have four color bands to indicate their resistance value. When told to insert a resistor fault a resistor is randomly selected so it is not necessary to determine resistor values. They can be measured with an ohmmeter if interested in their ohmic value.

A Word About Zero Ohm Resistors

Some components on the top and bottom of the PCBs are not fixed resistors but what are called zero ohm resistors. A Zero Ohm Resistor, abbr. 0ΩR in this training program is the equivalent of a jumper wire. All zero ohm resistors look like a small “dogbone” resistor and have a single black band painted in the center of the resistor body. Extra 0ΩR resistor are included in the plastic parts bag.

Zero Ohm Resistor

Inserting some circuit problems for troubleshooting purposes simply require removing a 0ΩR from the bottom of a PCB to create an OPEN circuit.

Always pull a 0ΩR straight UP to remove it from the two terminal pins holding it in place.

The leads of the zero ohm resistors are a tight fit in the new mounting pins. It may be difficult to remove a 0ΩR the first time.

USE CAUTION WHEN REMOVING A ZERO OHM RESISTOR FOR THE FIRST TIME TO AVOID BREAKING OFF THE WIRE LEADS OF THE 0ΩR IN THE MOUNTING PINS.
PULL STRAIGHT UP TO REMOVE

It is best to gently pull straight up slowly BUT FIRMLY to remove the 0ΩR the first time. After a 0ΩR is removed and replaced the mounting pins become "broken in" and the 0ΩR can be easily removed and replaced thereafter.

Some circuit faults call for inserting a fixed resistor in place of a 0ΩR to create a voltage drop. In other troubleshooting scenarios a 0ΩR is inserted to create a shorted load or a short-to-ground. Full instructions are provided in the Confidential Instructor Guide (I/G).

There are an assortment of 50Ω, 100Ω and 150Ω resistor values in a small plastic bag labeled Resistor Bag, H-RB01/02. One Resistor Bag is included in each Starter Kit. Each resistor value contained in the Resistor Bag is designed to work with the Lamp Circuit to provide significant circuit faults that can be discovered by DMM voltage readings. The fixed resistors in the Resistor Bag, H-RB01/02 are the only resistor values to be used with the Lamp Circuit.

Check the resistor values with your ohmmeter for practice. The readings will be close to the actual resistor value. For example a 50Ω resistor may test a little low at 48.9Ω or a little high at 51.2Ω. Resistor values can vary a small percentage of the written value. Precision resistor, which are much more expensive and not used in this program, will test exactly as their designated value.

Inserting Problems

Follow the instructions given in the Instructor Guide to insert a resistor type fault for a particular number problem. A resistor is randomly selected from the resistor bag for a voltage drop (Vd) type fault. The resistor is installed on the bottom of the PCBs (as directed in the Instructor Guide) to produce a Vd problem at some point in the circuit. It may be helpful to use a long nose pliers for removing the zero ohm resistors and inserting another resistor or 0ΩR. Once the fault is installed begin troubleshooting that problem from the TOP of the PCBs. NEVER TROUBLESHOOT PROBLEMS ON THE BOTTOM OF THE PCBs.

Recording DMM Troubleshooting Readings

Different resistor values are selected at random to insert a particular problem which affects the actual voltage reading. Readings will vary depending on the resistor value randomly selected for that problem.

Therefore answers in the Instructor Guide do not record actual readings because the reading depends on the value of the fixed resistor used for a problem.

Instead, the I/G answers are word phrases like "Low B+" instead of an actual DMM reading of "10.42V" or 9.35V. The same is true on the ground side of the circuit where a ground side reading is written as "more than 0.1V" or "high B-" instead of an actual DMM reading of "3.25V" or "2.27V." When you check your answers in the I/G they will be recorded as "low B+" rather than an actual reading.

In this way, different resistor values can be used for a wider variety in DMM readings so that you may troubleshoot the same problem more than once and get different readings each time. This also helps increase student familiarity with a wider range of defective circuit DMM readings.
Starter Kit, H-111, Original Version

The Starter Kit, H-111 original version, shown to the right, is the first design of the H-111 PCBs (printed circuit boards). The following explains differences between the original version of H-111 and the new version designated with an "A" as H-111A. Both H-111 and H-111A are identical in operation and either one can be used with any H-111 or H-111A exercise or workbook. Minor changes between the PCBs are discussed below.

Original H-111, Power Board H-PCB01

Notice the voltage regulator circuit components are mounted on the top of the Power Board, H-PCB01, between the Red and Black Posts. Ignore these components as they are not part of the hands-on troubleshooting training program. Their function is to provide a regulated 13.8V value of B+ from the unregulated (raw) voltage provided by the Power Supply H-PS01 and are mounted out of the way at the top of the Power Board, H-PCB01.

Positive Post of the Vehicle Battery

The positive post of the vehicle battery IS NOT the Red Post. Instead you are to use the small black Loop Pin marked +BATT just below the red post as the positive terminal of the vehicle battery for all measurements and tests.

Test Point TP1

Test Point TP1 is shown at the top of Fuse F1. The electrical connection point of TP1 is not connected to Fuse F2. In fact Fuse F2 is a direct connection to Diode D1.

Connectors C11 and C22

These are intended to be two connectors in the HOT-AT-ALL-TIMES circuit but they cannot be disconnected on the H-111 Power Board, H-PCB01. They simply simulate where connectors could be inserted in the wiring harness.

Lamp Board H-PCB02

The Lamp Board is essentially the same for all H-111 or H-111A kits. The Lamp Board from either version can be used with either the Power Board H-PCB01 in H-111 or the Power Board H-PCB01A in H-111A.

All these issues are improved with the new version designated H-111A on the next page.
Starter Kit, H-111A Revised Version

The Starter Kit H-111A has minor improvements which do not change operational characteristics of the Starter Kit in any way. Power Supply H-PS01 and Power Boards from H-111 and H-111A are fully interchangeable with each other as well as Lamp Boards from either H-111 or H-111A.

H-111A Power Board H-PCB01A
All voltage regulator circuit components are mounted on the bottom (copper) side of the H-PCB01A between the Red and Black posts. This keeps the regulator circuit components out of sight of the student.

Positive Post of the Vehicle Battery
The positive post of the vehicle battery is NOT the red post. Instead you are to use the small RED Loop Pin marked +BATT and B+ just below the red post as the positive terminal of the vehicle battery for all measurements and tests.

Test Point TP1
Test Point TP1 is shown moved to the top of Fuse F1 AND Fuse F2. The electrical connection point of TP1 is now connected to both to Fuse F1 and Fuse F2. The B+ voltage to both fuses now comes from TP1.

Connectors C11 and C22
C11 and C22 connectors now employ zero ohm resistors in the HOT-AT-ALL-TIMES circuit. REMOVING EITHER ZERO OHM RESISTORS OPENS THAT CONNECTOR. Removing zero ohm resistor C-11 separates C11-A from C11-B. When zero ohm resistor C22 is removed the connection between C22-A and C22-B is removed. When the zero ohm resistor is removed consider that one connector is disconnected. For normal operation of the Power Board H-PCB01A with other circuit board connected to C700 it is necessary to insert zero ohm resistors in C11 and C22 to have B+ at TP9.

Lamp Board H-PCB02A
The Lamp Board in H-111A is identical to the Lamp Board in H-111. The only change is noted when the Lamp Board H-PCB02A is disconnected from the Power Board to trace a short-to-ground. Grounding the DMM at TP14 allows the student to "see" the short-to-ground between TP13 and Pin 1. The original Lamp Board H-PCB02 would not allow this.

Mix and Match
It is permissible to mix and match "A" PCBs with original PCBs. The same is true for Power Supply H-PS01 in the H-111 and H-111A. Everything is interchangeable.

Revised H-111 now referred to as H-111A
DC Power Supply H-PS01
A small unregulated DC power supply, Part Number H-PS01, is supplied with "The" Hands-On Program's Starter Kit. The H-PS01 plugs into a USA wall socket and has a red and black wire for connection to the Red (+) and Black (-) terminal posts on the Power Board.

DO NOT allow the red and black wires of the H-PS01 to make contact with each other (short together) while the H-PS01 is plugged into a wall socket. This will short circuit and possibly damage the H-PS01 and void the warranty. Tie a knot in either the red lead or black lead from the H-PS01 to make the leads of different length. This will help prevent the leads from shorting together when disconnected from the two posts.

The H-PS01 power supply has an U.S.A. standard AC plug to fit into a wall socket with 110-120 VAC (Volts Alternating Current). There is no ON/OFF Switch associated with the H-PS01.

- To turn the Power Supply ON plug into a 110-120V AC wall outlet.
- To turn the Power Supply OFF unplug from the wall outlet.

Always unplug the H-PS01 power supply from the wall socket when not in use or when connecting or disconnecting the red and black wires from the terminal posts.

- Make it a habit to IMMEDIATELY disconnect the H-PS01 from the wall socket after using.

- Do not leave the H-PS01 plugged in while inserting problems in the PCBs. Disconnect the H-PS01 from the wall socket before inserting faults in the PCBs or when connecting or disconnecting the red and black wires.

ALWAYS observe correct polarity when connecting the red and black wires from the H-PS01 to the terminal posts at the top of the Power Board. The RED WIRE connects to the RED POST. The BLACK WIRE connects to the BLACK POST.

NEVER REVERSE THE CONNECTIONS. Each terminal post has a screw on cap. As the end cap is unscrewed a hole appears in the terminal post shaft as shown below. Insert the red wire into the Red terminal shaft's hole and tighten down the red end cap lightly. Slide the black wire into the Black terminal shaft hole and tighten down the black end cap slightly. DO NOT over tighten the terminal posts. If they loosen simply tighten the locking nut on the bottom of the post.

An alternate DC power supply should NOT be used to power the PCBs. The Power Board contains an electronic voltage regulator circuit between the two terminal posts to convert the raw unregulated DC power from the H-PS01 into a regulated DC voltage to simulate the voltage (B+) of a vehicle's 12-14 volt system. Using any DC power supply other than the H-PS01 may damage the electronic voltage regulator circuit and void the warranty.

DO NOT use a 12V car battery in place of the H-PS01 power supply. It could damage the electronic voltage regulator circuit.

DO NOT connect a battery charger to a battery being used to power up the PCBs in an attempt to keep the car battery charged while troubleshooting.

It's dangerous. Charging batteries emit gases that are highly explosive if exposed to a spark. Use only the approved DC power supply H-PS01.

CAUTIONS USING THE H-PS01 DC POWER SUPPLY

1. ALWAYS UNPLUG THE H-PS01 POWER SUPPLY WHEN NOT IN USE.

2. ALWAYS UNPLUG THE H-PS01 POWER SUPPLY WHEN INSERTING A CIRCUIT FAULT IN THE PCBs.

3. DO NOT CONNECT THE H-PS01 RED AND BLACK WIRES TO ANYTHING OTHER THAN THE POWER BOARD RED AND BLACK POSTS.

4. NEVER ALLOW RED AND BLACK WIRES TO MAKE CONTACT WHILE THE POWER SUPPLY IS PLUGGED IN.

FOLLOW THESE DIRECTIONS AT ALL TIMES. For those countries with 220V electrical systems a power supply is supplied for 220V lines. An extra Power Supply can also be purchased for 220 Euro or UK style electrical sockets.
Exploring the POWER BOARD

The first circuit board to review is the Power Board which provides the "B+" (voltage) supply and "B-" the ground circuit to all PCBs plugged into Connector 700 at the bottom of the Power Board. In a vehicle this would be called the Power Distribution System of the vehicle. The Power Board and Lamp Board are shown connected in Figure 1.

**PLEASE STUDY THE POWER BOARD CIRCUIT ANALYSIS CAREFULLY TO AVOID MISTAKES PERFORMING THE EXERCISES.**

The Red Terminal Post

Just below the red terminal post is a red "loop" test terminal called the +BATT or the B+ Test Point. This is used as the FIRST positive voltage source test point or B+ feed for all circuits in this hands-on training program. Do not use the red post for any (B+) voltage measurement. The red post is simply a connection point for the red (+) wire from the H-PS01 Power Supply. The +BATT red loop pin represents the vehicle battery's positive (+) post or the B+ terminal on the back of the generator (alternator).

The Black Terminal Post

The black terminal post at the top left of the Power Board is labeled -BATT or B- (say B minus). The black terminal post represents the vehicle battery's negative terminal post and is the primary ground point for all testing. Use the -BATT terminal post for purposes of grounding the DMM for circuit voltage measurements or when tracing shorts-to-ground.

Trace the Voltage Side of the Power Board

The red loop pin feeds B+ to diode D1, a Polarity Sensing Diode located just below the Red Post.

Polarity sensing diodes are discussed in "The" Vehicle Electronics Home Study Training Course in Lesson 44, Pages 4-5 and Lesson 49, Pages 1-4.

Diode D1 shuts the circuit down (prevents electron current flow) if the H-PS01 power supply red and black leads are connected to the terminal posts in reverse polarity. Reverse polarity means the red wire is accidentally connected to the black post and black wire is accidentally connected to the red post.

Reverse polarity is the same thing as trying to jump start a vehicle with the jumper cables connected in reverse polarity, as covered in Lesson 17, Page 6; Lesson 49, Pages 1-4.

Diode D1 protects all circuits from high electron current attempting to flow in the wrong direction due to reverse polarity voltage being connected to the Power Board's Red and Black posts.

This can be done on a vehicle during "jump starting" a dead battery and the jumper cables are connected in reverse.
Trace the Voltage Side of the Power Board
GROUND DMM BLACK TEST LEAD TO -BATT

TP1 (Test Point #1) is the first B+ test point provided after Diode, D1. The B+ at TP1 splits to supply B+ to two fuses F1 and F2. Fuse, F1 (3A) supplies B+ to TP2, the voltage input terminal to the IGNition SWitch, S1. TP3 is the output terminal of S1. S1 is a 3 position, surface mount switch. The switch terminals are not accessible for voltage checks from the top of the PCB. Use TP2 to check B+ going into S1 and TP3 to check the B+ coming out of S1 when S1 is toggled to the UP (top) position. The Ignition Switch, S1, is only CLOSED when the toggle is toggled UP.

TP3 connects to TP4. A 0ΩR (zero ohm resistor) connects TP4 to what is called the "B+ Terminal". The 0ΩR between the B+ Terminal and TP4 can be moved to connect the B+ Terminal to TP17 so the Push/Release Switch S2 can be used to control a circuit. You will be instructed when to do this in future training programs. For now leave the 0ΩR connected between TP4 and the B+ Terminal.

Switches, S3 and S4 are surface mount slide switches, S3 is on the voltage side and S4 is on the ground side. Each switch has an input test point and an output test point just like S1 and S2 for voltage checks to determine voltage levels at the switch terminals. Back to tracing the voltage side.

The B+ Terminal connects to TP5, the B+ feed or input to switch, S3, the voltage side control switch. TP6 is the output terminal of S3 and connects to TP7 at C700. When the B+ Terminal has B+ and S3 is CLOSED (slide UP), B+ appears at TP7 if the B+ circuit is operating correctly. Any circuit connected to C700 will receive its B+ from TP7. Use TP7 to verify that B+ is available at C700. Do not measure B+ at the exposed pins of C700. That is what TP7 is for. If normal B+ is present at TP7 it can be considered that B+ is available at the proper pin of C700.

Trace the Ground Side of the Power Board

Start at the Black (-BATT) Terminal at the top left of the Power Board. This is the primary ground point for "B-" (say B minus) or the ground side voltage of 0.00 volt written as 0.00V.

The black post connects to G100 which would be the same as the engine ground cable or the accessory (sheet metal) ground cable.

The next ground is G101 at the bottom left of the Power Board. It is understood that G101 connects back to G100 through the engine block or sheet metal.

From G101 the ground circuit connects to TP12, the ground input terminal to S4, the ground side control switch.

When S4 is CLOSED (slide UP) the ground circuit or B- appears at TP11 the output terminal of switch S4. TP11 connects to TP10 to place ground, or B-, at C700 which grounds any PCB plugged into C700 when S4 is CLOSED.
Connector C700
The connector C700 at the bottom of the Power Board contains 12 pins. Do not use the connector pins for troubleshooting test points. A numbered TP is provided for every circuit passing through C700.

Test Point TP7 brings B+ to the connector C700 when S3 is slide UP. On the Lamp Board TP13 is on the opposite side of C700 to provide the B+ to the Lamp Board.

Test Point TP10 brings B- to the connector C700 when S4 is slide UP. On the Lamp Board TP14 is on the opposite side of C700 to provide the B- to the Lamp Board.

Connecting a PCB to C700 completes an operating circuit for study and troubleshooting practice with B+ and B- being available at C700.

Expect a wide range of electrical problems to be inserted into the Power Board and Lamp Board when connected together. Problems occur as OPENs, SHORTS and Voltage drops (Vds) appear at any point in the voltage or ground side of each circuit.

Ground DMM During Voltage Measurements

- VERY IMPORTANT -

Always connect the DMM's Black Test Lead to the Black (-BATT) Terminal Post at the top of the Power Board when ever it is necessary to ground the DMM black test lead for circuit voltage measurements NO EXCEPTIONS!

There is no better ground test point for your DMM's COM (Black) Test Lead.

When checking circuit voltages, use the black terminal post for grounding the DMM black test lead because the black terminal post is the most negative point electrically (or best ground) on the circuit boards just as it is on a vehicle. This eliminates many potential errors in voltage measurement that can occur by grounding the black test lead at any other ground point in the PCBs.

The same is true on a vehicle. A vehicle's negative battery post (-BATT) is the most negative point (0.00V) and is usually the easiest to access on a vehicle for purposes of grounding the DMM's black test lead. This troubleshooting tip will eliminate errors in voltage measurements especially when checking the voltage on the ground side of vehicle circuits.

Reminders Using The H-PS01 Power Supply
(1) ALWAYS UNPLUG THE H-PS01 POWER SUPPLY WHEN NOT IN USE.

(2) ALWAYS UNPLUG THE H-PS01 POWER SUPPLY WHEN INSERTING A CIRCUIT FAULT IN THE PCB.

(3) DO NOT ALLOW THE RED AND BLACK WIRES TO MAKE CONTACT WHILE THE POWER SUPPLY IS PLUGGED IN.

H-PS01 Power Supply Voltage
The H-PS01 Power Supply is a non-regulated DC power supply which means the voltage output varies widely with the load placed on the power supply.

The H-PS01 works in conjunction with the electronic regulator circuit on the bottom of the Power Board (at the top) to provide the DC voltage to operate a circuit, such as the Lamp circuit, when it is connected to Connector C700 at the bottom of the Power Board.

When the load is zero, the power supply is not supplying current to a circuit and the terminal post voltage is higher.

When the circuit is turned ON, a load is placed on the power supply which lowers the power supply voltage to the normal operating voltage.

Measure H-PS01 Power Supply Voltage
To measure the H-PS01 voltage follow these steps.

(1) Connect the Lamp Board to the Power Board.

(2) Connect the UNPLUGGED H-PS01 red and black leads to the Red and Black terminal posts.

(3) Place the DMM test leads on the red (+) and black (-) terminal posts located at the top of the Power Board as shown below in Figure A. Set the DMM to the 20V, 30V or 40V DC range whichever your DMM provides.

When checking circuit voltages, use the black terminal post for grounding the DMM black test lead because the black terminal post is the most negative point electrically (or best ground) on the circuit boards just as it is on a vehicle. This eliminates many potential errors in voltage measurement that can occur by grounding the black test lead at any other ground point in the PCBs.

The same is true on a vehicle. A vehicle's negative battery post (-BATT) is the most negative point (0.00V) and is usually the easiest to access on a vehicle for purposes of grounding the DMM's black test lead. This troubleshooting tip will eliminate errors in voltage measurements especially when checking the voltage on the ground side of vehicle circuits.

Reminders Using The H-PS01 Power Supply
(1) ALWAYS UNPLUG THE H-PS01 POWER SUPPLY WHEN NOT IN USE.

(2) ALWAYS UNPLUG THE H-PS01 POWER SUPPLY WHEN INSERTING A CIRCUIT FAULT IN THE PCB.

(3) DO NOT ALLOW THE RED AND BLACK WIRES TO MAKE CONTACT WHILE THE POWER SUPPLY IS PLUGGED IN.

(4) Plug in the H-PS01 to 110-120 VAC wall socket.

(5) On the Power Board turn IGN SW (S1) ON (toggle UP). Slide S3 and S4 UP. The Lamp should be "ON."

(6) Record the voltage at the Power Board Red (+) and Black (-) terminal posts. Write the voltage measured in the DMM display in Figure A. The voltage should be in the range of approximately...
16.0-17.50 volts. This is the unregulated (raw) DC voltage produced by the H-PS01.

A regulated power supply is used to maintain a fairly constant output B+ voltage whether the AC power line voltage is a little higher or a little lower between different locations. The electronic voltage regulator circuit is mounted on the underside (copper side) of the Power Board between the Red and Black terminal posts to control the output voltage and keep it fairly constant.

**Fig. B**

The DMM is shown connected to measure the regulated B+ at the +BATT (B+) terminal produced by the H-PS01 and the electronic regulator circuit. Follow these steps:

7. Place DMM test leads as shown in Figure B.
8. Turn IGN SW, S1, ON (toggle UP), S3 and S4 slide UP. The lamp should be ON.
9. The voltage measured at the +BATT or B+ Red Loop Pin should be approximately 13.65 – 13.95V. Write the voltage found in the DMM in Figure B.

The B+ measured at the +BATT or B+ Red Loop Pin changes from no-load (lamp OFF) to loaded condition (lamp ON). The voltage is lower when the lamp is ON as the lamp draws electron current from the power supply (B+). This verifies the proper operation of the voltage regulator circuit.

**Hot-At-All-Times Circuit**

Figure 2 below shows the HOT-AT-ALL-TIMES circuit. This second B+ circuit exists from TP1 through fuse, F2 (3A) which feeds a Hot-at-all-times circuit to TP8 and TP9, the Hot-at-all-times input to C700 TP9.

C11 and C22 are connectors which have 0QRs added to the PCB H-PCB01A (H-111A version). Each "C" connector now comes with a 0QR creating an actual connector. C11 and C22 complete the circuit when a 0QR is inserted in C11 and C22. When a 0QR is removed, that connector is disconnected or the circuit is OPEN at that point.

TP8 is a test point between the two connectors. The Hot-at-all-times circuit is not used with the Lamp Board but will be used later with the Relay Circuit Troubleshooting Trainer, H-PCB05 (H-115) and The Wire Harness Troubleshooting Trainer, H-PCB06 (H-116).
Scanning The Top Of The PCBs

Before using the PCBs for any hands-on exercises or inserting troubleshooting problems, they must be configured (set-up) correctly to operate properly. We call this "scanning the top of the PCBs." This requires a brief visual inspection of the top of the PCBs to verify that everything is in place for proper circuit operation.

1. Start at the H-PS01. The red/black output leads of the H-PS01 Power Supply are connected to the two terminal posts at the top of the Power Board and make good electrical contact.
2. The H-PS01 is plugged into a 110-115 VAC wall socket.
3. Fuses, F1 (F2 not used with Lamp Board) are good fuses. Do not use more than a 3A fuse.
4. There must be a zero ohm resistor between the B+ Terminal and TP4 to use S1 as the Ignition Switch.
5. S3 & S4 must be CLOSED (slides UP).
6. There must be zero ohm resistors in J1 and J2 on the Lamp Board.
7. There must be a good #1445 lamp in the lamp socket.

The PCBs are now correctly configured for testing, measuring and troubleshooting problems.

If the lamp does not turn ON when S1 is toggled UP and S3 and S4 are CLOSED (slides UP), it may mean there is a problem on the bottom of the PCBs. "Scanning the bottom of the PCBs" for correct set-up conditions is covered in the Instructor Guide H-IG111A.

If all set-up conditions on the top and bottom of the PCBs are met and B+ is at the +BATT terminal the lamp will operate when S1, S3 and S4 are CLOSED.

Using Push/Release Switch S2

Future hands-on programs will cover using S2, the Push/Release Switch. It is not used with the Lamp Board. To use S2 it is necessary to move the 0ΩR to connect between the B+ Terminal and TP17.

Note On Schematic Diagram Symbols

It is customary on schematic diagrams to draw switches (solenoids & relays, etc.) in the OPEN or REST position as is shown in Figure 3 and the other illustrations used in this training program. A technician is expected to mentally CLOSE the switch when visualizing circuit operation as in tracing electron current or tracing through a schematic diagram.

Do not misunderstand that the switch is too remain OPEN when operating the circuit. It is understood that to turn a circuit ON the switches must be physically CLOSED to complete the circuit.

The Hot-at-all-times Circuit

Future training with the other boards H-113, H-115 and H-116, The Wire Harness Troubleshooting Trainer will use the Hot-at-all-times circuit. For H-111A the Hot-at-all-times circuit is not used.
LOAD SWITCH CONTROL WITH S3 AND S4

All vehicle circuits are controlled by either switching voltage to a load (Switch-to-Voltage control) or switching ground to a load (Switch-to-Ground control) to turn a load ON or OFF.

The "LOAD" in a Circuit

The "LOAD" in a circuit is the component that the circuit turns ON/OFF. A series circuit is a circuit with only one path for electron current. There is only one load in a series circuit.

(A parallel circuit is a circuit with more than one path for electron current. Each path is called a branch of the parallel circuit. A simple parallel circuit is the head lamp circuit of a vehicle where two head lamps are used for night time driving. Each head lamp is the only load controlled in the branch.)

Switches S3 and S4 on the Power Board are designed to configure a circuit so that either Switch-to-Voltage control (S3) or Switch-to-Ground control (S4) is possible with the Power Board for a wider variety of circuit experiments.

In order to discuss the operation of S3 and S4, the Lamp Board, H-PCB01/02 or H-PCB01/02A must be connected to connector C700 on the Power Board.

Figure 4 at the left is an illustration of the Lamp Board connected to the Power Board to complete the circuit and the location of S3 and S4. Notice the switches are drawn in the OPEN position which is standard schematic convention for indicating switches on schematic diagrams.

The Lamp Board consists of a 1445 lamp as the load. The load is the component in the circuit that the circuit controls. TP13 is on the voltage side supplying B+ to Pin 1 of the lamp through 0QR (zero ohm resistor) J1. TP14 is on the ground side supplying B- to Pin 2 of the lamp through 0QR J2.

To provide both power (B+) and ground (B-) to the lamp, both switches (S3 and S4) must be CLOSED at the same time. The switch contacts are CLOSED when both S3 and S4 slides are UP as shown below in Figure 5.

Fig. 5 S3 & S4 switch configuration

S3 and S4 are mounted on the lower section of the Power Board just above C700 and play a pivotal role in controlling the lamp (or load) and in all other circuits connected to C700 in future training modules.
Controlling The Lamp With S3 And S4

Figure 6 is a simplified schematic, called a "straight-line" schematic of the Lamp Board interconnected to S3 and S4 on the Power Board to illustrate how these two switches can be used to control the load, the lamp on this PCB.

A straight line schematic is used in electrical and electronics to re-draw a circuit into a straight line to highlight certain aspects of a circuit so it is easier to understand circuit operation. Some minor circuit details can be eliminated in a straight line schematic for clarity because they might be unnecessary to understanding the circuit's operation or purpose.

In Figure 6 below, the two 0ΩRs in J1 and J2 on the Lamp Board and connector C700 have been deleted from the straight-line schematic to enable us to focus attention on the specific elements of how the circuit is controlled by S3 and S4. The straight line schematic diagram in this example is drawn to point out only how S3 and S4 control the lamp.

If the lamp is good and there are no electrical problems in the circuit, OPEN connections or corroded connections causing a Vd, the lamp should operate properly. At this time the lamp should be ON (operating).

Observing Switch-to-Voltage Control

When the control switch is wired into the voltage side of the load it is called a Switch-to-Voltage control circuit.

To simulate Switch-to-Voltage control, S4 must remain CLOSED to "permanently" complete the ground side of the circuit. Then S3, on the voltage side of the load becomes the control switch which can be toggled UP/DOWN to turn the lamp ON/OFF.

Figure 7 below shows the switches set up for Switch-to-Voltage control. S3 is the ON/OFF switch (S4 must remain CLOSED).

To control the lamp ON/OFF, cycle S3 for Switch-to-Voltage control of the lamp load. Pin 1 of the lamp is at 0.00v when S3 is OFF/DOWN because B+ voltage has been disconnected from lamp pin 1.
Observing Switch-to-Ground Control

When ground is switched to control a load it is called a Switch-to-Ground control circuit. Figure 8 below shows the S3-S4 set up for Switch-to-Ground control of the lamp load. To simulate Switch-to-Ground control, S3 must be CLOSED to "permanently" complete the voltage side of the circuit and provide B+ to lamp Pin 1. Then S4 becomes the control switch that is toggled UP/DOWN to turn the lamp ON/OFF.

![Switch-to-Ground Control Diagram](image)

Fig. 8 Switch-to-Ground Control using S4

Pin 2 of the lamp is at B+ when S4 is OFF because ground or B- (0.00V) has been disconnected from the lamp circuit Pin 2.

Remember Pin 2 is always used to designate the B- or ground side pin of the load in Veejer training.

Which Load Side Control Is Best?

It makes no difference to lamp operation which side of the load the control switch is located. Placing the control switch on the voltage side or the ground side does not affect lamp operation at all.

Yet, in some situations a particular circuit may always be connected Switch-to-Voltage or Switch-to-Ground control depending on circumstance decided by the design engineers for purposes of fail-safe.

In other words it may be safer for vehicle operation to control the voltage side versus the ground side of a circuit in a particular situation such as a vehicle accident. But again, this is a decision for the design engineer.

As technicians, in repairing a circuit we should always restore it to its original design of Switch-to-Voltage or Switch-to-Ground control.

Practice Exercise Using S3 and S4

Now for some practice measuring voltages in the lamp circuit using the load control switches S3 and S4. Either switch may be used to control the load. Practice measuring the voltages at the lamp terminals, Pin 1 and Pin 2 as follows.

1. Turn S1 ON. Make sure S3 and S4 are both ON (both slides UP or the CLOSED condition). The lamp is ON and electron current is flowing.

Exercise

Do the following voltage tests with the lamp ON to better understand how S3 and S4 control a load.

1. Measure the voltage at Lamp Pin 1 and Pin 2 when the lamp is ON (S3 and S4 slide UP) and record voltages below.

   MAKE SURE YOUR DMM IS GROUNDED AT THE -BATT BLACK POST AT THE TOP OF THE POWER BOARD. THIS CORRESPONDS TO THE NEGATIVE TERMINAL OF THE VEHICLE BATTERY, -BATT.

   Voltage at Pin 1 ______ V
   Voltage at Pin 2 ______ V

   NOTE: Pin 1 should be about 13 volts (good B+) and Pin 2 should be about 0.0x volts (good B-). The "x" means the digit could be a 0 reading (0.00) or a 9 reading (0.09) with no change in excellent ground circuit performance.

2. Toggle S3 to turn the lamp OFF. This is switch-to-voltage control of the lamp.

   Voltage at Pin 1 ______ V
   Voltage at Pin 2 ______ V

   NOTE: The voltage drops to zero (no B+) on Pin 1 when S3 is OFF (no voltage to the load).

3. Slide S3 UP and Lamp should be ON.

4. Toggle S4 to turn the lamp OFF. This is switch-to-ground control of the lamp.

   Voltage at Pin 1 ______ V
   Voltage at Pin 2 ______ V

   NOTE: The voltage rises to B+ on Pin 2 when S4 is OFF (no ground or B- to the load).

5. Slide S3 and S4 UP and Lamp should be ON to complete this exercise.

If a load is OFF and does not respond to the control switch turning it ON, measure the voltage on both sides. If B+ is found the problem is on the ground side. If 0.0V is found the problem is on the voltage side.
Straight Line Schematics

Figure 9 shows a straight line schematic of the Lamp Board and its interface from the B+ Terminal on the Power Board just above TP5 and induces the ground circuit provided on the Power Board through connector C700.

A straight line schematic can be created (redrawn) to clarify a circuit schematic which may seem difficult to understand the way it is shown in the shop manual.

Notice how confusing the Power Board and Lamp Board schematic is on the ground side of the lamp circuit the way the ground circuit is drawn back in Figure 4 and also appears on the white silk screen on top of the PCBs. A straight line schematic of the circuit can be drawn to clarify the ground circuit of the lamp circuit.

A straight line schematic diagram of both the voltage and ground sides can be drawn placing all components and connections in a straight vertical line between B+ at the top and B- (ground) at the bottom and eliminate confusion in the schematic.

Straight line the lamp circuit schematic starting at the terminals of the load, the lamp. It is on the ground side where the most电路 confusion seems to be and the straight line will help the most. Let's begin at lamp Pin 2 and straight line the ground side of the circuit.

Tracing the Ground Side

The ground side is shown in Figure 9 already drawn in a straight line. Trace through the circuit as described and follow along. Start at Lamp Pin 2 to trace down the ground side of the lamp circuit. Ground, B-, is applied to Pin 2 through 00R-J2, TP14 through C700, TP10, TP11, through the CLOSED contacts of S4 (shown drawn OPEN), TP12 to ground connection G101. It should be understood that G101 connects back to G100 and the -BATT negative terminal of the voltage source. On a vehicle this would be -BATT.

Tracing the Voltage Side

Start at Lamp Pin 1 to trace the voltage side of the lamp circuit. B+ is applied to Pin 1 through 00R-J1, TP13, C700, TP7, through the CLOSED contacts of S3, (drawn OPEN as is always done on schematic diagrams), to TP5 which is connected to the B+ Terminal on the Power Board. That's far enough for the voltage side.

Not shown in Figure 9 is a 0QR from the B+ Terminal to TP4, TP3 the CLOSED contacts of S1, TP2, Fuse F1, through Diode, D1, to the +BATT or positive terminal of the voltage source (B+).

Complete drawing the voltage side of the lamp circuit for practice beginning at the B+ Terminal and trace back to +BATT, B+. Draw the circuit at the top of Figure 9 as you trace the circuit.
What Are Voltage Drops?

A Voltage Drop (a term abbr. as "Vd" in this training program) occurs anytime electron current flows through resistance. The resistance could be the normal resistance of a physical resistor as shown below, or resistance present in a length of a wire.

All resistance develops (causes) a Vd as electron current passes through resistance. Figure 9A below illustrates the symbol for resistance (9A-1) and the polarity of a Vd (9A-3) across a resistance as electrons move from left to right through resistance.

1. Schematic Symbol for Resistance

| Physical Resistor |

2. No Electron Current so there is no Vd

3. Electron Current flows left to right and polarity of the corresponding Vd

Fig. 9A Polarity of Vd across resistance

Notice above in (Fig. 9A-2) when there is no electron current through the resistance there is NO Vd. The Vd appears ONLY when electrons are flowing. The side the electrons enter the resistance is a negative polarity compared to the opposite side the electrons exit the resistance is a positive polarity.

This is referred to as the polarity of the voltage drop across the resistance and can be measured with a DMM. Polarity of a Vd is true regardless of what the resistance actually is. The resistance could be nothing more than a corroded or loose connection. The side electrons enter is negative and the opposite side they exit is positive. That's always true.

A small amount of Vd in a length of wire is acceptable and proves that the length of wire is able to safely pass the intended level of electron current in amps. The normal Vd of wiring is measured in millivolts per linear foot. Millivolts are thousands of a volt and abbreviated as "mV."

All connections have some resistance. A good connection has a very small Vd in the range of millivolts (mV) because it has low resistance if it is a good connection. Should a connection develop resistance from corrosion, the connection Vd will increase to indicate a poor connection.

A circuit load provides the major resistance in a circuit to electron current passing through the circuit. In fact, the load (works, operates, does it's job) as electrons pass through it. If electron current does not pass through the load the load will not work, operate nor do it's job.

The load Vd should be the largest Vd in a circuit approaching almost the level of B+ applied to the circuit. There are three major points to consider when measuring a Vd in a circuit.

1. Electron current must be flowing through the circuit to measure a Vd. If the electron current is turned OFF, as is the case when the circuit is turned OFF, any Vd in the circuit disappears (drops to zero). Vds across resistance in a circuit do not exist when electron current is NOT flowing.

2. Never disconnect a circuit load from the circuit to test for Vds. Disconnecting the load is the same thing as turning the circuit OFF. Electron current ceases and Vds disappear.

3. Never disconnect a circuit connector from the circuit to test for voltage or Vds. Disconnecting a connector is the same thing as turning the circuit OFF, electron current ceases and Vds disappear.

Some Vd in wires and connections is considered normal when electron current flows. Too much Vd indicates a circuit problem. The following are three basic Vd measurements that can be performed in any circuit on any vehicle to reveal a lot about the electrical conditions in the circuit. How much Vd is an excessive Vd is also addressed.

The Vehicle Electronics Training Course
Lessons 15 and 16 explain what voltage drops (Vds) are, how they occur in circuits and how to measure them.

In the next series of three voltage drop exercises we will discuss three voltage drop tests that can be performed on any circuit on any vehicle. They are explained using the Power Board and Lamp Board to get familiar with the voltage drop measuring procedure.

These voltage drop tests are fast and easy to perform on any vehicle circuit. They do not require a schematic diagram if the two posts of the battery and the two terminals of the load are accessible. These three voltage drop tests are explained next.

1. The Vd of the voltage side of the circuit (Vd_v).
2. The Vd of the ground side of the circuit (Vd_g).
3. The Vd of the Load of the circuit (Vd_load).