(877) 351-9573
AES# 17-400

SIGNALrouter

V7.6 7/2025

Patent #10281493

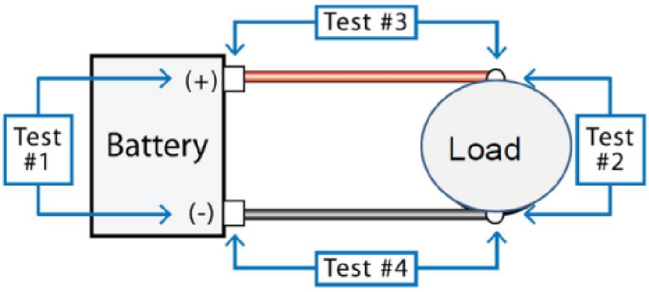
Use with any Digital Multimeter or Scope

(With 4mm banana jacks.)

Quickly Select and Isolate Circuits for Voltage and Voltage Drop Testing

Four Key Tests

Testing the Complete Circuit



Determine Power or Ground issues without moving your leads.

- **SAVE TIME**: STOP climbing in and out of a vehicle to change your meter lead locations when testing starting, charging and other electrical systems.
- **EASY:** *Connect the test leads once for all four tests.*
- **INCREASED SAFETY** : Enables one person to activate a load and complete the *"Four Key Tests"* shown above with *just a turn of the switches*. No missed communications between a helper and the technician.

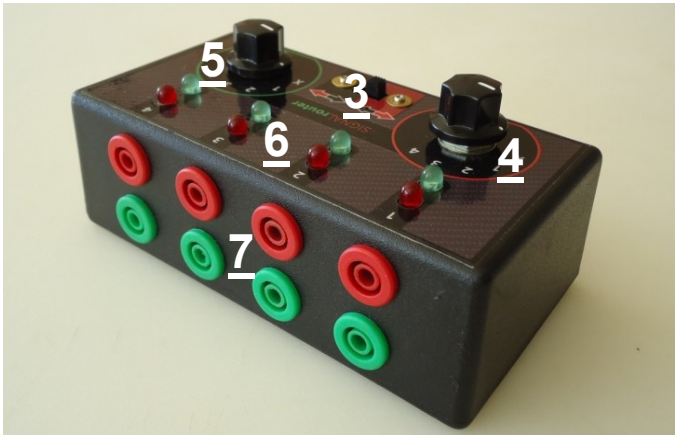
The solo technician can: *Control the circuit and select your test points at the same time!*

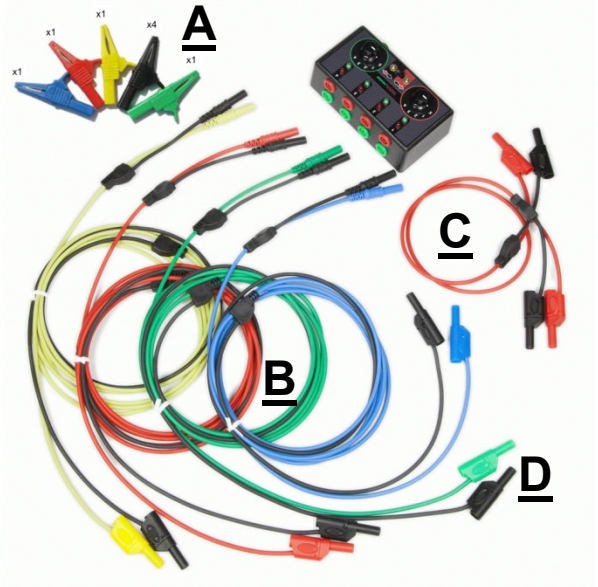
1. Use ***"Clear Flood Crank"*** (included on many fuel injected gasoline vehicles) for Starter System Testing.
2. Easily use the ***"Vehicle's Electronic Throttle"*** to control engine speed while testing the charging system or any circuit requiring engine speed changes.
3. ***"Test Drive and isolate multiple voltage test locations"*** to assist in isolating intermittent circuit issues often caused by bumps and vibrations.

Page left intentionally blank.

Table of Contents

Page left intentionally blank.





Signalrouter Component Identification

1) **250 mA fuse** protects both the Signalrouter and your meter fuse.

2) **Signalrouter Output sockets** connect to your meter, scope or both.

3) **Meter Polarity switch** allows the output signal polarity to be quickly changed for effective use of a meters Min/Max function.

4) **Red Signalrouter control switch** allows the independent selection of the signal leads plugged into the **red input sockets**.

5) **Green Signalrouter control switch** allows the independent selection of the signal leads plugged into the **green input sockets**.

6) **Signalrouter indicator lights** show which signal connections are being passed through to the Signal Output sockets then to your meter input.

7) **Signalrouter input sockets (ports)** – plug in location of the extension leads. The red input sockets controlled by the red switch and the green input sockets controlled by the green switch. (Note: the switch numbers correspond to the socket numbers).

8) **Access screws** for cover removal to replace the 9V battery for the Signalrouter indicator lights. (Note: The box will function without the battery as it only powers the indicator lights)

9) **Lead set components:** Test Leads are designed to withstand automotive environments:
- Shielded from tip-to-tip for maximum noise immunity
- Heat resistant
- Flexible
- Small enough to easily pass under hoods and through windows for road testing

   A. **Alligator style clamps** (1 per color and 4 black)

   B. **(4) 10 foot colored & black shielded test lead sets.**

   C. **(1) red/black shielded meter connection lead**

   D. **All signal leads come with the "piggy back" plugs to allow for easy extension.**

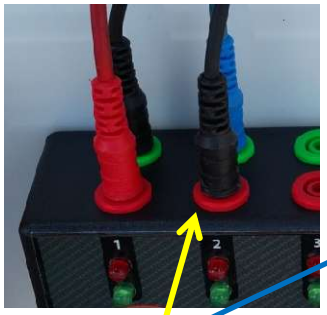
How Signalrouter works - Single battery starting system. - Complete voltage and voltage drop tests - One technician .

Step 1 - Connect **red lead set** to the battery *(Ground & Power)*

Step 2 - Connect **blue lead set** to Starter Solenoid Stud(+) and Starter Ground (-)

Step 3 - Route lead sets to the **driver seat**. Connect to the Signalrouter as shown in Step 4.

Step 4: Complete connections as shown in photo.



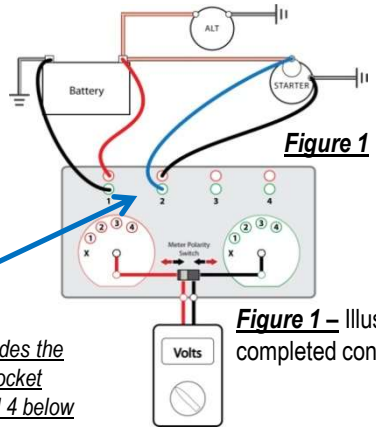


Figure 1

Figure 1 – Illustrates the completed connections

Note: *reversing this connection provides the operator the additional Red/ Green socket combinations to complete tests 3 and 4 below*

Step 5: Disable the vehicle starting or use the ***"Clear Flood Crank"*** mode if the vehicle is equipped to complete the four tests shown below without leaving the driver seat.

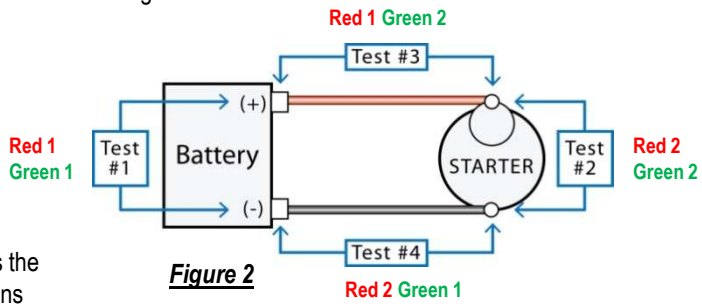
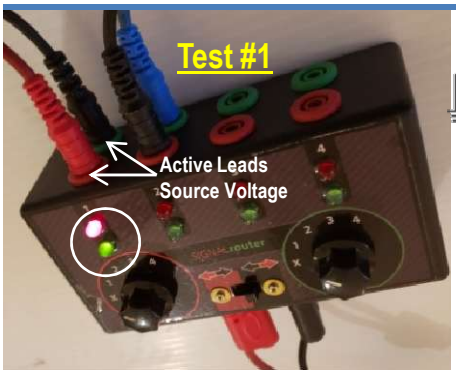
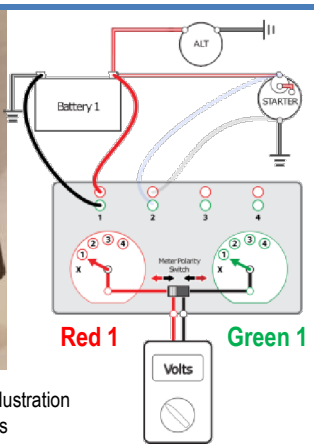


Figure 2

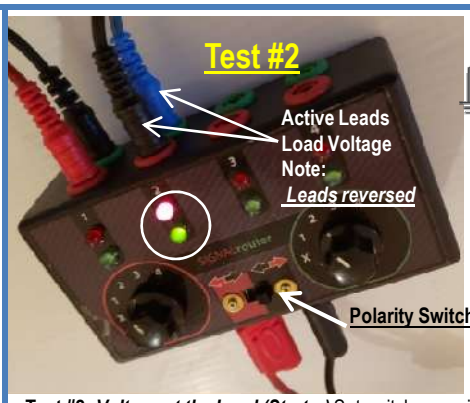
The Red and Green switch position shown above and below determine which test lead combination is being viewed.

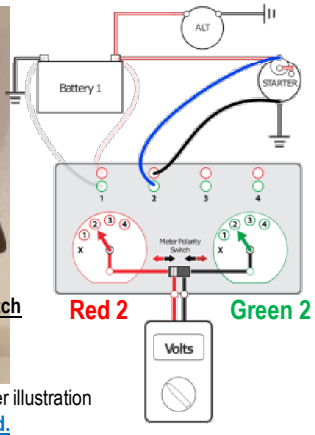




Test #1- ***Battery (Source) Voltage*** Set switches per illustration

1) Read Open Circuit Voltage Desired ≥ 12.5 Volts
2) **Activate the circuit**
3) Source Voltage while cranking ≥ 9.6 Volts



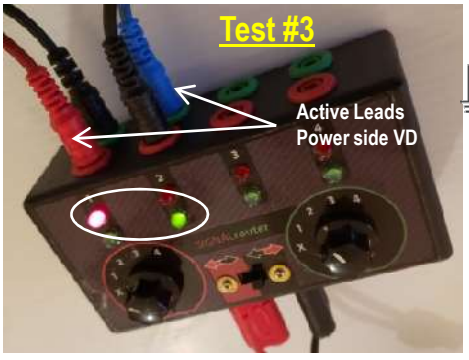


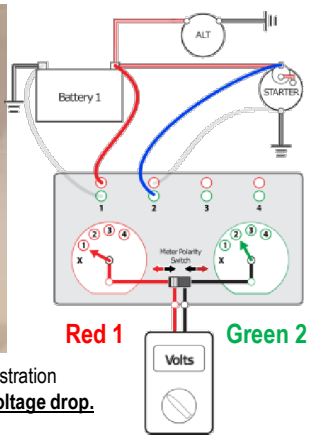
Test #2- ***Voltage at the Load (Starter)*** Set switches per illustration

Activate the circuit and read total voltage at the load.

Desired ≤ **.5 Volts** of battery cranking voltage.

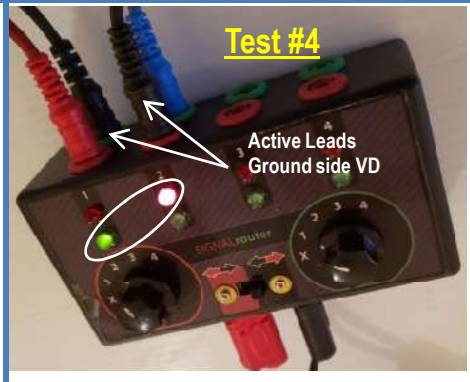
*(Note: Connections **reversed at the Signalrouter** and will read in reverse polarity. To change simply move the polarity switch.)*

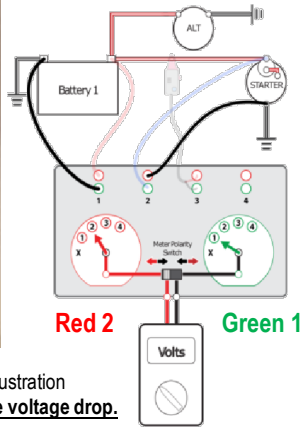




Test #3- ***Power side voltage drop*** Set switches per illustration

1) **Activate the circuit and read the power side voltage drop.**
   (Meter sees the Red and Blue leads)
2) Desired **.1** Volt per 100 amp of starter current or vehicle specification





Test #4- ***Ground side voltage drop*** Set switches per illustration

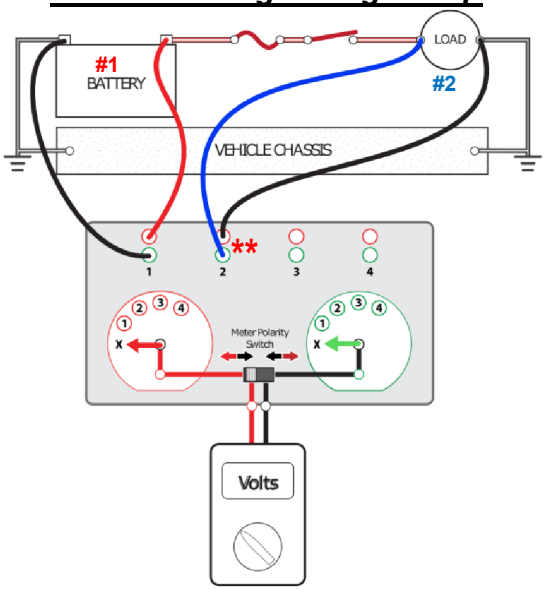
1) **Activate the circuit and read the ground (-) side voltage drop.**
   (Meter reads the two Black leads)
2) Desired **.1** Volt or vehicle specification.

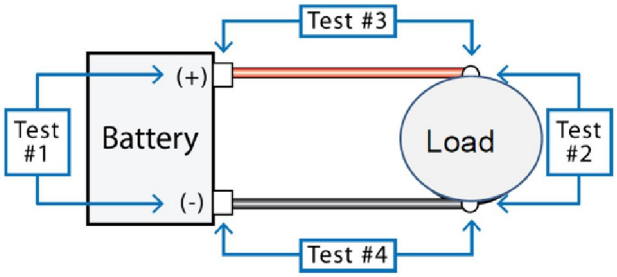
Basic Circuit Testing

(Add a Scope (pg 26) for more circuit detail)

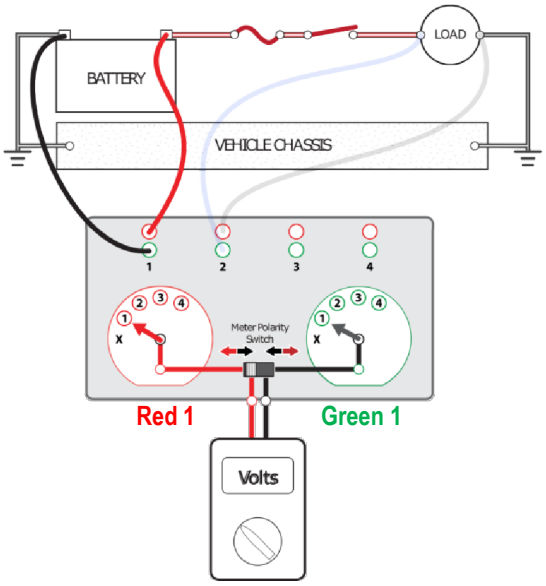
These **four** tests determine the integrity of any circuit and are excellent for **any load.** Examples: starting or charging systems, control circuits, fuel pump issues, electric window issues, lighting issues, fan issues etc. Gives the **technician working alone** the ability to quickly switch through these **four key tests** while controlling the circuit.

Direct Reading Voltage Drop





Lead set #1 - Connect to Battery
Lead set #2 - Connect to the Load (See above load examples.)
(Note : ** Reverse these connections at the SignalRouter)



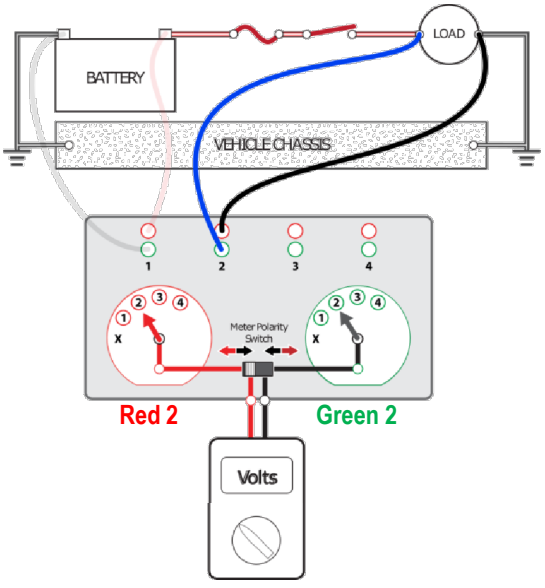
Test #1 ❑ *Battery (Source) Voltage*

(A) ***Open Circuit Battery Voltage*** ***≥ 12.5 V***
Determine the battery's current **S**tate **o**f **C**harge by testing before any load is applied.

(B) ***Energize*** the circuit and read the **Loaded Circuit Battery Voltage**

Measures the source voltage being supplied to the load.

Note : This voltage will vary with the amperage required by the load. (Example: starter versus a light)



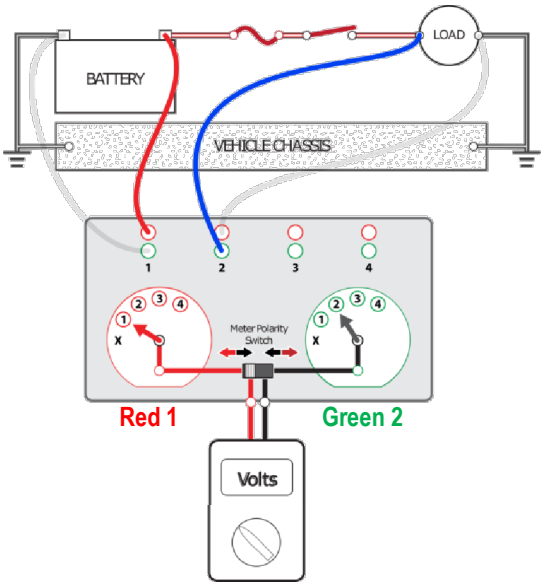
Test #2 ❑ *Voltage at the Load*

Energize the circuit and read the **Voltage at the Load**

- The voltage ***at the load*** will **always** be less than ***source voltage*** the difference between them is the **Total Volt Drop**.
- ***Test 1*** voltage minus the ***Test 2*** voltage should be **≤ .5 V** (or specification for a load)
- Is the load voltage **consistent** or **intermittent** (does it change as expected as additional loads are turned on or during a test drive flickering light(s), fuel pump issues, etc.)

Determine which side of the circuit has the a problem.

If the total voltage drop at the load is greater than desired or intermittent use the following tests to determine which side of the circuit has excessive resistance causing the excessive voltage drop.



Test #3

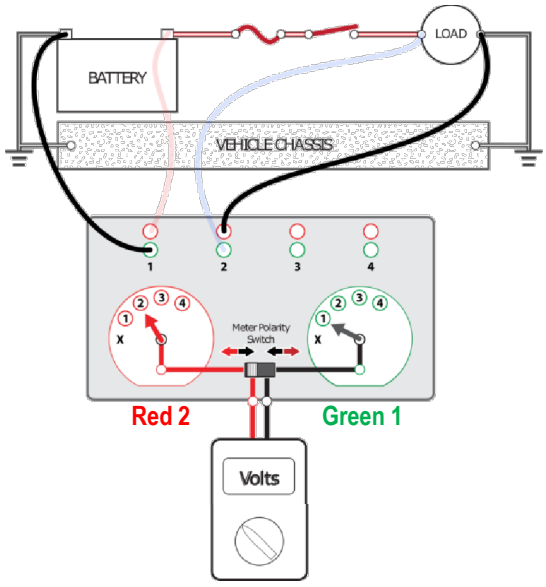
❑ Power side Volt Drop

Energize the **Circuit**

Measure from ***Battery Positive post*** to the ***Load Positive connection.***

This tests the integrity of all of the components in the **Power** side of a circuit including the connections, wiring, switches, circuit protection, etc.

Note: The **ground circuit** is the ***most shared circuit*** on a vehicle and can be affected by other energized circuits. Example: Dash lights dim or flicker when the heater blower motor is turned on.



Test #4

❑Ground side Volt Drop

Energize the **Circuit**

Measure from the ***Load Ground*** to ***Battery Ground post***

This tests the integrity of all of the components of the ***Ground*** circuit including wiring, connections, switches, chassis components, etc.

Starter System Test - Single Battery

#1) Battery Connections

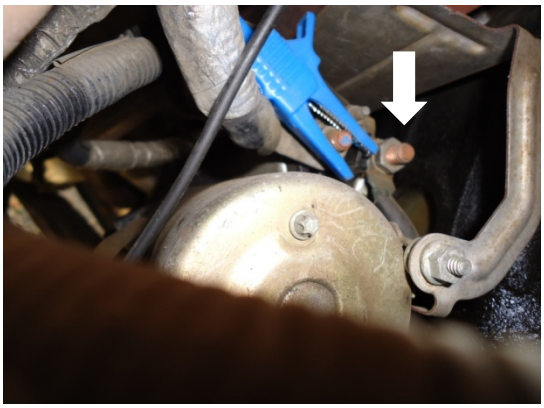
Lead set 1 (Red w/Black)

1. Make the Power and Ground Lead connections with the long leads provided.
2. Route the meter ends into the passenger compartment.

#2) Starter Connections

Lead set 2 (Blue w/Black)

Starter Solenoid **Power** Connection



1. Connect the **Blue leg** of the lead set to the starter/battery stud on the starter solenoid.

Note: To include the voltage drop of the starter solenoid simply move the Blue lead to the other large stud on the solenoid (see arrow).

Starter **Ground** Connection

1. Connect the Black leg of the lead set to the starter ground.
2. Route the meter ends into the passenger compartment.

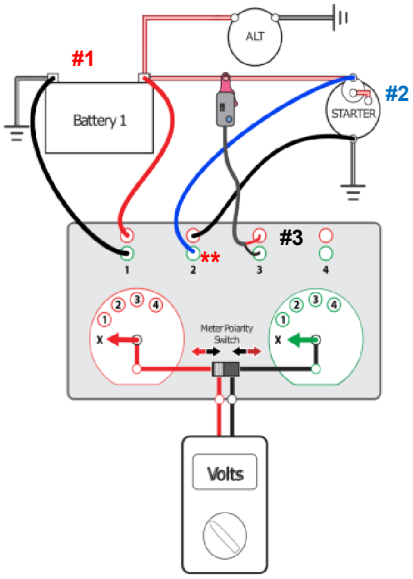
#3) Signalrouter Connections

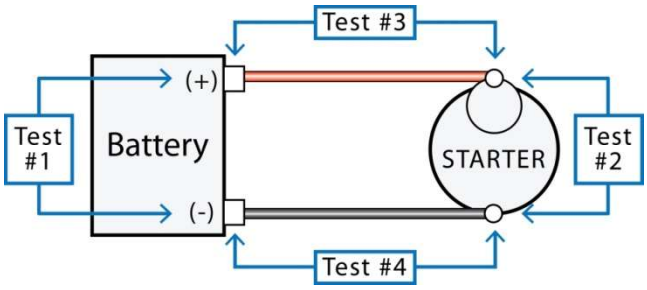
1. Plug the ***Red/Black lead set*** into the position 1 jacks.
   Red lead to the **red port** and **black lead** to the **green port**.
2. **Reverse** the ***Blue/Black lead set*** when plugged into the position 2 jacks.
   Blue lead to the **green port** and **black lead** to the **red port.**
   Note: This will read in reverse polarity. It can be simply changed by the Polarity Switch for Min/Max use.
3. Connect the Signalrouter output ports to your meter, scope or both

Page left intentionally blank.

Single Battery Starter Test

(Add a Scope (pg 26) for more circuit detail)

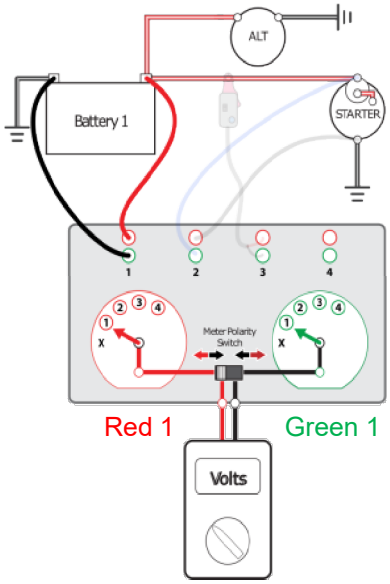




Lead set #1 - Connect to Battery

Lead set #2 - Connect to Starter (Note : ** Reverse the connections at the SignalRouter)

Lead set #3 (Optional Inductive Amp Clamp)



Test #1 ❑ *Battery (Source) Voltage*

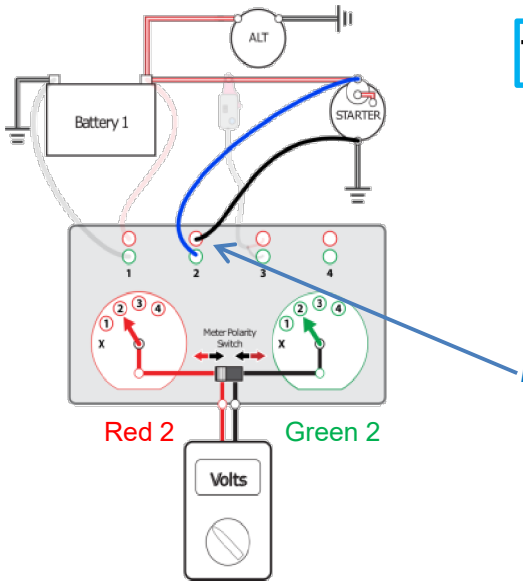
(A) ***Open Circuit Battery Voltage* ≥ *12.5 V***

Determine the battery's current **S**tate **o**f **C**harge by testing before any load is applied.

(B) **Energize the starter for each of the following tests**

*Note: Use **"Clear Flood Crank"** or Disable the engine start if necessary.*

Cranking Voltage at the Battery ≥ 9.6 V
Verifies the battery's ability to carry the load.



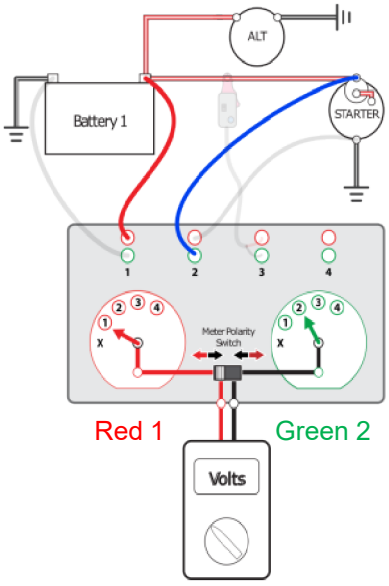
Test #2 ❑ *Voltage at the Starter*

Energize the starter

Desired : ≤ .5 Volt less than battery cranking voltage or vehicle specification

*Note: These connections are **reversed when connected to the Signalrouter** and **will read in reverse polarity.** To utilize the meter Min/Max function simply change the polarity switch.*

Determine which side of the circuit has the a problem.



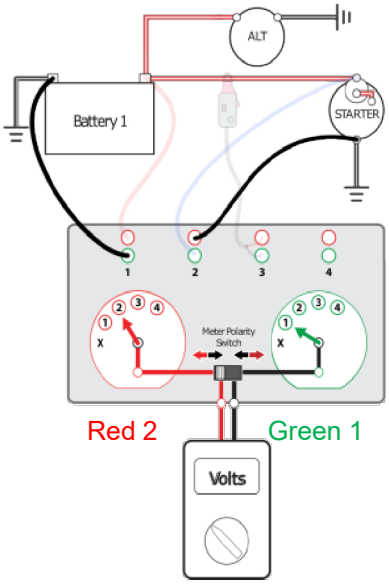
Test #3

❑ *Power side Voltage Drop*

Energize the starter

All inclusive Voltage Drop from Battery Positive post to Starter Post (Desired ≤ .1 volt per 100 amps of starter current or vehicle specification.)

This tests the integrity of all of the components in the Power side of the circuit including the connections, wiring, switches, etc.



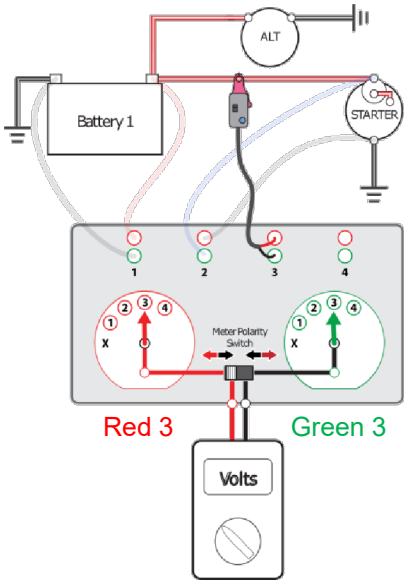
Test #4

❑ *Ground side Voltage Drop*

Energize the starter

All inclusive from Battery Ground post to Starter Ground. (Desired ≤ .1 volt per 100 amps of starter current or vehicle specification)

This tests the integrity of all of the components of the ***Ground*** circuit including wiring, connections, chassis components, switches,, etc.



Test #5

❑ *Optional: Inductive Amp Clamp*

Use to establish amperage draw of the starting system during steady state cranking.

Use vehicle specifications

The greater the amperage the greater the voltage drop.

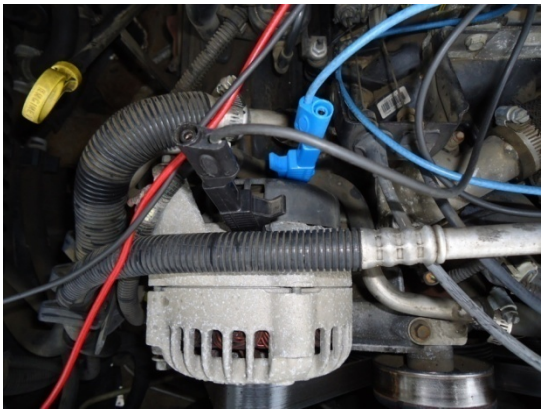
Charging System Test - Single Battery

#1) Battery Connection

Lead set 1 (Red w/Black)

1. Make the Power and Ground Lead connections with the long leads provided.
2. Route the meter ends into the passenger compartment.

#2) Alternator Connection



Lead set 2 (Blue w/Black)

1. Make the colored lead connection to the alternator B+ terminal stud and the, black ground lead to the alternator frame (frame grounded) or alternator ground connection on an above ground alternator.
2. Route the meter ends into the passenger compartment.

*An **optional inductive amp clamp** can complete the charging picture.*

Clamp to the Main Alternator Output lead

Route the amp clamp leads into the passenger compartment and plug into port 3 on the Signalrouter . Zero the meter per clamp instructions.

#3) Signalrouter Connections

1. Plug the ***Red/Black lead set*** into the position 1 jacks.
   Red lead to the **red port** and **black lead** to the **green port**.

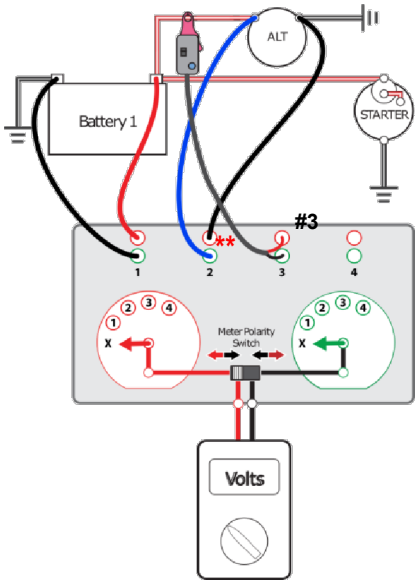
2. **Reverse** the ***Blue/Black lead set*** when plugged into the position 2 jacks.
   Blue lead to the **green port** and **black lead** to the **red port.**
   Note: This will read in reverse polarity. It can be simply changed by the Polarity Switch for Min/Max use.

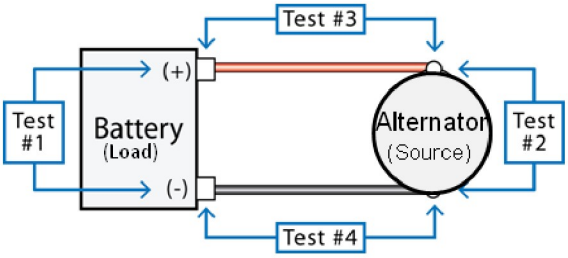
3. Connect the Signalrouter output ports to your meter, scope or both

Page left intentionally blank.

Single Battery Charging System Test

(Add a Scope (pg 26) for more circuit detail)



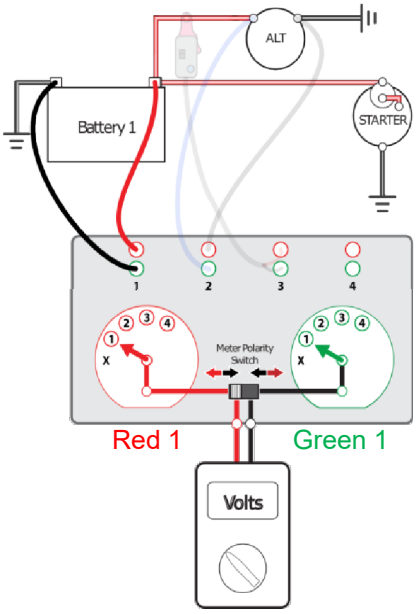


Note: *The battery is now **one** of the alternator's loads .*

Lead set #1 - Connect to Battery

Lead set #2 - Connect to Alternator (Note : ** Reverse the connections at the SignalRouter)

Lead set #3 (Optional Inductive Amp Clamp)



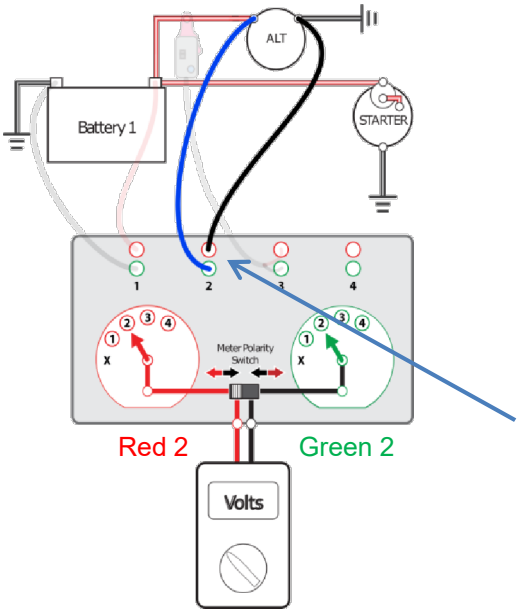
Test 1: ❑ **Battery Voltage**

(A) **Open circuit Battery Voltage (Desired ≥ 12.5 V)**
Verify the battery is charged.

Vehicle running for Test 1 – Test 5

*Note: Use the **Throttle pedal** to control engine speed (1500 -2500 rpm) while changing vehicle loads. (Example: Rear window defogger, heater blower, headlights, etc.)*

(B) **Charging Voltage at the Battery ≥ **13.5 V**
Verifies the alternator's ability to carry all of the vehicle loads and maintain the charge of the battery.



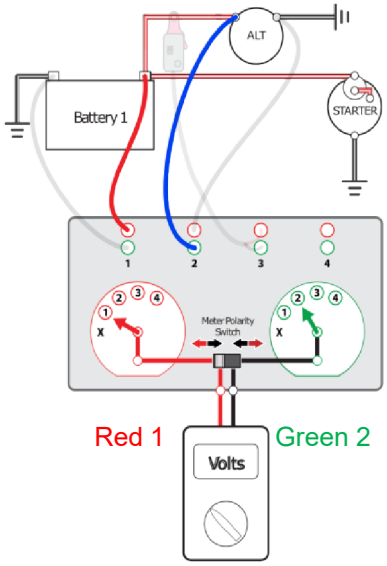
❑ *Output Voltage at the Alternator*

Test 2: **Desired : ≥ ** 13.5 with "vehicle loads" operating.**

** **See the vehicle specifications as there are many different computer controlled charging strategies.**

*Note: These connections are **reversed when connected to the Signalrouter** and **will read in reverse polarity.** To utilize the meter Min/Max function simply change the polarity switch.*

Determine which side of the circuit has the a problem.

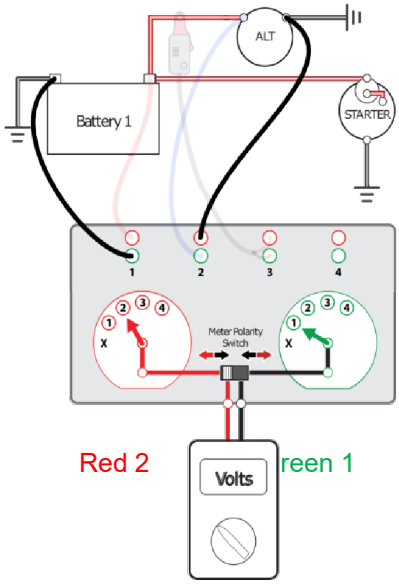


Test #3

❑ Power side Voltage Drop

All inclusive Voltage Drop from Battery Positive post to Alternator Positive Post

*This tests the integrity of all of the components in the **Power** side of the circuit including the connections, wiring, switches, etc.*

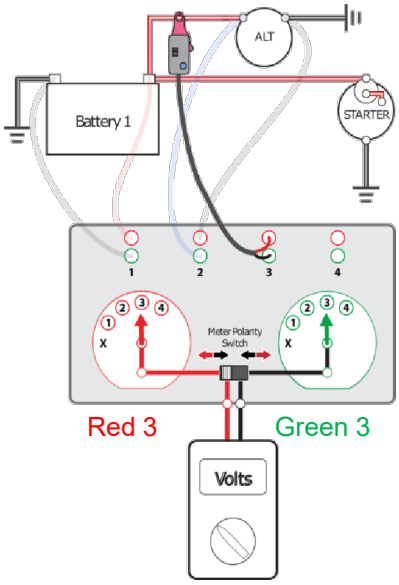


Test #4

❑ Ground side Voltage Drop

All inclusive from Battery Ground post to Alternator Ground.

This tests the integrity of all of the components of the ***Ground*** circuit including wiring, connections, chassis components, switches,, etc.



Test #5

❑ Optional: Inductive Amp Clamp

Use to establish the total amperage output of the charging system while vehicle loads are being applied.
(Use vehicle/alternator specifications.)

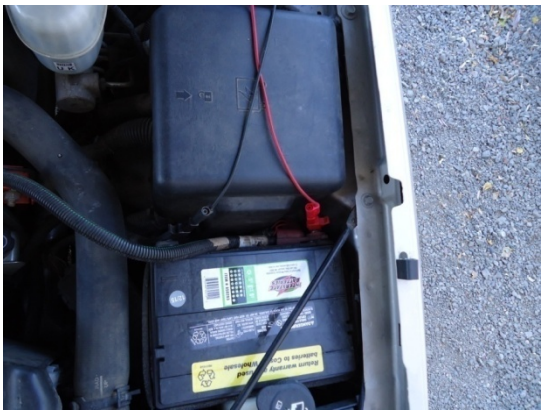
Connect around the main alternator charging wire. This will provide the **total alternator output** amperage. This amperage is **divided** between the Battery and **all other vehicle** system loads.

Starter System Test - Parallel Batteries Power and Ground

Connect Battery # 1

Lead set 1 (Red w/Black)

1. Make the Power and Ground Lead connections with the long leads provided.
2. Route the meter ends into the passenger compartment.



Connect Battery # 2

Lead set 2 (Blue w/Black)

1. Make the Power and Ground Lead connections with the long leads provided.
2. Route the meter ends into the passenger compartment.

Starter connections

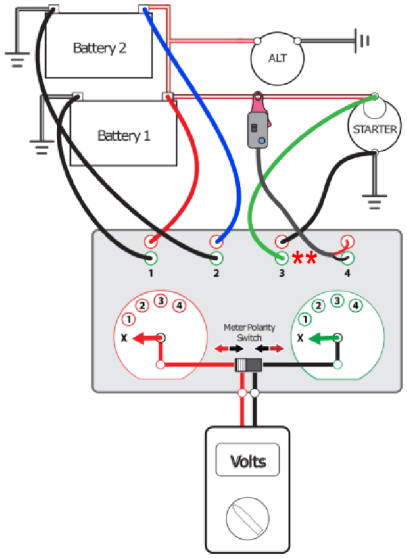
Lead set 3 (Green w/Black)

1. Connect the Green leg of the lead set to the starter/battery stud on the starter solenoid.
2. Connect the Black leg of the lead set to the starter ground
3. Route the meter ends into the passenger compartment

Signalrouter Connections

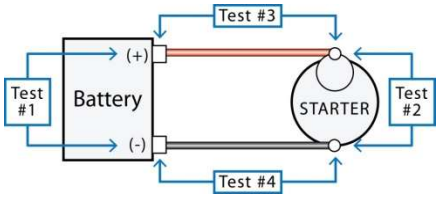
1. Plug the ***Red/Black lead set*** into the position 1 jacks.
   Red lead to the **red port** and **black lead** to the **green port**.
2. Plug the ***Blue/Black lead set*** into position 2 jacks.
   Blue lead to the **red port** and **black lead** to the **green port.**
3. **Reverse** the ***Green/Black lead set*** when plugged into the position 3 jacks.
   Note: This will read in reverse polarity. It can be simply changed by the Polarity Switch for Min/Max use.
. Connect the Signalrouter output ports to your meter, scope or both

Page left intentionally blank.



Parallel Battery Starter Test

(Add a Scope (pg 26) for more circuit detail)

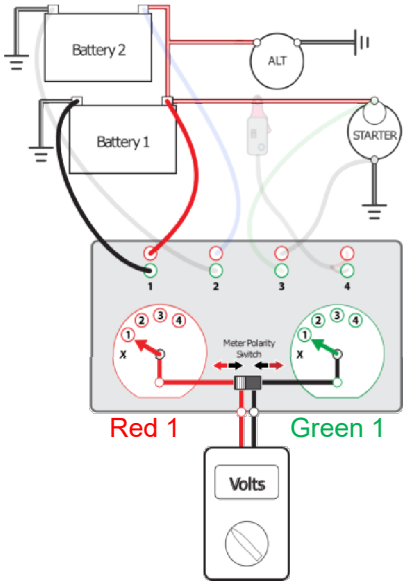


Duplicate these tests for each battery or battery bank.

Consistency between the batteries or battery banks is critical.

Lead set #1 - Connect to Battery 1 (or Bank 1 with multiple batteries)
Lead set #2 - Connect to Battery 2 (or Bank 2 with multiple batteries)
Lead set #3 - Connect to the Starter (Note : ** Reverse the connections at the SignalRouter)
Lead set #4 (Optional Inductive Amp Clamp)

❑ Battery Voltages



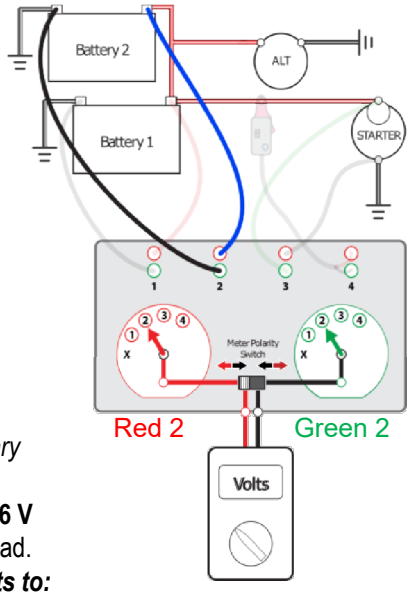
Battery 1 ← **Determine:** → Battery 2

Open circuit Battery Voltage (Desired ≥ 12.5 V)
*Verify the batteries are **charged** and **equal***

Energize the starter for Test 1 – Test 5

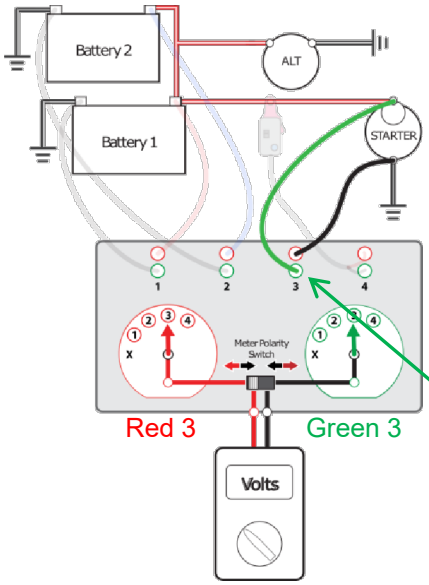
Battery 1 ← **Test 1:** → Battery 2

*Note: Use **"Clear Flood Crank"** or Disable the engine start if necessary*



Cranking Voltage at each Battery or Battery Bank ≥ 9.6 V
Verifies each battery's ability to carry its share of the load.
NOTE: Unequal voltage between the two batteries points to:
1) A battery problem developing
2) Unequal battery charging (See pg 19)

❑ *Voltage at the Starter*



Test 2:

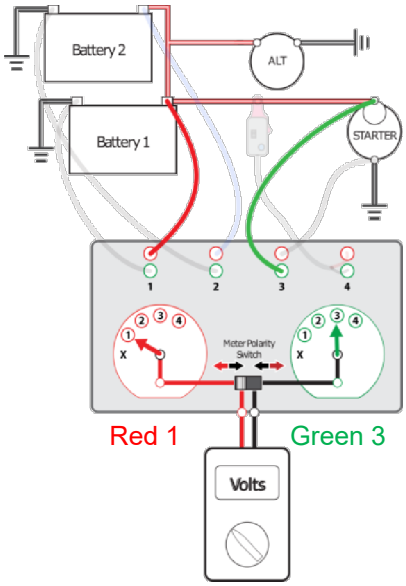
Energize the Starter

Note: Parallel battery systems share the amperage load to and from the starter.
Each battery or battery bank should contribute 50%.

Desired : ≤ .5 Volt less than battery cranking voltage or specification.

*These connections are **reversed when connected to the Signalrouter** and **will read in reverse polarity.** To utilize the meter Min/Max function simply change the polarity switch.*

Determine which side of the circuit has the a problem.

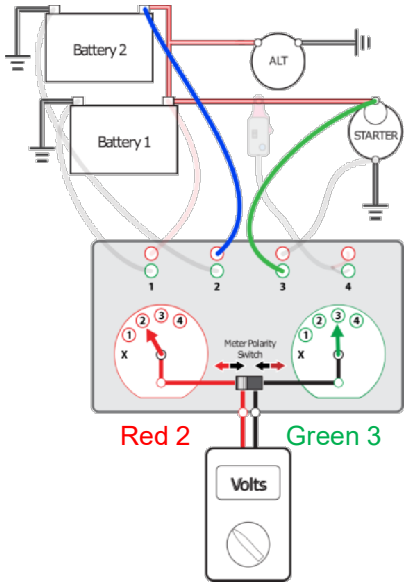


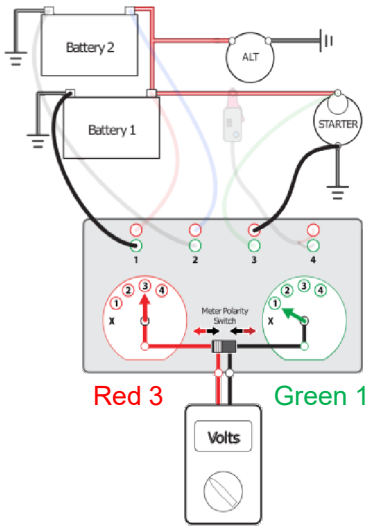
❑ Power side Voltage Drop

Battery 1 ← **Test 3:** → Battery 2

All inclusive Voltage Drop from each Battery Positive post to Starter Post (Desired .1 volt per 100 amps of starter current or specification)

This tests the integrity of all of the components in the Power side of the circuit including the connections, wiring, switches, etc.



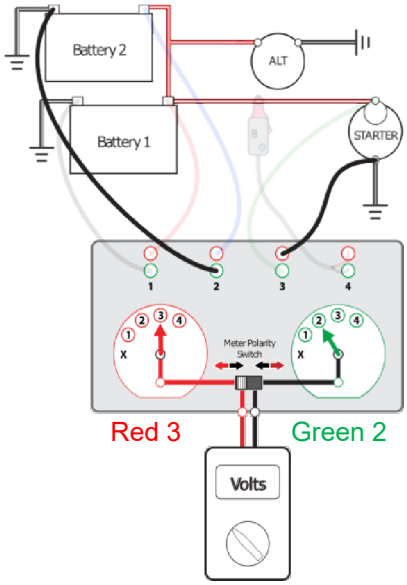


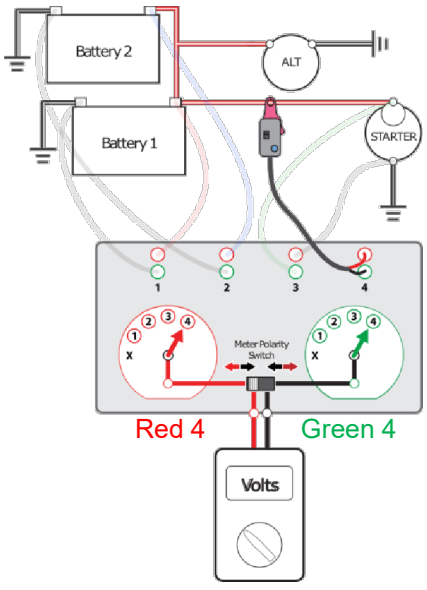
❑ Ground side Voltage Drop

Battery 1 ← **Test 4:** → Battery 2

All inclusive from each Battery Ground post to Starter Ground. (Desired .1 volt per 100 amps of starter current or specification or specification)

This tests the integrity of all of the components of the ***Ground*** circuit including wiring, connections, chassis components, switches,, etc.





Test 5:

❑ Optional: Inductive Amp Clamp

Use to establish amperage draw of the starting system during steady state cranking.

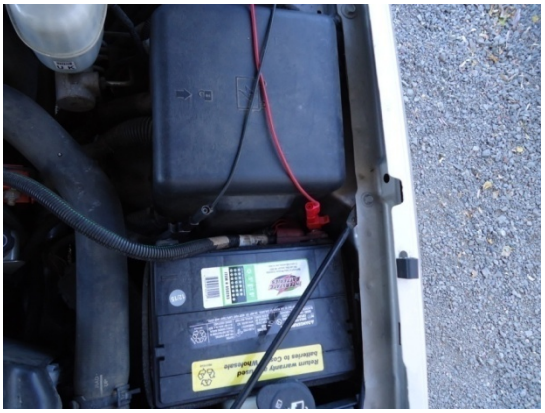
Use vehicle specifications

The greater the amperage the greater the voltage drop.

Basic Charging System Test - Parallel Batteries

#1) Battery Connection

Lead set 1 (Red w/Black)



1. Make the Power and Ground Lead connections with the long leads provided.

2. Route the meter ends into the passenger compartment.

#2) Battery Connection

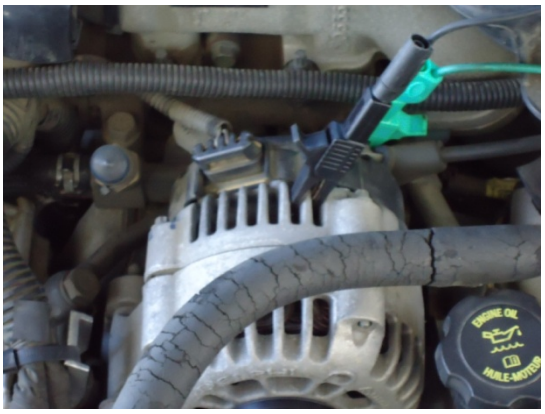
Lead set 2 (Blue w/Black)

1. Make the Power and Ground Lead connections with the long leads provided.

2. Route the meter ends into the passenger compartment.

#3) Alternator Connection

Lead set 3 (Green w/Black)



1. Make the colored lead connection to the Alternator B+ terminal and the, black ground lead to the alternator frame (frame grounded) or alternator ground connection on an above ground alternator.

2. Route the meter ends into the passenger compartment.

3. *Note : Add an optional Amp Clamp to the Alternator B+ cable to see total charging system output. Connect to port 4. (Not shown)*

Signalrouter Connections

1. Plug the ***Red/Black lead set*** into the position 1 jacks.
   Red lead to the **red port** and **black lead** to the **green port**.

2. Plug the ***Blue/Black lead set*** into position 2 jacks.
   Blue lead to the **red port** and **black lead** to the **green port.**

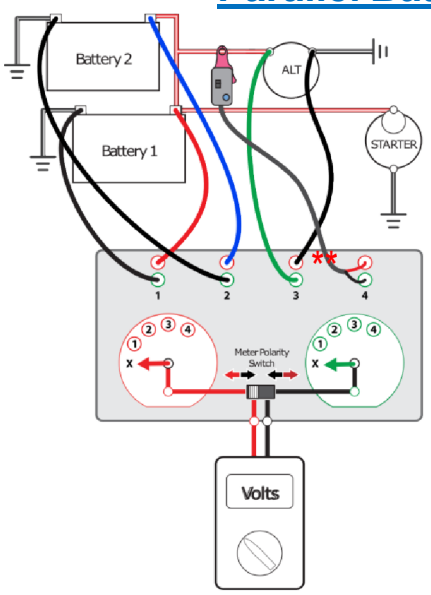
3. **Reverse** the ***Green/Black lead set*** when plugged into the position 3 jacks.
   Note: This will read in reverse polarity. It can be simply changed by the Polarity Switch for Min/Max use.

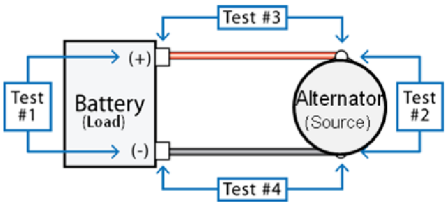
. Connect the Signalrouter output ports to your meter, scope or both

Page left intentionally blank.

Parallel Battery Charging System Test

(Add a Scope (pg 26) for more circuit detail)





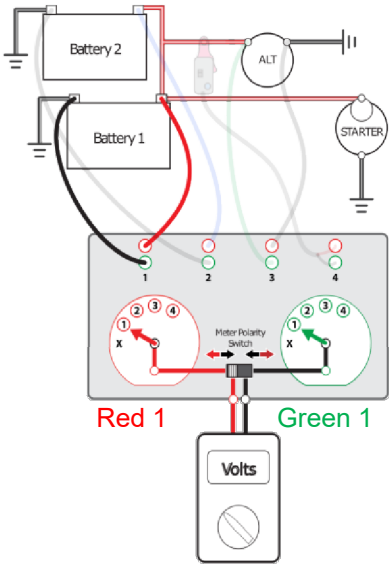
Duplicate these tests for each battery or battery bank.

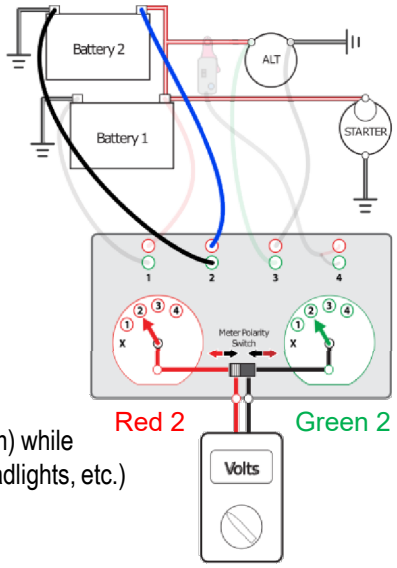
Consistency between the batteries or battery banks is critical.

Alternator becomes the source voltage and the batteries is just one of the loads.

Lead set #1 - Connect to Battery 1 (or Bank 1 with multiple batteries)
Lead set #2 - Connect to Battery 2 (or Bank 2 with multiple batteries)
Lead set #3 - Connect to the Alternator (Note : ** Reverse the connections at the SignalRouter)
Lead set #4 (Optional Inductive Amp Clamp)

❑ Battery Voltage





Battery 1 ← **Determine:** → Battery 2

Open circuit Battery Voltage (Desired ≥ 12.5 V)
*Verify the batteries are **charged** and **equal***

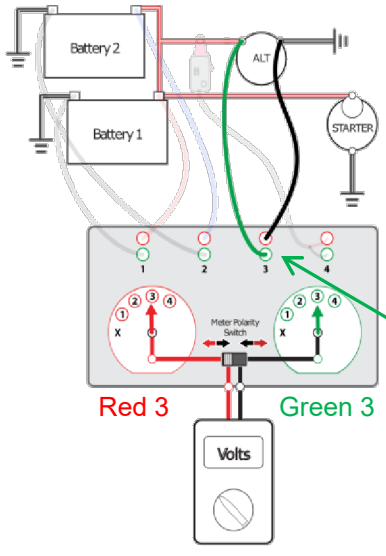
Vehicle running for Test 1 – Test 5

Battery 1 ← **Test 1:** → Battery 2

*Note: Use the **Throttle pedal** to control engine speed (1500 -2500 rpm) while changing vehicle loads. (Example: Rear window defogger, blower, headlights, etc.)*

Charging voltage at the batteries should be equal .
Unequal charging will usually be caused by:
1) Power or Ground cable voltage drop
2) Batteries reaching their life expectancy.
3) Note: Cable voltage drop can/will contribute to premature battery failure.

❑ *Output Voltage at the Alternator*



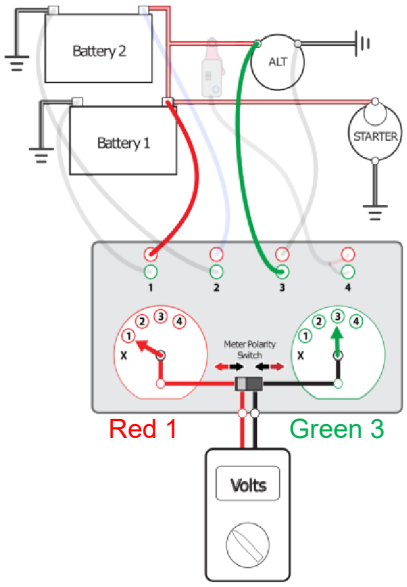
Test 2:

Desired : ≥ ** 13.5 with "vehicle loads" operating.

**** See the vehicle specifications as there are many different computer controlled charging strategies.**

*These connections are **reversed when connected to the Signalrouter** and **will read in reverse polarity.** To utilize the meter Min/Max function simply change the polarity switch.*

Determine which side of the circuit has the a problem.

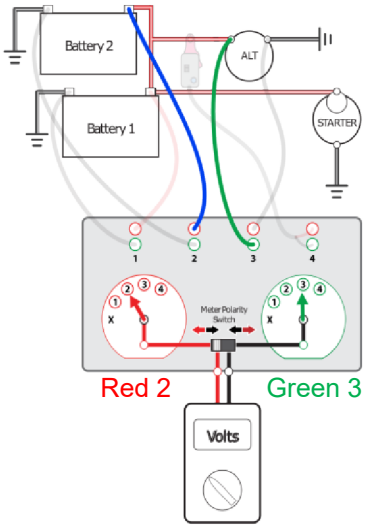


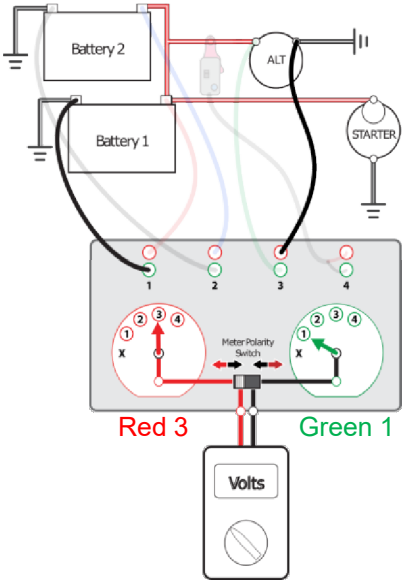
❑ Power side Voltage Drop

Battery 1 **Test 3:** Battery 2

All inclusive Voltage Drop from each Battery Positive post to Alternator Post

*This tests the integrity of all of the components in the **Power** side of the circuit including the connections, wiring, switches, etc.*



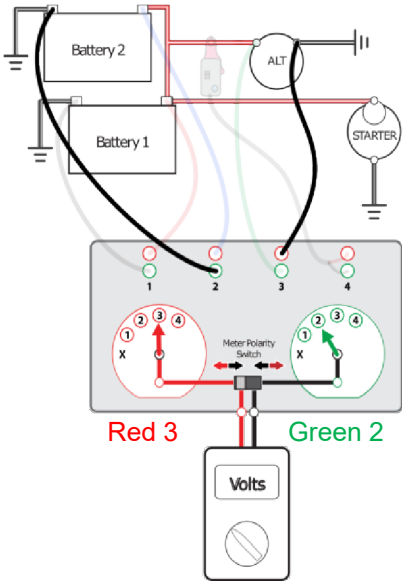


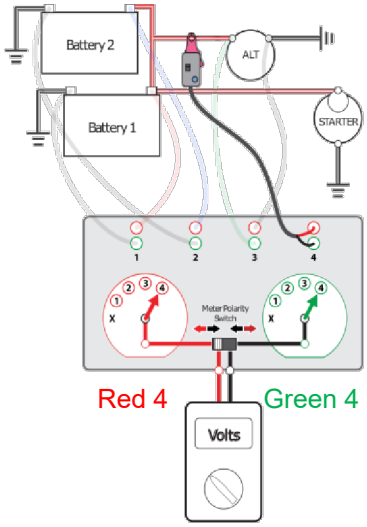
❑ Ground side Voltage Drop

Battery 1 **Test 4:** Battery 2

All inclusive from each Battery Ground post to Alternator Ground.

*This tests the integrity of all of the components of the **Ground** circuit including wiring, connections, chassis components, switches,, etc.*





❑ Optional: Inductive Amp Clamp

Test 5:

Use to establish and monitor amperage output of the charging system while applying normal vehicle loads. (Lights, heater/AC blower, electric widow defogger, etc.)

Use vehicle/alternator specifications

Connect around the main alternator charging wire. This will provide the **total alternator output** amperage. This amperage is **divided** between three locations in this system. Battery 1, Battery 2, and **all other vehicle** systems.

Using an Inductive Amp Clamp with the Signalrouter

- **Starter Connection**:

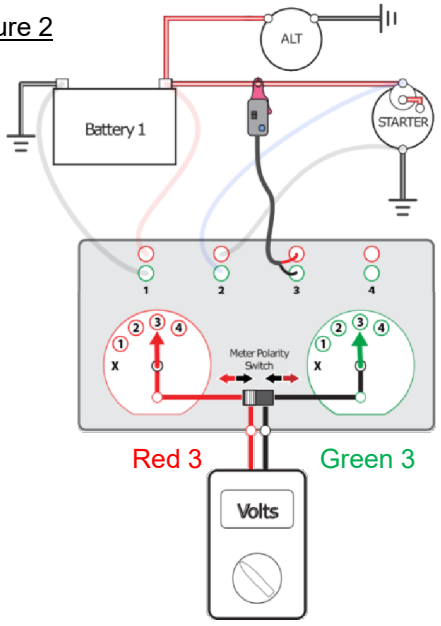
1) ***Be aware of shared power or ground circuits, the clamp placement can skew your readings.***
Example: Glow plugs, the fuel pump, accessories left on in the vehicle may all effect your amperage reading if they remain active during the start function.

2) Plug your Inductive Amp Clamp into an available input socket set and select with the Red and Green control switches on the Signalrouter. Example :Red 3, Green 3 (single battery system see Figure 2) Red 4, Green 4 (parallel battery system)

3) Follow the instructions provided with the Inductive Amp Clamp to zero the meter prior to hooking to the load cable you want to test (Starter).

4) To get precise information the starter speed must stabilize when the readings are taken. This requires the vehicle to crank only.

Figure 2



***Note 1**: The longer the starter takes to come up to design speed, the longer it continues to draw higher amperage. Excess voltage drop will slow the starter to cause this problem. Amperage reading at this point could easily condemn the starter when the problem was the voltage drop.*

***Note 2**: A significant difference between the voltage drop on one circuit leg (power or ground) when compared to the other circuit leg (power or ground) provides the technician with the starting point of the repair. The technician should fix the voltage drop problem and then re-evaluate the starting system.*

***Note 3**: A "dragging starter" will also draw excessive amperage which in turn will increase the voltage drop of the circuit. However, it will increase the voltage drop on both sides (power and ground) of the circuit.*

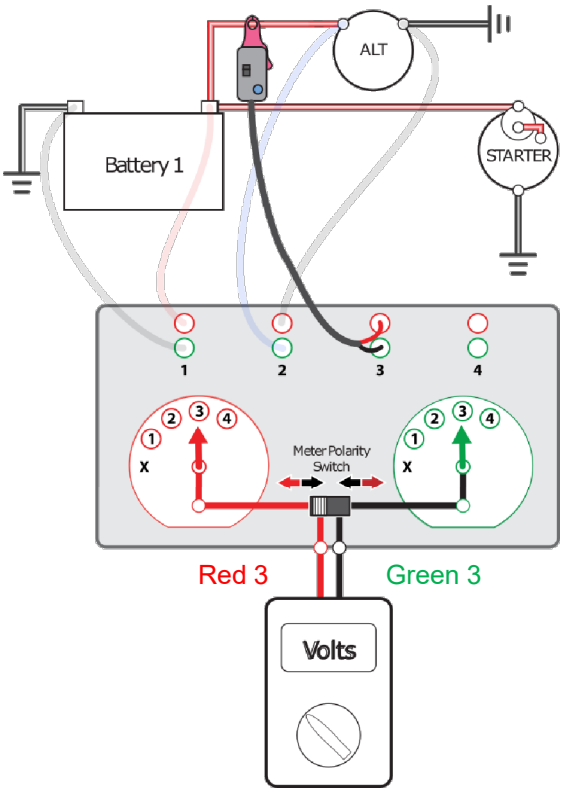
Amp clamp connected to battery ground cable.

Amp clamp connected to starter power cable.

Using an Inductive Amp Clamp with the Signalrouter

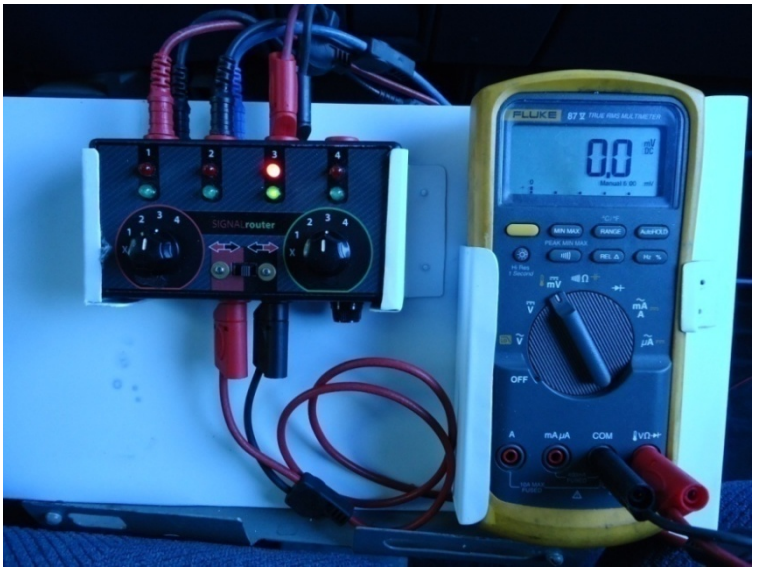
Alternator connection:

To isolate alternator output, connect to the alternator output cable (B+) prior to any other point on the vehicle. Once the vehicle starts the alternator becomes the source voltage and the battery is just another load.



1) Plug your Inductive Amp Clamp into an available input socket set and select with the Red and Green control switches on the Signalrouter. Example :Red 3, Green 3 (single battery system).

2) Follow the instructions provided with your Inductive Amp Clamp to zero your clamp prior to hooking to the load cable you want to test. (Alternator, starter, fuel pump etc. either power or ground side). See photo 1 below. *Be aware of shared power or ground circuits.*



Using the alternator as an example, you stay in the vehicle to adjust different loads (blower motor, headlights, rear window defoggers, seat heaters, etc) and control the engine speed with the throttle. Easily, the technician sees the alternator response to the changing loads and rpm by switching between voltage (Red 2 & Green 2) and amperage (Red 3 & Green 3). *Note, connecting to a battery cable will only show the amperage charging the battery.*

Isolate Power side Volt Drop

(Direct reading Volt Drop Method – The Meter does the Math)

•Divide up the circuit at accessible points. (ie: back probe connectors, junctions, and as a last resort carefully pierce the wire with an appropriate tool. *Note: Repair any damage to wires or connectors when complete.)*

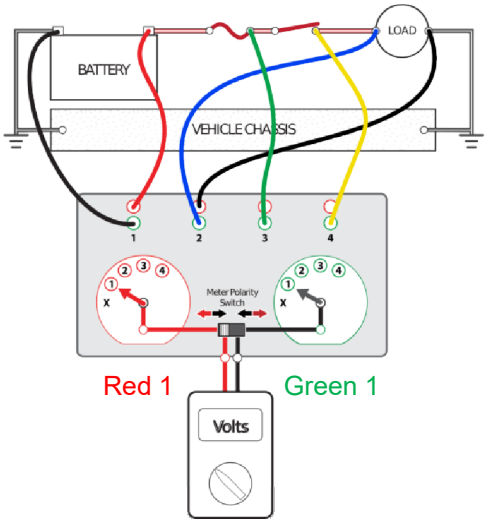
•Add leads 3 and/or 4 to these locations.

•See below illustrations

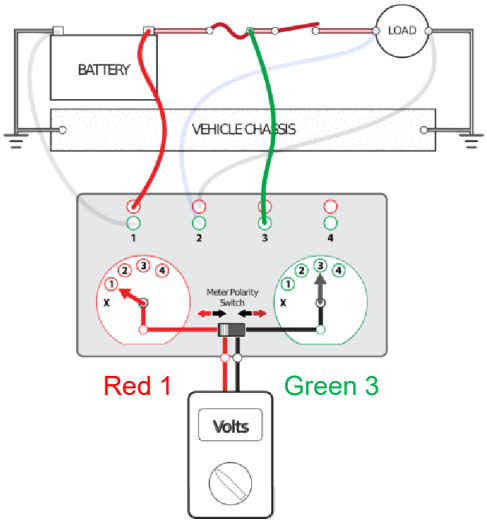
•Activate the circuit for each test.

Testing the first half of the circuit. (Source voltage to a test point)

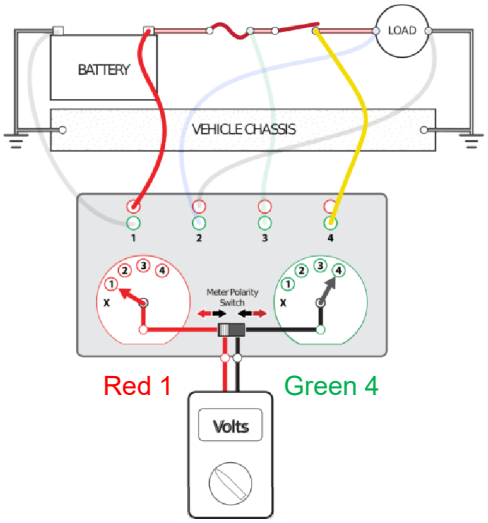
Sample connection points



Volt Drop to test point one



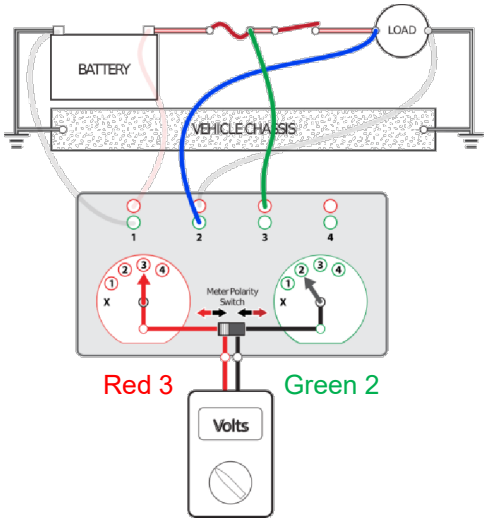
Volt Drop to test point two



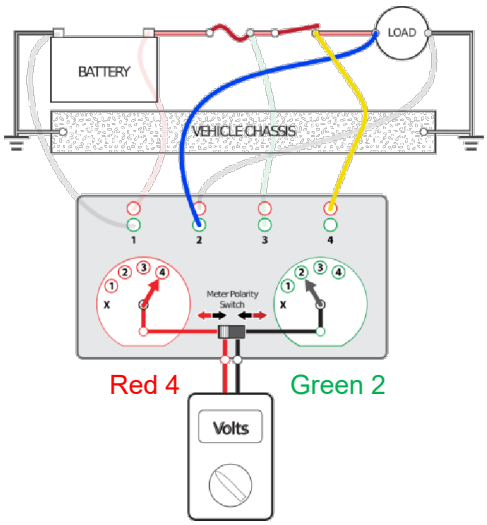
Testing the second half of the circuit. (The test point to the Load)

Move the banana plug(s) at the **Signalrouter** from the **Green socket(s)** used in the tests above to the **Red socket(s)** as shown below. *(This keeps the lead movement in the palm of your hand.)*

Volt Drop test point one to load

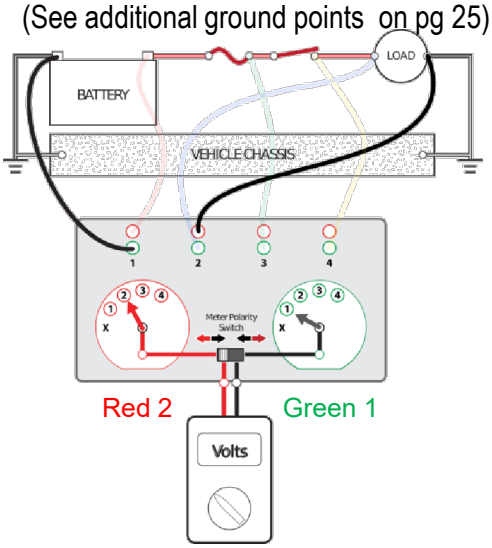


Volt Drop test point two to load



Volt Drop all inclusive Ground

(See additional ground points on pg 25)



Isolating the Voltage Drop: Power Side

(Common Ground Method)

- **Choose key points within the circuit to break down the problem location.**
- **Using a common ground will bring consistency to your troubleshooting.**

1) **Green Switch will stay on position 1** - the common ground will provide a known consistent ground.
2) **Red Switch 1** shows the source voltage.
   - This is the total voltage available to the load.
3) **Red Switch 2** will show the voltage at the fuse output.
   - The difference in the voltage reading between red switch position 1 and 2 is the voltage drop of that portion of the circuit.
4) **Red Switch 3** will show the voltage at the output of the switch.
   - The difference in the voltage reading between red switch position 2 and 3 is the voltage drop of the switch and all connections from the fuse output. The difference in the voltage reading between red switch position 1 and 3 is the voltage drop of the switch and all connections from the battery.
5) **Red Switch 4** will show the voltage to the load.
   - The difference in the voltage reading between red switch position 3 and 4 is the voltage drop of the wiring and connections from the output of the switch to the input of the load. The difference in the voltage reading between red switch position 1 and 4 is the total voltage drop of the switch and all connections from the battery.

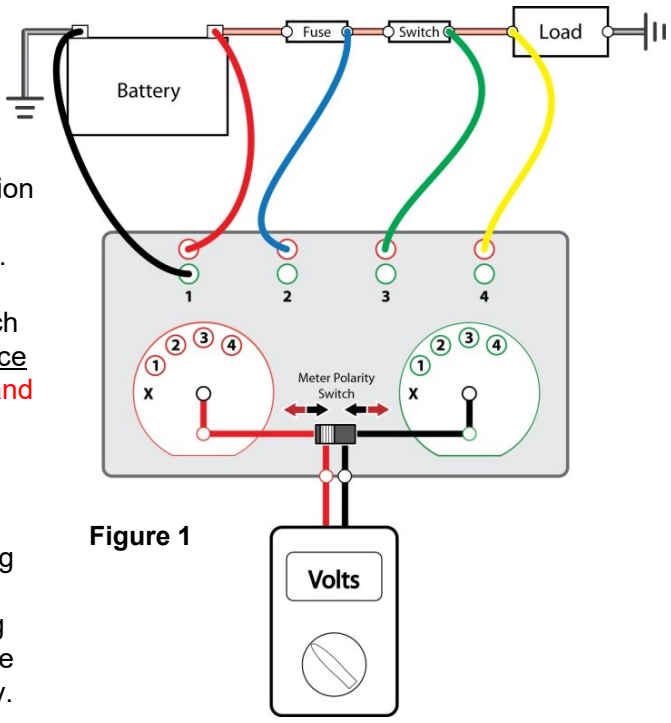


Figure 1

Variation:

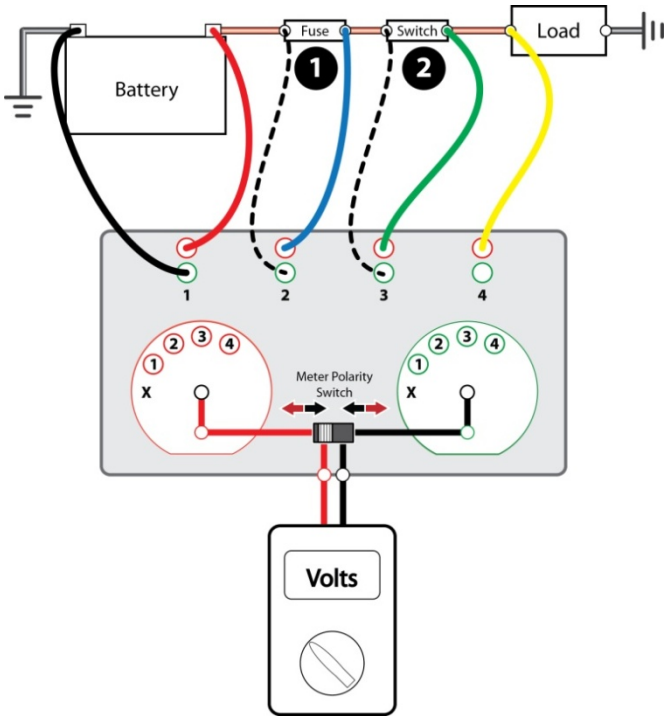
The addition of the two leads dotted in Figure 2 will further increase the detail of the information available to the technician. These leads are already in position because of the combination lead sets.

- Frequently the input of the fuse is a fuse panel or a Bussed Electrical Connection (BEC).
- Worn out switches can easily have excessive voltage drop and this can quickly be identified .

1) **Red Switch 1** and **Green Switch 2** shows the actual voltage drop from the battery to the fuse panel input.
2) **Red Switch 2** and **Green Switch 2** shows the actual voltage dropped in the fuse panel (Reverse polarity)
3) **Red Switch 2** and **Green Switch 3** shows the actual voltage dropped from the fuse to the switch.
4) **Red Switch 3** and **Green Switch 3** shows the actual voltage drop of the switch (Reverse polarity)

Note: Determine shared current paths power or ground. They can/will change your test results. *Use the schematic(s) if available.*

Figure 2



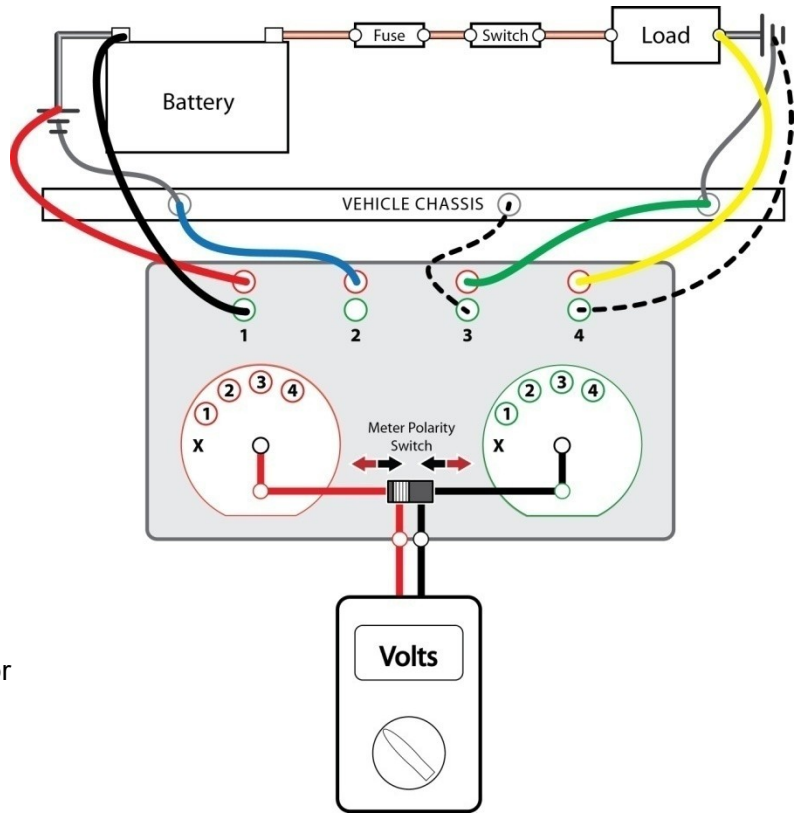
Isolating the Voltage Drop: Ground Side

This is the most commonly shared current path on a vehicle.

This is the most common circuit failure on a vehicle.

Isolating the ground side voltage drop is often the most challenging. Multiple paths the current can follow combine with multiple loads that may feed into the shared ground path. Therefore an organized approach is mandatory.

The following are some sample test locations for the chassis ground system. It will be up to the technician to determine the best testing locations.



Red Switch 1 and **Green Switch 1** the first leg of the ground system.

Red Switch 2 and **Green Switch 1** will show the voltage drop from the chassis ground connection or ground strap to the battery ground connection.

Red Switch 2 and **Green Switch 3** will show the voltage drop within the chassis points including bolted and riveted cross members.

Red Switch 3 and **Green Switch 3** will show voltage drop within chassis connections to the ground straps.

Red Switch 3 and **Green Switch 4** will show voltage drop within chassis ground through the ground strap.

Red Switch 4 and **Green Switch 4** will show the voltage drop from the ground strap location to the load ground

- **Secure the Signalrouter Leads to the vehicle and test drive to help find intermittent glitches caused by motion or vibration.**
- **Works for both power and ground circuit issues.**

See pages 21 and 22 for additional information on voltage and voltage drop.

Using a Digital Storage Oscilloscope (U-Scope or DSO) with the Signalrouter for more signal detail

1. Connect your scope leads (one channel) in **parallel** with your meter using the kit's stacking banana plugs.
2. Note the leads can be connected to either end of the meter input cable though connecting as shown in photo 1 allows for scope accessories to be added easier see photo 2 & 3.
3. Set the Scope's Time, Voltage and Trigger as normal for the desired test.
4. A scope can be used with or without a meter.

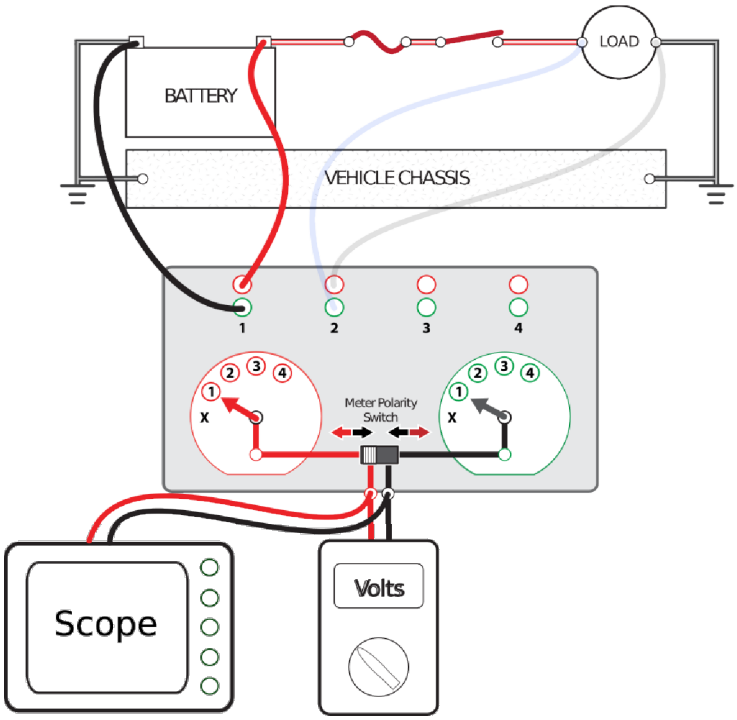


Photo 1 : Connections set up for the Cranking Voltage Test
See page ## for pattern examples.

Photo 2 : Add an AC Filter to capture:

1. "Relative Compression" while cranking and read the "Steady State" cranking voltage at the same time.

2. Alternator Ripple Voltage while reading Alternator Output voltage at the same time.

Photo 3 : Add a 10:1 Attenuator to capture a fuel injector pattern or any other relay or solenoid pattern.

(Note by turning the Signalrouter switches you can cycle through up to four injectors.)

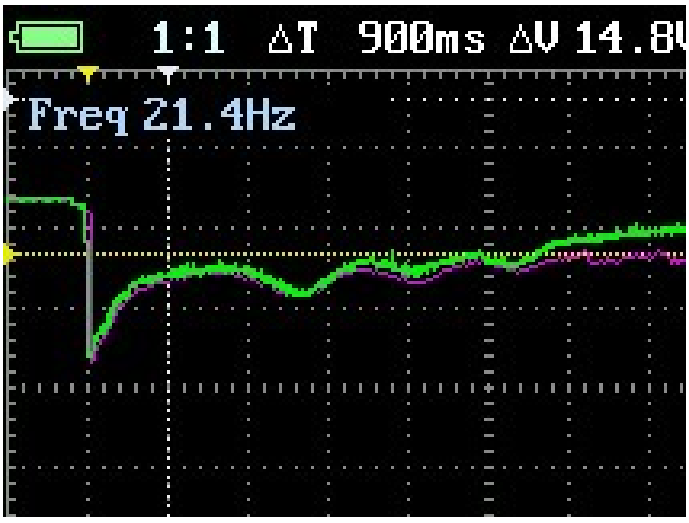
Signalrouter setup is the same as the Basic Starter System Test.

1) Connect the U-Scope lead to the U-Scope.
2) Connect the other end into the stacking plugs attached to your meter. *Match the meter polarity.*

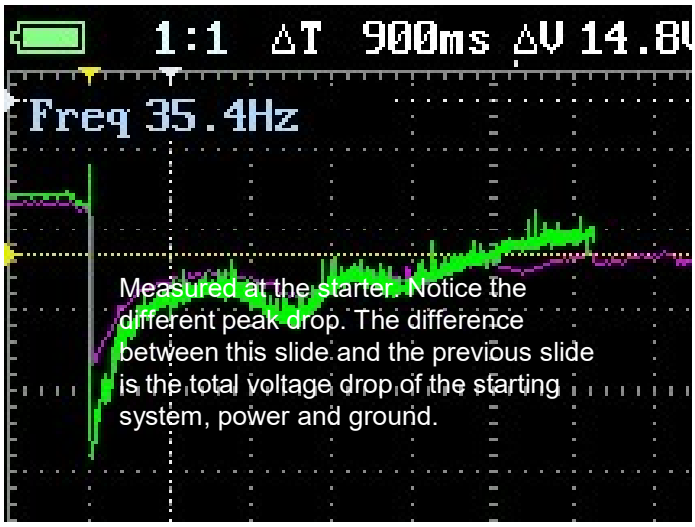
The same Signalrouter switch selections used in the Basic Starter System Test will show the enhanced circuit information shown below.
These are details you can see quickly without disabling the vehicle start function.

Note: The green signal in the photos below are the test signals. When switched at the Signalrouter from the battery to the starter the signal became thicker with more "noise". This is do to the scope "seeing" the brushes making and breaking contact as the starter armature rotates. The more we refine the signal voltage as with the two voltage drop examples the more "noise" you see.

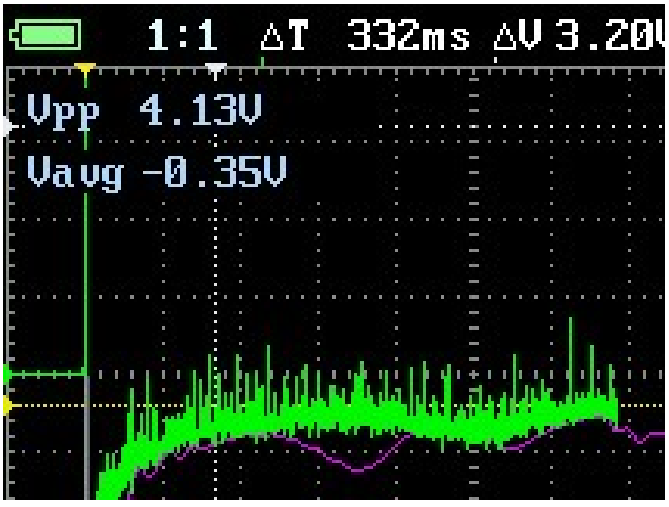
1) Cranking voltage at the battery. Red1 Green1



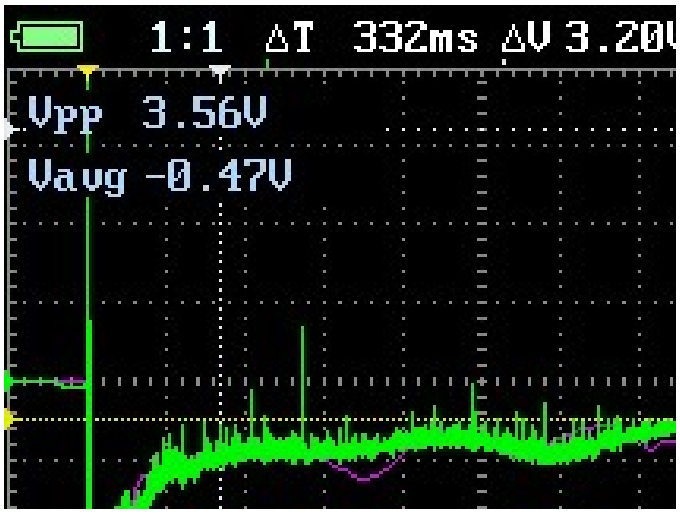
2) Cranking voltage at the starter. Red2 Green2



Actual voltage drop power side Red1 Green2
Note the change in voltage setting. Each horizontal line represents 500mV. This shows about a 200mV drop as the starter speed stabilizes. **(Image below)**



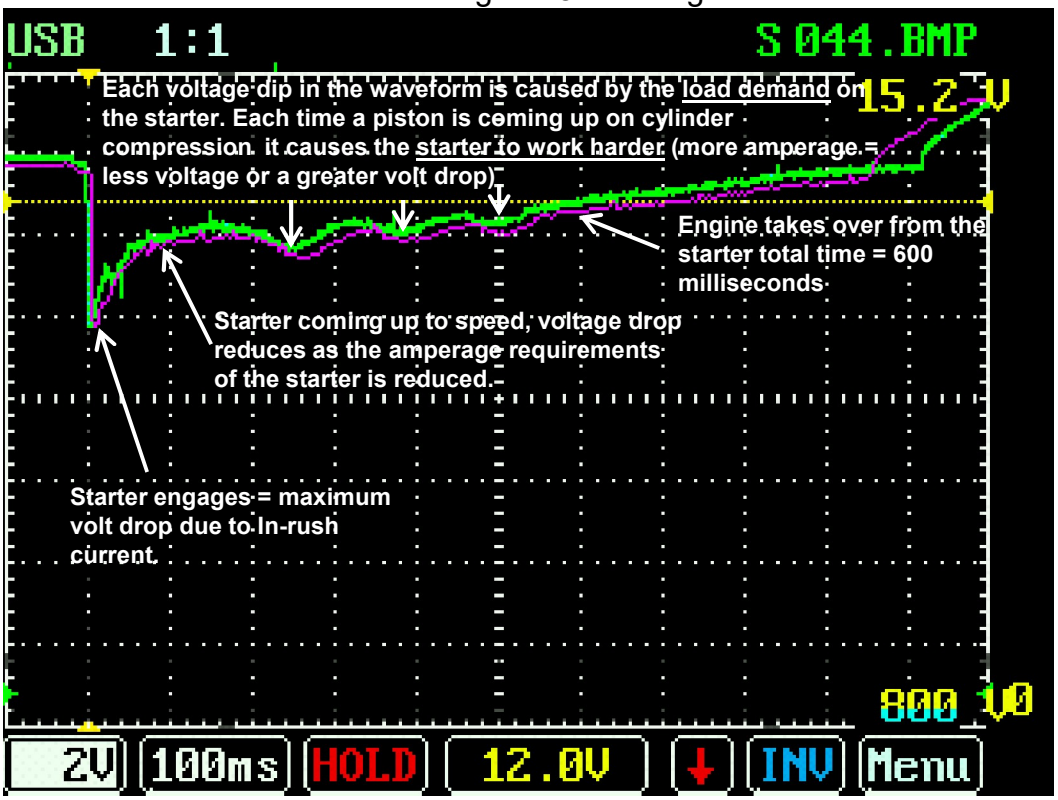
Actual voltage drop ground side Red2 Green1
Note the change in voltage setting. Each horizontal line represents 500mV. This shows about a 260mV drop as the starter speed stabilizes. **(Image below)**



Vehicles often start so quickly that it is difficult to capture the desired voltage readings without disabling the starting of the vehicle. A scope will capture critical information in the normal start cycle.

The voltage picture you can see.

Small block gas V8 cranking.



Voltage

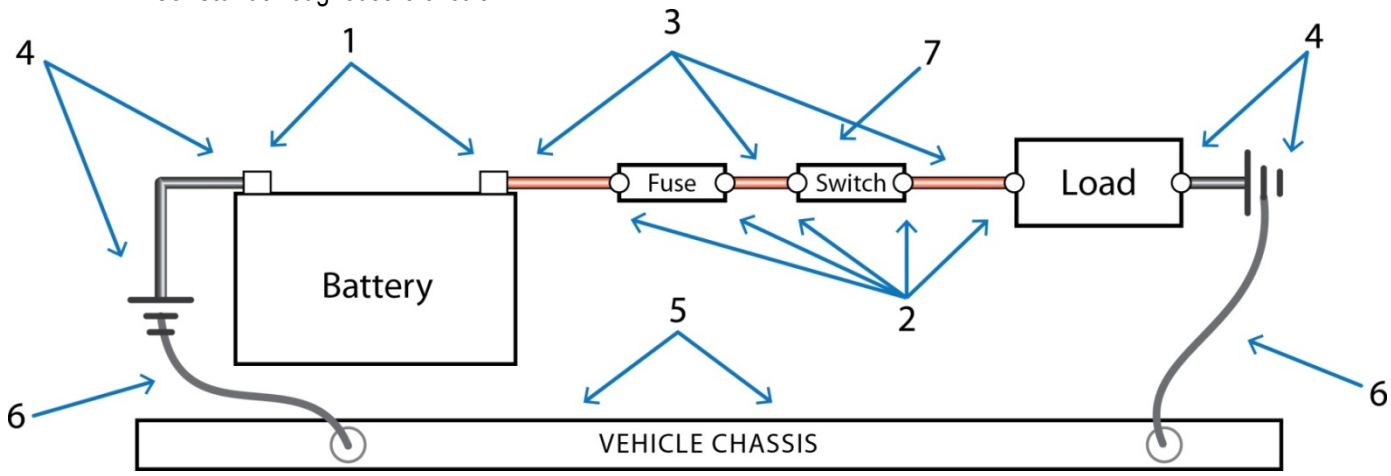
Time

Each dotted square in this view represents 2 volts and 100 milliseconds

Review of Circuit Basics: How Kirchhoff's laws affect your troubleshooting!

❑ Kirchhoff's voltage law states: the sum of all **voltage dropped** within a closed circuit must equal the **source voltage.**

❑Kirchhoff's amperage law states: The **amperage** within a closed circuit will remain **constant** throughout the circuit



Points of potential volt drop in this simple circuit.

1) **Battery connections:** both the power and ground side
   a) Top post battery from the post to the clamp on both the positive and negative cables
   b) .Side post between the mating surfaces of the battery and cable

2) **Junctions, Terminals, and Connections:** Every point in a circuit that has a connection designed to be separated. These points are prime for corrosion that lead to voltage drop.

3) **Wire:** Every section of wire between each junction or connection can have damage that can cause voltage drop. Chaffing, previous repairs, or sections of wire to close to a heat source such as the engine or manifolds can all effect voltage drop.

4) **Primary ground connections:** This includes the **battery connections** as well as the **load connections** at each point of contact: *Confirm direct bolt in items such as starters, alternators and the brackets are part of a complete volt drop test.* The ground path in almost all vehicle circuits is a shared path. This means amperage through the ground will be the total of all active circuits. When trying to verify a problem it is important to be sure you are re-creating the circumstances that created the concern. Higher ground side amperage through a shared ground will increase the voltage drop through that point.

5) **Chassis points:** Bolted or riveted cross members, brackets and frame attachments are often used for a grounding path, but as the vehicle ages these points of contact can develop significant voltage drop.

6) **Grounding or bonding straps:** Failure to properly re-install will create ground side voltage drops and some very erratic symptoms. Electricity looking for a path of return has been known to use engine coolant, wheel bearings, steering linkage, and transmission shafts just to name a few.

7) **Circuit components :** Relays, switches, etc. can all contribute to voltage drop.

Example: If the switch in the simple circuit above was developing an increased internal resistance do to "arcing and fretting" it will rob voltage from the load.
Source (battery) voltage = 12.6 Volts
Voltage drop across the switch = 700 mV (.7 Volts)
Resulting voltage to the load = 11.9 Volts
Note: Series resistance in a circuit is cumulative so each point of drop will add to the total loss to the load. Power or ground makes no difference.

Basic Circuit Voltage Troubleshooting Tips:

1) When voltage is **exactly** the same at both the **source** (battery) and any **load** (light bulb, fuel pump, starter, etc) there is **NO** current flowing.

2) **Load:** The load is what does the work in a circuit. Examples: Starter, starter solenoid, alternator, fuel pump, window motors, light bulbs, window defogger, any of the control relays for the above items, O2 sensor heater, transmission shift control circuits, etc. *The goal of all circuits is to drop all of the design voltage across the load.*

3) There will **ALWAYS** be a drop in voltage between the **source voltage** and **load voltage** when the circuit is operating. Every **operating** circuit has **voltage drop** (resistance) with the question being, is it **acceptable**? (.5 V in a 12 V circuit and 1 V in a 24 V circuit are an initial guideline for an acceptable voltage drop in a circuit.)

4) **Excess resistance** in a circuit is an **un-desired load** thereby creating **excess voltage drop** that will reduce the function of the circuit. Examples that can cause increased resistance: Corroded wires or connections, mechanical damage to the wires including partial cuts, nicks and abrasions, poorly crimped connectors, switch, relay or solenoid contacts that become pitted from use, etc.

5) **Excess resistance** in a circuit causes **excess voltage drop** resulting in less voltage available to operate the load. Voltage drop on either side of the circuit **power or ground** has exactly the same outcome of reduced device operation (ex: dim light, slow cranking starter, poor charging alternator, etc) or non-operation (ex: no light, no cranking, no charging, etc).

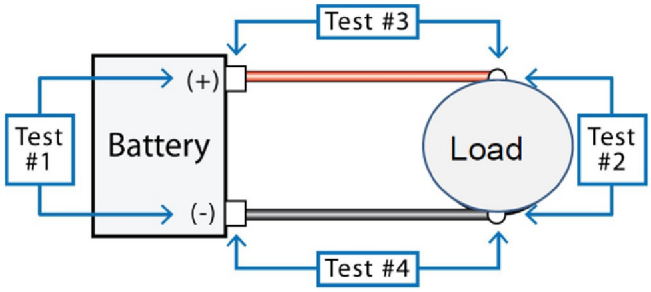
6) The only way to **accurately test** for circuit resistance is with the circuit active and measure the **voltage drop** within the circuit. *An Ohm meter test can not be used on an active circuit and therefore will not depict the true resistance value of a circuit.* The Ohm meter can only give you information about removed or isolated components of the circuit or the continuity of the circuit. (**Important note**: good continuity does not necessarily mean low voltage drop.)

7) Current flow (**AMPERAGE**) in a circuit is always a factor of the **voltage** and the **resistance** throughout the circuit (Ohms Law). If the **voltage drop** (resistance) **increases** above its design limit the available **current** to a device will **decrease** thereby decreasing the device output . (ex: slow cranking starter , poor charging, a dim light, fuel pump issues, etc)

8) **The sum of all loads in a circuit will equal system voltage.** Generally each circuit should have one load dropping the “full “ supply voltage. Remember, every wire, connection, switch, etc. will have an acceptable voltage drop. **This also includes the ground side of the circuit.** When one of these items has an excessive voltage drop it becomes a secondary load in the circuit. The work being done by this secondary load usually results in heat. The loss is further compounded as heat also increases resistance and it becomes a vicious cycle.

A system for Voltage & Voltage Drop Testing

The V-4 Test- This simple series of four tests will quickly help determine the integrity of any circuit.



Test/Location	Voltage *
#1 / V-1 (Source Voltage)	
#2 / V-2 (Load Voltage)	
#3 / V-3 (Volt Drop Power)	
#4 / V-4 (Volt Drop Ground)	

Step #1 - **Always** determine the **O**pen **C**ircuit **V**oltage **(OCV)** before energizing the circuit.

OCV- Open Circuit Voltage is the standing battery voltage before any load or charge is applied. It is used to determine the battery **S**tate **o**f **C**harge (**SOC)**. *Use the connection shown in Test #1*

Step #2 -***Energize the circuit*** **– The circuit must be energized to do the following tests.**

Test #1 – Determines if the ***Voltage Source*** can supply the "***design voltage"*** to the ***Load***.

Source Voltage – The voltage supplied to a circuit by the battery before the vehicle is running. Once the vehicle is running the alternator becomes the source supply and the battery becomes one of the loads. ***This is of particular importance if the battery has a low state of charge requiring a higher than normal charge current.***

Test #2 – Determines if the ***Load*** is receiving the correct voltage (***design voltage***).

Load: The load is what does the work in a circuit. Examples: Starter, starter solenoid, alternator, fuel pump, window motors, light bulbs, window defogger, any of the control relays for the above items, O2 sensor heater, transmission shift control circuits, etc. *The goal of all circuits is to drop all of the design voltage across the load.*

Test #3 – Determines if there is any "***Excess Resistance"*** on the ***positive side*** of the circuit.

Excess resistance in a circuit is an **un-desired load** thereby creating **excess voltage drop** that will reduce the function of the circuit. Examples that can cause increased resistance: Corroded wires or connections, mechanical damage to the wires including partial cuts, nicks and abrasions, poorly crimped connectors, switch, relay or solenoid contacts that become pitted from use, etc

Test #4 – Determines if there is any "***Excess Resistance"*** on the ***ground side*** of the circuit.

Excess resistance in a circuit is an **un-desired load** thereby creating **excess voltage drop** that will reduce the function of the circuit. The ***ground side*** is the most shared circuit on the vehicle. It relies heavily on chassis components as a return path to complete the circuit. Chassis rust and corrosion, loose chassis rivets or bolts, damaged or missing ground straps and wires are frequently the cause of ***very erratic symptoms*** as the circuit searches for a return path to the source. create many that may Examples that can cause increased resistance: Corroded wires or connections, mechanical damage to the wires including partial cuts, nicks and abrasions, poorly crimped connectors, switch, relay or solenoid contacts that become pitted from use, etc. In addition to all of the e

Comparison Testing

•**Testing ABS Wheel Sensors**: Connect one set of leads to each sensor and secure to allow the vehicle to be test driven. These can usually be back probed, but any insulation damage at the connection must be repaired. The ***SIGNALROUTER*** allows the user to select the signal to be tested. Follow the manufacturer's procedures and specifications for the desired meter settings and readings.

•**Testing Oxygen Sensors**: Connect one set of leads to each sensor and secure to allow the vehicle to be test driven. These can usually be back probed, but any insulation damage at the connection must be repaired. Follow the manufacturer's procedures and specifications for the desired meter settings and readings. (Good opportunity to include a U-Scope or other Digital Storage Oscilloscope (DSO) to view the active pattern). The ***SIGNALROUTER*** allows the user to select the signal to be tested.