



Photoillustration: Harold A. Perry; photos: Jupiter Images



WIRING DIAGRAM COLOR- CODING:

More Than Meets the Eye

BY JORGE MENCHU

One of your earliest childhood memories may be a remonstrance to ‘color inside the lines.’ Coloring *on the lines* is a simple tool that can be used to increase your understanding of even the most complicated electrical circuits.

Fueled by creativity and driven by relentless work, Albert Einstein was able to see through the foggy windshield of complexity and find the fundamental principles that are the pavement of our universe. His work laid a foundation that has allowed others to build upon, leading to a harnessing of nuclear energy and space travel. While the technology of automotive repair may not be on a par with nuclear energy or space travel, there is something important we can take from Einstein’s journey: the power of “simple” and the value of the technician’s perspective.

The power of simple is manifested in that others were able to build from the foundation Einstein identified and defined. They were able to accomplish things they most likely could not have otherwise. We also have experienced this phenomenon. Consider Ohm’s law. Georg Ohm did the hard work and broke down the complex to a simple law. We use the principles contained in that law as a starting point to understand the complexities of electricity and circuit dynamics.

WIRING DIAGRAM COLOR-CODING

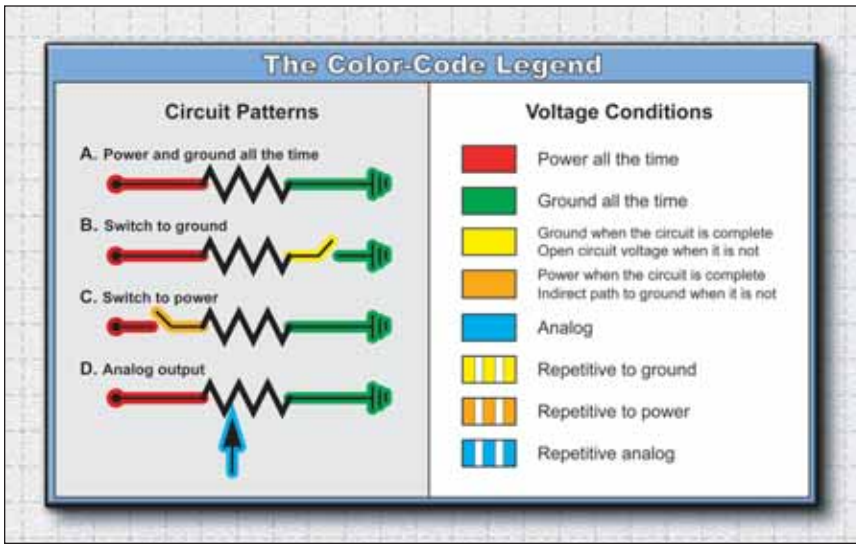


Fig. 1

Illustrations: Jorge Menchu

As a technician, I naturally look at things from a nuts & bolts perspective. As technicians, we understand objects and assemblies. We understand how things come apart and go back together. Isn't this what Einstein and Ohm did? They figured out how "it" comes apart, which led to the ability of others to put "it" back together.

In our experience, we disassemble, repair and reassemble objects we can see and touch. Our goal is a repair. However, to repair today's vehicles, we must expand our understanding beyond things we can touch, see and use wrenches on. We must apply the technician's approach to learning, information gathering and analysis.

Wiring Diagram Color-Coding

Wiring diagrams happen to be a perfect vehicle for carrying the principles of technicians beyond nuts & bolts. First, the simple act of color-coding helps to bring out the true wealth of your knowledge and is an excellent step in diagram analysis. Beyond that, it's an amazing tool for developing the awareness needed to get on the road to becoming an expert learner.

In this article, I show some of the ways the elements of learning, information and the technology fit together. As a result, you'll learn techniques that will increase your analytic and knowledge-building efficiency, which you can apply to any learning challenge.

In the July 1997 issue of *MOTOR* I introduced wiring diagram color-coding in the article titled *Mastering Complex Diagrams*. This article is a complement/update to that one.

The power source for color-coding is the Color-Code Legend (Fig. 1 above). It is to wiring diagrams and circuits as what Ohm's law is to electricity and $e = mc^2$ is to energy and matter.

The Color-Code Legend was born from the process of identifying the simple within the complex. Try it for yourself. Bring together a handful of circuit diagrams and look for the simplified patterns in those circuits. You'll find that every circuit must have a load and every load must have a power side and a ground side. Most circuits are switched

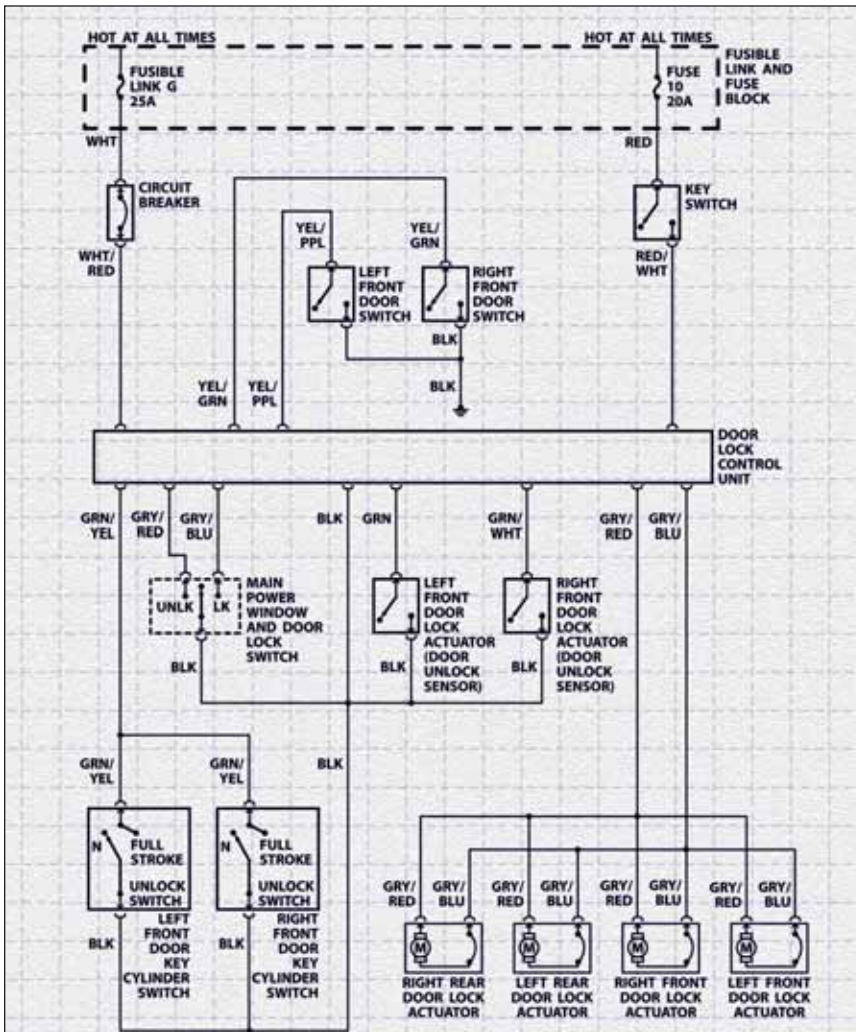


Fig. 2

WIRING DIAGRAM COLOR-CODING

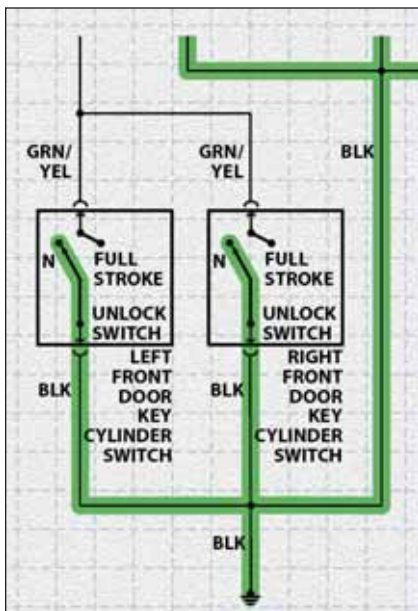


Fig. 3

and some loads are variable. Bring this information together and you end up with the four basic circuit patterns shown in the Color-Code Legend.

The top circuit in the Color-Code Legend is “the one.” It’s a graphical representation of the rules all circuits must abide by. The other three circuits build from it and account for fundamental variations. In addition, all circuits build from at least one of these patterns or a combination of them.

From the technician’s perspective, the Color-Code Legend can best be understood by taking apart its assembly and identifying the subassemblies that make up the whole. Study these simple circuit assemblies and master every aspect of them. If you don’t master the simple stuff, you have no chance with the complex.

Building to a 100% knowledge requires the ability to identify the voltage conditions within these circuits. This is where the colors come in. Each circuit displays a unique voltage condition. In the Color-Code Legend I’ve already highlighted each condition with a color.

Each color/voltage condition should be self-explanatory. Note that yellow and orange, which represent the switched portions of the circuits, actually represent two voltage conditions

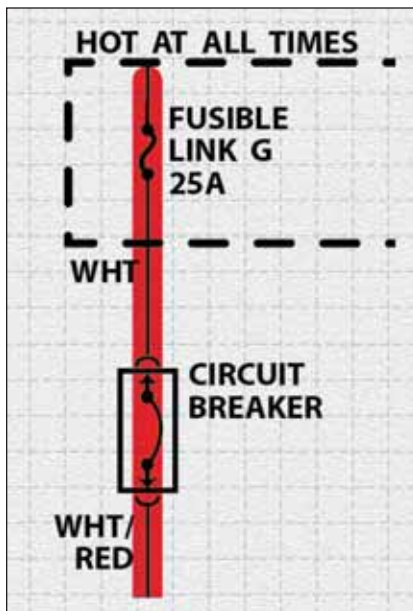


Fig. 4

that depend on the condition of the switch—open or closed.

I’ve made one important change from the ‘97 article. Green and yellow are now swapped. Green identifies ground all the time and yellow is switched to ground. The change was made to reflect a more standardized color-coding based on the colors of a logic probe, where green is logic low and yellow is switching.

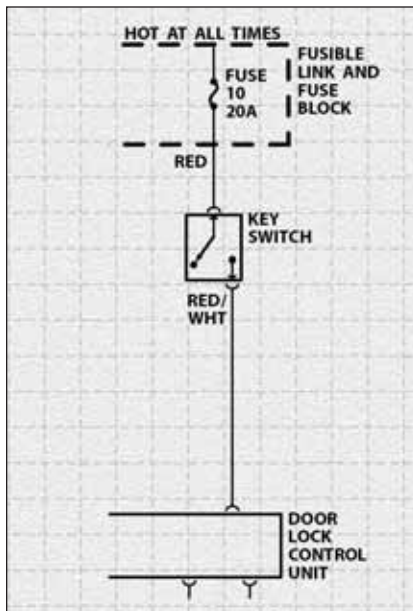


Fig. 5

Is it okay to use other colors? Yes, but I recommend using the colors I’ve selected. Doing so helps to create a standard. Also note that if you have trouble differentiating these colors, try fluorescent highlighter pens.

The next step in mastering the Color-Code Legend is to fully understand the implications of test results for each circuit section/color. For example, if you’re testing a yellow circuit, what does it mean if you read 0 volts? What does it mean if you read a voltage? Can you make a list of all possibilities? You might be surprised at how simple it is.

The process of color-coding is to “pull an Einstein” on the wiring diagram. From the technician’s perspective, instead of being caught up in the complexities of the system, we’re going to find the simple parts, examine them and see how they combine to make the complex. We do this by finding the circuit patterns illustrated on the Color-Code Legend within the diagram, then color-code appropriately.

Before we start, here are three learning patterns that set the framework for the color-coding process:

- Relate new information to existing knowledge. We learn by relating new information to that which we already know. Therefore, *what we know* be-

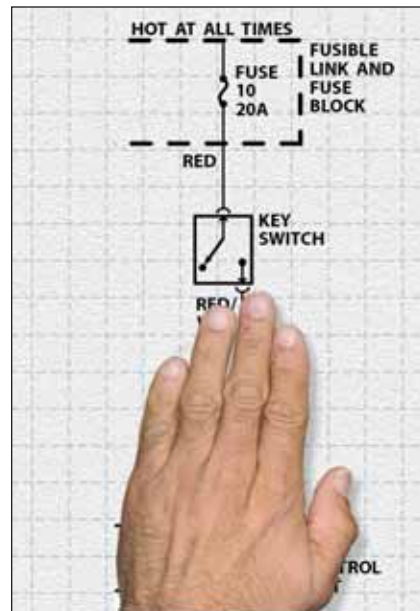


Fig. 6

comes the starting point for learning something new.

- Work from known to unknown. We purposely look for what we *know* first, which will help us resolve what we *kind of know*, which will leave us to focus on what we *don't know*.

- Progress from simple to complex, easy to hard, obvious to not so obvious. Starting with the simplest, easiest and most obvious is a very effective and efficient way of dealing with lots of variables.

Great Expectations

Before color-coding, or before starting any new job, it's a good idea to take inventory of what you know about the system. This establishes an expectation that's a starting point for system analysis that also goes hand in hand with color-coding. While color-coding, look for the graphical representation of your expectation in the diagram!

To help turn your existing knowledge into a concrete expectation, try developing a list of questions to ask yourself. Here are a few to start with:

- What are your past experiences with this type of system?
- What actions must the user take to operate the system and what are the results?
- What are some of the system's design considerations from an engineer's perspective?

Fig. 2 on page 42 is a diagram of a door lock system of a '96 Nissan Altima. In brief, we all know how it works from a user's perspective, a technician's perspective, and we know what functions an engineer had to satisfy while designing it. Think about these things. Imagine them. Now let's color-code.

Our First Color

Our rules say we need to start with the easiest and most obvious. So, which color/circuit section would that be? Green, of course, and here's why: Almost every diagram shows a ground that's usually identified clearly by a ground symbol.

With green crayon or highlighter in hand, locate the ground symbols. Highlight the circuit starting at the symbol and go until you get to a component

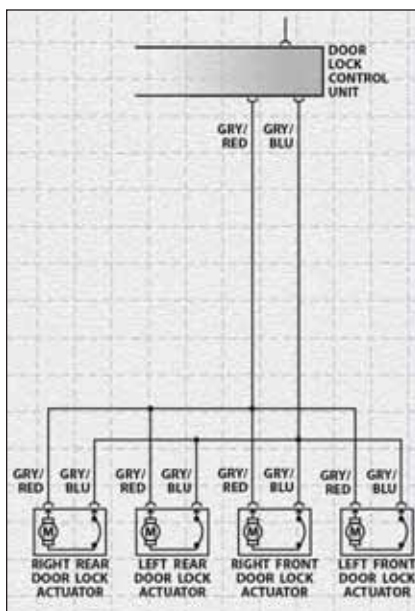


Fig. 7

that changes the voltage condition, such as a switch or load.

What about the dots the wires cross over? If you're not sure, this is a good opportunity to put into practice a powerful learning technique: If you don't know the answer, find the question.

Now step back and do an overview. Look for other applications of the dot and ask yourself these questions: *Could the dot be a component? What if the*

dot represents a junction? Would the rules of circuits be followed or broken?

If you conclude the dots are wire junctions, then the green color should continue to all branches, as shown in Fig. 3 the previous page.

Ready for the next easiest color, red? Remember, *red represents power all the time*. Therefore, red is applied to a section of the circuit that's connected directly to a power source. Don't mix it up with a *hot when on* or a wire connected to power via the ignition switch or any other type of switch.

Did you find any "hot at all times" in this diagram? If so, you might be wondering if you should color through the fuse or circuit breaker. The answer is found in this question: *Under normal conditions, does a fuse or circuit breaker affect the voltage condition?* If the answer is no, color on through (Fig. 4).

Are you done with red? Now, pick another color—orange or yellow, you decide. Check out Fig. 5 and refer to the Color-Code Legend (Fig. 1). What color should the wire between the door lock controller and the key switch be? Before reading on, turn on your self-awareness, look at the circuit, think about it and pay attention to what you're doing. If I asked you to describe how you came to your conclusion, could you?

Perhaps the correct color/voltage

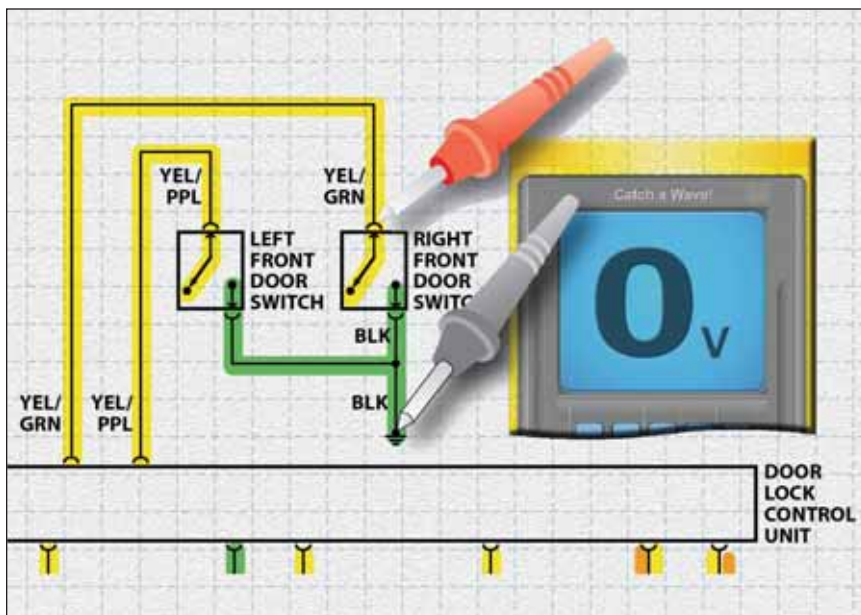


Fig. 8

WIRING DIAGRAM COLOR-CODING

condition is obvious to you. If it's not, then why are you having problems? More than likely you're letting what you don't know control and confuse you.

Try this even if you did identify the correct color/voltage condition: Start with an overview of the circuit by taking inventory of what you know, kind of know and don't know about it. In this

case, we're going to examine each component of the circuit.

- We don't know the voltage condition/color for the section of circuit in question.
- We don't know what's inside the door lock controller.
- We understand the role of a switch.
- We understand that power all of

the time is connected to one side of a switch.

Now let's focus on what we know. We do that by getting what we don't know out of view. This is important to prevent us from getting sucked into the black hole of confusion. Put your hand over the door lock controller and the wire in question, as shown in Fig. 6 on page 44.

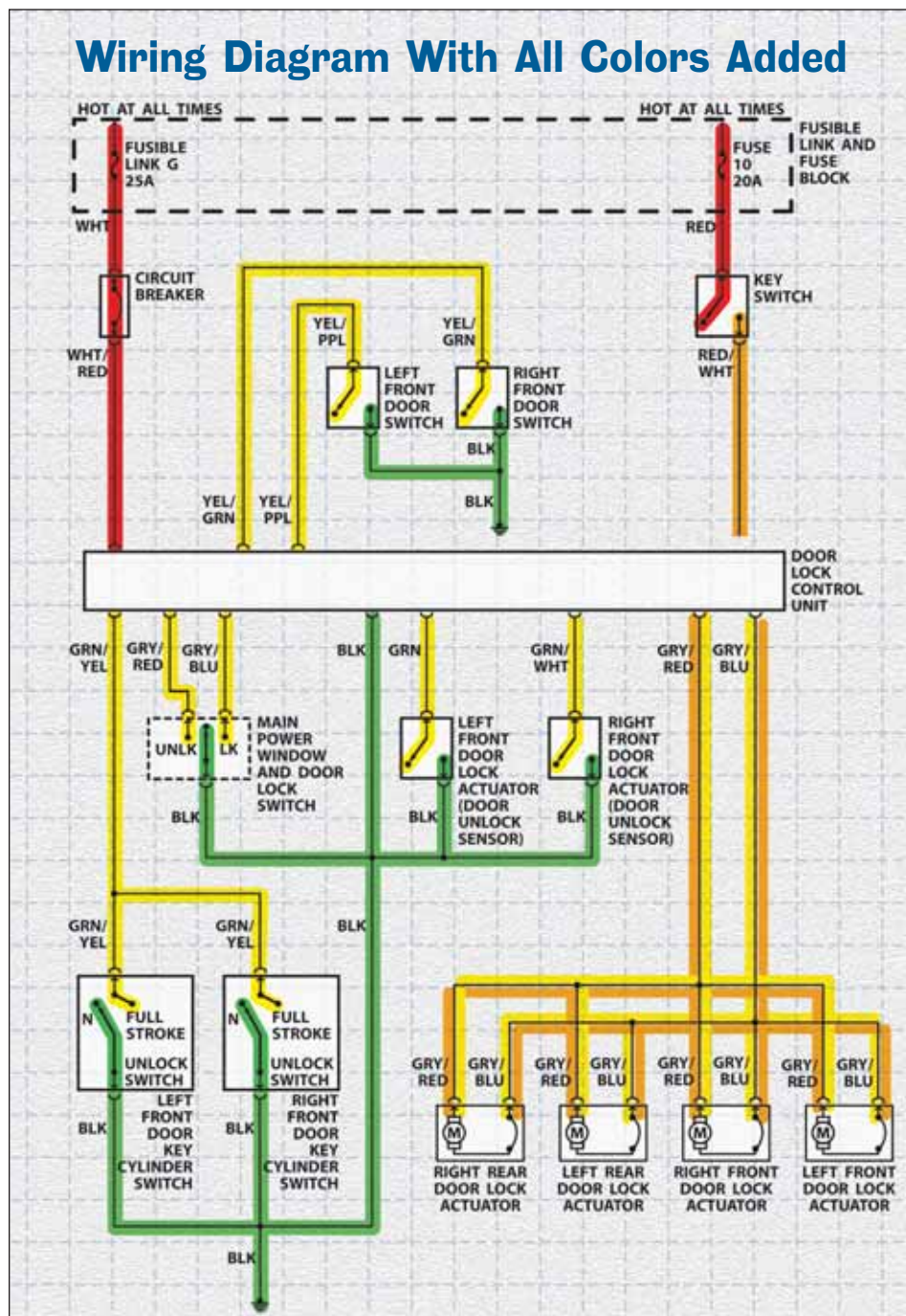
Now look at what you have. A simple switch connected to power all the time. That means only one thing about the wire under your hand: It has to be a switch to power—no ifs, ands or buts. It has to be a switch to power regardless of what else is under your hand. Regardless of what's inside the mysterious door lock controller.

What color represents switch to power? Check the Color-Code Legend! Go ahead and finish color-coding the rest of the diagram.

All done? What color did you use on the wires to the door actuators (Fig. 7, page 45)? The information in the diagram does not indicate a power or ground source. If you put a color on those wires, were you sure about the color you chose, just kind of sure or not sure at all?

Let's take a look. The first thing to realize is that the diagram does not directly tell us what conditions exist there. Therefore, we have to find the answer outside of the diagram. Let's start by reviewing what we already know about the system.

When we initially took inventory about the system, at minimum we thought about the driver's perspective, the technician's and the engineer's. From the driver's perspective, he pushes a button to lock and unlock. From the engineer's perspective, we know there's a mechanism in each door that has to perform two functions—lock and unlock. From the technician's perspective, we can look at the diagram and see that each door has a door lock



actuator that's identified with a motor symbol. If it's a motor, it could just spin a cam to lock and unlock. If this were the case, each motor would most likely be connected to a power or ground all the time and then be switched by the door lock controller. However, if it's an actuator, then it's most likely set up to push or pull, which coincides with the driver's experience.

So, how do you get a motor or an actuator to push or pull or move forward and reverse? The answer is found in the characteristics of motors and actuators. Are they polarity-sensitive? What happens if the polarity is reversed? It reverses the current, which reverses the fields, which results in an opposite action.

Hmm, that explains why there's no clear indication of a power or ground source to the actuators in that diagram. The door lock control unit must alternate the power and ground sides of the actuators, depending on lock or unlock. Since each motor still needs a power

side and a ground side, this means both sides are switched, and when one side is orange, the other side has to be yellow. Reverse the action and it changes to yellow and the other side to orange!

At this point the color-coding should be complete. Examining the diagram should reveal the visual organization color-coding results in.

The colors also expose the similarity in testing of the circuits. For example, regarding all circuits coded yellow (Fig. 8, page 45), if you read 0 volts, then it's most likely for one of these reasons: 1. the voltage source is dead, 2. there's an open between the test point and the voltage source; 3. there's a short to ground between the load and the switch; 4. the circuit is complete between the test points and "switched to ground."

Conclusion

Visually organize a wiring diagram. Prove the diagram at least holds up to the fundamental laws of circuits. Identify

similar testing procedures. Clearly see the value of building your knowledge from simple to complex. Maximize your existing knowledge and make yourself more efficient.

Then use color-coding to keep you moving along the road to becoming an expert learner. Use color-coding to help you:

- Develop self-awareness and a built-in signaling system that keeps you on track.

- Develop learning awareness so you can identify the patterns and techniques of learning.

- Continue to learn and build your knowledge and understanding of technology.

It's just like the parts of an engine. If you put them together in the right order, you'll end up with a smooth-running engine. See you on the road!

This article can be found online at www.motormagazine.com.

WANT TO FIX IT IN 26 OR 6?

PROBLEM: 2003 CHEVROLET TAHOE MANUAL HVAC SYSTEM: THE DRIVER'S SIDE TEMPERATURE CONTROL IS IN-OPERATIVE

TROUBLE TREE DIAGNOSTIC

1. Did you perform the HVAC Diagnostic System Check?
2. If YES, Go to Step 2
3. If NO, Go to Diagnostic System Check - HVAC Systems - Manual
4. Important: If during this diagnostic procedure the HVAC control module is disconnected a recalibration of actuators must be performed to avoid misdiagnosis.
5. Recalibrate actuators. Refer to Actuator Recalibration.
6. Turn ON the ignition, with the engine OFF.
7. Observe the Diagnostic Trouble Code (DTC) List in Heating and Air Conditioning.
8. Does the scan tool display any DTC, B0414, B0424 or B3770?
9. If YES, Go to Diagnostic Trouble Code (DTC) List
10. If NO, Go to Step 3
11. Turn ON the ignition, with the engine OFF.
12. Place the blower motor switch in each speed position.
13. Does the blower motor operate in any of the speed positions?
14. If YES, Go to Step 4
15. If NO, Go to Blower Motor Inoperative
16. Does the blower motor operate at the desired speed?
17. If YES, Go to Step 5

CONTINUED ON PAGE 124



CONFIRMED FIX:
REPLACE TEMPERATURE ACTUATOR

IDENTIFIX DIRECT-HIT

1. Tap on the control head and drivers temperature actuator to see if the actuator starts to work.
2. Check at the actuator: 12 volts on the Brown wire, 5 volts on the Light Blue and Black wire, Ground on the Yellow wire.
3. Monitor the voltage on the Dark Blue wire at the drivers temperature actuator after disconnecting and reconnecting the control head and starting the engine. It should be the same as the signal on the White and Black wire on the passenger side temperature actuator.
4. Check for loose terminals at the actuator and the HVAC control head.
5. Check for loose or backed out terminals at the right Instrument Panel (IP) junction block connectors C4, C5 and C8 if the above voltage checks are incorrect.
6. If all tests pass, the temperature actuator is defective.

When was the last time a trouble tree got you to a confirmed fix in less than 6 steps?

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