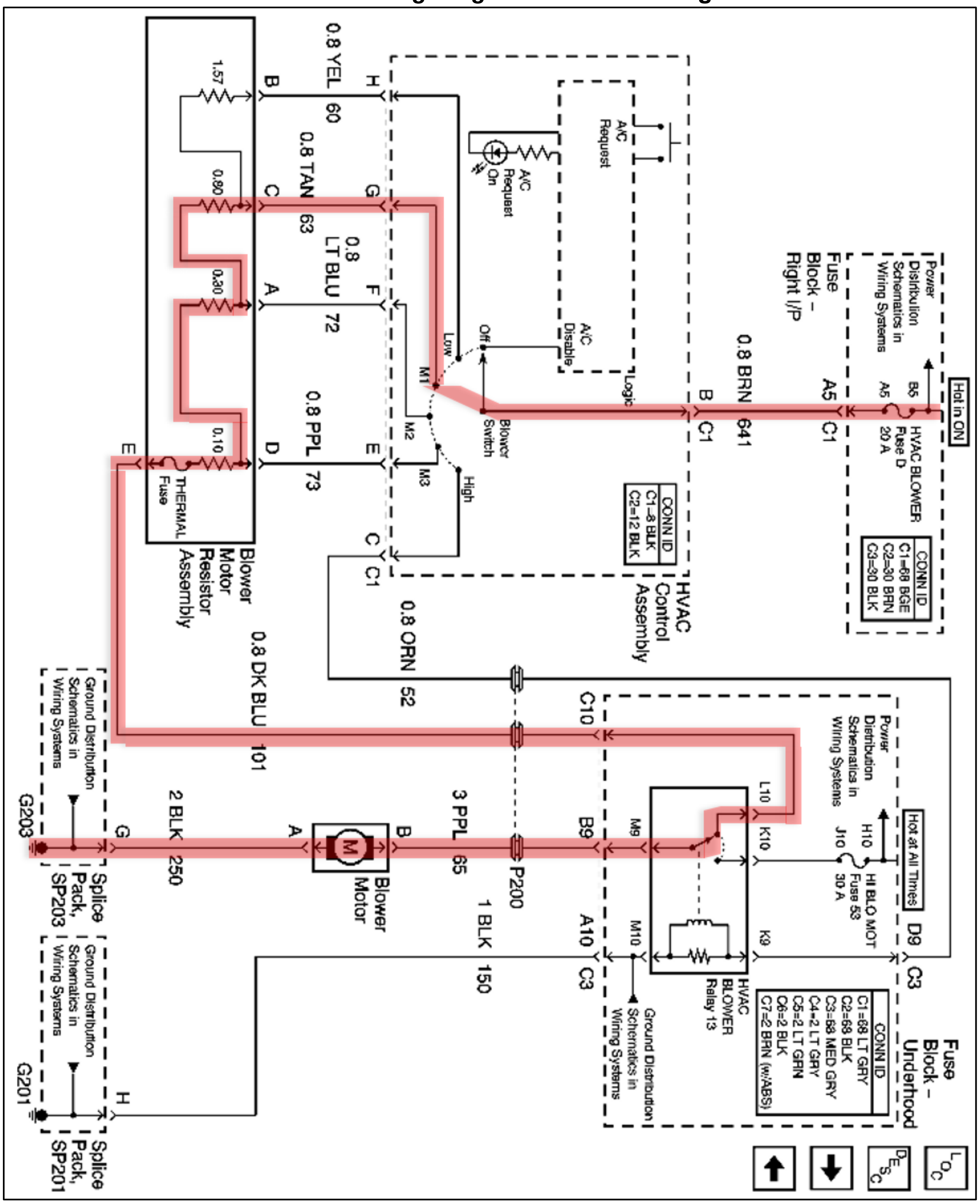
[FROM PAGE 2-17] CIRCUIT CONSTRUCTION

Series Circuits

GM Blower Motor Series Circuit Example

In the spirit of making sure you understand something and then confusing you again, we're going to discuss this complex real-world diagram. Trace the current path in the diagram below with the Blower Switch in the 'M1' position.

2005 Grand Am Blower Motor Wiring Diagram – Trace Through 'M1'



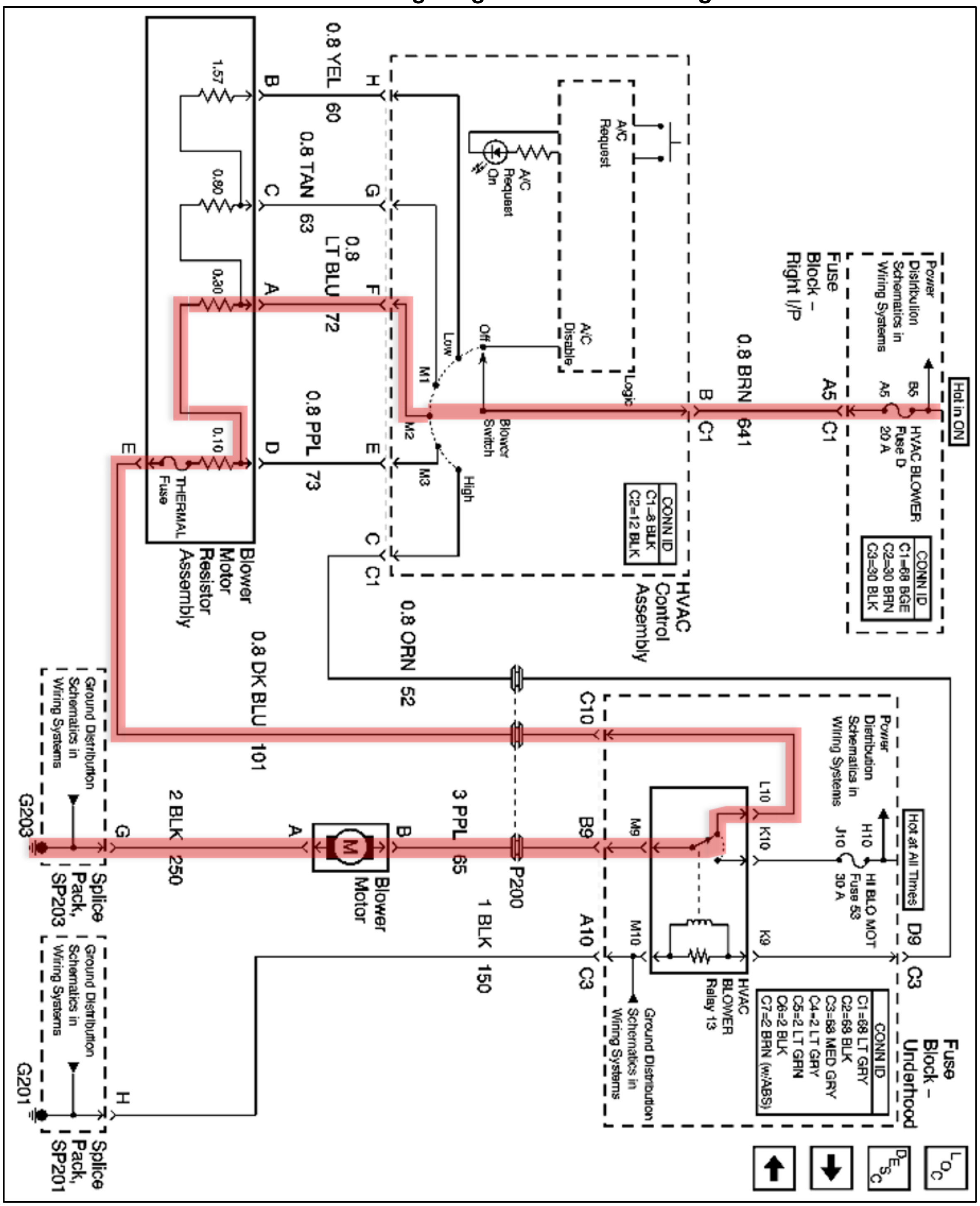
[FROM PAGE 2-18] CIRCUIT CONSTRUCTION

Series Circuits

GM Blower Motor Series Circuit Example – Continued

This is the same diagram, so use it to trace the current path when the Blower Switch is in the 'M2' position.

2005 Grand Am Blower Motor Wiring Diagram – Trace Through 'M2'



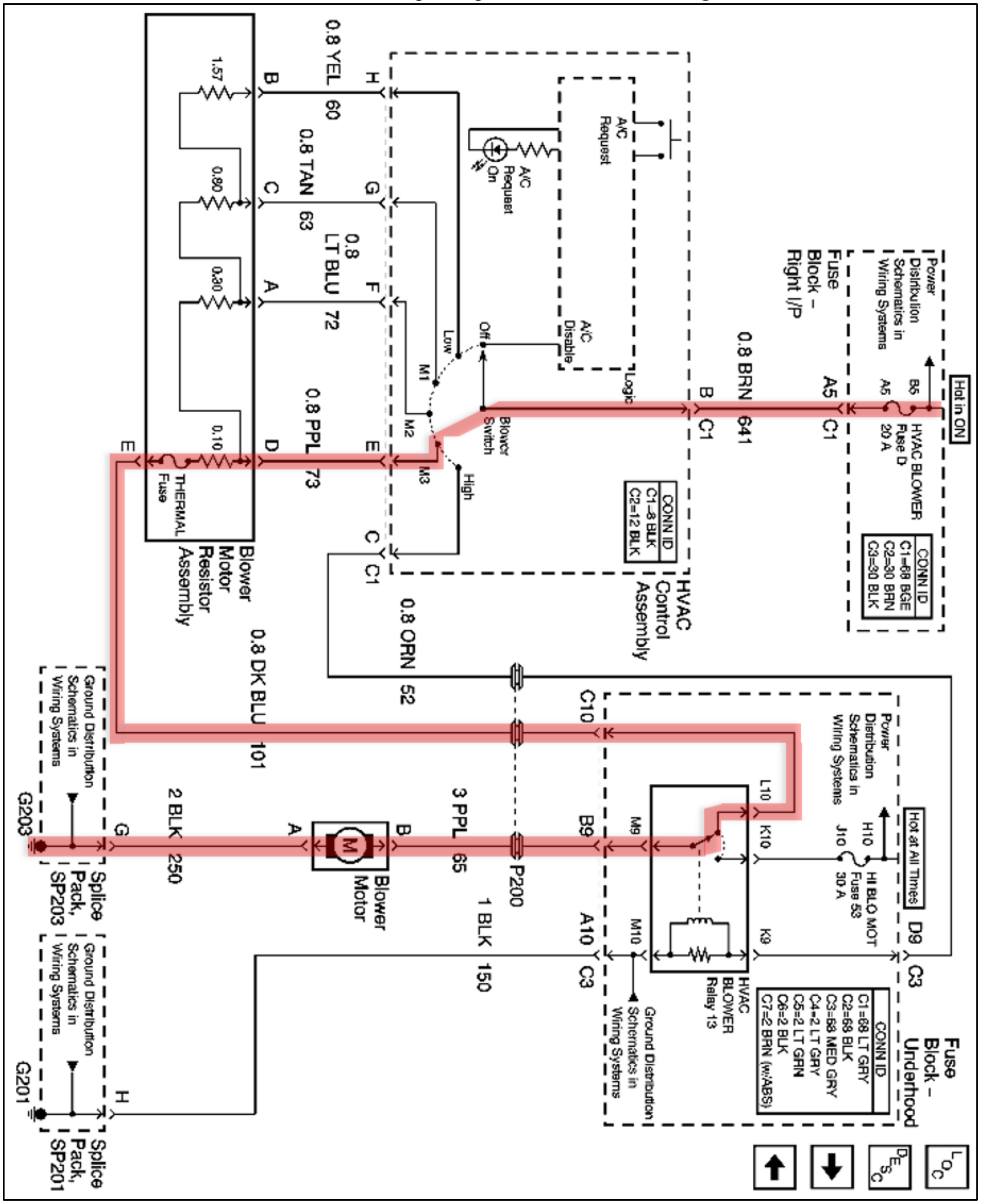
[FROM PAGE 2-19] CIRCUIT CONSTRUCTION

Series Circuits

GM Blower Motor Series Circuit Example – Continued

Use this diagram to trace the current path when the Blower Switch is in the ‘M3’ position.

2005 Grand Am Blower Motor Wiring Diagram – Trace Through ‘M3’



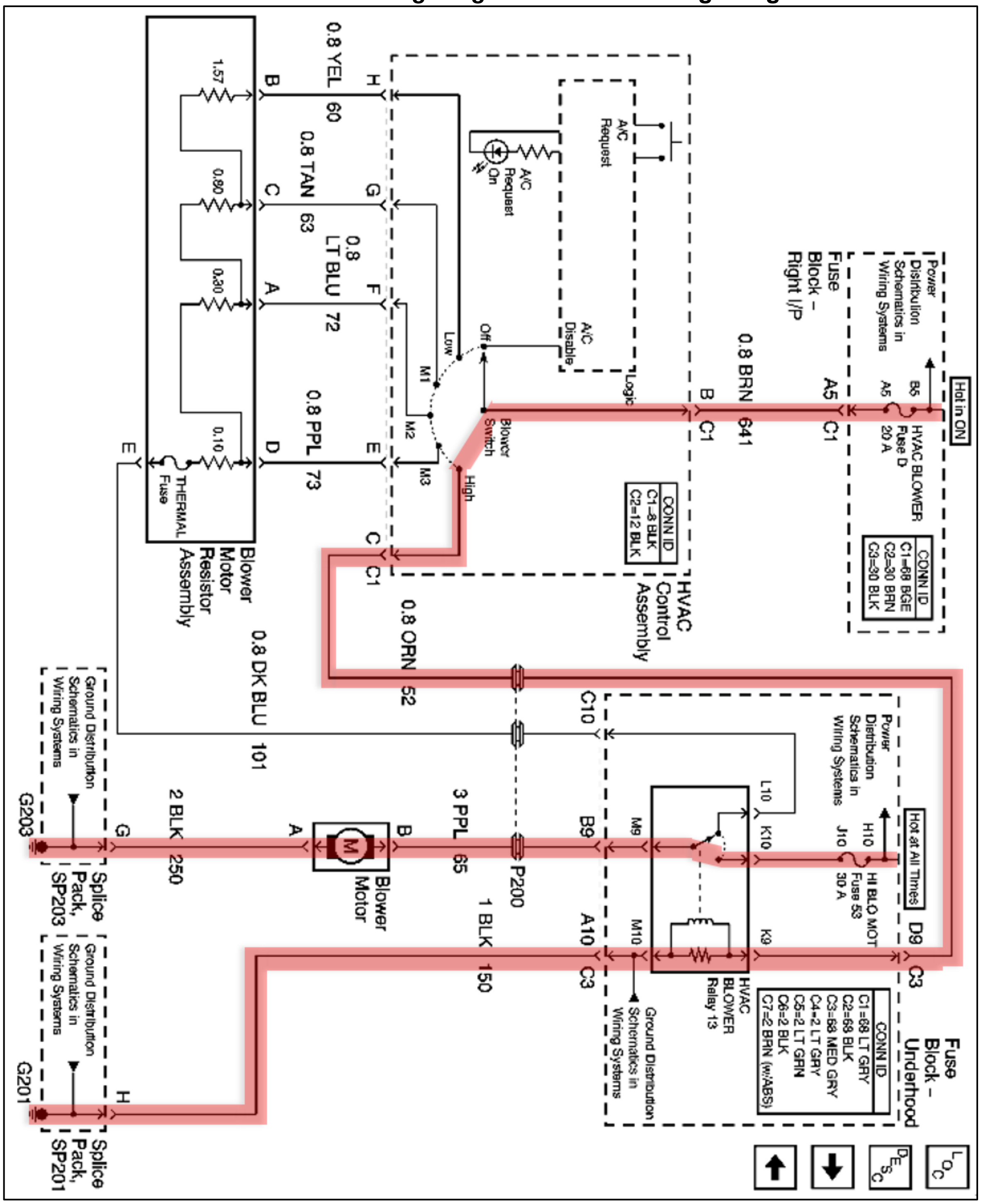
[FROM PAGE 2-20] CIRCUIT CONSTRUCTION

Series Circuits

GM Blower Motor Series Circuit Example – Continued

From 2-20. Use this diagram to trace the current path when the Blower Switch is in the 'High' position.

2005 Grand Am Blower Motor Wiring Diagram – Trace Through 'High'



[FROM PAGE 2-21] CIRCUIT CONSTRUCTION

Series Circuits

GM Blower Motor Series Circuit Example – Continued

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

Blower Motor Questions:

1. Is there ever more than 1 current path? All switch positions place different numbers or resistors in series except for 'High'. Therefore, there is never more than 1 current path to the blower motor.

2. With the Blower Switch in the 'M2' position, what is the voltage at the HVAC Control Assembly terminal H? Battery voltage. In a series circuit, voltage is measured up to the open. In 'M2', the voltage drops across the 0.3 and 0.1 Ohm resistors in the blower current path, but that voltage is also connected to the other resistor circuits. Since the switch 'Low' and 'M1' positions are open, voltage does not drop across the 0.8 and 1.57 Ohm resistors. Therefore, battery voltage is present at HVAC Control Assembly terminals F, G & H.

3. With the Blower Switch in the 'High' position, what is the voltage at the HVAC Control Assembly terminal H? In 'High', the resistor is not used, so there is no voltage at terminal H or anywhere else in the resistor.

4. With the Blower Switch in the 'High' position, what controls the current flow? In 'High', the current path for lower speeds bypasses the resistor and is used instead to close the relay contacts. The relay contacts complete a higher current path from a higher current fuse. The 'High' current path contains no resistors, so only the spinning resistance of the blower motor limits current flow through the entire circuit.

Blower Circuit Fault Example:

If a customer concern is that the blower motor does not operate in the 'M1' and 'M2' positions:

1. Where in the circuit is the most likely fault? The blower switch, since an open 'M1' or 'M2' resistor would prevent 'Low' fan operation as well.

2. Where in the circuit should you make the first measurement? HVAC Control Assembly terminals F & G in the appropriate switch positions.

3. What would be the best and/or easiest tool to use? Lots of options, but a Power probe could be used to verify no voltage, and then used to back feed the circuit to force blower operation. This verifies that the blower, resistors, and related wiring are all OK.

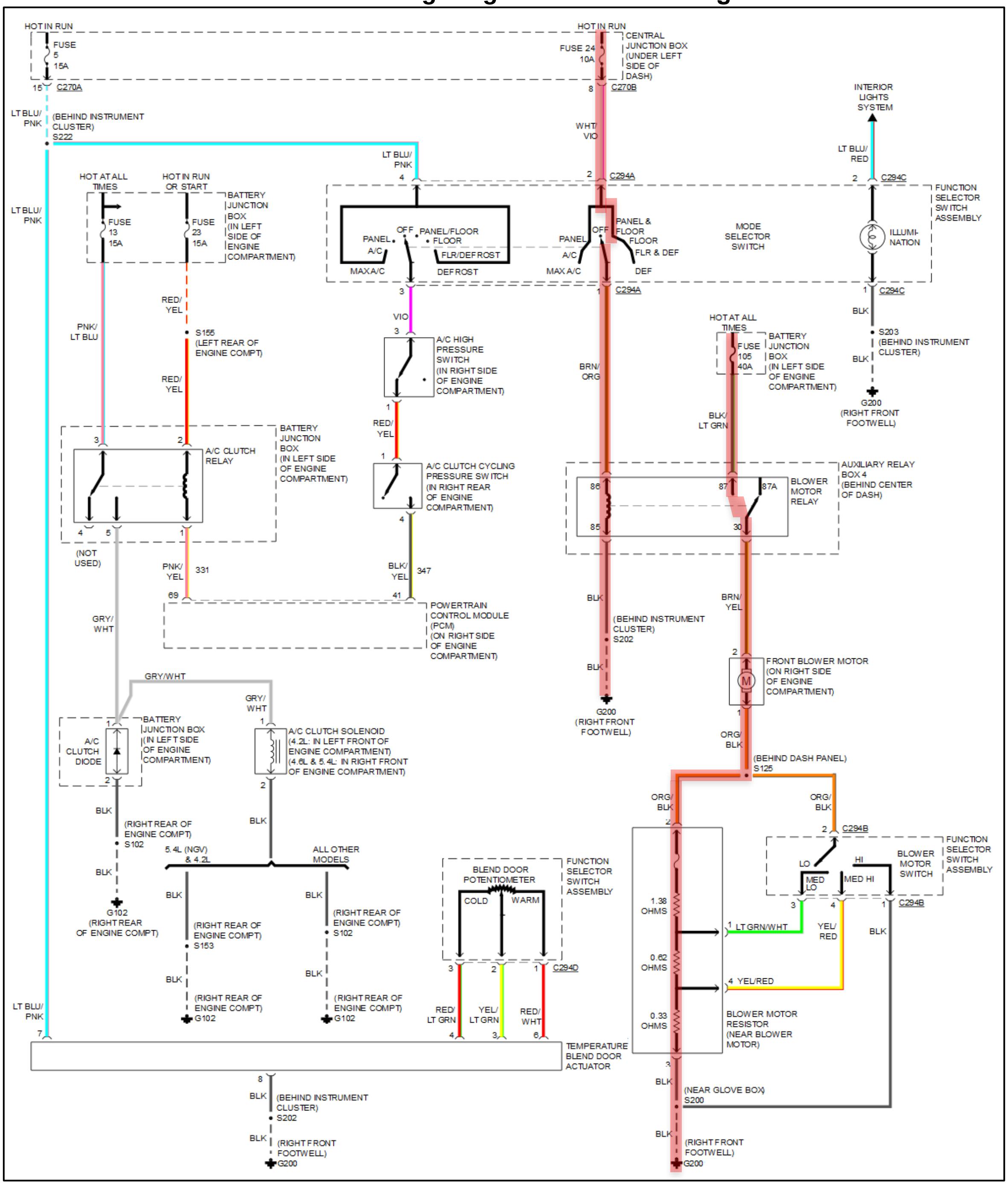
[FROM PAGE 2-22] CIRCUIT CONSTRUCTION

Series Circuits

Ford Blower Motor Series Circuit Example

This Ford blower circuit is a little different. Use this diagram to trace the current path when the Function Selector Switch Assembly is in the 'FLOOR' and 'LO' positions. How can the blower operate in 'LO' when there's no path through the switch in that position?

2002 Ford F150 Blower Motor Wiring Diagram – Trace Through 'FLOOR' & 'LO'



Courtesy of MotoLogic

[FROM PAGE 2-23] CIRCUIT CONSTRUCTION

Series Circuits

Ford Blower Motor Series Circuit Example – Continued

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

Blower Circuit Fault Example:
If a customer concern is that the blower motor does not operate in the 'MED HI' and 'HI' positions:

1. Trace the parts of the circuit that you know are working correctly based on other blower positions working correctly.

2. Based on the trace, what are the most likely possible faults?
   Like the previous example, this has to be a switch or related wiring or connections fault because a resistor fault would affect 'Lo' and 'Med Lo' blower operation as well. For example, if it worked in 'Med Hi' and 'Hi' but not 'Lo' or 'Med Lo', then an internal resistor fault would be likely (the fuse or the 1.38 Ohm resistor).

3. Based on experience, what is the most likely fault on the list?
   Blower motor switch.

4. What is the one test that will instantly verify the most likely fault, or instead lead you to check less likely causes?
   Use a Power Probe or fused jumper to supply power to terminals 1 & 4 of the blower motor switch. If the blower runs, you've accomplished 2 things: The blower switch has been condemned by elimination, and the blower resistor, blower motor, and ground connection have all been verified.

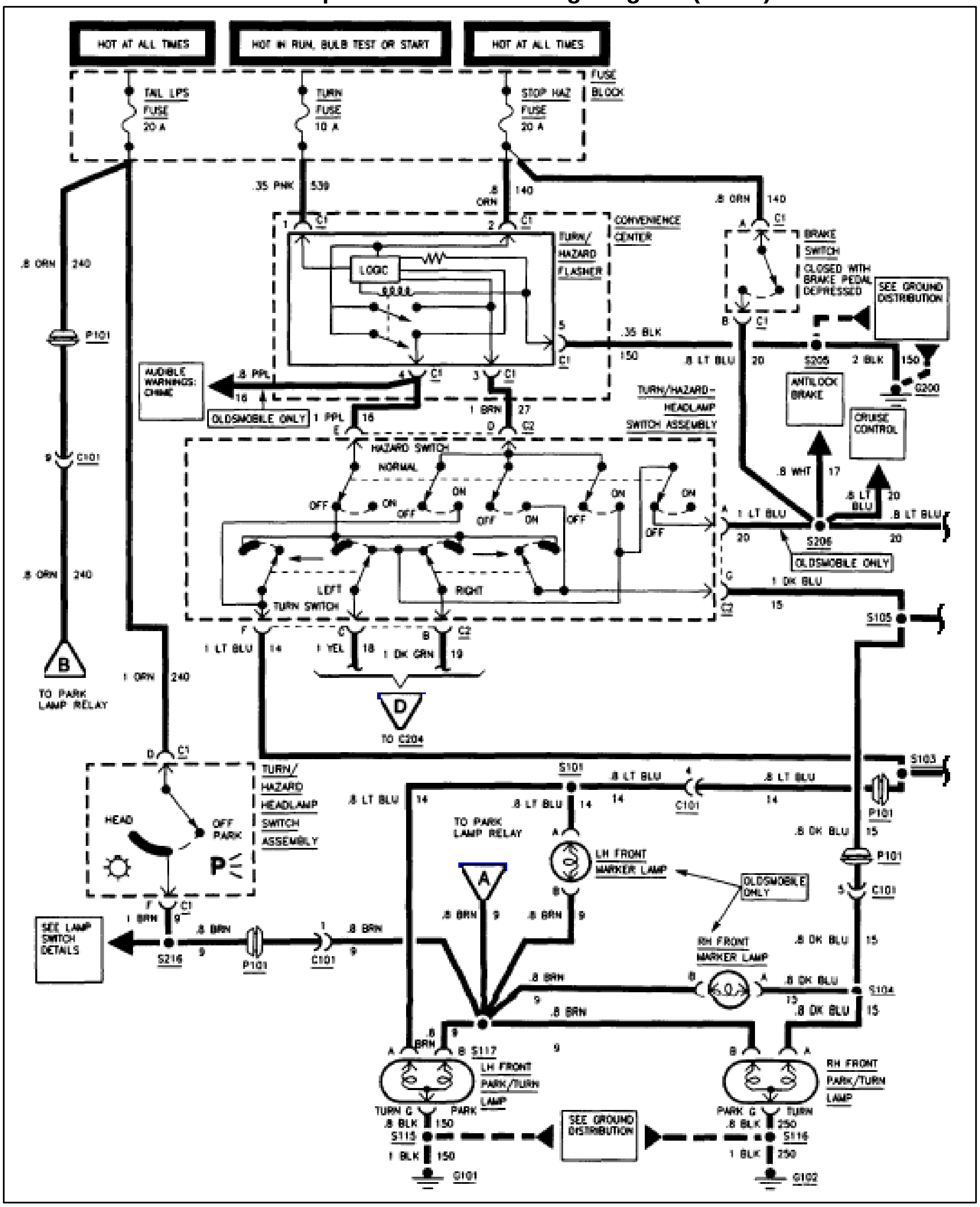
[FROM PAGE 2-33] CIRCUIT CONSTRUCTION

Parallel Circuits

Diagnose by Elimination & Comparison Example

A 1997 Pontiac Grand Am comes in with a complaint of no brake lights. The STOP HAZ fuse is blown. The technician replaces the fuse, and it doesn't blow using signals or hazards, but it does blow when the brake pedal is pressed. Now what?

1997 Pontiac Grand Am Stop/Brake/Hazard Wiring Diagram (1 of 2)

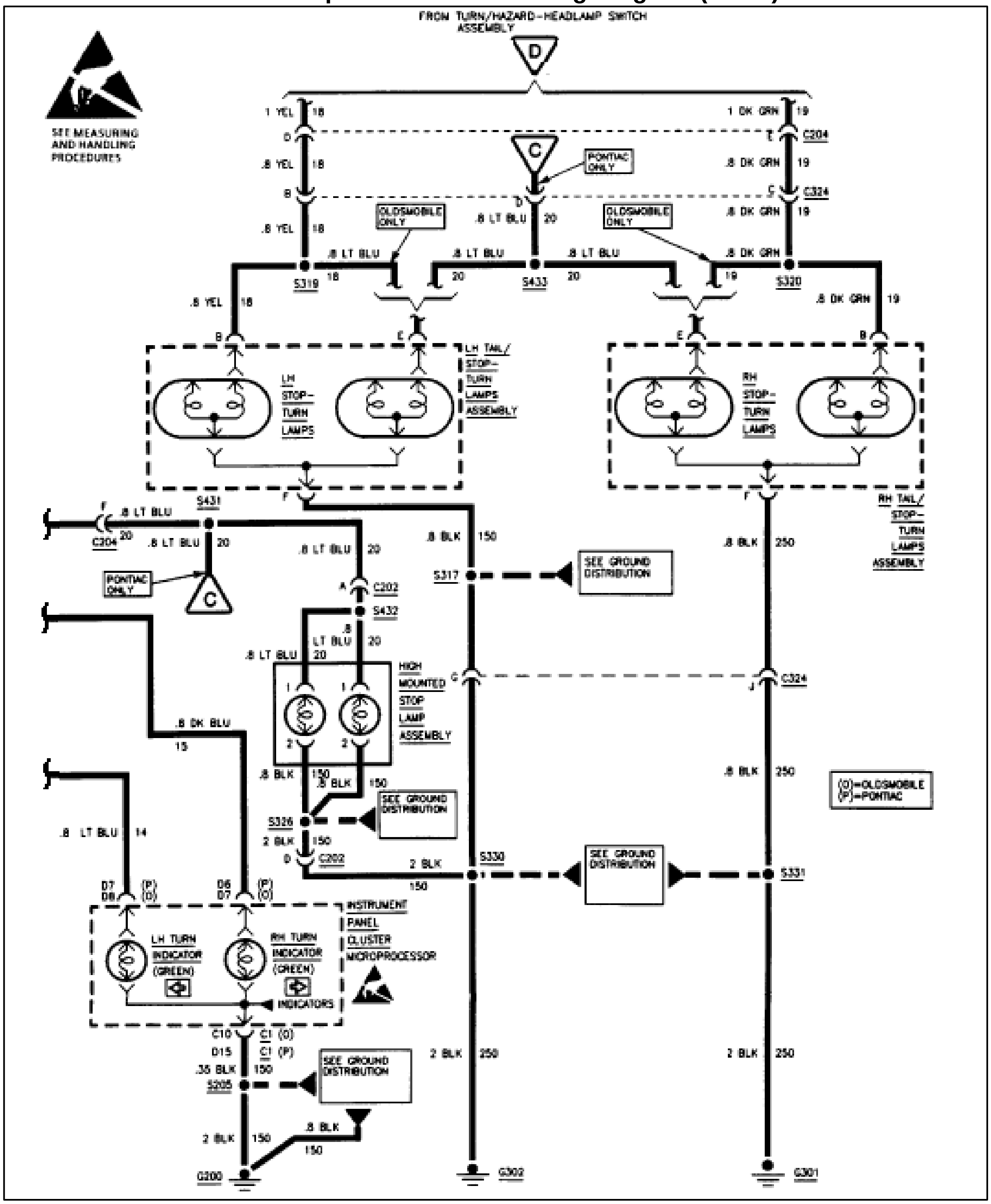


[FROM PAGE 2-34] CIRCUIT CONSTRUCTION

Parallel Circuits

Diagnose by Elimination & Comparison Example – Continued

1997 Pontiac Grand Am Stop/Brake/Hazard Wiring Diagram (2 of 2)



[FROM PAGE 2-35] CIRCUIT CONSTRUCTION

Parallel Circuits

Diagnose by Elimination & Comparison Example – Continued

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

1. To avoid actual circuit testing as long as possible, what should the technician do next?

Check wiring diagrams to see if the different fuse-blowing conditions can help eliminate circuits, connections, and components from the possible cause list.

2. Given these observations, what can be said about the circuit between the fuse and the brake switch?

It couldn't possibly have a fault. If a fault was present in that segment of the circuit, the fuse would blow immediately.

3. What 2 points is the short between?

In the LT BLU circuit between the brake switch and the high mounted stop lamp assembly, including parallel branches to the turn/hazard-headlamp switch assembly, the ABS system, cruise control, and the branch from Splice S431 to the tail lamp bulbs. These circuits are only used for brake lamp operation, and are isolated by the turn/hazard-headlamp switch assembly in all other lighting states.

Alternate Fuse Replacement Strategy

4. What could be done to perform this test without repeatedly blowing fuses?

A load substitution device could have been used to move the load to across the fuse cavity. This would allow for a complete circuit for testing, while limiting current to keep the circuits safe. Use of a test light or other bulb across the fuse cavity has an added benefit: The lit bulb means the fault is current. As sections of the harness are isolated, you can watch for the bulb to go out to see when you've disconnected the segment with the short. Refer to 'Load Substitution Tools' in Section 4: Appendix for tool information. To see how this device is used check out the following case studies in Section 3:

- 2003 Monte Carlo SS No Rear Parking Lamps
- 2007 Fusion MIL On

[FROM PAGE 2-36] CIRCUIT CONSTRUCTION

Parallel Circuits

Parallel Circuit Review Questions

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

For this exercise, we will be focused on parallel circuits. Refer to 'Series Circuit Rules' on 2-13 and Parallel Circuit Rules' on 2-26.

1. How does amperage behave in a parallel circuit?
   Each branch is its own series circuit, so series circuit rules apply. The current is determined by the resistance and source voltage (Amps = Volts / Ohms). The total current through the main line and all branches is simply the current through all series branches added together.

2. How does voltage drop in a parallel circuit?
   All available voltage drops across loads in a complete series circuit. Since a parallel circuit is just a collection of series branches, each branch drops all available voltage.

3. How does resistance behave in a parallel circuit?
   Resistance determines the current flow through a series branch of a parallel circuit. Therefore, high or low resistance in one branch does not affect resistance (or current flow) in other branches. However, it does affect total current flow in the main line (a power or ground leg shared by all branches).

4. What are the characteristics of the 'main' line of a parallel circuit?
   It is a power or ground circuit that splits off into parallel branches. It has no loads of its own. Current through the main line is the sum of the current through all branch lines. Main line faults affect all branches.

5. What are characteristics of a 'branch' line of a parallel circuit?
   Each branch line is a series circuit, so all Series Circuit Rules (page 2-13) apply. Current through a branch is limited by the resistance in the branch. Branch line faults affect only the faulty branch (unless an over-current fault opens a circuit protection device shared by all branches).

6. What is the result of adding branches to a parallel circuit (i.e. trailer wiring, aftermarket lighting, or other accessories)?
   Adding branches will add to main line current. This does not affect other branches unless extra current flow exceeds the fuse capacity or causes voltage drop. Current flow heats wires, connections, or switches, causing resistance to rise and overall current flow to drop.

7. What is the result of removing branches of a parallel circuit (i.e. missing bulb, unplugged connector, or broken wire)?

[FROM PAGE 2-36] CIRCUIT CONSTRUCTION

Parallel Circuits

Parallel Circuit Review Questions – Continued

8. When measuring resistance in parallel circuits, what step(s) should a technician take to ensure an accurate measurement?
    a. Use an Ohmmeter
    b. Isolate the branch being tested
    c. Depower the circuit
    d. All of the above

[FROM PAGE 2-38] CIRCUIT CONSTRUCTION

Parallel Circuits

Parallel Circuit Review Exercise #1

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

The following questions require the use of the diagram on the facing page.

1. Calculate the total resistance in the circuit, assuming each load is 12 Ohms.

   4 Ohms

2. Calculate the amperage that would be displayed on the Ammeter installed in place of the fuse, based on the resistance value from question 1.

   A = V / R, or A = 12 / 4, or 3 Amps

3. How many Amps would be flowing in each of the three branches (A, B and C)?

   Ohm's Law is applied to each branch: A = V / R, or A = 12 / 12, or 1 Amp

4. What should the DVOM read at point 'V1'?

   12 Volts. There is ground at any point past the bulb filaments, and power at any point before the filaments. If not, there low source voltage or resistance anywhere in the power or ground main lines.

5. What should the DVOM read at point 'V2'?

   12 Volts. There is ground at any point past the bulb filaments, and power at any point before the filaments. If this measurement is lower than at 'V1', there's resistance between the splice on the power side and the splice on the ground side (but not in the bulb, since extra resistance there would affect current flow, not voltage drop).

6. What would be the result of unwanted resistance at connector C100?

   That's in the main line, so extra resistance would reduce current flow in all branches, making the bulbs dim.

7. What would be the result of unwanted resistance in branch A of the circuit?

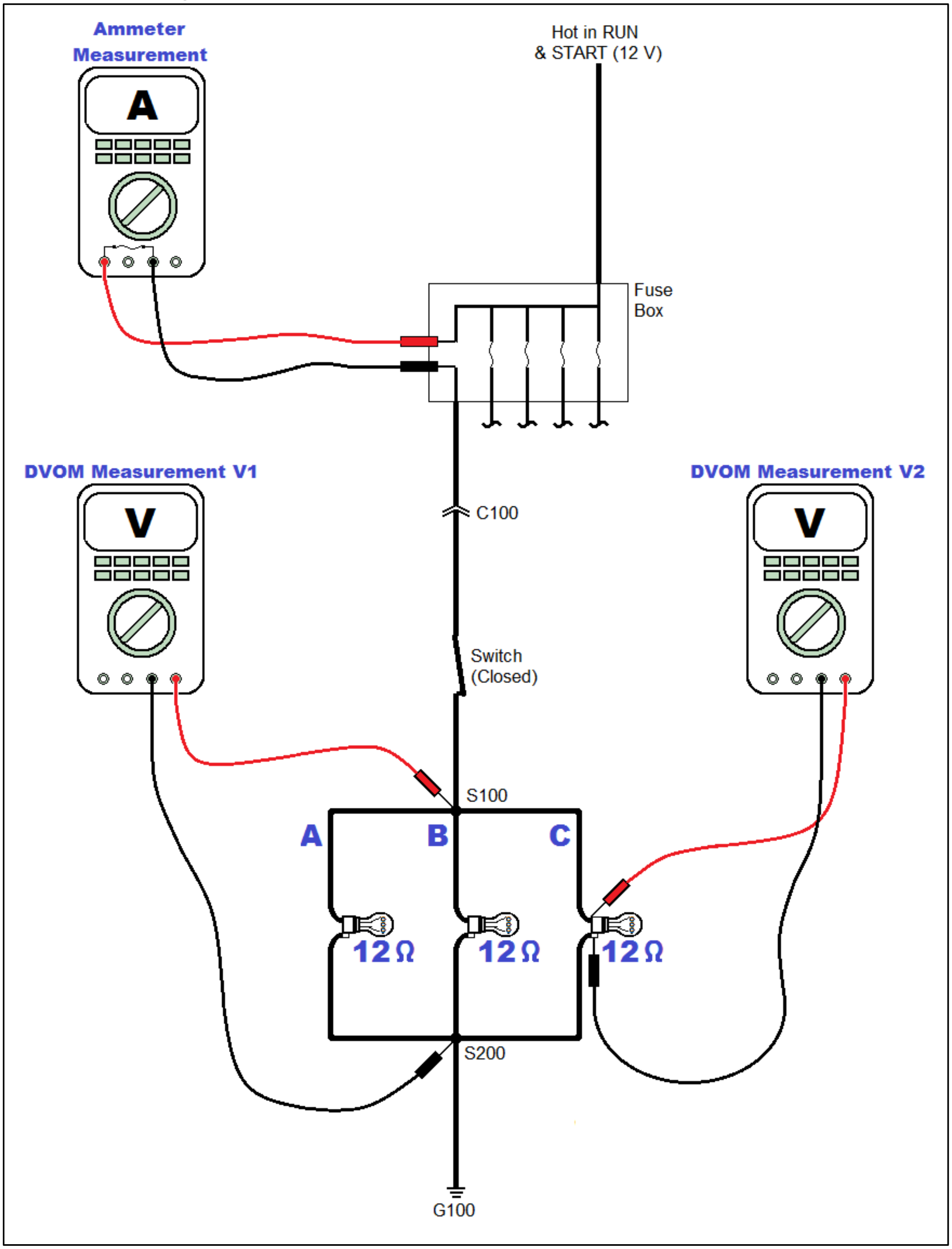
   Main line current would be reduced, but *only* because the branch A current would be reduced. Only the branch A bulb would be dim.

[FROM PAGE 2-39] CIRCUIT CONSTRUCTION

Parallel Circuits

Parallel Circuit Review Exercise #1 – Continued

Exercise #1 Diagram & Test Connections



[FROM PAGE 2-40] CIRCUIT CONSTRUCTION

Parallel Circuits

Parallel Circuit Review Exercise #2

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

The following questions require the use of the diagram on the facing page.

1. Calculate the total resistance in the circuit, assuming the following loads: Branch A = 10 Ohms, Branch B = 20 Ohms, Branch C = 30 Ohms.

   5.46 Ohms: Calculations shown on pages 2-30 & 2-31.

2. Calculate the amperage that would be displayed on the Ammeter installed in place of the fuse, based on the resistance values from question 1.

   A = V / R, or A = 12 / 5.46, or 2.2 Amps

3. How many Amps would be flowing in each of the three branches (A, B and C)?

   Ohm's Law is applied to each branch: A = V / R
   Branch A: A = 12 / 10, or 1.2 Amps
   Branch B: A = 12 / 20, or 0.6 Amps
   Branch C: A = 12 / 30, or 0.4 Amps

4. What should the DVOM read at point 'V1'?

   12 Volts. There is ground at any point past the bulb filaments, and power at any point before the filaments. The varying resistance of the parallel loads doesn't affect this measurement.

5. What should the DVOM read at point 'V2'?

   12 Volts. There is ground at any point past the bulb filaments, and power at any point before the filaments. If this measurement is lower than at 'V1', there's resistance between the splice on the power side and the splice on the ground side (but not in the bulb, since extra resistance there would affect current flow, not voltage drop).

6. What would be the result of unwanted resistance at connector C100?
   That's in the main line, so extra resistance would reduce current flow in all branches, making the bulbs dim.

7. What would be the result of unwanted resistance on branch A of the circuit?
   Main line current would be reduced, but *only* because the branch A current would be reduced. Only the branch A bulb would be dim.

8. What would be the result of unwanted resistance at splice S100?
   That's in the main line, so extra resistance would reduce current flow in all branches, making the bulbs dim.

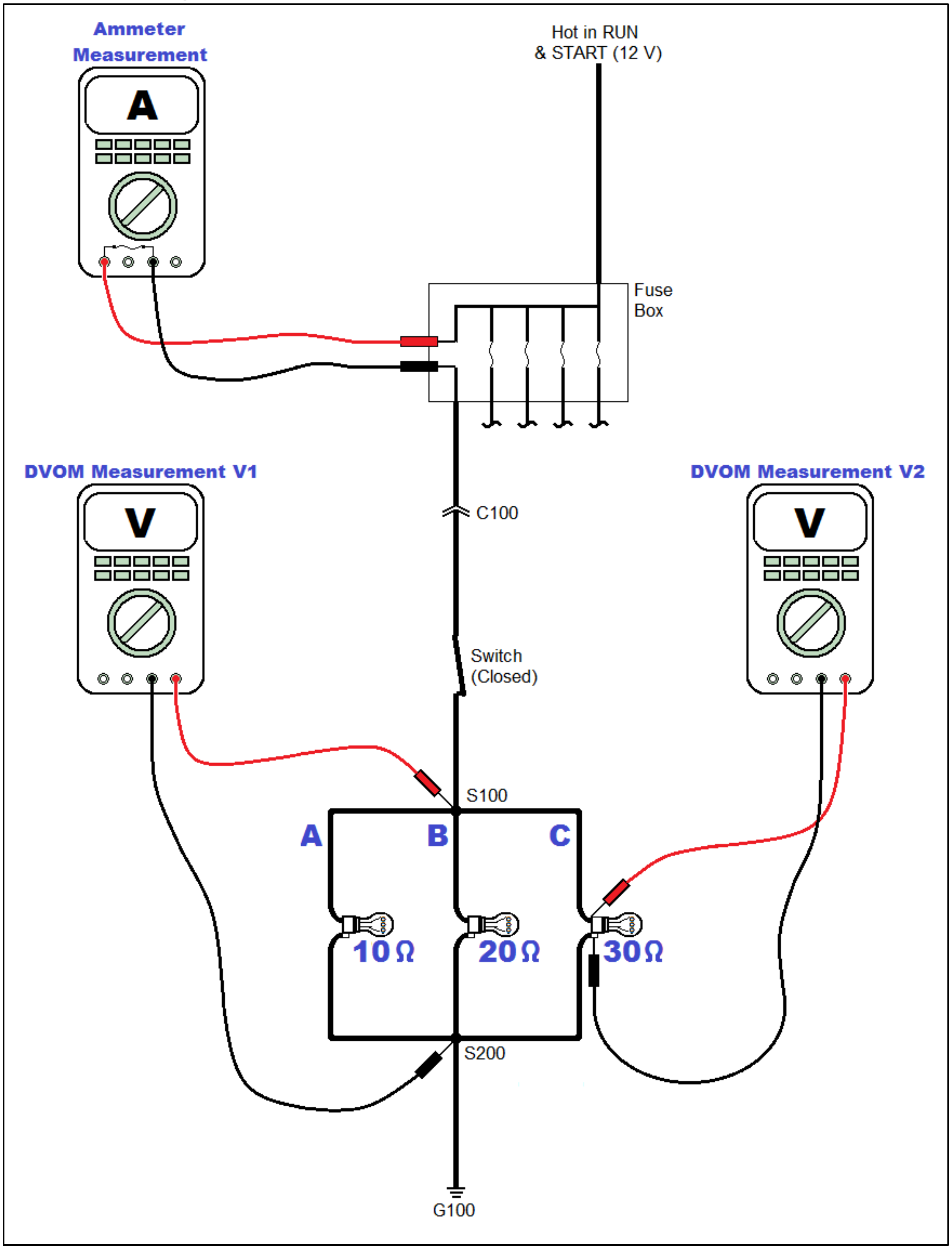
9. What would be the result of unwanted resistance on branch B of the circuit?
   Main line current would be reduced, but *only* because the branch B current would be reduced. Only the branch B bulb would be dim.

[FROM PAGE 2-41] CIRCUIT CONSTRUCTION

Parallel Circuits

Parallel Circuit Review Exercise #2 – Continued

Exercise #2 Diagram & Test Connections



[FROM PAGE 2-42] CIRCUIT CONSTRUCTION

Parallel Circuits

Parallel Circuit Review Exercise #3

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

1. When testing for a short to ground, what tools & tests could assist in diagnosing the concern?
   Use a load substitution device across the fuse cavity to allow for a complete circuit without blowing fuses or damaging circuits/components. The use the circuit isolation and overlaying techniques to find and verify the area of the short.

2. Where can a technician access the circuit for testing? Prioritize from the easiest to most difficult.
   At the fuse, as stated above. Then isolating starting from the load is usually easiest due to ease of access. It's also in between power and ground sides of the circuits, so load removal is a great way to divide the diagnosis in half (i.e. the short is still there when disconnected, so the short is in the power side of the circuit).

3. What can you determine if the fuse only opens when the switch is closed?
   The short is past the switch. It could still be in the switched power, switched ground, ground or the load itself, but at least you've ruled out the switch and constant power circuit.

4. What are some strategies a technician can use to isolate the fault in an individual branch?
   Disconnect the load, disconnect inline connectors, or remove splice packs/junction connectors. After these easy steps are taken, harder steps may be required. These include cutting wires, unsoldering splices, and backing terminals out of connectors.

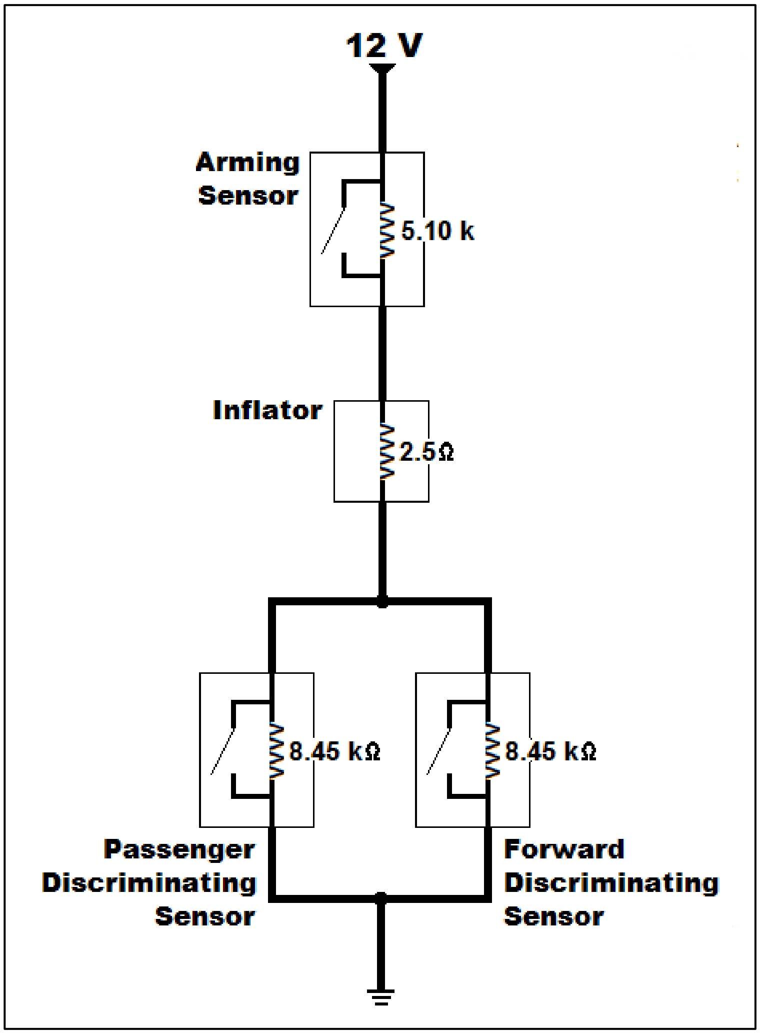
5. What can you determine if a replacement fuse opens immediately with the switch in the open position?
   The short is between the fuse outlet and the switch.

6. What are some strategies a technician can use to isolate the fault in the main line?
   Install a load substitution device across the fuse cavity and then check wiring diagrams/component locations for any easily accessible connectors to see if the fault can be tracked to a smaller section of wiring. You can also use a fused jumper from the fuse inlet cavity to the switch output terminal to power the rest of the circuit to verify all other wires and components.

[FROM PAGE 2-51] CIRCUIT CONSTRUCTION

Combination Series/Parallel Circuits

Series/Parallel Airbag Exercise



This series/parallel diagram shows a *very* simplified version of an airbag diagram. Airbag control modules keep a very close eye on system voltages, so they aren't very tolerant of resistance fluctuations, voltage drops, loose connections, etc. You may be called upon to struggle through some of these calculations during a real diagnosis.

There are 4 resistors in the diagram to the right. The arming sensor and inflator resistors are in series, but the discriminating sensors are in parallel. Therefore, both series and parallel rules apply:

- Series resistance is added
- Parallel resistance reduces overall resistance

When diagnosing this hypothetical circuit, you'd first want to read up on how the module monitors system operation, detects faults and records crash data. To verify this during a diagnosis, you'd need to calculate total circuit current flow, resistance, and voltage drops. Most of the time those specifications aren't available, but with this diagram you have all you need: Measure source voltage and make predictions based on series and parallel circuit rules, where appropriate.

<u>Expected Total Resistance</u>

First, we need to convert all values to the same units:

- 5.10 kΩ = 5,100 Ω
- 2.5 Ω = 2.5 Ω
- 8.45 kΩ = 8,450 Ω

Next, parallel resistance is calculated, and because each resistor has the same value, the easy formula can be used: 8,450 Ω / 2 branches = 4,225 Ω. Now the total resistance is just a matter of adding the values:

$$\mathbf{R1 + R2 + \frac{(R3\ or\ R4\ value)}{2} \quad = \quad 5{,}100 + 2.5 + 4{,}225 \quad = \quad 9{,}327.5\ \Omega}$$

[FROM PAGE 2-52] CIRCUIT CONSTRUCTION

Combination Series/Parallel Circuits

Series/Parallel Airbag Exercise – Continued

Expected Total Current Flow

From the total resistance number we can easily calculate total current flow through the circuit. Assuming a 12 Volt source:

A = V / R
A = 12 / 9,327.5
A = 0.0013 Amps (1.3 mA)

This is the current you'd expect everywhere in the series part of the circuit, though you'd see only half of that when measuring in either of the parallel branches.

Expected Voltage Drop

To calculate the voltage drop across any of the resistors (assuming the switches are all open), multiply the current by the individual resistance.

V = R x A
R1 = 5,100 Ω x 0.0013 Amps = 6.63 Volts
R2 = 2.5 Ω x 0.0013 Amps = 0.003 Volts (3 mV)
R3 & R4 in parallel = 4,225 Ω x 0.0013 Amps = 5.49 Volts

To check your work, add your results to make sure they're close to the source voltage.

6.63 + 0.003 + 5.49 = 12.123 Volts

Because of rounding off, the voltage drops will never add exactly up to source voltage, so 12.123 Volts is close enough to 12 Volts.

Now it's Your Turn

Using the diagram on the previous page, answer the following questions:

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

1. What would happen in the circuit to total resistance if the switch in the arming sensor closed?

   When that switch closes, it bypasses the 5,100 Ohm resistor. Total resistance drops to 4,227.5 Ohms.

2. What would happen in the circuit to total resistance if the switch in one of the discriminating sensors closes?

   Total resistance would drop to 5,102.5 Ohms. When either sensor switch closes, it bypasses the 8,450 Ohm resistor, but this only drops total resistance by half (4,225 Ohms) because that *was* the resistance added to the total circuit with both switches open. On the other hand, if one of the discriminating sensors were open or disconnected, the total resistance would rise by 4,225 Ohms because all current would have to flow through the remaining discriminating sensor.

[FROM PAGE 2-52 & 2-53] CIRCUIT CONSTRUCTION

Combination Series/Parallel Circuits

Series/Parallel Airbag Exercise – Continued

3. What would happen to total circuit resistance if the switch in both the arming sensor and one discriminating sensor close?

   Total circuit resistance would only be 2.5 Ohms. Sure, the other discriminating sensor is still in the circuit, but it's parallel to a branch with no resistance, so the current will choose the unresisted path to ground.

4. What would happen to current flow if the switch in the arming sensor closes?

   At 12 Volts and 4,227.5 Ohms, current flow would rise from 1.3 mA to 2.8 mA.

5. What would happen to current flow if the switch in one of the discriminating sensors closes?

   At 12 Volts and 5,102.5 Ohms, current flow would rise from 1.3 mA to 2.4 mA.

6. What would happen to current flow if the switches in both the arming sensor and one discriminating sensor close?

   At 12 Volts and 2.5 Ohms, current flow would rise from 1.3 mA to 4.8 Amps.

7. What would the voltage drop be across the airbag inflator if the switch in the arming sensor closes?

   V = A x R, or V = 2.8 mA x 2.5 Ohms, or 0.0028 A x 2.5 Ohms, or 7 mV

8. What would the voltage drop be across the airbag inflator if the switch in one of the discriminating sensors closes?

   V = A x R, or V = 2.4 mA x 2.5 Ohms, or 0.0024 A x 2.5 Ohms, or 6 mV

9. What would the voltage drop be across the airbag inflator if the switch in the arming sensor and one discriminating sensor close?

   V = A x R, or V = 4.8 Amps x 2.5 Ohms, or 12 Volts

10. What would current flow be if the arming sensor resistor was open?

    0 Amps. The circuit would be open because the open resistor interrupts the current path (assuming the arming sensor switch is in its default state of 'open').

11. What would current flow be if the airbag inflator was open?

    0 Amps. The circuit would be open because the open resistor interrupts the current path.

[FROM PAGE 2-53 & 2-54] CIRCUIT CONSTRUCTION

Combination Series/Parallel Circuits

Series/Parallel Airbag Exercise – Continued

12. What would current flow be if one of the discriminating sensor resistor was open?
    There's still a complete path, but total resistance would be higher (5,100 Ohms + 2.5 Ohms + 8,450 Ohms = 13,552.5 Ohms. Current flow would drop to under 0.8 mA.

13. What would the voltage drop be across the airbag inflator if the arming sensor resistor was open?
    0 Volts. There would be no electrical pressure difference between those 2 points.

14. What would the voltage drop be across the airbag inflator if the inflator resistor was open?
    12 Volts. There would be no continuity through the inflator, but the electrical pressure difference between those 2 points is equal to source voltage.

15. What would the voltage drop be across the airbag inflator if one of the discriminating sensor resistors was open?
    From question 12, the current flow would drop to 0.8 mA. So V = 0.0008 Amps x 2.5 Ohms, or 2 mV.

16. What would happen to the circuit if there was an additional 100 Ohms of resistance between the arming sensor and airbag inflator?
    Total resistance would rise to 9,427.5 Ohms. Current would drop slightly from 1.29 mA to 1.27 mA.

17. What would the voltage drop be across the airbag inflator if there was an additional 100 Ohms in a connection at the left hand branch of the discriminating sensors?
    Total resistance would still rise, but not by 100 Ohms. Using the 'hard formula' from 2-30 & 2-31, the parallel circuit resistance would be 4,250 Ohms, for a total series and parallel circuit resistance of 9,352 Ohms.

18. What would the voltage drop be across the airbag inflator if there was a 100 Ohm resistor in parallel to the one of the discriminating sensors?
    Parallel circuit resistance would drop to 97.75 Ohms because of the additional path (using the hard formula to calculate), decreasing total resistance to 5,200.25 Ohms, and increasing current flow to 2.3 mA. Therefore, voltage drop across the airbag inflator would be V = 2.3 mA x 2.5 Ohms, or V = 0.0023 Amps x 2.5 Ohms, or .00575 Volts (5.75 mV).

[FROM PAGE 2-54] CIRCUIT CONSTRUCTION

Combination Series/Parallel Circuits

Series/Parallel Airbag Exercise – Continued

19. What would happen to voltage drops and amperage readings if the source voltage was increased to 36 Volts?

    All calculations using Ohm's Law would use 36 Volts instead of 12, so total current flow would triple and voltage drops would triple. Resistance would remain the same.

20. If the DVOM was replaced with a computer, would the computer be able to detect, shorts to ground, opens, shorts to voltage, the addition of unwanted resistance or low resistance in the circuit?

    Absolutely! That's one of the functions of this type of circuit. The computer can watch voltage drop and know whether or not everything is in the default state (resistances all correct and switches in the proper state). Any opens, shorts, or closed switches affect current flow and voltage drop in very predictable ways, giving the engineers a couple of different ways to not only flag a fault, but to make a pretty good guess as to its location.

[FROM PAGE 2-72] CIRCUIT TESTING

Voltage Drop Exercises

Single Load, Open Switch Measurements

For this exercise, we will be focused on voltage drop through an open circuit with a single load. Please write the expected DVOM reading and explanation in the space provided.

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

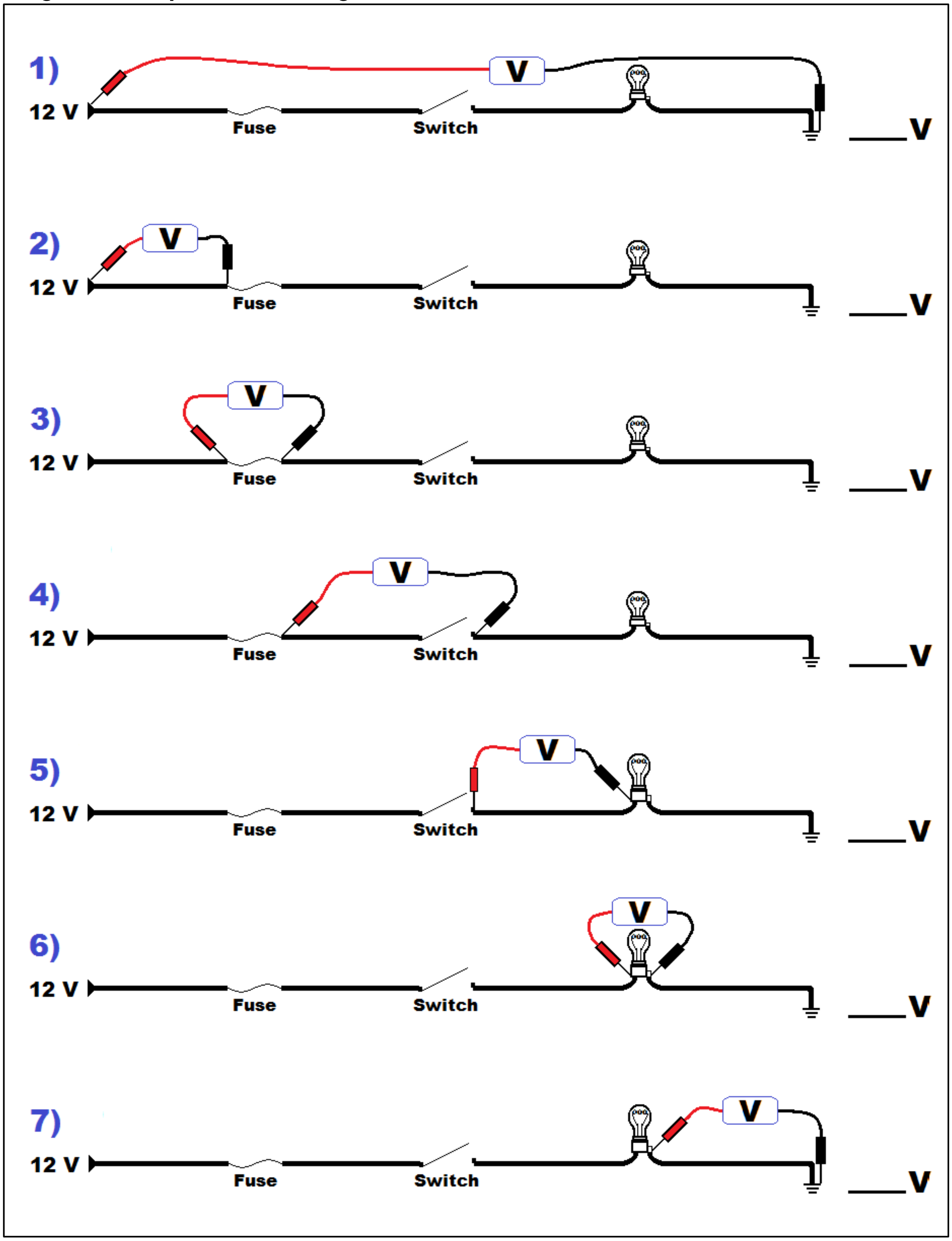
1. What should the DVOM display in the first circuit on the facing page? Why do we see this reading?
   12 Volts. This is the open circuit potential, not a voltage drop.
2. What should the DVOM display in the second circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points.
3. What should the DVOM display in the third circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points.
4. What should the DVOM display in the fourth circuit on the facing page? Why do we see this reading?
   12 Volts. This is the open circuit potential, not a voltage drop.
5. What should the DVOM display in the fifth circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points.
6. What should the DVOM display in the sixth circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points.
7. What should the DVOM display in the seventh circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points.

[FROM PAGE 2-73] CIRCUIT TESTING

Voltage Drop Exercises

Single Load, Open Switch Measurements – Continued

Single Load, Open Switch Diagrams



[FROM PAGE 2-74] CIRCUIT TESTING

Voltage Drop Exercises

Single Load, Closed Switch Measurements

For this exercise, we will be focused on voltage drop through a complete circuit with a single load. Please write the expected DVOM reading and explanation in the space provided.

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

1. What should the DVOM display in the first circuit on the facing page? Why do we see this reading?
   12 Volts. This is the voltage drop.

2. What should the DVOM display in the second circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points unless there's unwanted resistance in the wire.

3. What should the DVOM display in the third circuit on the facing page? Why do we see this reading?
   Near 0 Volts. There's no pressure difference between these 2 points unless there's unwanted resistance in the fuse. A very small voltage drop is normal. Google 'fuse voltage drop chart' or refer to the Appendix for specs.

4. What should the DVOM display in the fourth circuit on the facing page? Why do we see this reading?
   Near 0 Volts. There's no pressure difference between these 2 points unless there's unwanted resistance in the wire or switch contact. It's normal for the switch to drop a little voltage (mV).

5. What should the DVOM display in the fifth circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points unless there's unwanted resistance in the wire.

6. What should the DVOM display in the sixth circuit on the facing page? Why do we see this reading?
   Near 12 Volts. This is the voltage dropping across the load. Any difference between the measurement and 12 Volts is the voltage drop across other parts of the circuit.

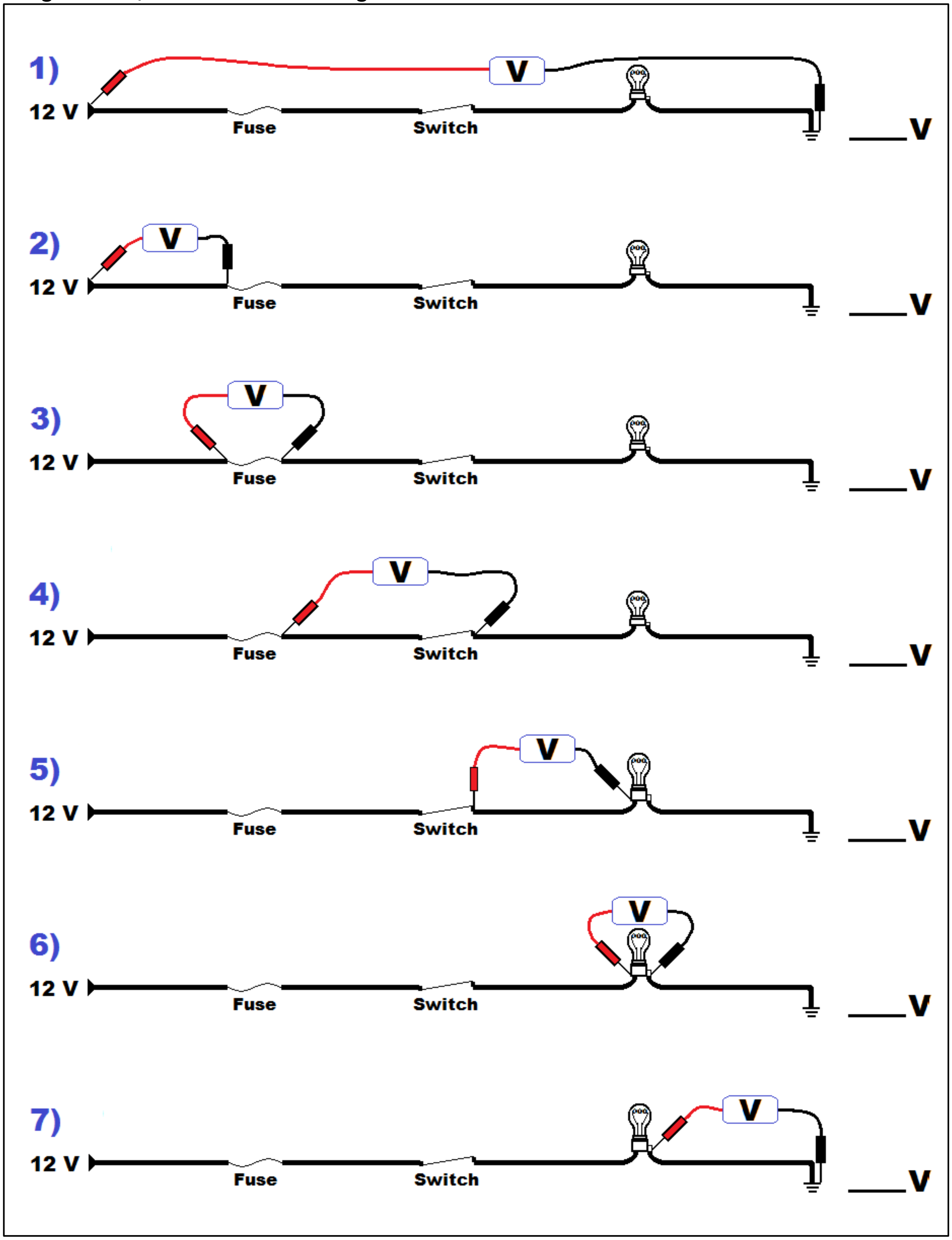
7. What should the DVOM display in the seventh circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points unless there's unwanted resistance in the wire or ground connection.

[FROM PAGE 2-75] CIRCUIT TESTING

Voltage Drop Exercises

Single Load, Closed Switch Measurements – Continued

Single Load, Closed Switch Diagrams



[FROM PAGE 2-76] CIRCUIT TESTING

Voltage Drop Exercises

Multiple Series Loads, Open Switch Measurements

For this exercise, we will be focused on voltage drop through an open circuit with multiple loads. Please write the expected DVOM reading and explanation in the space provided.

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

1. What should the DVOM display in the first circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points because the circuit is open (0 Volts at both sides).

2. What should the DVOM display in the second circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points because the circuit is open (0 Volts at both sides).

3. What should the DVOM display in the third circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points because the circuit is open (0 Volts at both sides).

4. What should the DVOM display in the fourth circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points because the circuit is open (0 Volts at both sides).

5. What should the DVOM display in the fifth circuit on the facing page? Why do we see this reading?
   12 Volts. This is the open circuit potential, not a voltage drop.

6. What should the DVOM display in the sixth circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points because the circuit is open (0 Volts at both sides).

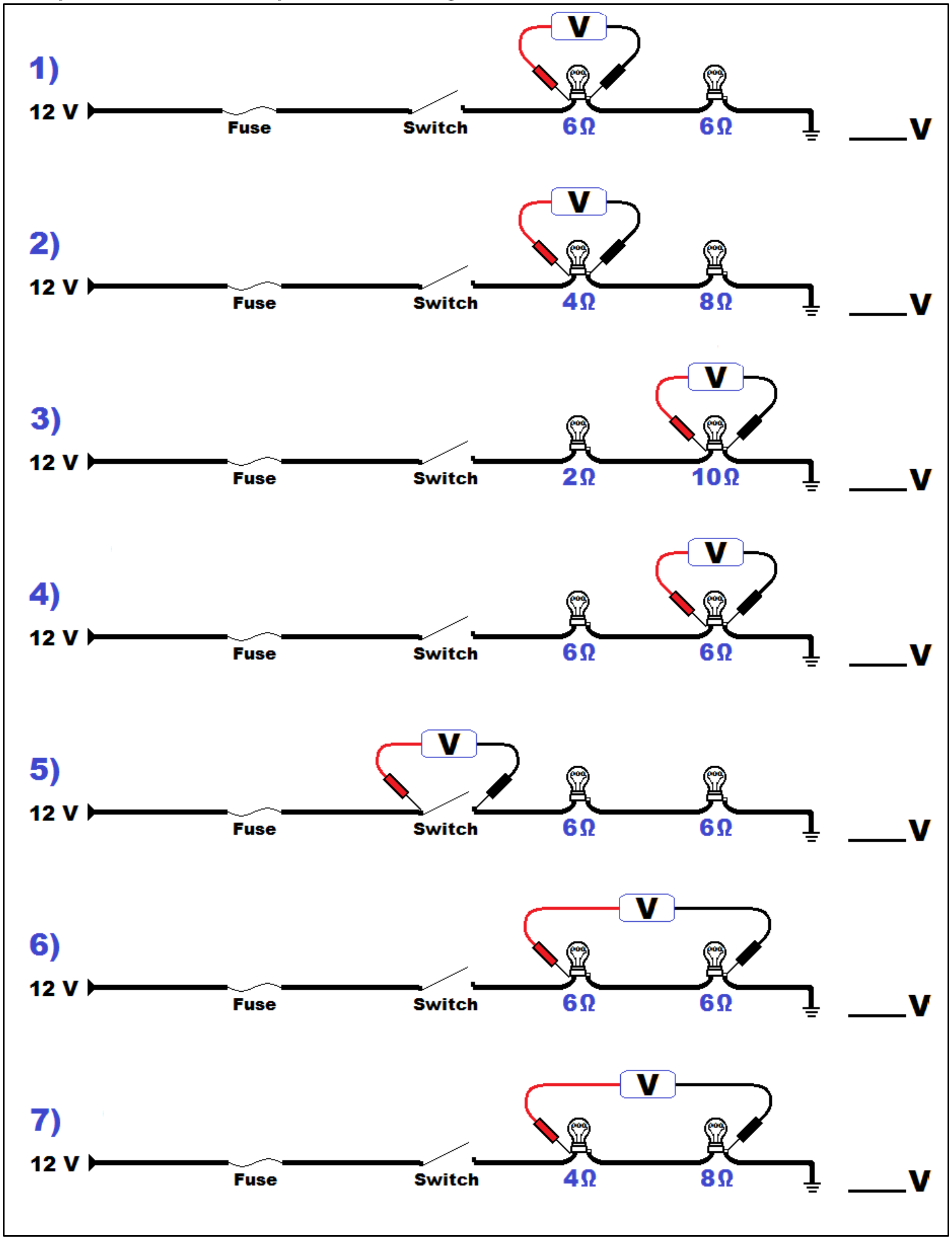
7. What should the DVOM display in the seventh circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points because the circuit is open (0 Volts at both sides).

[FROM PAGE 2-77] CIRCUIT TESTING

Voltage Drop Exercises

Multiple Series Loads, Open Switch Measurements – Continued

Multiple Series Loads, Open Switch Diagrams



[FROM PAGE 2-78] CIRCUIT TESTING

Voltage Drop Exercises

Multiple Series Loads, Closed Switch Measurements

For this exercise, we will be focused on voltage drop through a complete circuit with multiple loads. Please write the expected DVOM reading and explanation in the space provided.

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

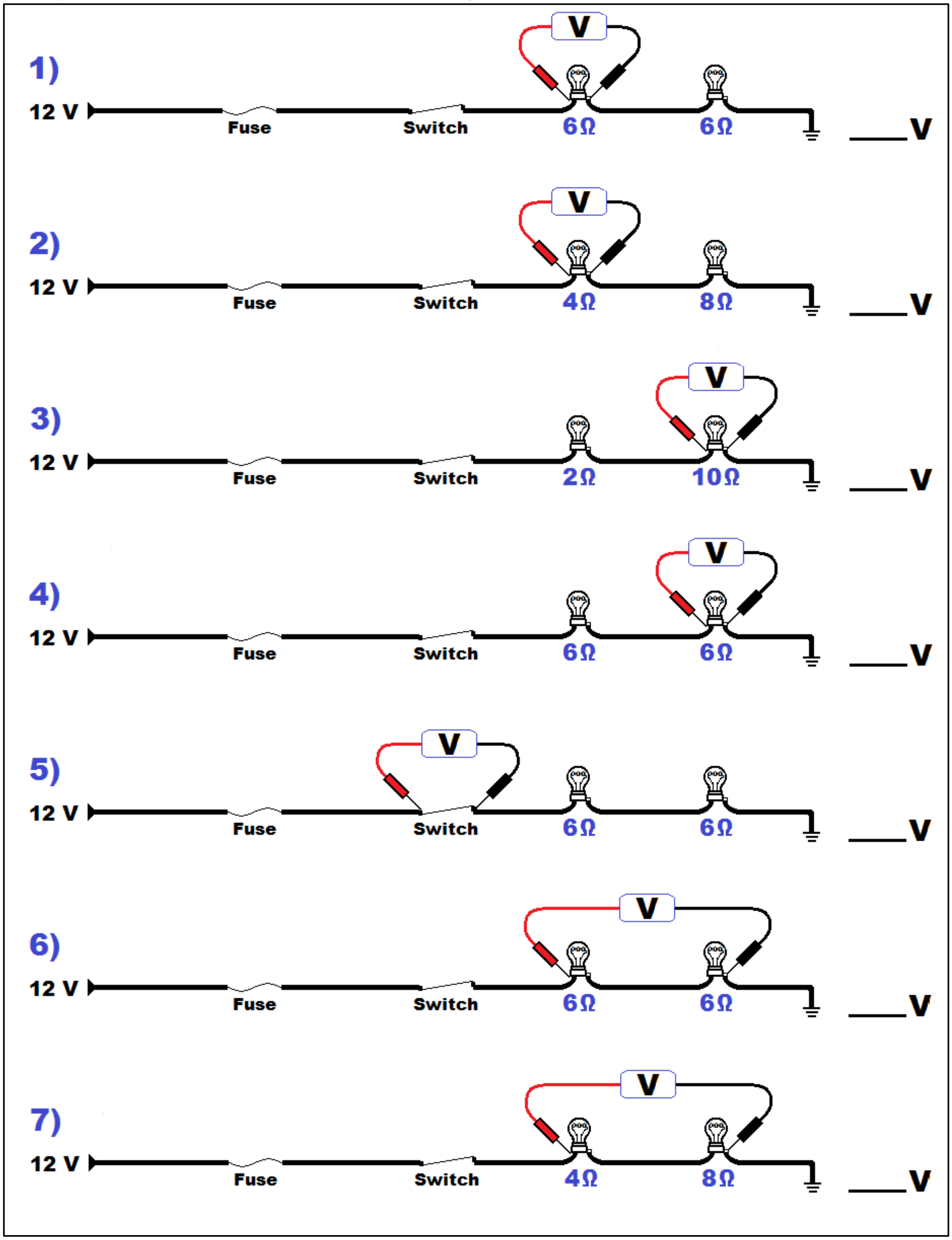
1. What should the meter display in the first circuit on the facing page? Why do we see this reading?
   6 Volts. In this closed circuit, the loads have the same resistance so they each drop half of the voltage (minus any small drops across wires, connections, and other devices).
2. What should the meter display in the second circuit on the facing page? Why do we see this reading?
   4 Volts. 1 Amp is flowing through a total of 12 Ohms. So according to Ohm's Law, the drop through 4 of those Ohms is: V = 1 Amp x 4 Ohms, which is 4 Volts.
3. What should the meter display in the third circuit on the facing page? Why do we see this reading?
   10 Volts. 1 Amp is flowing through a total of 12 Ohms. So according to Ohm's Law, the drop through 10 of those Ohms is: V = 1 Amp x 10 Ohms, which is 10 Volts.
4. What should the meter display in the fourth circuit on the facing page? Why do we see this reading?
   6 Volts. In this closed circuit, the loads have the same resistance so they each drop half of the voltage (minus any small drops across wires, connections, and other devices).
5. What should the meter display in the fifth circuit on the facing page? Why do we see this reading?
   0 Volts. There's no pressure difference between these 2 points unless there's unwanted resistance in the switch contacts.
6. What should the meter display in the sixth circuit on the facing page? Why do we see this reading?
   Near 12 Volts. This is the voltage dropping across the loads. Any difference between the measurement and 12 Volts is the voltage drop across other parts of the circuit.
7. What should the meter display in the seventh circuit on the facing page? Why do we see this reading?
   Near 12 Volts. This is the voltage dropping across the loads. Any difference between the measurement and 12 Volts is the voltage drop across other parts of the circuit.

[FROM PAGE 2-79] CIRCUIT TESTING

Voltage Drop Exercises

Multiple Series Loads, Closed Switch Measurements – Continued

Multiple Series Loads, Closed Switch Diagrams



[FROM PAGE 2-80] CIRCUIT TESTING

Voltage Drop Exercises

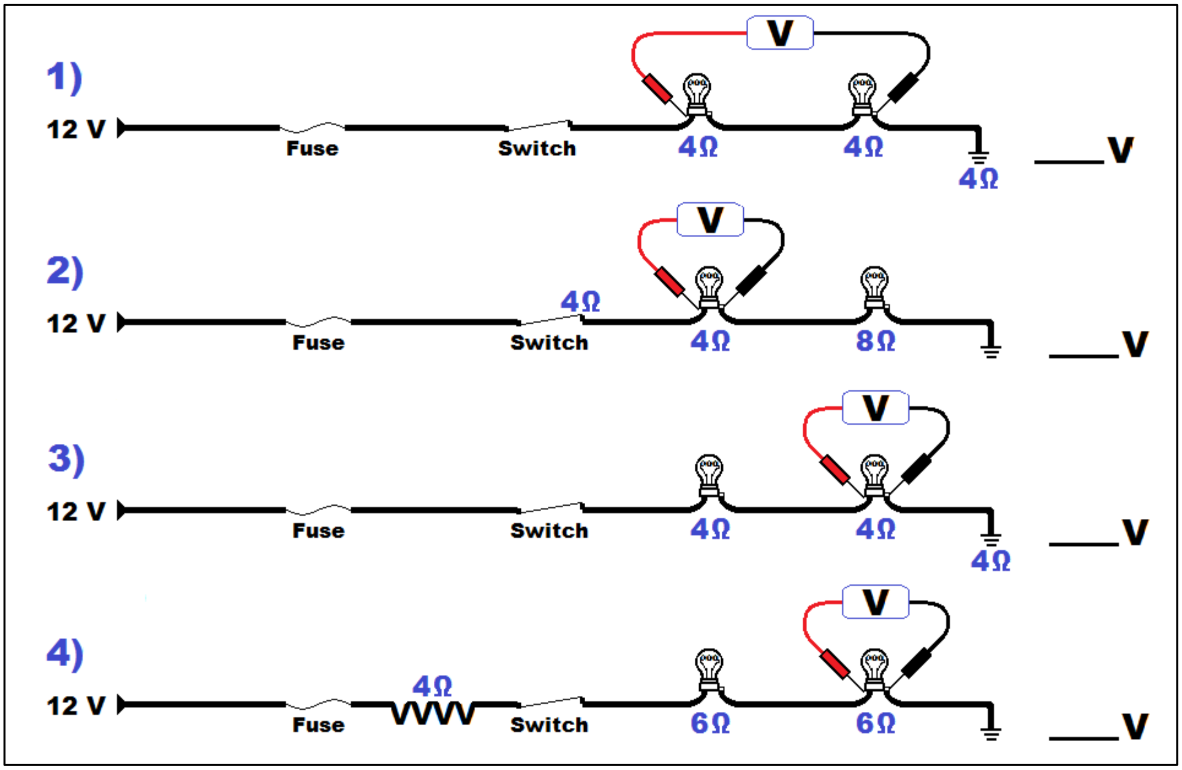
Unwanted Resistance Measurements

For this exercise, we will be focused on voltage drop through unwanted resistance. Please write the expected DVOM reading and explanation in the space provided.

Note: ***For the answers, download the free PDF from www.atgtraining.com under the 'Downloads' tab.***

1. What should the DVOM display in the first circuit below? Why?
   A = V / R, so A = 12 / 12, or 1 Amp. To figure voltage drop across two of the 4 Ohm bulbs, use Ohm's Law: V = 1 Amp x 8 Ohms, or 8 Volts.
2. What should the DVOM display in the second circuit below? Why?
   A = V / R, so A = 12 / 16, or 0.75 Amps. To figure voltage drop across the 4 Ohm bulb, use Ohm's Law: V = 0.75 Amps x 4 Ohms, or 3 Volts.
3. What should the DVOM display in the third below? Why?
   A = V / R, so A = 12 / 12, or 1 Amp. To figure voltage drop across the 4 Ohm bulb, use Ohm's Law: V = 1 Amp x 4 Ohms, or 4 Volts.
4. What should the DVOM display in the fourth circuit below? Why?
   A = V / R, so A = 12 / 16, or 0.75 Amps. To figure voltage drop across the 6 Ohm bulb, use Ohm's Law: V = 0.75 Amps x 6 Ohms, or 4.5 Volts.

Unwanted Resistance Diagrams

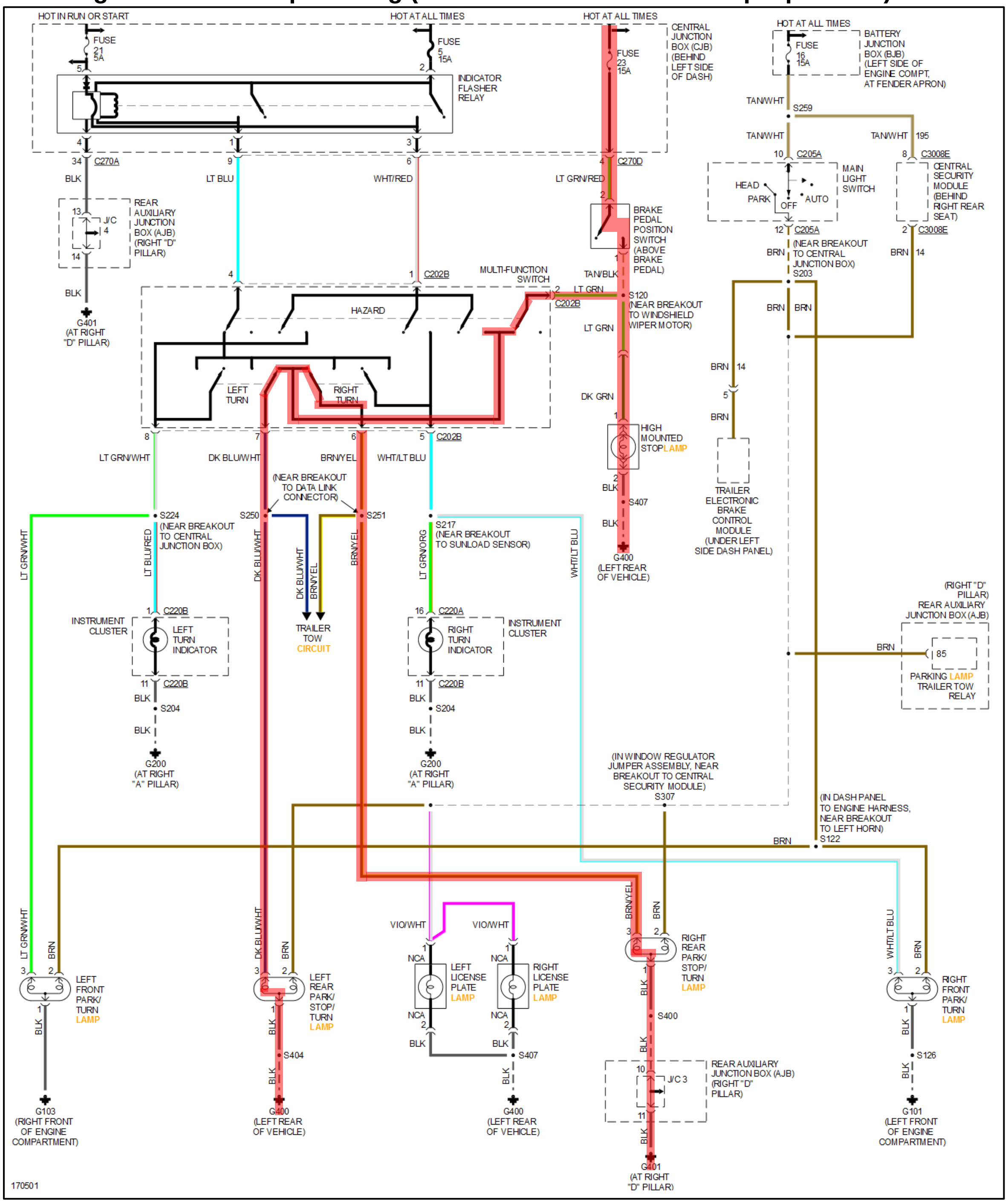


[FROM PAGE 3-121] CASE STUDIES

Short to Power

2003 Explorer 'Whacky' Lighting – Continued

MotoLogic Exterior Lamps Wiring (Use to Trace for Brake Lamp Operation)



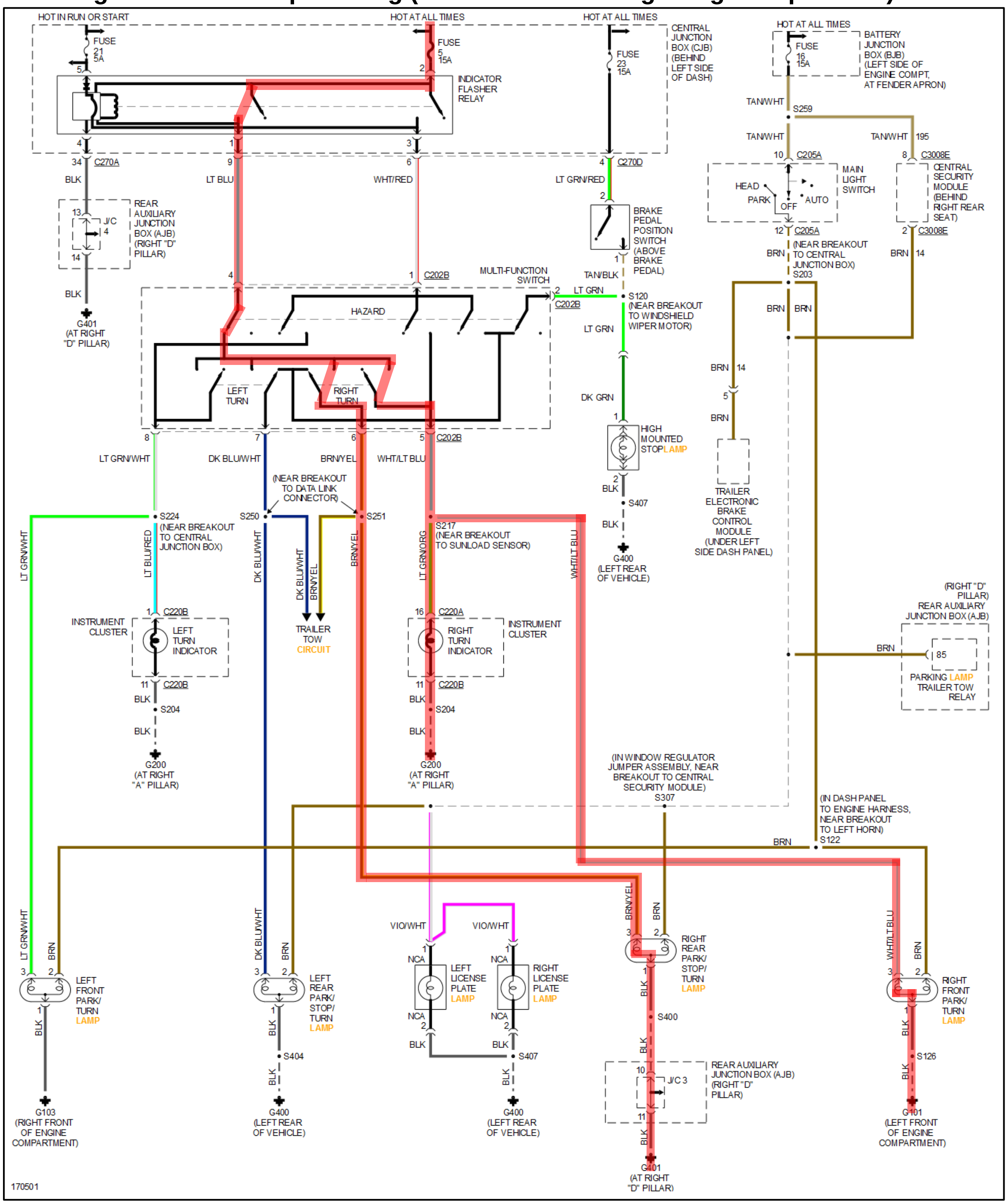
Courtesy of MotoLogic

[FROM PAGE 3-122] CASE STUDIES

Short to Power

2003 Explorer ‘Whacky’ Lighting – Continued

MotoLogic Exterior Lamps Wiring (Use to Trace for Right Signal Operation)



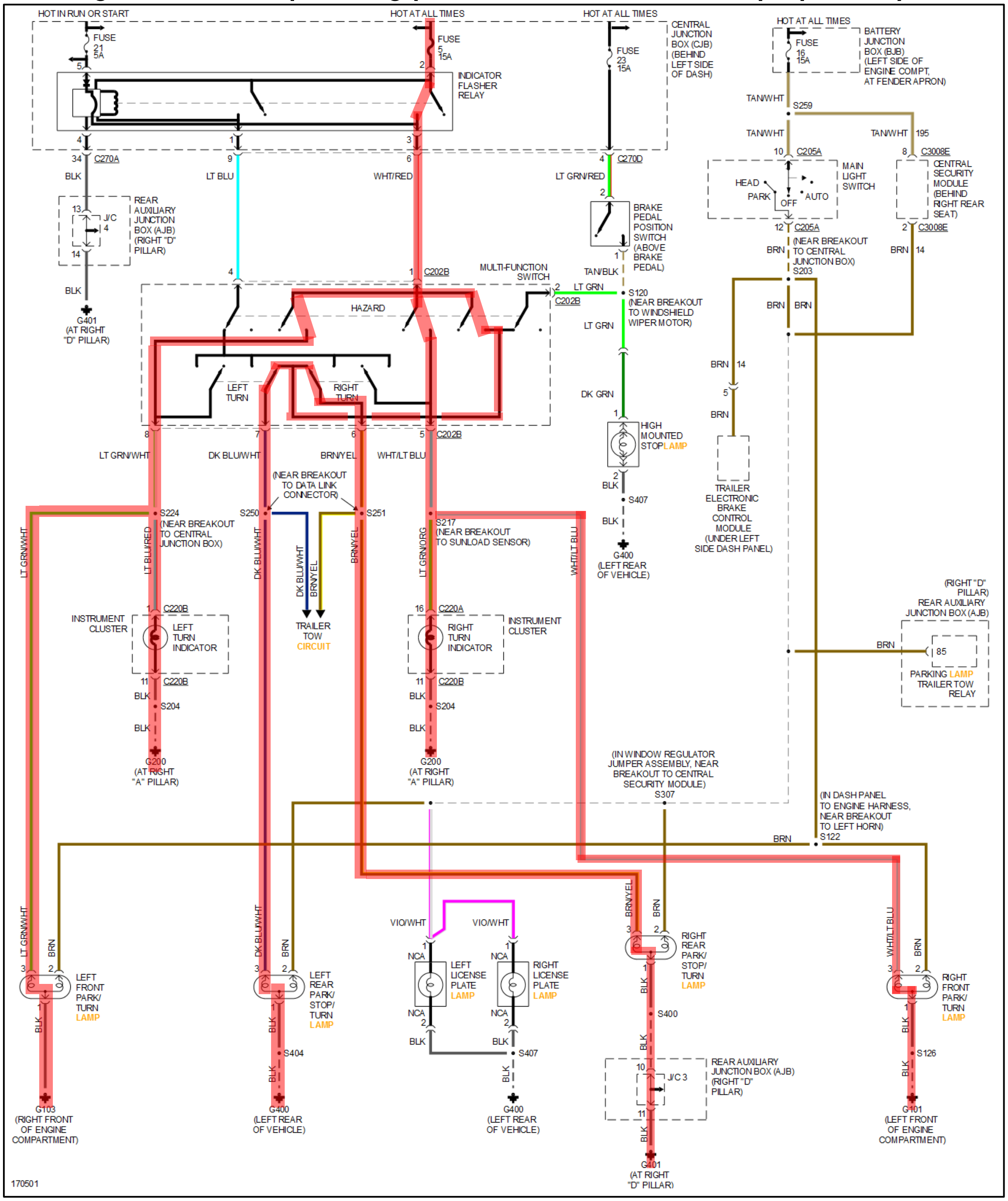
Courtesy of MotoLogic

[FROM PAGE 3-123] CASE STUDIES

Short to Power

2003 Explorer ‘Whacky’ Lighting – Continued

MotoLogic Exterior Lamps Wiring (Use to Trace for Hazard Lamp Operation)



Courtesy of MotoLogic

[FROM PAGE 3-124] CASE STUDIES

Short to Power

2003 Explorer 'Whacky' Lighting – Continued

MotoLogic Exterior Lamps Wiring (Use to Trace for Headlamp Operation)