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The key to isolating the cause of the misfire is to understand what a misfire really is. Let's take an in-depth look!

30 **ADVANCED CONCEPTS FOR THE 12-VOLT TECH**

With the introduction of EVs that feature high-voltage AC- and DC-based components, let's seek to expand the knowledge of a 12-volt tech.

**THE TRAINER:
AVOID THESE
COMMON
CAUSES OF A/C
COMPRESSOR
FAILURE**



EXPLAIN SERVICES EASIER THAN EVER

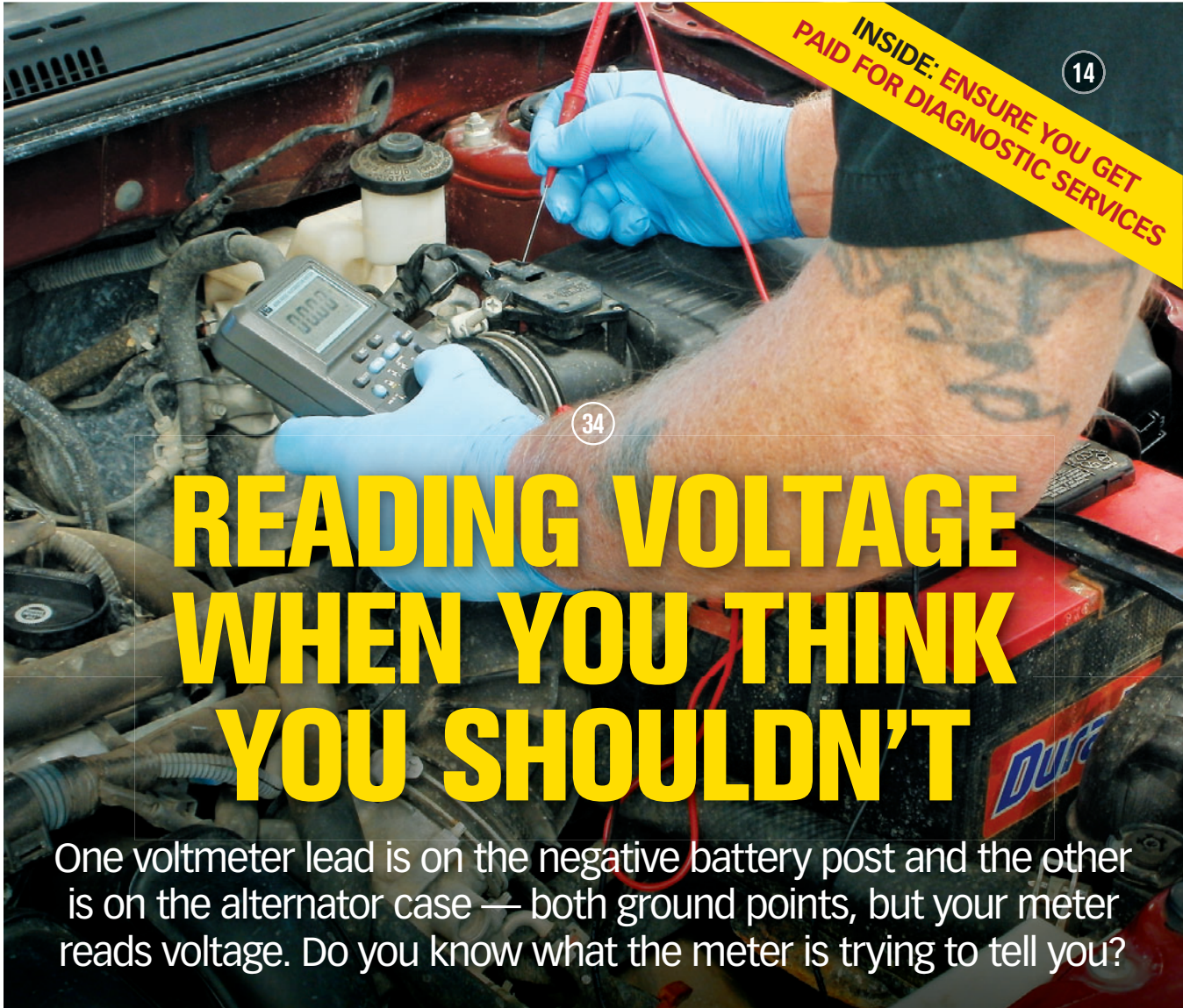


MOTOVISUALS
SERVICE & REPAIR ANIMATIONS



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READING VOLTAGE WHEN YOU THINK YOU SHOULDN'T

One voltmeter lead is on the negative battery post and the other is on the alternator case — both ground points, but your meter reads voltage. Do you know what the meter is trying to tell you?

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GET EASY-TO-FOLLOW WIRING DIAGRAMS

Gary Hixson, marketing manager for ProDemand with Mitchell 1, walks you through how the update can help you find the exact wiring diagram you need, which can then make you a more efficient and accurate diagnostician.

Using real wiring diagrams, Gary shows how the update takes seemingly simple ideas and brings them to life. No more flipping through 16 pages of wiring diagrams to find one small section. Jump to the area you need. Interactive diagrams allow you to click on components to highlight wires. Highlight the entire length of the wiring to keep your place from page to page. Bringing together a variety of information into a wiring diagram, Mitchell 1 illustrates how the new features can improve your skills. Watch and learn how to utilize the update for yourself.

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INDUSTRY TRAINING

ASA NORTHWEST TO HOST 12TH AUTOMOTIVE TRAINING EXPO

PETE MEIER //
Director of Training

➔ March offers the professional technician, shop owner and educators three impressive training opportunities: VISION, the TST Big Event and ASA Northwest's Automotive Training Expo — more commonly referred to simply as "ATE."

With the challenges facing our industry, it is more important than ever to stay up with the changes. Automotive technology is increasing at a pace never before seen and even what you learned

a few years ago can be, in some cases, already antiquated information. ATE offers its attendees an excellent value for their training dollar. Two and half days of leading technical and management seminars with more than 60 presentations to choose from, all vetted by the ASA Northwest training committee to ensure that the content meets the needs of those attending.

In addition to the training, a trade show hall provides you with the opportunity to interact with more than 50

>> ATE CONTINUES ON PAGE 6

BREAKING NEWS

LEGISLATION

VA GOVERNOR CALLS TO ELIMINATE SAFETY INSPECTION PROGRAM

➔ In his budget briefing, Virginia Gov. Ralph Northam unveiled plans to eliminate the state's motor vehicle safety inspection program.

The Automotive Service Association (ASA) opposes the elimination of state vehicle safety inspections and believes these programs benefit the motoring public. ASA is urging Virginia repairers and vehicle owners to go to this link to send a letter to their representatives in opposition to these bills.

"Regular safety inspections by a qualified technician can identify and repair most safety issues arising from normal wear and tear on the vehicle," ASA Washington D.C. representative Bob Redding said.

That, however, is contrary to the Virginia governor's opinion.

According to Northam, "data shows that there is no connection

>> VA CONTINUES ON PAGE 6

TRENDING

REGISTER FOR ACPN CONFERENCE

The Automotive Content Professionals Network Knowledge Exchange Conference, set to take place May 3-6 at the Hyatt Regency Seattle in Seattle, Wash., is now open for registration.

MOTORAGE.COM/ACPN47

TECHFORCE LAUNCHES NEW CAMPAIGN

The TechForce Foundation has launched the "Be a Pathfinder" campaign to highlight education and career opportunities for students who have a natural talent for working with their hands.

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ASE INTRODUCES NEW LANGUAGE OPTIONS

Since January 2020, technicians taking certain ASE certification tests — A4, A5, A6 and G1 — will have the option to see each question in a split-screen Spanish/English format.

MOTORAGE.COM/SPANISH

NASTF ANNOUNCES ELECTION RESULTS

The National Automotive Service Task Force (NASTF) is pleased to announce the overwhelming approval of the 2020 NASTF Board of Directors and officer election slate.

MOTORAGE.COM/ELECT

NEW TECHNOLOGY AT CES 2020

Hyundai, Hexagon and Valeo presented a new technology capable of pinpointing a vehicle's exact location while on the road using High-Precision Positioning to further enhance safety systems.

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>> **ATE CONTINUED FROM PAGE 4**

aftermarket companies ranging from big parts houses to diagnostic equipment manufacturers. At the same time, it's a great chance to mingle and network with others and build both business and personal relationships that will last a lifetime.

The host venue, the Doubletree by Hilton Seattle Airport hotel in SeaTec, Wash. (just outside of the city of Seattle) is conveniently located just minutes from the Seattle International airport and shuttle service is available to and from. The event is entirely contained in one place, making it easy to find your way from class to class, and the included

meals in between.

Technicians — you've likely heard the term "ADAS." But do you truly know what it means? And more importantly, do you understand that you may be unknowingly changing how these systems work, just from performing a "routine" repair or service? That's only one reason you need to stay current in your technical education. And if you have any "shorts" in your fundamentals, then mastering these advanced systems is even more of a challenge.

Shop owners — take advantage of this opportunity to build your team and your culture of continuing education. The lessons learned in the various classes can

be the start of building a new sense of purpose in your shop or take your business to the next level — it all depends on you and the example you set.

Teachers — not only can you earn continuing education credits by attending, there is also a featured event just for you! Join together with attending shop owners for the ATE Educators' Roundtable, a sharing of thoughts and ideas for all. Think of it as your Industry Advisory Council on steroids!

No matter what role you play in the industry, there is something for you at ATE!

Be sure to stop by the Motor Age Training booth and say "Hi!" **TL**

>> **VA CONTINUED FROM PAGE 4**

between highway safety and these inspections. That's why 35 other states don't have them."

Additionally, Northam believes the program is an unnecessary expense for Virginians and that elimination of the program will help save consumers millions.

Northam would like to eliminate the vehicle safety inspection program and reduce vehicle registration fees by half. He would also like to raise the state's gas tax to increase funding for Virginia's transportation system.

The Virginia House of Representatives and Senate have each introduced their own versions of bills aimed at eliminating the state's motor vehicle safety inspection program. Virginia is one of 15 states with programs designed to protect the motoring public.

The University of Texas at Austin and the Pennsylvania Department of Transportation both have completed studies that support periodic motor vehicle safety inspections. They also have concluded these inspections do improve motor vehicle highway safety. **TL**

DRIVE 2020 TO BE LARGEST IN EVENT HISTORY

MOTOR AGE WIRE REPORTS //

DRIVE EXPO 2020, set for August 28-30, 2020, will showcase a full line-up of premier industry brands, influential auto aftermarket executives and a collective of educational seminars — all tailored for the repair shop owner.

Among the many leading companies to be represented at DRIVE EXPO 2020 will be BOLT ON TECHNOLOGY and TEKMETRIC. Both are returning to the EXPO. Each knows the importance of having the unique opportunity to speak directly with each business owner attending as an invaluable tool for their

respective business strategies.

BOLT ON TECHNOLOGY Founder and CEO, Michael Risich, says "The DRIVE clients that attend the EXPO are a great match for BOLT ON. Our team can't wait to meet with — and learn from — everyone at this event."

TEKMETRIC Co-founder and CFO, Prasanth Chilukuri, adds, "DRIVE'S proven training techniques, combined with TEKMETRIC'S innovative cloud-based shop management software empowers shop owners with industry leading training and technology. We are ecstatic to partner with DRIVE, a world-class organization that is committed to the success of repair shop

owners and their well-being"

DRIVE Vice President of Sales, David Saline adds, "The upcoming DRIVE EXPO will be the most comprehensive and extensive since we began the EXPO. It is our mission to bring shop owners and best-in-class exhibitors together for this 3-day event."

In addition, Carm Capriotto of RemarkableResultsRadio will be included over the 3-day EXPO. As a preeminent industry advocate, Carm's resource catalog has more than 600 audio workshops where the aftermarket professional can learn about insights and trends shaping the future of this industry. **TL**

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Move beyond fixing cars to provide great experiences

Understand that customers buy based on feelings

This month, we examine a challenge we all face, but few of us realize what it does to our customers and associates. Let's listen to a former shop owner and now ATI Performance Coach, Charlene L. Parlett, AM.

I grew up in a mechanic's home. During the day, my father was a manager at the largest motorcycle dealership in the state. Evenings and weekends, he worked out of his home garage on British and European motorcycles. Fewer and fewer places wanted to deal with these bikes, so he got referrals from a lot of shops and owners' clubs. Most weekends I hung out in the garage with my dad helping him take apart an engine, clean parts in the varsol tank or shine up a bike that was ready for the owner to pick up. Every weekend there would be five to 10 people hanging out at the garage. One was a journalist for a major Washington, D.C., paper. Another owned several businesses. Several master auto techs were also among the regulars, fascinated with the similar-

ities and differences between working on these (now classic) motorcycles and automobiles. The conversations were rarely about the bikes — they were often (respectful) dialog on different political views, the latest findings in *National Geographic* or *Popular Mechanics*, and a lot of good-hearted ribbing about whose bike was going to take awards at the next event.

SUCCESSFUL SHOPS VIEW EACH CUSTOMER AS A POTENTIAL LIFELONG RELATIONSHIP.

These men and women loved spending a Sunday afternoon hanging out in a motorcycle shop. My dad's garage was nothing special. There was no spotless waiting room, no free snacks and everyone was expected to work while they were there, either taking something apart or cleaning up. But my dad made them feel welcomed, ac-

cepted, fun, challenged. They were there because it felt good to bring their bikes to him, and their friends to him, and their friends' friends to him.

Remember why you started a business

When I ask shop owners what made them want to own their own shop, their big WHYs are almost always "I knew I could take better care of customers than the person I worked for;" "I wanted to spend more time with my family;" or "Owning my own shop was always a dream of mine." I rarely meet a shop owner who says they opened their shop to get rich. While having more money is always a factor, it is never their first answer to why they became a shop owner.

For me, owning my own shop was all about great customer service. I wanted to be the place people knew they could trust to be honest, fair and do great work. And it was. But after a few years of daily grinding, we forgot what our real reason for starting the business was. We worked from open to close and many hours beyond that. We began to see customers and employees as necessary evils. We took home smaller paychecks than we ever did as employees of someone else.

We started to think all we did was fix cars. The danger is that the cheapest guy in town does, too. I wanted to be more than that to my customers. We had to remember our big WHY.

"People buy feelings . . . how your business anticipates those feelings and satisfies them is your product."¹



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Treat customers how you'd like to be treated

Think about a restaurant you really love. Is the food extraordinary? Maybe — but if the tables are filthy, the bathroom scary, the servers smell like ashtrays, and your order is wrong, it won't matter how good the food is — you won't be back. So, think about it again. Do you look forward to going there? Do you go often enough that the host smiles and recognizes you? Do you have a favorite drink they bring you without asking? Does it have mood lighting, attractive décor, aromas that entice? The more you think about it, the more the food becomes secondary. Yes, it has to be good food prepared correctly — but the good food isn't the main reason you love to go there. You go there because it feels good to go there — soothing, romantic, exciting, appreciated.

Think about the worst place you ever worked. Why was it the worst? Did your manager treat you badly? Were you constantly being asked to put in extra hours when you wanted to go home? Did you dread going to work each day? The worst thing about it was probably not the job duties; it was how you felt about being there.

People buy feelings

Why should you care how people feel about your shop? Because people (both customers and employees) buy based on feelings.

How do your customers feel about you? Are they frequent visitors? Do they introduce friends and new neighbors to you? Do they leave a review about their wow experience — or do you just fix their cars? If you review your database and the majority of customers never darken your door a second time, it's probably because all you did was fix their car. You didn't make them feel special, important, valued, appreciated. You made them feel like a transaction.


Successful shops view each customer as a potential lifelong relationship. That first phone call or service is a first date; we want that second date, and third and fourth. They can get their car fixed at a dozen other shops; they come back because it feels good to bring it back.

Another indication that your shop is creating a great customer experience is the score you get when you complete ATI's Customer Service Evaluation Tool. The higher the score, the more likely that your shop is doing everything right to keep your customers happy. If you're low on the scale, at least you'll know that you have work to do and where to start.

Create an experience-centered culture

How does your crew feel about you? Do they show up early to chat with you and each other over coffee? Are they smiling throughout the day? If you want better productivity in the shop, evaluate why productivity is low. Do you have a training issue (head), a tools issue (hands) or a culture issue (heart)? If it is a culture issue, be honest with yourself about how that happened and what you need to do to fix it, because it's already hurting your profitability. They'll be more likely to stay long-term with you. A 2017 Gallup report states, "The modern workforce knows what's important to them and isn't going to settle. Employees are willing to look and keep looking for a company whose mission and culture reflect and reinforce their values."² Your service advisor and technicians will be more productive and provide better customer service when they see their job as having significance, and something they look forward to each day.³ In the midst of the worst technician shortage we've ever faced, a positive work environment and a great manager/owner are non-negotiables in a technician's decision to move to another shop.

How about you? Do you look forward to going to the shop? Or have the reasons you stepped into ownership been pushed to the side to make it through each day? Even a good shop owner with a positive attitude gets stuck in the weeds and forgets to make time to work on the big picture. So, take a step back and remember why you opened the doors on that first day. Was it to take care of people? Spend time with family? Give back to your community? Can your customers and team members feel that big WHY when they come in the doors? Or — do you just fix cars?

To find out where your shop stands, get ATI's Customer Service Evaluation Tool. Answer a series of questions, get a score and see how you rank on the customer service scale. Simply go to actionlinetraining.com/2020-02 for a limited time. 

Sources:

1 "The E-Myth Revisited: Why Most Small Businesses Don't Work and What to Do About It," by Michael Gerber

2 <https://news.gallup.com/reports/199961/7.aspx>

3 <https://www.forbes.com/sites/victorlipman/2013/09/23/surprising-disturbing-facts-from-the-mother-of-all-employee-engagement-surveys/#5686c7693120>



CHRIS "CHUBBY" FREDERICK

is the CEO and founder of the Automotive Training Institute. ATI's 130 full-time associates train and coach more than

1,700 shop owners every week across North America to drive profits and dreams home to their families. Our 32 full-time Certified Performance coaches have helped our members earn over ONE BILLION DOLLARS in return on their coaching investment since ATI was founded. This month's article was written with the help of former shop owner and ATI Performance Coach, Charlene Parlett, AM.

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Management development is a process, not a seminar

In Part 2 of this series, learn the shop owner's responsibility in the process

Jobbers and WDs tell me shop owners are not interested in business management courses. This is true based on the fact jobbers and WDs sold seminars in the past and called them business management seminars or courses. They, in fact, were not. They were sales courses or product information seminars. This industry does not need another sales course. The jobber and WD have failed their customers. The trust was and has been broken and that is not fixed overnight. They sold the shop owners sales courses and seminars focusing on sales techniques making the shop busier through increased activity and selling more parts, forcing shop owners to work harder and not smarter. Sales went up, but income did not. The credibility of these jobbers and WDs is gone in many areas of the country.

Many shop owners, as licensed technicians, are nervous about approaching the real issue of shop business management on their own. I've heard from them, "I will not understand, as I wasn't that good in school at math and English;" "I'm a tech, not a pencil pusher;" "I would embarrass myself;" "That's why I have a bookkeeper because business management is nothing but numbers and paperwork that bean counters have to understand and prepare for the government." These reasons are seldom spoken to their jobber or WD — instead, they say to their jobber or WD, "It is too expensive;" "I don't have time;" "I don't need another course, I know what I'm doing;" "No one can show me something I don't already know;" or "That stuff isn't worth it anyway — it's different here." To all shop

owners clinging to these "excuses," wake up and do the math. You bought yourself a job and you know it, and you are covered in debt that has increased your stress to undesirable levels, which is affecting your family relationships. Do you want to do something about it or not? If not, then please stop your complaining and whining and accept your future consequences.

THIS BUSINESS HAS CHANGED. IF YOU ARE GOING TO REMAIN, YOU MUST CLEARLY UNDERSTAND BUSINESS MANAGEMENT AS A CEO.

Understanding real shop business management is easier than you think; however, you must work with it because it has not been part of your daily activity in your shop throughout your career. If you are a shop owner and a licensed technician, you can grasp and understand proper business management! However, the real question is do you want to learn? If you don't want to learn, then no one can help you and you should wind down your business and get out now while you can as the next three years are going to be challenging to say the least!

If you do want to learn, then plan the time now and enroll into a proper money-back guarantee business course that is independent shop specific. I'm confident, if the course is the right one that allows you to study your own numbers in depth, you truly will enjoy it.

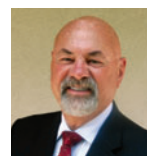
You did not create the current industry issues. This is just reality today. This

business has changed and if you are going to remain in it for the next five to 10 years, you must clearly understand the business management side of it learning it from a CEO perspective. You cannot ignore this any longer.

The independent sector of the automotive aftermarket industry is at critical crossroads in its development. Without a proper business focus now, the net income will not be produced to obtain the right equipment, to upgrade facilities, to find, retain and pay the best technicians and service advisors and to provide management with a life.

It is time to stop listening to the emotions that have misled us, or the previous generation who worked under different circumstances. It is time to slow down and learn to do the math of each individual business. Math does not lie. Professional business development and business acumen will not let you down.

Consider where you will be three years and five years from now. Be honest. Will your current business methods guarantee that you will be here in a healthy and financially prosperous manner? Prove the math right, or prove the math wrong, but take the time to take the right look at YOUR math. **ZZ**



BOB GREENWOOD, AMAM, is president and CEO of Automotive Aftermarket E-Learning Centre Ltd. (AAEC), which provides business

management resources for the automotive aftermarket. Bob has more than 36 years of business management experience and is one of 150 worldwide AMi-approved instructors. greenwood@aaec.ca

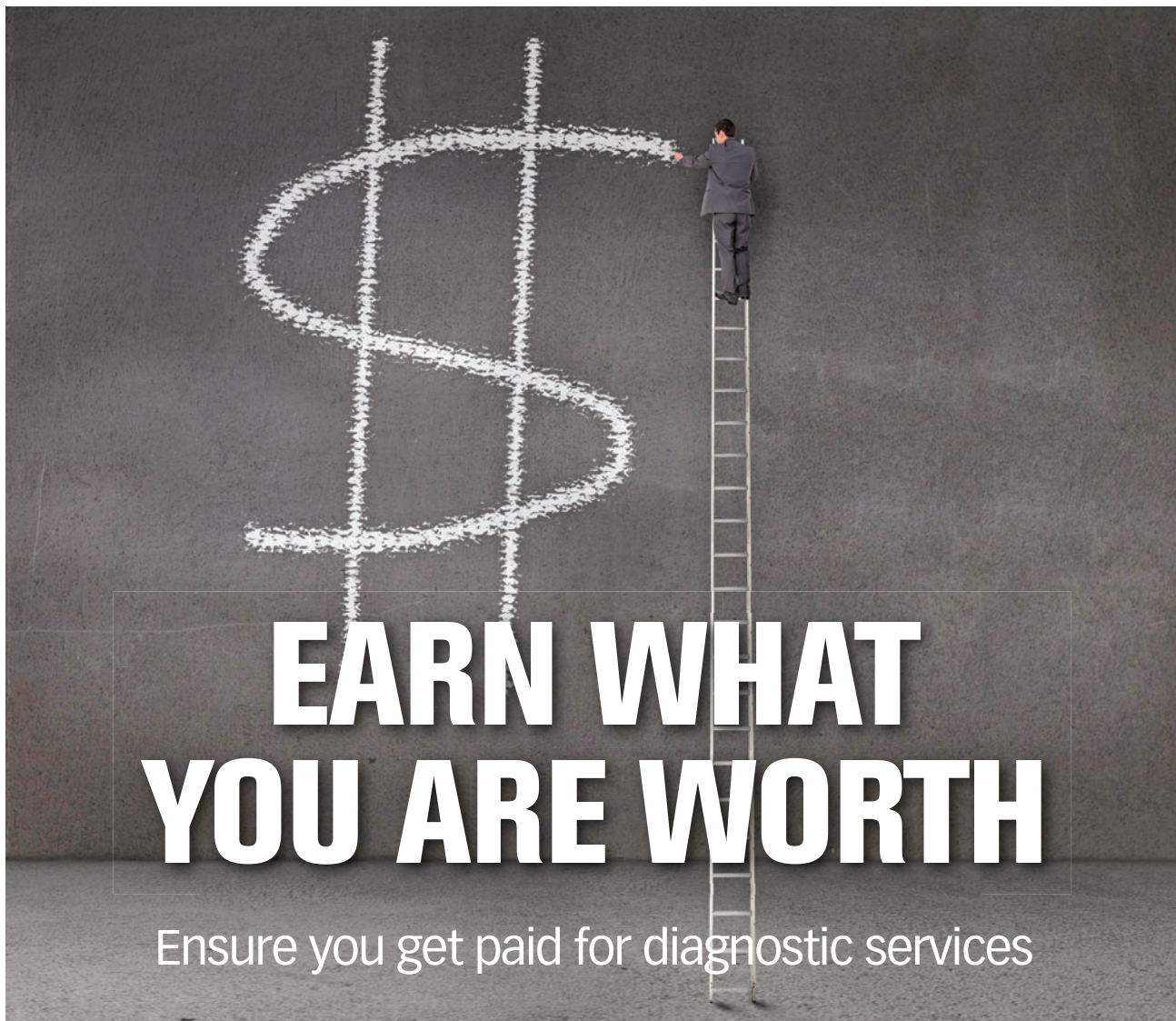
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EARN WHAT YOU ARE WORTH

Ensure you get paid for diagnostic services

JEREMY O'NEAL // Contributing Editor

Completing a profitable repair is a complex puzzle that may leave your hard-earned profits in your customer's bank account. Many repairs begin with a diagnostic service. Getting paid for diagnostic services can be a daunting task. Let's face it — most consumers think we should have an app or computer that tells us exactly what is wrong with the car. When a customer brings a vehicle to a repair shop, they are contracting with the shop to find the root cause of the client concern and successfully re-

pair these concerns. Anything less than a successful repair is viewed as failure, and some customers will go so far as to say the shop “ripped them off.” Properly repairing vehicles is a complex task that even the best shops struggle with. Not to mention the diagnostic service is the most expensive labor operation the shop can perform. In order to be successful and create the income you deserve, there are three keys to getting paid for your diagnostic services. They are:

1. Build profitable diagnostic packages and charge a fair price for them.
2. Prepare an awesome sales presentation that removes the fear from the transaction.
3. Create a diagnostic and repair process that eliminates comebacks and fixes the car right the first time.

Key #1: Build profitable diagnostic packages and charge a fair price for them

The most critical part of profitability for an automotive repair shop is collecting money for every segment of time utilized on every vehicle, every day, at the proper

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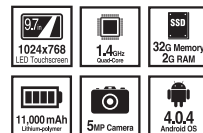
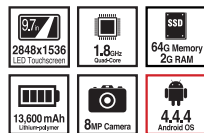
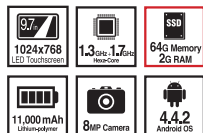
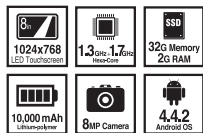
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rate. Automotive repair shops generate revenue from two main sources: parts and labor. When a technician is performing a diagnostic test, that labor operation is not providing parts revenue. This fact is what makes the diagnostic service the most expensive labor operation the shop can perform. To recover the lost revenue from testing, it is important to charge a higher labor rate for these services. Variable labor rates have been used in the auto repair industry for years and help shops create the profits they deserve. A fair markup on your labor rate is typically 25 percent to 50 percent of your baseline rate. Remember, we are trying to recover the lost gross profit on the part sales, not 100 percent of the part sale.

Let's look at an example.

Notice in our illustration, the shop has a baseline labor rate of \$100 per hour. To recapture the lost profit of the missing part gross profit from this labor operation, we are marking up our labor rate 25 percent, or adding \$25 to the rate. In addition, our Level 1 package is going to include an additional resource fee to recover the fees associated with accessing information and updating our diagnostic tools. These fees are typically not figured into the baseline labor rate of most shops. Through extensive research, we have found a \$12.51 fee is a reasonable addition to the package to recover the amount of money spent to provide these services.

Our new package price is going to charge \$137.51 instead of \$100 for a Level 1 testing package. Setting this up in your shop management system is as simple as building a canned job and setting the labor rate at the new rate. You can add the fee in separately or just build it into your new rate.

Notice the additional annual revenue collected of \$32,821.25. This money can go a long way to providing new tools, training, benefits and even a higher paycheck for a diagnostic technician.

There is no set rule when creating your pricing. Your shop is unique and has many special talents and should be compensated accordingly. If you need help creating your pricing model, please send me an email at jeremy@advisorfix.com and I will be happy to help you master this critical pricing puzzle for your shop. This is for a basic diagnostic package that typically can be completed in one hour. For those tough diagnostic packages, we move into our advanced testing package, which we will cover in a future article. Now that we know what to charge, let's take a look at how to make the presentation.

Key #2: Prepare an awesome sales presentation that removes the fear from the transaction

The sales presentation is where the customer decides if they will pay your fees or not. This is where you have to shine! The first step to selling diagnostic packages is to really believe in your process. The diagnostic and repair process are designed to help the customer get their concern resolved in the least amount of time, and it also ensures that the shop follows a logical step-by-step process to save the customer time and money. Let's look at an example of the verbiage you might consider when selling diagnostic packages.

Mr./Mrs. ____, based on your concern there are a number of things that can cause the concern you've described. So right now what we have are more questions than answers. In order to resolve

AdvisorFix Diagnostic Package Pricing Worksheet			
Jeremy O'Neal (JeremyOneal@outlook.com) is signed in			
Billable Hours	1	Labor Rate	\$ 100.00 \$ 100.00
Labor Rate Multiplier	0.25	Labor Charge	\$ 100.00 \$ 25.00
Additional Resource Fee			\$ 12.51
Total Retail Price for Diagnostic Package			\$ 137.51
Comparison of Pricing Models			
Old Pricing Model			\$ 100.00
New Pricing Model			\$ 137.51
Difference			\$37.51
Number of Packages Sold Per Year			875
Additional Revenue Created			\$32,821.25

your concern, we need to begin with our Level 1 Testing Package. Here's the checklist that my technician Tim will be using today. This process is designed to help you get this concern resolved in the least amount of time, and it also ensures that we follow a logical step-by-step process to ensure we save you time and money. When he's finished with this test, I'll get his report and we'll be able to review the results together. You have my word that I'll do everything within my power to save you money and get this car back on the road in the most efficient way. The fee for our Level 1 Test is \$137.51. I just need your signature here and I'll get Tim started on it right away.

If the customer objects to the testing fee and asks, "You mean you're going to charge me just to look at it?" you can respond with the following:

We would be wasting a lot of your time, and your money, if we went ahead and did any service that we thought might solve your problem. So rather than guessing, we like to take the guesswork out of it completely. We need to complete a root cause analysis to find out what failed and more importantly why it failed.

Our testing more than pays for itself when you consider the amount of time and money that would be wasted if we

tried to take shortcuts or guess as to what the problem could be. I'd rather be up front and honest with you about having to charge for professional testing fees. Again, you have my promise that our team will do everything we can to fix your car in the most affordable way. I just need your signature on the estimate so we can begin.

Key #3: Create a diagnostic and repair process that eliminates comebacks and fixes the car right the first time

Let's face it, nobody wins when a vehicle is not properly repaired. A comeback or misdiagnosis is one of the costliest transactions for a shop. Creating a system that provides valuable information for your client as well as ensuring you are taking the necessary steps to eliminate comebacks and misdiagnosis will help you maximize profits. A good repair process on a vehicle incorporates several items. These all lead to a proper diagnosis and a successful repair, ultimately saving both the shop and client time and money. What should be in your repair process?

- Proper write-up. Ensure the customer's concern has been properly documented.
- Baseline test. This includes a basic visual inspection of the basic systems on the vehicle, including fluid levels and condition, wiring, connectors, vacuum hoses, air intake boots, oil leaks, evidence of rodent damage, etc.
- Complete scan of the onboard computer system
- Research ECM updates, TSBs, SIBs and Recalls

- Confirmation of client concern
- Pinpoint or isolation testing of suspected failed components that factually verifies cause of failure.
- Confirmation of resolution of client concern

Using the system outlined above provides the client with valuable information about their vehicle. This not only

ensures a proper repair, but it justifies the diagnostic charges the customer should pay. If you provide the right customer deliverable in the form of a checklist, PDF printout of the scan report, and any factory-level testing plans, the customer begins to understand the complexity of the testing process and their resistance will melt away. **WZ**



JEREMY O'NEAL is a long-time industry trainer, and founded Advisorfix in 2010. He is currently president and lead sales

trainer, and owner-operator of Freedom Auto Repair. jeremy@advisorfix.com

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Massachusetts R2R hearing profiles major issues

Legislation and ballot initiative in play

With a crowded auditorium of aftermarket and automaker representatives, the Massachusetts Joint Committee on Consumer Protection & Professional Licensure held a hearing discussing Right to Repair legislation being considered in the Massachusetts Legislature. What got us here?

The 1990 Clean Air Act Amendments (CAAA) provided an opportunity for independent repairers' concerns about being "locked out" of the service information necessary to repair vehicles. With more sophisticated vehicle technologies assured with the 1990 CAAA enactment, independents sought legislation mandating that automakers give independent repairers the same service information provided franchised new car dealers. This language applied to emissions service information only.

After several attempts, the U.S. Environmental Protection Agency (EPA) got it right. The latest and current regulations required this be done on automaker websites. What was missing was non-emissions information, which came later. First, Right to Repair bills were introduced in the states and in the U.S. Congress. The Automotive Service Association signed an agreement with the automakers assuring independents both non-emissions and emissions service information, tool information and training in 2002. Later, aftermarket organizations signed a Memorandum of Understanding (MOU) with automakers in Massachusetts on access to information.

The hearing highlighted that this process has worked to date. So, what's the problem? Kevin DiVito, president of Mobile Auto Solutions, noted in his testimony: "Many leading industry businesses across the U.S. are based on repair data being widely available. You must be willing to invest the time in yourself and your business in order to keep up with rapidly changing automotive technology. We are able to service current model year vehicles with identical equipment to the dealer."

DiVito did mention that Tesla "does not currently offer a way



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for the aftermarket to scan and program their vehicles." ASA President Ray Fisher also stated in his testimony that "the information is available and our members can fix their customer's cars."

Important for independent repairers was Fisher's additional comments that noted repairers' concerns for new vehicle technologies in the future. Fisher stated: "...I am here because of our concern about vehicle data access and the path forward with rapidly changing vehicle technologies. Both the Obama and Trump Administrations have opted to issue guidelines relative to many new vehicle technologies, defining state and federal regulatory responsibilities, but as of yet, they have not addressed vehicle data access concerns. The 115th Congress passed autonomous vehicle (AV) legislation overwhelmingly in the U.S. House of Representatives, but AV legislation never made it to the U.S. Senate floor. This is regrettable, because the vehicle data access and cybersecurity stakeholder provisions passed by the U.S. Senate Commerce Committee did not become law. This was an opportunity to bring all interests together and work with federal regulators on a

data access and cybersecurity solution. It is important that the industry — or federal policymakers, if the industry fails — determines a vehicle data access and cybersecurity path forward."

The 116th Congress has had numerous hearings on new vehicle technologies, privacy and data, but has yet to offer a formal solution for vehicle data access. With 2020 being an election year, there is much clock pressure for the legislative calendar. If an industry solution is not meant to be, there will be even more hearings in Washington, D.C. and in state capitals across the country like the industry witnessed on a rainy day in Boston, Massachusetts. The opportunity for resolution is now. *ZZ*

ROBERT REDDING is the Automotive Service Association's Washington, D.C. representative. He has served as a member of several federal and state advisory committees involved in the automotive industry. rredding@reddingfirm.com

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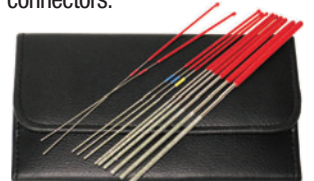
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It is all about time and how you use what you are given

AS THE SINGLE MOST IMPORTANT ASSET YOU MANAGE, TIME MUST BE USED EFFECTIVELY

CHRIS CHESNEY // Contributing Editor

Here I am again sitting on a flight as the holidays approach, realizing this article is due and my only chance of getting it done is to knock it out at 39,000 feet from row 8, seat D. If you've been following my byline, you may recognize that this is a fairly regular occurrence; I just happen to be able to craft a decent message when under the gun. However, as I consider my current pressure situation, I begin to reflect on how this lack of time (or as some may put it lack of time management), and I wonder how do we all deal with time in our businesses? There are only 24 hours in a day, and there are only 365 days in a year, every year (except this year, in 2020 you get one extra day). My point with this thought is to remind you: time is limited. We are all granted a fixed amount of time on this earth and a limited amount of time in our industry serving others. So you might be thinking by now, who cares? Everyone is dealing with the same time issue. You, me, our kids, the schools, our customers. Who cares?

The answer: everyone cares about the limited time in their day. Time is the single most important asset that we manage daily; technology can't make more of it. We are all challenged with using it effectively, and if we waste it there is no one to blame, right? Well, I respectfully disagree. We are all in the service business, and as a member of this

service industry, it is our responsibility to operate our business with a spirit of service rather than simply provide automotive services. The foundation of a service-based business is the management of time for those we serve. Nothing has more value than giving back a few minutes, an hour or even a day to a mother who has three kids in two different schools who are all actively involved in after-school activities while she works a full-time job and has a car in need of service or repair. I have always believed that this industry has the responsibility of managing our customers' time above all else. We should be positioning our businesses with this focus. Imagine a promotion where instead of proclaiming your staff's ability to diagnose a data network issue or your ability to calibrate the new onboard technologies, you instead offer your customers back two hours in their day.

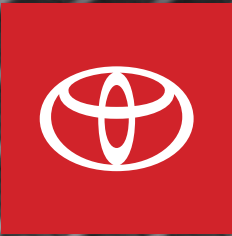
Let me provide an example. Most of our customers don't get up in the morning and decide to bring their vehicle in for service. Maintaining their vehicle or getting into an accident and needing a repair is a time suck and less desirable than going to the dentist. And we don't even need the customer to be present while we service their vehicle! What we do understand is that customers need to commit dollars in their budget to have their vehicle serviced or repaired. Second, and this is probably the biggest roadblock to you seeing that vehicle show up at your shop: they need to figure out how they

are going to shuffle their time and routine so they can get their vehicle to you while still getting the kids to school, making the afternoon pickup or meeting and everything in between. This can cause massive stress to families, but it is the single biggest opportunity for you to differentiate your business.

So, here is my challenge to you: think of innovative ways to demonstrate to your customers that you recognize the stress associated with servicing and repairing their vehicle, and that you have a new program that recognizes how to interact when they are at work. You can simply reach out with text or push notifications to remind them they are due for service, or design a program that offers to pick up their car, service it and return it to their place of work in time for them to leave at their normal time. On the collision repair side, you can use text alerts to keep them completely in the loop on the repair process and when their vehicle will be completed. This is a concierge level of service that simply gives your customer the gift of time. There are many other ways you can provide this gift, but it is up to you to create ways in your core business to gift your customers opportunities each day through smart and dedicated time management. *TL*



CHRIS CHESNEY is the Senior Director of Customer Training for Carquest Technical Institute (CTI) and Advance Professional. chris.chesney@carquest.com



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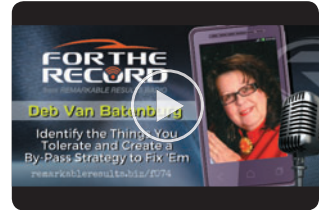
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MECHANICAL MOMENT

SERVICE REPAIR PROBLEMS AND SOLUTIONS THAT JUST MIGHT BENEFIT YOUR SHOP TECHNICIANS

CHEVY TANK FUEL TANK COLLAPSE/LEAKING

VEHICLE:

2000 Chevy K 3500, 4WD, V8-5.7L, VIN R, Automatic Transmission

MILEAGE:

187,233

PROBLEM:

The vehicle came in for a leak from the fuel tank area

DETAILS:

The technician found the fuel tank had collapsed and the seams were beginning to split. Strangely, there was no MIL on or DTCs from any modules. Early testing revealed that the EVAP system had no restrictions. Acting on the advice of the Tech-Assist consultant, he used a scan tool to command the canister purge and vent valve solenoids to operate. If either one was sticking open or closed, the gas tank could be subject to engine vacuum.

On test drive with the scan tool still con-

nected, the tech noticed the fuel tank pressure sensor PID indicated very high vacuum. The canister purge and vent valve solenoids were operating properly so the technician checked the EVAP canister. He found the canister was restricted causing engine vacuum to be applied to the fuel tank.

CONFIRMED REPAIR:

The EVAP canister and the gas tank was replaced, then the truck was taken on a long test drive. The fuel tank pressure sensor PID was within factory specifications and the tank showed no signs of collapsing. Problem solved!

This tech tip and others come from ALLDATA Tech-Assist, a diagnostics hotline of ASE-certified Master Technicians.

Learn more at [ALLDATA.com](https://www.alldata.com).

TRAINING EVENTS

FEBRUARY 19-22

MACS 2020 Training Event & Trade Show
Gaylord Opryland Resort
Nashville, Tennessee

FEBRUARY 21

ASA Arizona Shop Owner's Conference
Cliff Castle Casino & Hotel
Verde Valley, Arizona

MARCH 5-8

VISION Hi-Tech Training & Expo
Overland Park Convention Center
Overland Park, Kansas

MARCH 21

TST 2020 Big Event
Westchester Marriott
Tarrytown, New York

MARCH 25-26

AASA Vision Conference
Loews Chicago O'Hare Hotel
Rosemont, Illinois

MARCH 27-29

ASA Northwest ATE 2020
Doubletree Hotel
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APRIL 21-23

SAE World Congress
TCF Center
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MAY 9

Commitment to Training LIVE
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MISFIRE DETECTION — A NEW APPROACH

THE KEY TO ISOLATING THE CAUSE OF THE MISFIRE IS TO UNDERSTAND WHAT A MISFIRE REALLY IS. LET'S TAKE AN IN-DEPTH LOOK!

BERNIE THOMPSON //

Contributing Editor

No doubt emission concerns have changed the world. The modern vehicle is not exempt from these emission concerns. In fact, it is quite possibly the primary target of them. Any automotive technician can clearly see the effects of these emission concerns on a daily basis — from extended fluid changes to tailpipe gas emission levels. It does not take much for one to understand that, considering the millions of vehicles in operation, these concerns are quite valid. Tailpipe emission levels from millions of vehicles creates photochemical smog. Photochemical smog is a type of air pollution caused by chemical reactions that occur between the sun's ultraviolet light and pollutants such as volatile organic compounds (hydrocarbons) and nitrogen oxides (NOx). This reaction produces airborne particles and ground-level ozone.

In southern California, air quality became an issue in the mid-1960s. In 1967, the state of California established the California Air Resource Board (CARB). CARB set emission regulations that were forced on the automotive industries to control the air quality for human health. At first, these regulations covered the internal combustion engine's tailpipe and crankcase emis-

sions and in 1970, moved to regulate the fuel containment system. In 1996, further emission legislation was implemented on the automotive industries that we know as On-Board Diagnostics II (OBDII). These OBDII regulations included engine misfire.

Misfire effects and OBDII

OBDII legislation regulates two different effects from engine misfire. The first effect is an engine misfire that can damage the catalytic converter. The second effect is an engine misfire that increases the tailpipe emission levels more than 1.5 percent over the Federal Test Procedure (FTP) standards. Both of these engine misfire concerns will change depending on the engine operating conditions such as engine load and engine speed. Under full engine load, the catalyst temperature threshold is set at approximately 1850°F; above this temperature, catalyst damage may occur. Therefore, misfire rates will be set according to the catalyst temperature. For example, an engine running at 6000 RPM under WOT with an engine misfire rate of 5 percent may allow the catalyst temperature to exceed the threshold limit. However, at low load and low engine RPM, an engine misfire rate of 25 percent may be experienced before the threshold limit is hit. These engine misfire rates are only an example, as each engine is unique and will be calibrated

for its particular engine misfire to catalyst temperature rates.

To calculate the engine misfire rates, the misfires must be accurately determined. There are several ways that the Engine Control Module (ECM) can monitor for engine misfire. One method uses ignition ion density to determine flame resistance in the spark plug gap. This is accomplished by providing a high energy output that is great enough to bridge the spark plug gap, thus bringing the temperature well past the auto-ignition temperature of the fuel stock. A secondary ion current is then produced that continues to bridge the spark plug gap. A signal processor then analyzes this ionization signal created by the detection circuit. This data provides useful ignition system data such as engine misfire, combustion duration, engine knocking, approximate air/fuel ratio, indications of spark plug fouling and pre-ignition. This method is expensive and therefore not used in many vehicles.

Another method uses pressure sensors that are located in each of the cylinders. The cylinder pressure in an engine varies with the combustion of a fuel stock. By measuring the in-cylinder pressure a combustion event can be determined. To determine if a cylinder's combustion was complete or incomplete, the pressure will be looked up in a table. This table provides normal

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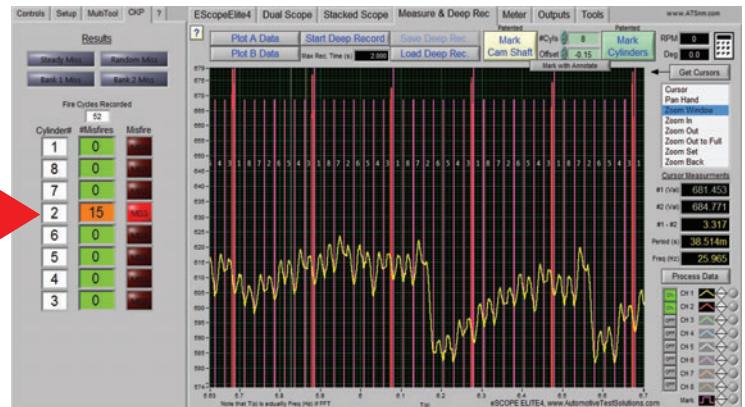
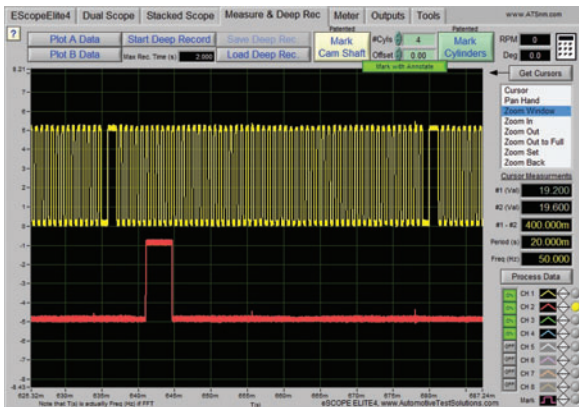


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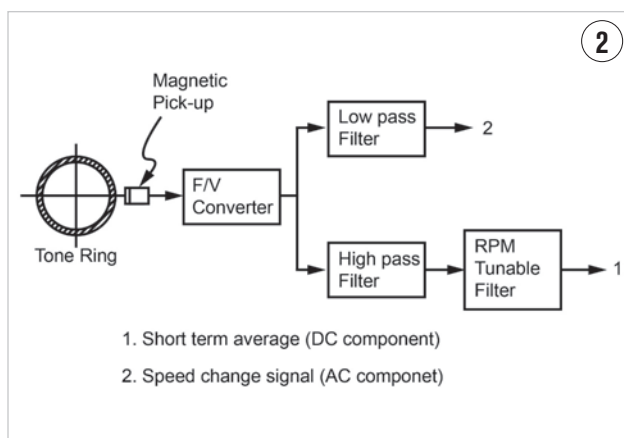
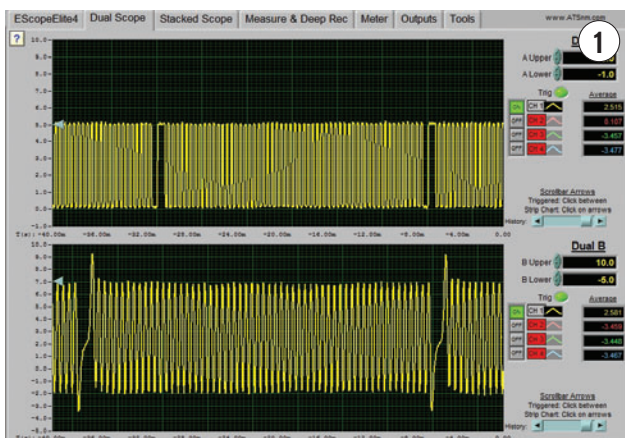
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1. Short term average (DC component)
2. Speed change signal (AC component)

pressures that should be produced for each of the engine operating ranges. These normal pressure ranges are then compared to the actual cylinder pressure that is currently produced by the pressure sensors. Additionally, the cylinder can be directly compared to other cylinders in a fire cycle. This method is expensive and difficult to implement in all engines and, therefore, rarely used.

Monitoring crank speed

The most common method uses crankshaft rotational velocity changes to determine combustion efficiency. This is accomplished using a trigger wheel (tone ring) that is made on, or attaches directly to, the crankshaft and a crankshaft position sensor. This trigger wheel is made of a ferrous metal that interacts with a magnetic field from the crankshaft sensor. This, in turn, produces a voltage output for each of the teeth on the trigger wheel in rotation. A waveform produced from one such trigger wheel is illustrated in **Figure 1**.

The trigger wheel can be made in many different configurations with different counts of teeth and different indexing points contained on the trigger wheel. If there is only one tooth for each cylinder, this is considered a low data trigger wheel. If the trigger wheel has many teeth, such as 36 teeth, this is considered a high data trigger wheel. With more teeth contained on the trig-

ger wheel comes more resolution for better engine control. For example, if the trigger wheel contained 36 teeth, it would provide 10 degrees of resolution. Whereas a 60-tooth wheel would provide 6.0 degrees of resolution.

As can be seen from **Figure 1**, the teeth on the trigger wheel produce a voltage output change based on the location of the teeth on the trigger wheel. These waveforms can be based on an analog voltage waveform or that of a digital waveform. Both types of waveforms are illustrated in **Figure 1**; waveform A is that of a digital voltage output and waveform B is that of an analog voltage output.

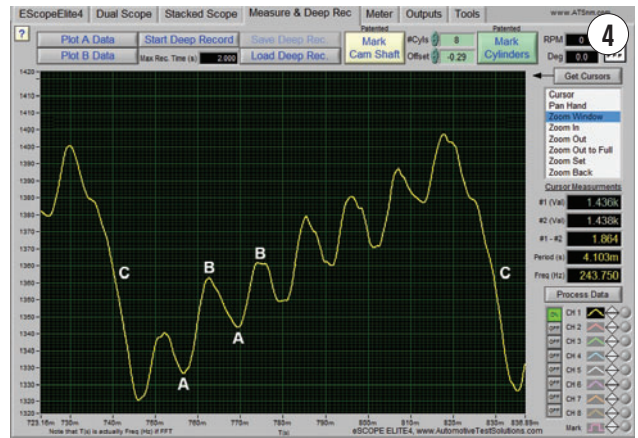
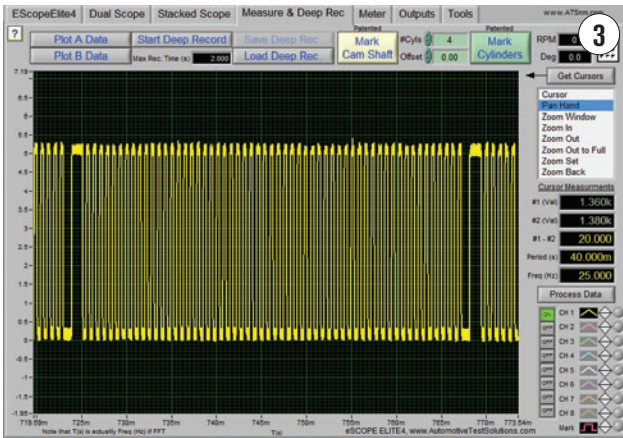
The trigger wheel will have some method for indexing it to the crankshaft that allows the crankshaft position to be known. This crankshaft position will give the crankshaft's plane locations in space. One such method is to have missing teeth located at some position around the wheel. One example is a 36-tooth trigger wheel where one tooth is missing. The ECM uses this indexing information to identify the crankshaft position. The crankshaft position must be known to locate where the piston position is within the cylinder bore. On a two-stroke internal combustion engine this is enough data since the fire cycle occurs each revolution of the crankshaft. However, this is not enough data on an Otto cycle four-stroke engine.

The Otto cycle engine has two complete crankshaft revolutions to complete the four engine strokes. Therefore, the use of just one sensor on the crankshaft would not provide the necessary data to calculate which of the engine strokes the engine is currently on. As the crankshaft rotates, it moves the piston toward the cylinder head until it reaches the Top Dead Center (TDC) point. It then moves the piston away from the cylinder head until it reaches the Bottom Dead Center (BDC) point. The use of one sensor can only indicate if the piston is at TDC or BDC. It cannot differentiate which of the four strokes the engine is on. Therefore, a second sensor, or a trigger voltage, must be used to locate crank angle space. Crank angle space is where the particular engine stroke that the engine is currently on (intake, compression, power, exhaust) can be identified.

Where and how fast?

The ECM uses a second sensor to calculate the stroke identification. This sensor is known as the camshaft position sensor. This sensor provides the necessary data to accurately calculate the engine stroke location. The camshaft position sensor gives the data on the valve openings and valve closings. Thus, the particular stroke the cylinder is on can be calculated.

Once the engine stroke is known and the piston position is known, the internal combustion engine can now



be controlled by the ECM. The ECM controls the engine so it can produce power with the best tailpipe emission levels. The ECM provides the base engine control functions, which include the air/fuel delivery and the ignition discharge delivery (gasoline-based engines use the spark event while the diesel-based engines use the injection event). These controls are directly related to the four strokes of the engine.

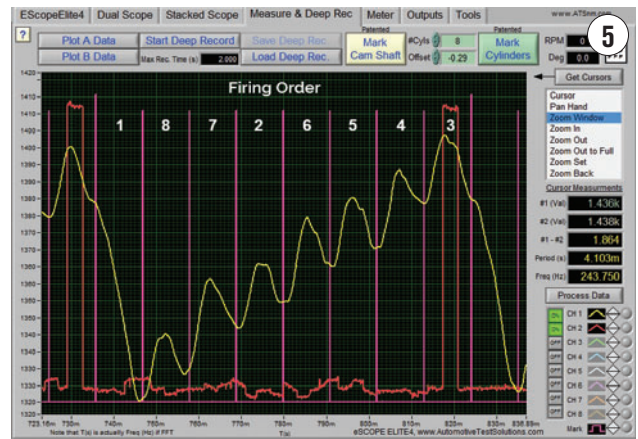
Each of these engine strokes changes the crankshaft velocity. On the compression stroke, the volume of air contained in the cylinder is compressed. This requires energy from the engine to complete the compression stroke. The engine stores energy in the rotational mass of the engine. This mass carries the crankshaft rotation through the parasitic pumping losses of the internal combustion engine.

The strokes of the engine directly affect the crankshaft rotational speed. As the piston moves toward the cylinder head compressing the air volume contained within it, the crankshaft speed slows down. Then as the ignition event starts the combustion of the fuel stock, the crankshaft speed increases. By monitoring the crankshaft rotational velocity (speed) the combustion process of the fuel stock can be determined. Thus, a cylinder misfire can be determined.

For the original equipment manufacturers (OEM) to use this data from the crankshaft sensor and obtain the lowest probability of error, specialized electronic circuits are used. One such circuit is shown in **Figure 2**. This circuit modifies the voltage changes from the crankshaft sensor to a voltage level using a frequency to voltage converter. This crankshaft data is then processed with a Discrete Fourier Transform algorithm. The Discrete Fourier Transform converts this signal into a point of frequency. This is then compared to an engine combustion model that is stored in the ECM.

Simple?

It is extremely difficult to locate misfires in an engine. The OEMs refer to this process as deconvolving the crankshaft an-



gular velocity. If the crankshaft's rotational speed is fast, then the time of the crankshaft slowing down and speeding up will be limited. When the crankshaft is rotating at 6000 RPM, the fire cycle is only 20ms; therefore, each stroke is only taking 5ms to complete. The flywheel or torque converter stores this rotating energy within its mass and uses it to carry the crankshaft through its pumping losses. At high velocities, the crankshaft speed experiences very little change. Additionally, the more cylinders that are contained within the engine, the less the crankshaft velocity changes. So it is easier to calculate the misfire data on a four-cylinder engine than it would be on a 12-cylinder. Therefore, the engine combustion model within the ECM must be accurately programmed to find misfires. Even if the model in the computer is correct, there can be problems with the misfire data process.

When these described methods or similar methods are utilized by the OEM and the misfires exceed a predetermined threshold, a Diagnostic Trouble Code (DTC) is set. This DTC indicates that the tailpipe emission has exceeded 1.5 percent of the Federal Test Procedure (FTP) standards or the catalyst temperature in the catalytic converter is too high. If the engine is misfiring but does not exceed the FTP, there may not

be a DTC set. Ever experience this for yourself? You can feel an engine misfire occur but no stored or pending misfire codes are present.

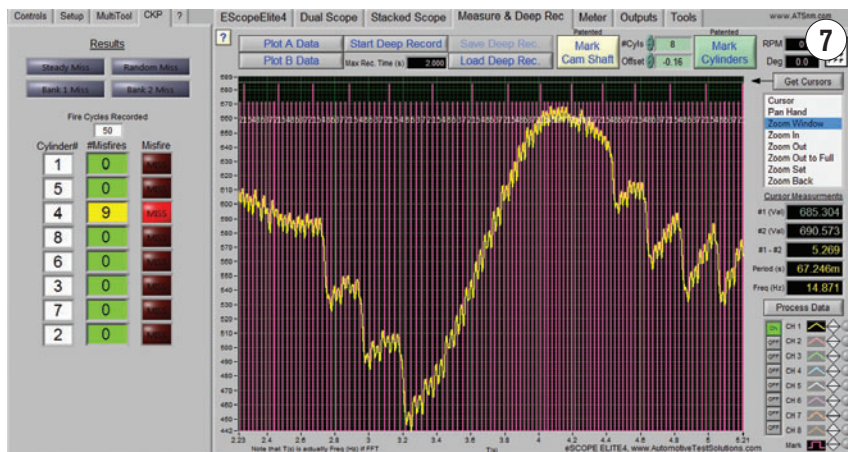
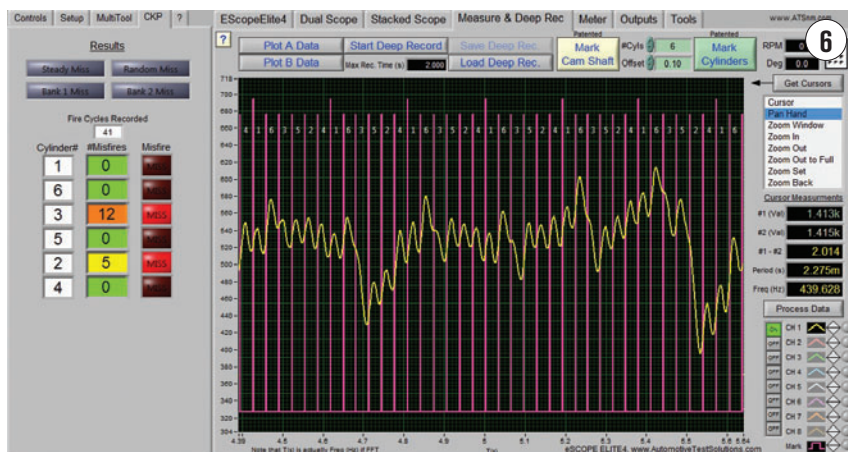
If the engine is misfiring at a rate where it exceeded the FTP tailpipe emission level, a P0300 DTC can be set. A P0300 DTC indicates that a random misfire is present in the engine. However, this DTC is fairly useless to the technician. At slower crankshaft speeds the technician can feel the misfire, but they need to know which cylinder(s) are misfiring or having incomplete combustion events.

In some cases, the onboard computer can analyze the data incorrectly and set a DTC for the wrong cylinder. For example, a P0303 DTC is set in the ECM. The technician will now try to diagnose this DTC but it is for the wrong cylinder. The cylinder that is really misfiring is cylinder 5 or a P0305 DTC.

Additionally, misfire DTCs can be set by other causes such as, but not limited to, the drive belt tensioner. When the drive belt tensioner clutch wears out, the tensioner begins to bounce. This changes the tension applied to the crankshaft. Which, in turn, can change the crankshaft velocity — which may set false misfire DTCs. In some cases, the trigger wheel can become loose from the crankshaft, allowing the trigger wheel to move. This may also cause false misfire DTCs as well as drivability concerns. Additionally, if the crankshaft sensor itself becomes loose, it can vary the sensor output setting and also set false misfires as well as drivability concerns. When the data for the misfire is contained within the ECM, it is very difficult to know WHY the ECM is setting or not setting misfire DTCs.

What if?

What would be helpful is if the technician could test the same data; that is, the crankshaft sensor output, that the ECM



is testing and setting or not setting DTCs for. This can be accomplished using an oscilloscope connected to the crankshaft position sensor with Channel 1 of the scope and connecting Channel 2 to an ignition event and then running the data through an incorporated algorithm.

In **Figure 3**, an engine crankshaft position sensor waveform with a misfiring cylinder is shown. This is the raw data gathered with an oscilloscope. No filtering or algorithm is being applied to the crankshaft position sensor waveform. This is what automotive technicians have been analyzing for over 40 years. As one can see, it is very difficult, if not impossible, to determine the crankshaft speed changes that occurred within this waveform. So, determining whether or not a misfire is present is not an easy task.

Figure 4 is the same data that is shown in **Figure 3**, except that an algorithm is now modifying this data. This unlocks the crankshaft velocity changes by using an advanced frequency plot algorithm, thus showing the combustion events that occurred or did not occur in the cylinders. Portions of the captured waveform are labeled A, B and C.

A is the point that the crankshaft speed reached its slowest speed, corresponding to TDC compression. B is where the crankshaft speed increased after firing the fuel stock and combusting it, accelerating the crankshaft speed. C is where the fuel stock did not combust, slowing the crankshaft speed. This crankshaft “slow down” indicates an incomplete combustion event.

The algorithm allows the crankshaft

velocity changes to be seen; however, this does not identify the specific cylinder that created it. It will be necessary to have a second trigger present to find crank angle space as shown in **Figure 5**. This second trigger can be from any of the ignition coils for a gasoline engine or fuel injectors for a diesel engine. In this example, the coil from cylinder 1 is used.

Once a sync signal is provided, the crankshaft speed algorithm can be analyzed. This is accomplished by applying a grid or overlay that breaks the crankshaft waveform into the cylinders contained within the engine. In **Figure 5**, a firing order for the engine cylinders has been marked. These cylinder grids provide the divisions for each cylinder in the engine. So, for a three-cylinder engine there are three divisions, for a four-cylinder engine there are four divisions, for a five-cylinder engine there are five divisions, for a six-cylinder engine there are six divisions, for an eight-cylinder engine there are eight divisions, for a 10-cylinder engine there are 10 divisions, and so on. These divisions, along with a firing order for the engine, allows the individual cylinders to be identified. The cylinder grids are essential to divide the crankshaft sensor waveform into the number of engine cylinders contained in the engine under test so they can be analyzed.

When applying the cylinder grid it will be placed from trigger to trigger. Now a known firing order for the engine under test can be applied to the cylinder grid. When all of these items are accomplished, one can determine which cylinder(s) have incomplete combustion events. In this case, cylinder number 1 is missing. As can be seen, the crankshaft speed slowed down after coming to TDC compression. This indicates that the combustion of the fuel stock did not occur.

As seen in **Figure 6**, this method can be automatically accomplished. In

the ATS Elite 4 and 8 trace scopes, this software allows an automated process which can identify which cylinder(s) have had a combustion event and which cylinders have not had a complete combustion event. In this example, a 6-cylinder engine is having incomplete combustion events. As can be visually seen, there are crankshaft speed changes that drop RPM on cylinder 3 and cylinder 2. The automated software has also determined that cylinder 3 and cylinder 2 are misfiring.

In **Figure 7**, there are multiple misfires occurring in time. When analyzing the data, the crankshaft RPM is evaluated both on the rise and fall. If the RPM rise rate does not increase with a large fall rate then the fuel stock did not fire. If the crankshaft RPM has a low rise rate and the fall rate is moderate then the fuel only partially com-

busted. If the rise rate is normal and the fall rate is normal then the fuel had a complete combustion event.

This technique will not work at higher RPM but works well at lower RPM. This is a quick way to verify the combustion events that are occurring within the cylinders of an engine. Additionally, this can help to diagnose both gasoline-based engines and diesel-based engines. You will find that this technique is a great help with many of your engine diagnostics. **LTZ**



BERNIE THOMPSON is an automotive diagnostician and trainer, and co-founder of Automotive Test Solutions in Albuquerque, N.M. He is an expert at diagnostics and

repair strategy and designs award-winning diagnostic tools and software for the automotive industry.

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DAVE MACHOLZ // Contributing Editor

After 20 years in the automotive repair business, I somewhat accidentally found my way into a high school automotive technology classroom as an instructor. Over 10 years, I have risen through the ranks and now hold the position of Assistant Dean with a community college automotive program, and I have enjoyed every second of it. In addition to my day job, you can also find me traveling the continental U.S. and Canada presenting classes for working technicians through WorldPac. There is truly nothing better than seeing the “lightbulb turn on” and having a student find success as a technician.

Over these last 10 years, it has become increasingly evident that many of the technicians that I instruct struggle with the concepts of electricity and electronics that are essential in the repair of modern automobiles. My most recent class dealt with the subject of a control module that used duty cycle to control a component. I realized that, in my attempt to describe how duty cycle control happened within a given frequency, my voice had apparently turned into the wonky trombone voice of Charlie Brown’s mother. It was clear that I was talking and that the class was hearing me, but the words that were coming out of my mouth were not connecting.

I would say that in every class I ever teach, regardless of skill level, this phenomenon occurs with at least a portion of the attendees. The core of this problem stems from an industry issue of no required certification level for techs, no required training and an overall failure of our industry to correct these underlying problems. This is a story for another article, but I’m always concerned with what we can do now to help technicians who struggle with electricity and electronics. This industry issue is compounded in light of the rapid increase in electronically controlled systems, such as ADAS, and the evolution of the Electric Vehicle market. In this

PHOTO: PICO TECHNOLOGY



ANALYZING HIGH-VOLTAGE WAVEFORMS with a scope requires a differential probe like this unit from Pico Technology. A total of three of these is required to acquire a 3-phase waveform.

article, we will look at some concepts that are need-to-know for today's technicians. Some of this may sound familiar, and if so, should be a good refresher for those who are more advanced. I hope to point out how advances in technology are compounding the need for advanced electricity and electronics knowledge and to shed some light on how to apply it.

AC - Alternating current – Let's start with AC. AC is typically defined by current flow that is both positive and negative in polarity. AC voltage and current flow are a familiar concept to technicians. AC is created by the vehicle generator/alternator as well as devices such as two-wire ABS and Crankshaft Position sensors. While most are familiar with the concepts of AC voltage and current, it may have been quite some time since you have "ohmed out" an alternator stator. In fact, it would not be unusual if you have never had an alternator apart in your lifetime.

AC applied

Fast forward to the electric and hybrid electric vehicles. The motor-generator (MG) unit on most EVs and HEVs is very similar in function to the alternator in terms of the AC concept. The main difference is that the rotor on an HEV or EV is typically a permanent magnet with no field winding. These MG units are capable of hundreds of volts during regeneration, so if you were not comfortable with diagnosing AC from an alternator, the voltage provides a "shocking" realization (pun intended). You will need to understand how AC is generated to understand how to diagnose and fix one of these issues. You will also need to know that if we send voltage/current to the windings of the stator that the MG unit will propel the vehicle.

A hypothetical case study supports why this knowledge is essential. Imagine a customer with a high-mileage HEV or EV comes in with the complaint of a slight shudder during



PHOTO: TOYOTA

HIGH-VOLTAGE CHARGING ISSUES will require advanced knowledge and access to a good scan tool.

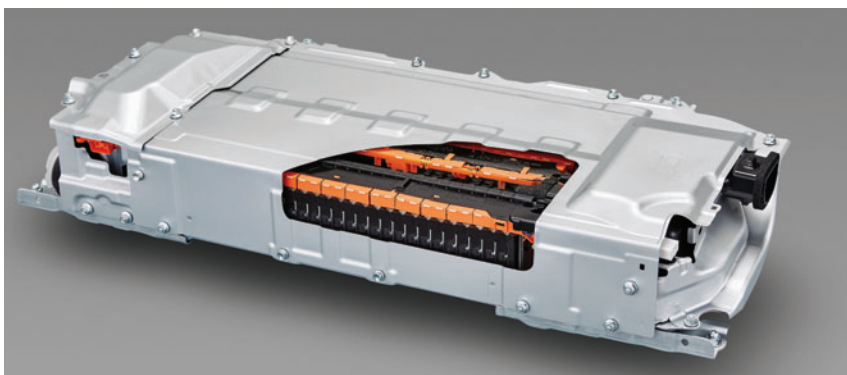


PHOTO: HIOKI

A MILLIOHMETER will be required when diagnosing complex motor-generator faults.

initial acceleration. There are no codes present in the engine control module or the high-voltage ECU. After confirming the complaint and ruling out other driveline vibrations, the technician thinks that this may be coming from a problem with the vehicle transaxle which, in this case, contains a motor-generator unit.

For the motor-generator to propel the vehicle, a high-voltage ECU supplies the sequencing of the positive and negative polarity through the three windings (U-V-W) of the stator. The smooth operation of the MG during acceleration is dependent upon the equal application of voltage through each phase during each polarity change. This is controlled by the high current-rated insulated gate bipolar transistors (IGBT). The IGBTs are essentially creating north and south magnetic field polarity in each of the phases of the stator and that acts as the "push-pull" force needed to turn the motor.



BATTERY CHEMISTRIES AND TECHNOLOGIES will require new training and tooling.

Providing the shudder is coming from an MG unit, the failure of an IGBT is one possibility for this vibration. But the more likely cause is a difference in the resistance of the three windings themselves. Each of the windings of the MG unit must be the same overall resistance to carry out the push-pull to propel the vehicle. To further explain this, the stator is allowing the voltage/current applied to each winding to provide the push and pull required to turn the rotor and essentially move the wheels. If the resistance of each winding is not identical, this could lead to a shudder phenomenon such as described by the driver of this problem vehicle.

Now that we understand how the AC concept is occurring, we have to determine which diagnostic practice to utilize. Factory service information would indicate the use of a megohmmeter or milliohmeter to properly diagnose one of these faults. For first-time HEV/EV repairers, this means a cost in tooling of about \$3,000 for both tools. If you read *Motor Age* every month, you will know we have covered these tools on several occasions. If you missed those features, be sure to search the searchautoparts.com archives.

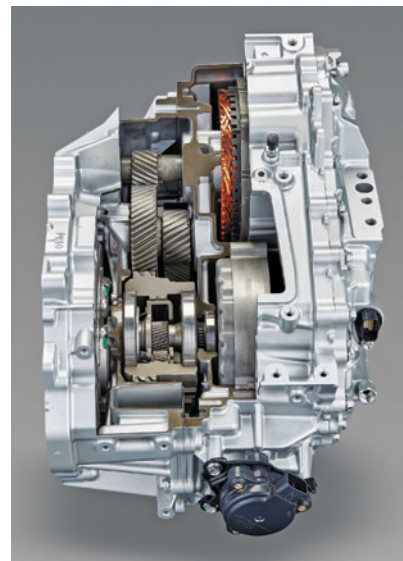
If you are not familiar with these tools, here is the Cliff's Notes version:

A megohmmeter will utilize a high voltage (typically 500-1,000) to provide an electrical pressure test (think cooling

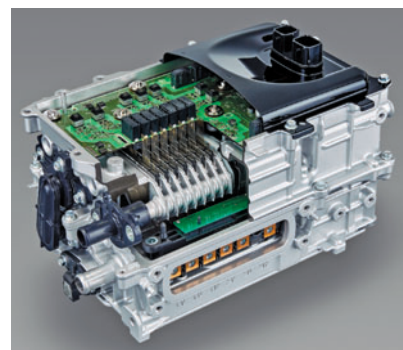
system) of the three phases of the stator or other HV components. This test will pinpoint large variances in resistance or will help to identify shorts between the three phases or shorts to chassis ground. The megohmmeter test would provide a good starting point in diagnosis at a price tag of around \$600. However, further testing may be required.

The milliohmeter will certainly help to identify the cause of a shudder. Utilizing a milliohmeter allows a technician to obtain precise resistance readings of each phase. Should one of the phases be different than published specifications, you have identified the culprit of the shudder. A variance in resistance of one winding will affect the pull-push of the rotor, especially at low motor speeds, but will not be as evident as the motor increases in speed. To obtain this information, a tech will need a good milliohmeter, which retails for approximately \$2,000.

The third way of testing the MG unit is through the use of a differential probe in conjunction with a PC-based lab scope. For the most part, this type of testing is not factory specified as there are still a great number of dealerships operating without lab scopes. Think of a differential probe as an attenuator for very high-voltage applications. A differential probe retails for about \$400 and you will need to utilize three — one for each phase. In addition, you will



TRANSAXLE AND MOTOR-GENERATOR DIAGNOSIS requires new knowledge, tooling and diagnostic capabilities.



THE INVERTER UNIT ON HEVs AND EVs provide complex AC to DC and DC to DC functions through the use of capacitors, transformers and Insulated gate bipolar transistors.

need to be familiar with lab scope operation. The beauty of the differential probe is that you can easily view the signals coming from the MG unit by putting the vehicle on the lift and turning the vehicle wheels while observing the waveforms acquired. A bad phase should be noticeable from the output amplitude. As noted earlier, there is not typically factory-supported diagnostic information for this procedure, and you may want to obtain some hands-on training before utilizing this tool for diagnostics.

PHOTOS: TOYOTA

More AC challenges

To charge plug-in HEVs and EVs, the vehicle owner will have to utilize the vehicle charging plug as well as the wiring connected to the electrical service in their home. The issue this brings to light is that you have an infrastructure side; a customer interface scenario, in which the customer has to connect the charger; and a vehicle side that determines if the connection to infrastructure has been properly established to begin the charging event. The challenge in these repairs will naturally come down to identifying which of these three parts of the charging equation are the cause of the concern. Is the infrastructure/charging unit in the home operating correctly? Does the customer understand how to operate the charger and how to properly connect to the vehicle? Or is it a vehicle charging system problem? These are certainly the issues you will run into once these vehicles make their way to high-level adoption.

The charging systems for PHEVs and EVs are designed and classified by ISO and SAE under standard J1772. The connector that interfaces with the vehicle is commonly known as a “J plug” for this reason. The two voltages available for chargers are known as “level 1” or “level 2.” Level 1 chargers are rated at 120V AC while level 2 is rated at up to 240V AC. As automotive technicians, AC voltage at this level is not something we are traditionally trained to repair. The answer to diagnosing these types of concerns may come in the form of a tool that is less intrusive than you might suspect — the vehicle scan tool.

Toyota PHV Charge Cancellation History – 2012+ Toyota Prius PHEV

If you have read enough of my articles over the years you may have noticed my affinity for the Toyota nameplate. In fact, in recent *Motor Age* issues, you may

have seen articles on new diagnostics and utilities available on the Toyota Techstream scan tool platform. Toyota offers a Utility function on the Techstream par-

ticularly for this application; if the customer has issues charging the vehicle, the Techstream may store a DTC. In the event it does not, it puts the technician in a position of determining where the trouble lies. With the Techstream charge cancellation history data, a technician can now determine where the problem in the EV charging system is located. If the problem is due to infrastructure, the technician knows that they may need to contact an electrician to service the EV charger side attached to the home’s electrical network.

Toyota makes this information available to the independent repair market via www.techinfo.toyota.com in the form of a paid subscription that provides technicians access to Toyota repair manual information, electronic wiring diagrams, Quick Training Guides, Tech Tips and Service Bulletins.

Batteries

Batteries may be the single technology that is keeping the EV market from taking off. As of today, most batteries are using some form of lithium-ion or nickel-metal hydride. Both lithium and nickel are natural limited resources, which makes it difficult to mass produce batteries. Additionally, the size and weight of the batteries required to operate EVs are astounding. If you have never seen the battery on a Tesla it is worth a look — it is basically the entire undercarriage of the vehicle and at one point, costs nearly \$40,000 to replace.

As technicians, we will have to have

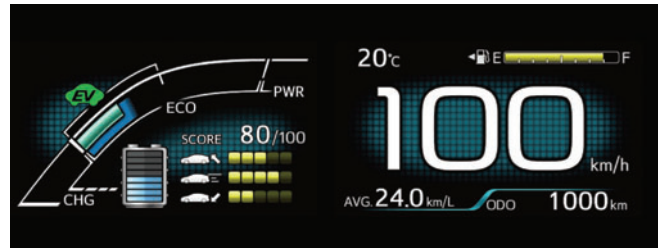


PHOTO: TOYOTA

THE MULTI-INFORMATION DISPLAY ON EVS tells the tale of the complex electrical/electronic systems on these vehicles.

a good understanding of battery chemistries. As these vehicles begin to age, we will need to know if the battery itself can be repaired or if it needs an entire replacement. When replacing, we will also need to know where to acquire the replacement battery. Another additional complication is moving the battery once it is delivered to your shop, as it may require a fork-lift or, at the very least, a pallet jack. Once it is near the car, you will also need to know how to install it. All this, plus you will also need to understand how to safely handle and install it, as it is potentially very dangerous without the proper knowledge of safety protocols.

Planning for the future

While EVs and HEVs are still a small part of the overall vehicle market, the technology they bring with them is leading us into a new time in automotive repair — a time to get serious about electrical diagnostics. Take every opportunity to immerse yourself in good literature, high quality training and, really, any opportunity to hone your skills (if you are still reading this you are on the right track). Remember that no one is going to invest more in you than yourself! **TL**



DAVE MACHOLZ is an instructor for the Toyota T-TEN, Honda PACT and general automotive programs at Suffolk County Community College in Selden, N.Y. He is an ASE CMAT and L1 technician and holds a New York State teaching certification in vehicle repair. liautotraining@gmail.com

READING VOLTAGE WHEN YOU THINK YOU SHOULDN'T

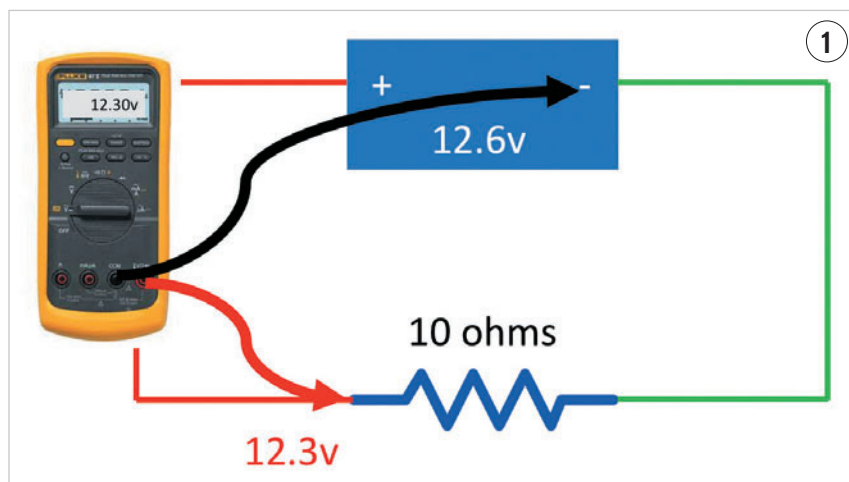
ONE VOLTMETER LEAD IS ON THE NEGATIVE BATTERY POST AND THE OTHER IS ON THE ALTERNATOR CASE — BOTH GROUND POINTS, BUT YOUR METER READS VOLTAGE. DO YOU KNOW WHAT THE METER IS TRYING TO TELL YOU?

PETE MEIER // Director of Training

Suck-bang-go-blow,” or a version thereof, is a phrase that every tech has heard. It describes the basic four strokes of an internal combustion engine. “Suck” is the intake stroke, “bang” is the combustion event at TDC of the compression stroke, “go” is the power stroke and finally, “blow” refers to the exhaust stroke. The basic function of the engine seems to be ingrained in our subconscious — we don’t even think about it as we go about diagnosing drivability concerns.

Let’s focus on the intake stroke for the moment. Just before the intake valve opens, the piston is moving upward in the cylinder and pushing out the post-combustion gasses through the open exhaust valve. Just before the exhaust closes, the intake opens to help clean out the last remnants and to help ensure that the new charge of air is nice and clean.

As the piston changes direction, the space above it grows and that causes the pressure in the cylinder to drop. If the intake valve opened directly to the air outside of the engine — air, by the



way, that is at atmospheric pressure and higher than the pressure in the cylinder — the pressure differential between the two would cause the air molecules to stream into the cylinder until the two equalized.

But it doesn’t, does it?

There’s a restriction between the high-pressure area (that is, the atmospheric pressure that lies outside the manifold) and it’s called the throttle plate. When the throttle plate is closed, the opening between the plate and throttle bore is just wide enough to allow some air in. There’s no difference in the force of the high pressure trying

to get to the low — it’s just not possible to do so rapidly. In other words, fewer air molecules can get to the intake side of the throttle plate over the same given time frame.

Wait a minute — that sounds like the MAF reading in grams per second!

When the throttle plate is open, the restriction to the air molecules is reduced and that high-pressure area will stream in to fill the low pressure area at a much higher rate, won’t it? If you don’t believe me, go grab your scan tool and graph the MAF data while you operate the throttle from idle to WOT and back.

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What's that have to do with solving electrical problems?

Remember Ohm's Law? Do you see the similarities?

The pressure differential between the atmospheric air outside the engine and the cylinder is what causes the air to flow. Similarly, the battery has a high number (pressure) of electrons gathered around the positive post and a lower number (pressure) at the negative post. When we place our voltmeter across the battery terminals, we are measuring that pressure differential. In fact, when we place our meter leads ANYWHERE in the circuit, we are measuring the pressure differential, or voltage, BETWEEN the meter's leads.

If we provide a path that connects the two sides of the battery, current is going to flow from one to the other, isn't it? Who hasn't accidentally arced a tool before?

The measurement of current is "amperage" or "amps" and is the equivalent of our MAF reading in grams per second. Both are a measure of flow.

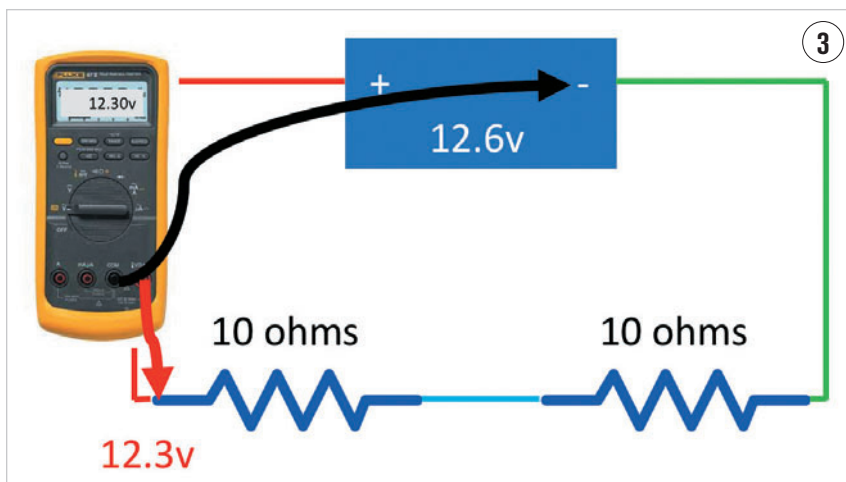
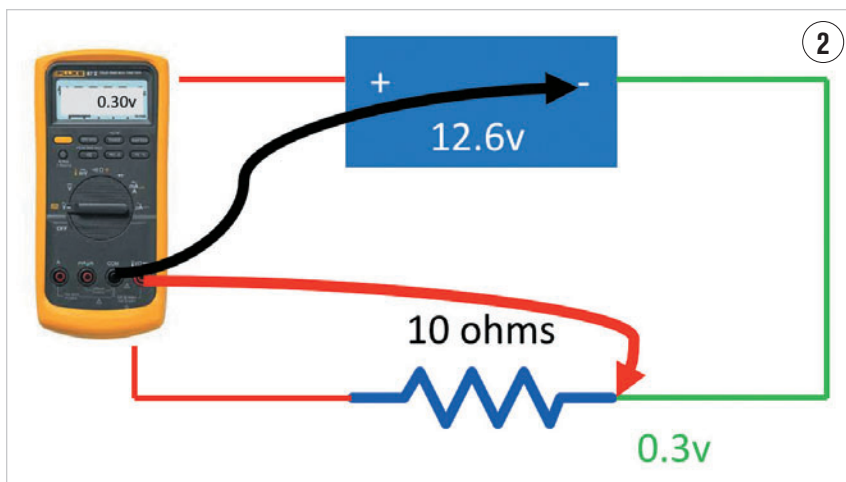
The debate is which way does current flow?

If we stick with our example, the answer would seem to be that current flows from positive to negative — that is, from the high pressure side of the battery to the low pressure side. This is called conventional current flow theory but is not entirely accurate. The electrons are negatively charged and the reality is that current flow is from negative to positive.

But who cares? Does that make any difference in how I fix the car?

No, it doesn't.

Finally, there is another factor that impacts the ability of current to flow in the circuit. That's the electrical term "resistance" and is measured in "ohms." Our throttle plate restriction is the image to consider when thinking of electrical resistance and Ohm's Law confirms what we know intuitively —



the more resistance there is, the lower the current flow.

One more consideration

"Current" is what does the work in an electrical circuit. The work may be illuminating a light bulb or turning a motor or creating the magnetic field that opens the fuel injector or fires the spark plug. And the device or component in the circuit that is responsible for doing the work is called "load."

But electrons don't move willingly, so we need to "force" that movement. That's the role of the pressure differential or "voltage." And, just like the throttle plate, there is some opposition to that current flow present, some "resistance."

A question for you. If you wanted to measure how much resistance to air-

flow existed in the intake path, would you take that measurement statically (with the pistons stationary in their respective cylinders) or would you perform that test dynamically (with the engine running)?

Dynamically, of course! How would you be able to measure any opposition to airflow if there was no airflow at the time of measurement?

The same applies to testing an electrical circuit's resistance. If resistance is the opposition to current flow, how can we test it accurately if there is no current flow? Did some say "with an ohmmeter?" Even that is not a true "static" measurement. The ohmmeter is performing a test that you can perform yourself and it's called "voltage drop."

Making sense of voltage drop

What happens to the air pressure after it overcomes the resistance caused by the throttle plate? It drops, doesn't it? And that, in the simplest explanation is voltage drop. In the case of an automotive DC electrical circuit, the applied voltage "drops" across the resistance of the "load", with next to nothing left over on the other side.

Remember this fundamental electrical principle.

"All voltage applied will be consumed by the resistance in the circuit."

In a perfect world, the load would be the ONLY source of resistance. But in reality, everything in the circuit offers some resistance. The fuses, the switch, the connections — even the wire itself — offers a small, almost minute, amount of resistance.

And the electrical pressure, or voltage, applied will drop across every one of them.

Back to the rule I just shared.

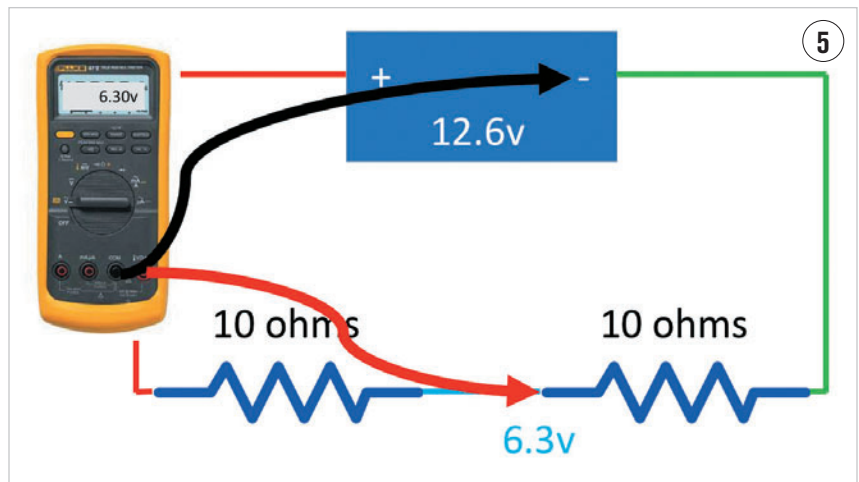
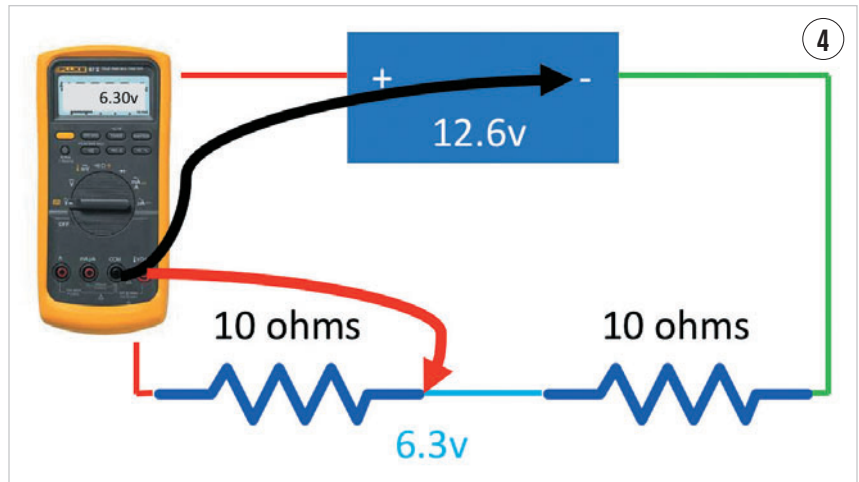
"All voltage applied will be consumed by the resistance in the circuit." is more accurately stated as "all voltage applied will be consumed by all sources of resistance in the circuit proportionally."

Do you understand that? It is vitally important that you do!

If one resistor has 10 ohms of resistance and we measure the drop in pressure (or voltage) across it, we'll get nearly source voltage at the positive side (Figure 1) of the resistor and almost a perfect 0.0 volts on the other side (Figure 2) of the resistor. Any minor variances can be accounted for by the wiring connecting the resistor to the battery, or voltage source.

Now add a second 10-ohm resistor in series with the first. What do you think will happen when we go down the line and take our measurements?

At the first resistor, we should still measure the source voltage we started



with just as we did earlier (Figure 3). Moving to the ground side of the first resistor, we'll now measure roughly half of the source voltage (Figure 4).

That's because the voltage is being shared between the two just as the rule we just learned explained.

"All voltage applied will be consumed by all sources of resistance in the circuit proportionally."

With no other major sources of resistance between the ground side of the first resistor and the positive side of the second, we should read the same amount of electrical pressure (Figure 5). And when we pass on to the ground side of the second, our reading should be the same as we saw on the ground side (Figure 6) of the first time around — nearly a perfect 0.0 volts.

Because all of the voltage has been consumed by all the sources of resistance in the circuit proportionally.

I can't stress this concept enough. It is the key to understanding the use of voltage drop when testing a circuit that is not operating as it should.

Current makes the circuit work

The other key is something you have likely heard mentioned more than you care to admit — Ohm's Law.

Remember what Ohm's Law has to say about the relationship between voltage and current flow?

If voltage decreases, current flow decreases.

Think a moment about the two-resistor circuit. We had just over 12v going in — but is that how much volt-

age was being applied?

We can use what we learned about using our voltmeter to answer that question. Remember how the voltmeter works? It measures the electromotive potential, voltage, between its leads. If we place our leads just across the resistor, what do you think we'll measure?

Approximately half of our source voltage (**Figure 7**)!

So only 6 volts or so was consumed by the first resistor. If this were a light bulb, what would expect to see?

A dim bulb, for sure!!

Is that dim bulb caused by the low voltage?

Not directly. The lower applied voltage was caused by the addition of resistance to the circuit - that second resistor wants its fair share of the total, remember? And that means lower current flow and THAT'S why the bulb is dim...or the motor spins slowly...or the injector doesn't open...

Solving problems using voltage drop

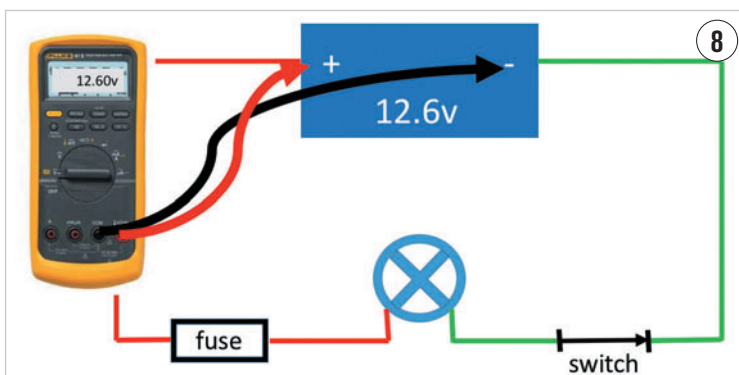
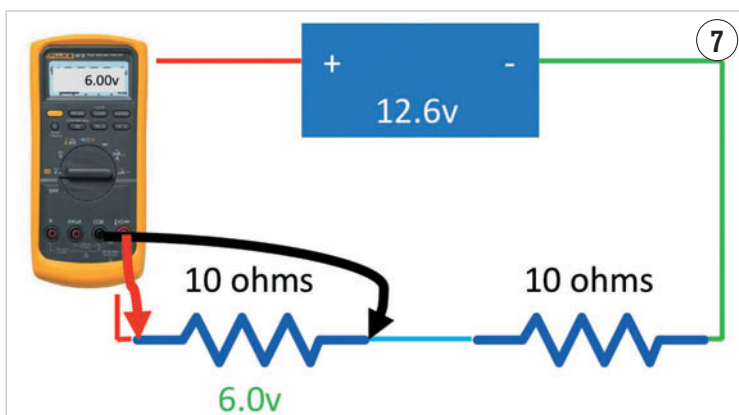
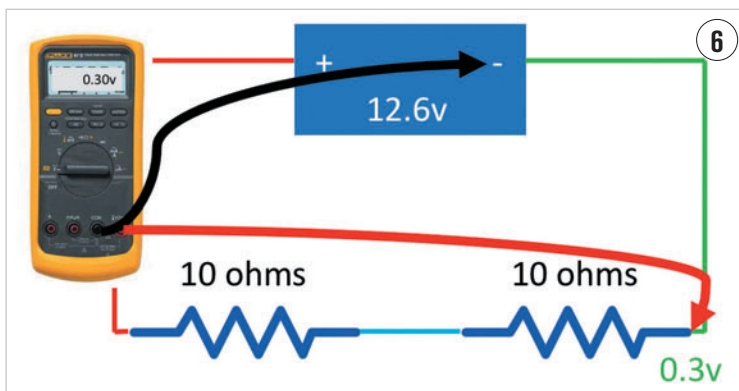
Let's apply this to the real world. If the customer is bringing you an electrical concern, it's more likely in the form of SOMETHING that isn't working as it should. A power seat won't move, a brake light isn't working, or something similar.

First step is to take a look at the wiring diagram and identify the load and its connections. Specifically, we want to identify where the voltage is coming in and where it's going back out to ground.

When you're first learning to understand voltage drop, take your first measurement directly at the battery (**Figure 8**). This is the source voltage you have to work with and should be taken under the same conditions that the circuit you are troubleshooting needs to operate. For example, I don't need to have the engine running (and the battery charging) to test a power window circuit but I do if I want to test the function of the A/C compressor clutch coil.

Now attempt to operate the circuit you're testing and move your positive meter lead to the positive side of the load as close to the load as you can get (**Figure 9**), leaving your negative meter lead at the battery. Voltage drop is a dynamic measurement and current must be flowing for voltage drop to occur. And this is the only way to test the entire circuit path at one time.

These two readings should be relatively the same, give or take a few tenths of a volt. Any difference is caused by every-



thing else in the circuit path - the wire, connections, switches, fuses, and the like.

Remember the rule?

"All voltage applied will be consumed by all sources of resistance in the circuit proportionally."

And the load in the circuit you're testing should be the ONLY real source of resistance in the circuit - so no pressure, or voltage, should be lost until AFTER it passes through the component.

Let's see if it does. Now move your meter lead to the ground side of the load (**Figure 10**).

You should read nearly 0 volts. The load should consume all of the available voltage except for the minute amount needed

to overcome the small resistances left after the load — again, the wiring, connections and so forth.

Let’s make it even simpler

Here’s a way to remove one of the three measurements and make your use of voltage drop as a testing method even easier. Rather than measure the voltage directly at the battery first, move your negative meter lead from the ground side of the battery to the positive side. Now skip to the second measurement and place your positive meter lead on the positive side of the load, as close as you can get (**Figure 11**).

This method lets the meter do the math for you. Remember how the voltmeter works? It reads the pressure differential between the test leads. If the circuit is operating correctly (electrically), then there should be very little voltage between the leads, just the few tenths of a volt that the minor resistance sources (also located between the leads) are consuming.

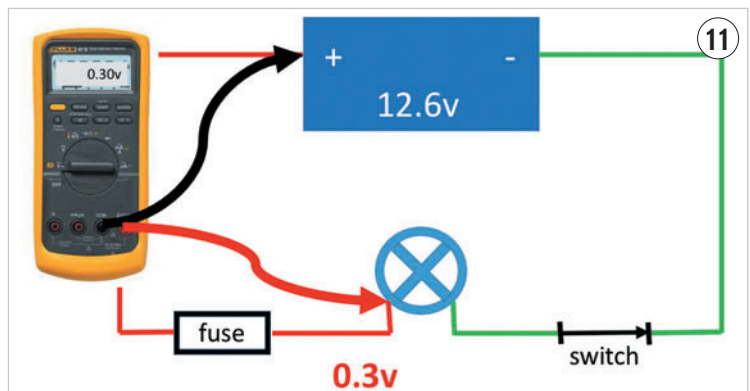
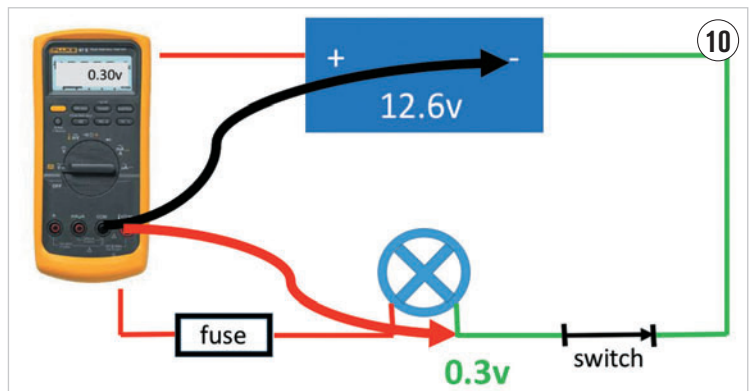
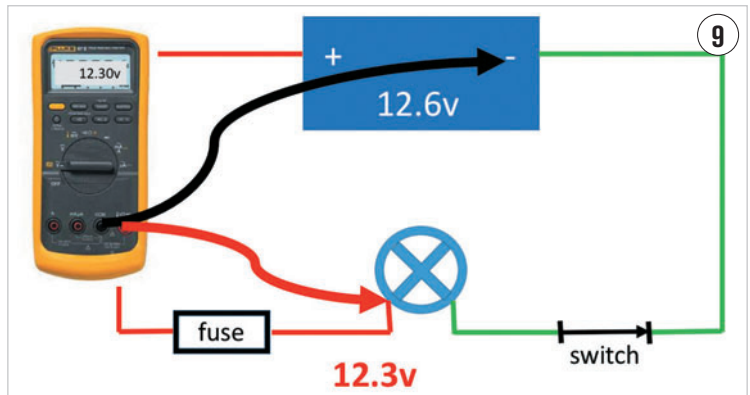
If you DO read a significant voltage, what does that tell you? Think about it.

That’s your “red flag” — there is some other source of significant resistance between the test leads and it’s demanding that amount of voltage for itself. Remember the reading we got on the positive side of the second resistor (back to **Figure 5**)? Think of the second resistor as the primary load and the first is your source of unwanted resistance, your “thief,” the reason the load is not getting the current flow it needs to work the way it’s supposed to!

If this test is OK, then we move on to the last test. Return the negative meter lead to the negative post on the battery and move the positive lead over to the ground side of the load. We expect to see only a few tenths, correct? Because the load is the primary source of resistance and should consume the majority of the voltage applied.

What if, instead, you measured significant voltage here? Same reason as we just discussed — there is a thief between your meter leads! Think about the two-resistor example one more time, only this time the first resistor is supposed to be there and the second is the “thief!” Remember the reading we got when we placed our meter lead on the ground side of the first resistor (back to **Figure 4**)?

Remember, it was nearly the same when we moved the lead to the positive side of the second resistor? That measurement is no different than when we measured for voltage on the positive side of the first resistor! The only difference is that we knew in our minds that we SHOULD read voltage



then and didn’t expect it when measured on the ground side!

And that, my friends, is why you can measure voltage even when your meter leads are both attached to (what you thought were) ground points! **TL**



PETE MEIER is an ASE certified Master Technician with over 35 years of practical experience as a technician and educator, covering a wide variety of makes and models. He began writing for *Motor Age* as a contributor in 2006 and joined the magazine fulltime as Technical Editor in 2010. Now the Director of Training, Pete believes in the mission of the magazine to “advance the automotive professional” and provides resources to working techs around the country through print, social media and YouTube.

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THIS IMAGE IS SHOWING the electrical management amperage sensor on the negative battery cable.

SHEDDING THE LOAD

WHAT HAPPENS WHEN DEMAND EXCEEDS SUPPLY ON THE VEHICLE'S ELECTRICAL SYSTEM?

MARK DEKOSTER // Contributing Editor

As I write this, we just recently passed Halloween and the refrain from Bobby "Boris" Pickett's "Monster Mash" song has been playing on the radio, so I thought I would start out to that tune with some paraphrase. "I was working on my Expedition late one night when my eyes beheld an eerie sight. The message center on the dash announced that modules and systems were being shut down. My car was doing 'The Load Shedding' mash."

Ahh yeah, I should just stick to my normal narrative.

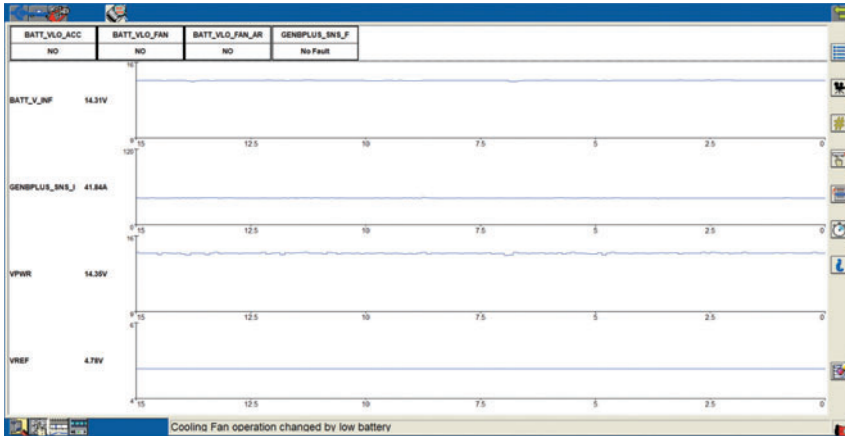
The story is true — I was prepping for an upcoming class and I was working in my garage on my 2015 Expedition, gathering some scans and screen shots for that class. I had been working for about 20-30 minutes, KOEO, and pretty much had all the data I wanted for the class. I decided to hook up one

more time just to be sure and plugged in my IDS and went to do another KOEO test. Instead of getting into KOEO the message center started announcing to me that various systems were being shut down, module after module appeared and said it was being shut down.

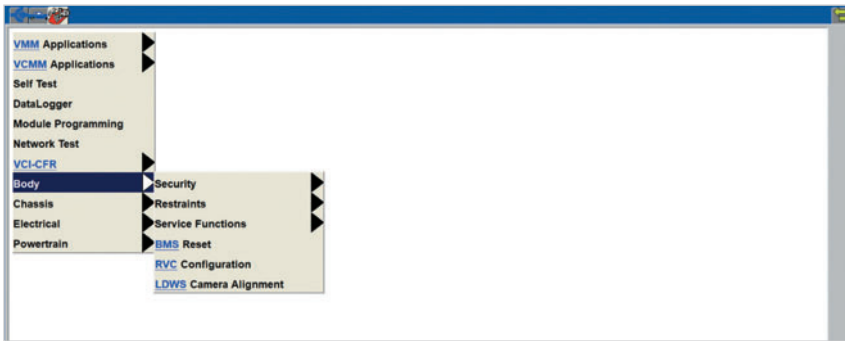
I clicked OK to each announcement and they finally stopped. I did a scan and had 15-20 U-codes. I was left scratching my head wondering what had happened? I had also been doing some electrical testing, so I had my voltmeter out and checked battery voltage and read 12.3V. As I thought about it, it occurred to me that perhaps there was a vehicle strategy that would reduce the load to keep sufficient charge in the battery to be able to start the vehicle. I pulled up the Ford Service Manual and sure enough began to read about load shedding.



WORK SMARTER NOT HARDER



THESE ARE PIDS IN A 2015 EXPEDITION that show whether the PCM is changing operation of accessories or cooling fan based on battery voltage being below a certain threshold.



ACCESSING THE BATTERY MONITOR RESET USING THE IDS

I contacted a co-worker from my days with Ford, who still works there, and asked him some questions about it. He confirmed that Ford has used load shedding for at least the last five years and in some case longer. Here is what I learned:

- What load shedding is
- The correct way to connect a scan tool to a Ford
- The correct method of doing flashing and recalibration
- The correct method and tool to use to provide power to the vehicle when doing these tests
- Perhaps, most importantly, how to connect a power source to the vehicle

What is load shedding?

I have used only Fords in this article in terms of specific information about this

system's operation. I can assure you that other OEMs have load shedding in their vehicles. They will work in a very similar manner to what I describe with Ford.

This article will give you a good overview of how the system works on Fords and I am sure much the same way on other OEs. This article is not intended to take the place of you using the appropriate service publication to become informed about how these systems work and in particular the one that may be sitting in your stall.

The information about how these systems work, test procedures and what gets shed and when, may be found in Ford Service Information through the PTS website and other service publications. With that in mind let's talk about what is going on with load shedding and energy management.

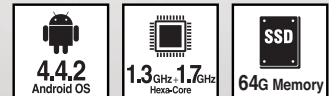


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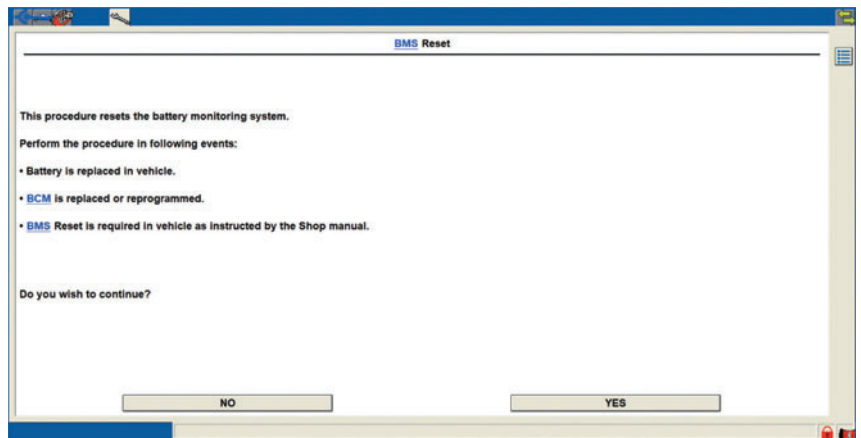
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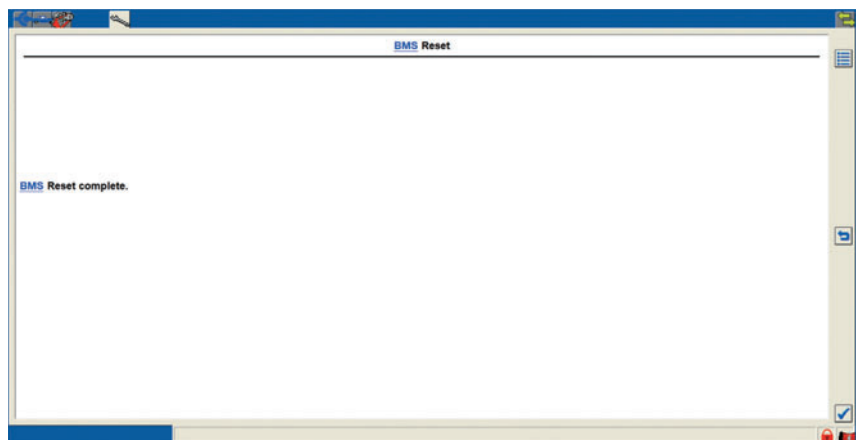
On late-model Fords (the earliest I've seen with this system is a 2013 Focus), Ford uses what they call a Smart Charge charging system that has the PCM controlling the alternator output. I should note that Ford as had the PCM controlling charging long before the 2013 model year. This system monitors multiple inputs and determines the best charging rate based on battery age, electrical load, ambient temperature, engine rpm and load shed strategy. Load shedding is controlled by the body control module and may be initiated by the PCM.

There are three running load shed states:

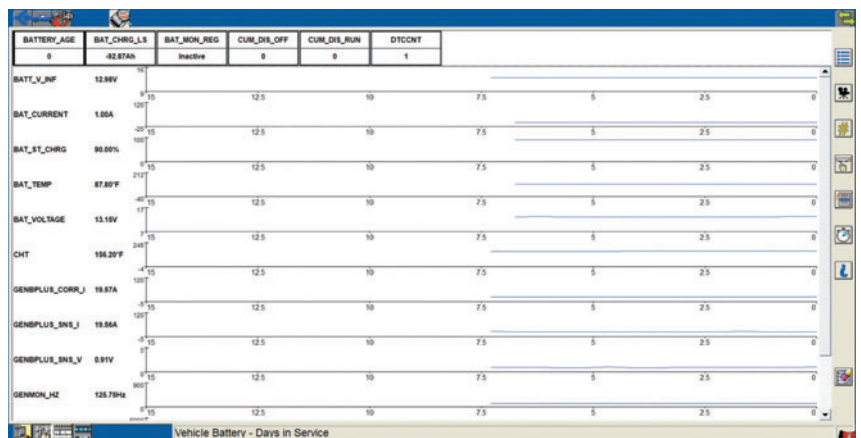
- Load shed 1 will be initiated if the alternator is at full load and the battery is discharging while driving with system voltage is below 11.5 volts. The BCM will start shutting off various accessories, like heated steering wheel or climate controlled seats. Depending on the vehicle and its options will determine what gets shut down at this point. They will be turned back on if and when system voltage returns to normal.
 - Load shed 2 transient will occurs when system voltage is below 11 and the Electronic Power Assist Steering (EPAS) requires power. Systems that are shut down also will depend on how the vehicle is equipped.
 - Load shed 2 continuous occurs when the transient condition last longer that 20 seconds. Again, systems turned off will be determined by how the vehicle is equipped. The Ford service manual will detail what accessories are turned off.
- The engine off load shed occurs when the BCM determines that the battery state of charge is below 50 percent or the vehicle is in ACC or RUN without the engine running for 45 minutes. The first system to be shut off in this state is



SCAN TOOL ASKING whether you're sure you want to reset the BMS. This is only done after putting in a new battery.



RESET HAS BEEN COMPLETED. PCM now will revise its charging strategy to a new battery.



DATALOGGER SCREEN showing BATTERY_AGE reset at 0 Days.

the audio/navigation system and there will be a message displayed that the system was shut down to preserve the battery.

Is there any way that I could have

not had this happen that night in the garage? Glad you asked, as that brings us to the correct and critical way to work on and service batteries in these vehicles.

Load shedding falls under the operation of the electrical energy management system. This system monitors the battery's state of charge, time in service, possible electrical circuit faults and of course the operation of the alternator. There is a sensor on the battery negative cable that sends the information about the battery and charging system to the BCM.

Proper connection of a scan tool

This sensor and load shedding is why it is critical to observe correct service procedures when doing any work on the electrical system or scanning, flashing, or recalibration of modules. Step one: when doing KOEO off testing or scanning you must connect a clean power source to the vehicle.

Connecting a scan tool is no different than any other — you plug it into the 16 pin DLC under the dash. What is recommended is that you also connect a clean power source to the vehicle before you really start testing. The exception to this? You're doing testing on the starting/charging system or it is a quick scan and off to other work.

When you are going to be spending time doing testing that will require electrical power and may cause the system voltage to drop below 12.4V, you want to first connect a clean power source to battery positive and an engine or chassis ground. DO NOT connect to the battery negative terminal. Your charger must maintain the system at 13V or more while working on the vehicle.

I am not going to go into lot of detail about clean power sources other than a reminder that it is critical that you use chargers that are regulated to not exceed 14.5 volts. I have a Midtronics that I use. By clean I mean that in the process of turning the 110v AC of the wall outlet into 12-14V DC that the AC current and voltage variation is removed.

I was at a used car store over the weekend helping my niece look at and find a vehicle to purchase. The vehicle we were looking at seemed to have a dead battery. The jump box the salesman used was dead, so the tech who worked there pulled out an extension cord and the shop charger. It was one of those big ones. I couldn't help but notice the wires were frayed and covered with black tape right at the clamps, you know what I'm talking about— rather than purchase new clamps and properly repair the wires we tape up the fray and hope for the best. I can only imagine what the quality of power was to that car.

Another side comment that is related to this topic. How many of you work on used cars at a dealer? You've seen the Uxxxx codes indicating low battery voltage as the car's battery goes dead while sitting on the lot. You've also seen a lot of overcharge Uxxxx codes by battery chargers put on high

and having the system voltage exceed the threshold for setting that code by going well over 14.5V.

Correctly connecting a power source

To connect power from an outside source to any of these vehicles requires that you connect the hot lead to battery positive. The ground lead is connected to a good under-hood ground.

Jump starting a vehicle with this system also requires that you do not attach the jumper cable to the negative battery post or connection.

What happens when you don't follow this protocol? You confuse the battery state of charge calibration and monitoring. The load shedding may not work correctly until the system has a chance to recalibrate itself.

The good news is that the system will reset itself, on its own, after the vehicle has set for at least 8-9 hours in sleep mode. I had to do that with my Expedition because although I did have a clean power charger, I had hooked it up to battery negative. I had not read the service manual to know that connecting to a body or engine ground was needed. I didn't know anything about the system and how it worked.

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Correct procedure for doing calibration or flashing

This is even more important when doing calibrations or flashing. If system voltage drops too far during that time, you don't need the BCM going into load shed! As with scanning and other testing, step one in calibrating or flashing is to connect a clean power source to the vehicle.

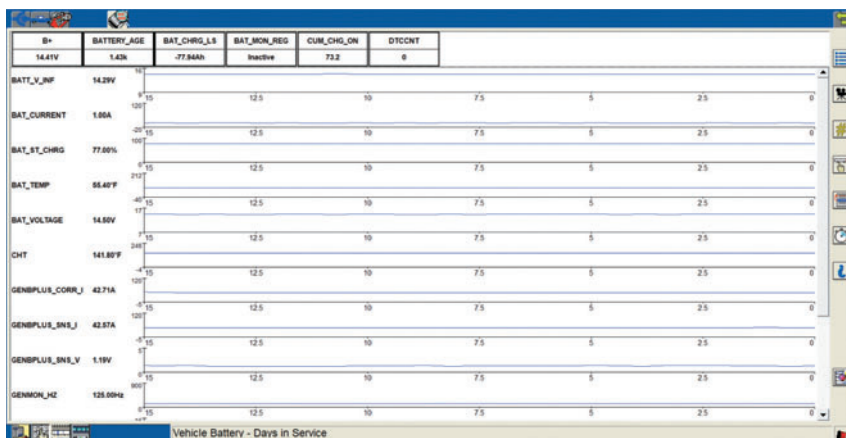
Electrical energy management system

As you might expect, the features of this system and how it deals with correct and incorrect connection outside power sources to the vehicle vary from one model of Ford to the next. Battery condition monitoring, load shedding all generically work the same but as you might expect will react differently on a Platinum Edition Expedition than on a base Focus.

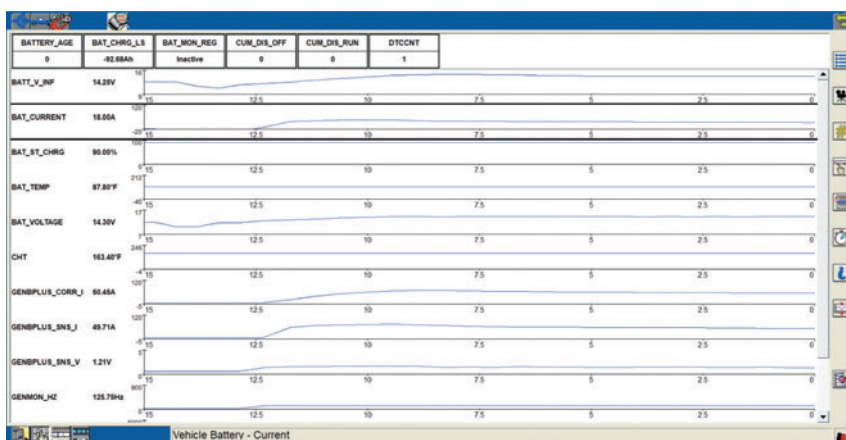
This system is also responsible for keeping the battery charged. It varies the charge rate based on things like battery condition and age, ambient temperature, and accessory demand. What gets very interesting is watching the PID that is monitoring current flow to and from the battery. There are times when the battery is actually providing some of the operating power requirements and other times when it is being charged and other times the alternator is providing all of the system's needs.

The reason this is done is twofold; well, actually it's one reason with two benefits. This is done to improve overall fuel economy. Improving overall fuel economy also lowers emissions.

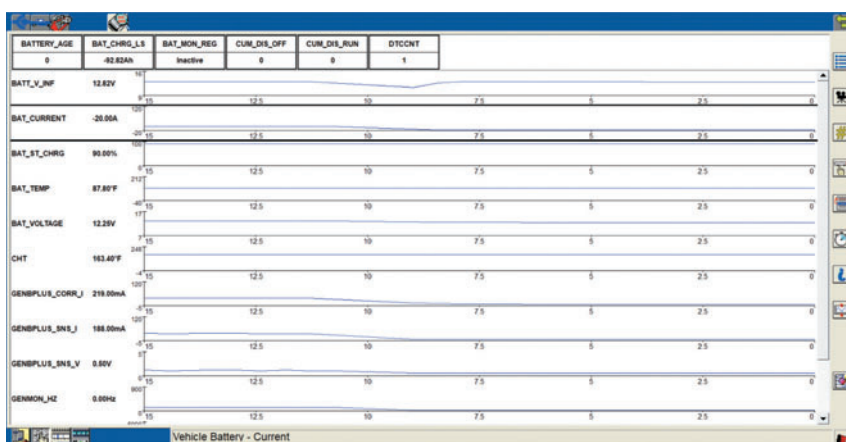
As I noted above, one of the features of the electrical energy management system is that it monitors battery state of charge, time in service, and therefore battery life. One of the options you may run across on your scan tool, particularly the IDS is the option to recalibrate the battery monitoring system. It would be a natural thought to consider doing



SCAN ON A DIFFERENT VEHICLE SHOWING the battery age at 1,430 days or 3.9 years.



SCAN SHOWING THAT THE BATTERY IS GETTING 18 AMPS at idle. Battery voltage is 14.30V. This amperage is being sensed at battery negative.



SCAN SHOWING THE SAME VEHICLE with the engine running and the battery is providing 18 amps to run electronic systems on the vehicle. Battery voltage is at 12.25V. This is being sensed at battery negative.

this if you've connected a battery charger or jump box incorrectly. Let's do it now rather than wait for the system to do it over the course of 8-9 hours.

DON'T do it.

Battery replacement is when you use the scan tool to do the recalibration. This resets the learned battery data, the



THIS IS THE 2015 EXPEDITION and various systems are being shut down. This what you see on the dash message center.

in-service time counter and lets the system know there is a new battery in the vehicle. Yes, you must have a scan tool to do this; there is no other way to do it.

Failing to do this reset after installing a new battery may cause unwarranted operation of load shedding and may limit the electrical energy management system functions.

Baseline electrical testing

Before I close out this piece let me do another quick reminder of checks that you should be doing whenever you're servicing the vehicle's electrical system. It never hurts to be reminded of those checks we all know we should do, and sometimes, we forget to do them.

First, checking starter current draw and voltage during cranking is a good practice, particularly for finding intermittent hard starts. I've run across more than one vehicle that "sounded" as if the starter was turning fast enough that the battery would not be a concern, yet a test of cranking voltage showed it under 10V. Cranking speed was really too low and when system voltage gets around 10V or less the vehicles control modules may go back to sleep.

Another critical test on the charging system is AC voltage. As you know the alternator (actually, "alternator" was a Chrysler brand name — it is an internally rectified AC generator) creates AC current and there are diodes within the component that rectify that output into DC current. Some AC does manage to get by the diodes — too much and strange things begin to happen, including decreasing the life of the battery.

The specs on this test are readings that are below 0.5VAC with the rpm at 1500+ and at least 20A output by the generator. In excess of 0.5V replace the generator.

Conclusion

The good news in learning about load shedding is that even if you have made incorrect connections when charging or jump

starting a vehicle equipped with it, you probably haven't created any real concerns for the owner. The OEs have been telling us for years that we should only ever connect to battery positive and a good body or engine ground. Now, there is good reason for that beyond just safety.

Last, don't forget to check if the car you're working on needs to have a scan-tool reset as part of installing a new battery. When you get a customer in who's done their own replacement or gone to a parts or big-box store and gotten a battery you might want to consider looking to see if this reset was done for them.

I've still seen load shedding occur a couple of times since that night, only because I didn't take the time to put the charger on before doing KOEO activities. Those old habits of "I'm just doing a quick check and don't need the power source," are hard to break. *TL*



MARK DEKOSTER has been fixing or teaching people how to fix cars for over 30 years. He has been a tech, trainer for Snap-on and Ford Motor Company, and currently is an associate professor at Ferris State University. He is the lead instructor in The Automotive Management Degree Program.
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THE CYBER TRUCK

A LOOK AT HOW “SECURE GATEWAY MODULES” ARE IMPACTING OUR ABILITY TO PERFORM EVEN ROUTINE TASKS

JOHN ANELLO // Contributing Editor

I recently received a distress call from a repair garage on a 2019 Jeep Grand Cherokee (Figure 1) where something in their bay went drastically wrong. The vehicle in question was a “waiter,” and the customer was in the office spending part of their day to have some preventative maintenance done to their vehicle. It’s bad enough that you have to deal with all types of diagnostic dilemmas that enter your working bay, but when you create the problem yourself, it becomes a chase to the finish line to correct the issue at hand before the owner of the vehicle finds out. I am sure that we have all been down this road at one time or another in our long history

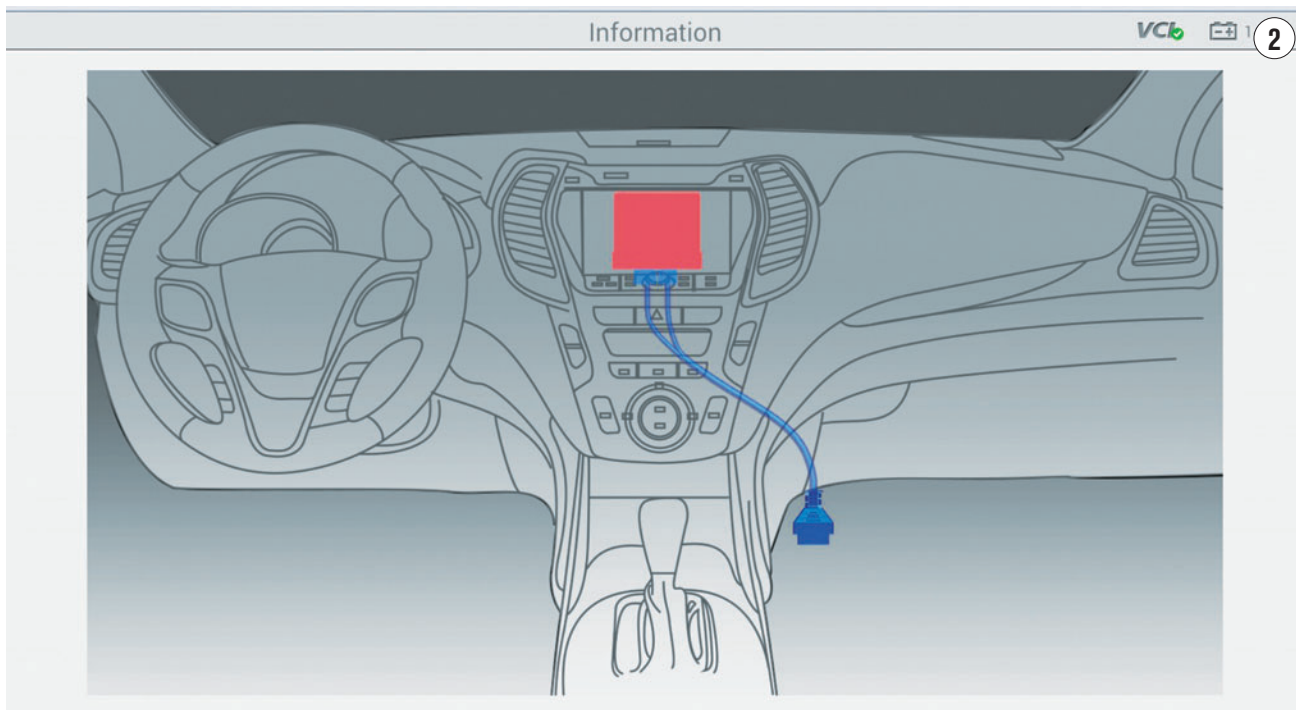
of working on so many vehicles with the daily distractions we are exposed to. It helps us to condition ourselves to never take the same path again.

Be sure!

The shop tech was trying to scan this vehicle to do a simple health check to make sure all was good during a routine maintenance service. He noticed some error codes stored in a few controllers, so he decided to clear them out. He was fully aware that this truck was a “cyber protected” vehicle that required a special cable to perform any bi-directional commands. The manufacturer of his scan tool also provides a warning screen to alert him that he needed to use the special cable if he



needed to do code clearing or any other bi-directional procedures such as calibrating sensors, bleeding brakes or activating relays and solenoids. The scan tool also provided him with a picture of the hookup location (Figure 2). He had used the adapter cable many times before, but when he went to use it this time it did not function properly



and he ended up with an inoperative front center panel display once he reassembled the center dash panel. At this point, he felt that he had shorted something out, so this is where he called me in for technical assistance while I was still in his area that morning.

When I arrived at the scene, I entered the shop through the garage door rather than through the office where the customer was waiting. I needed to do this job in stealth mode so as not to draw any attention to the problem at hand. The shop tech removed the upper part of the center dash to show me the procedure he used to access the Gateway Control Module in order to install a bypass cable into its harness connectors. Basically, you were supposed to unplug both Gateway Module connectors and plug them into this “Y-Cable” adapter and then hook the main part of the cable to the scan tool. The problem here was the module only had one of the connectors he was used to plugging into, but the second connector in the module was much larger (**Figure 3**). When he looked around in the same area he noticed a second connector that would fit the scan tool adapter and plugged it in (**Figure 4**). This was when all hell broke loose.

It turns out that this second connector was a feed cable for the front display panel, and it was shaped in just the right dimension to accommodate the Y-Cable. When this was done, the fuse blew in the engine compartment fuse box to protect the panel’s circuit that was exposed to a direct path to ground from the Y-Cable. The module he was plugging into was not the Gateway Control Module, but rather the A/C Control Module that was located in the same place that other Chrysler trucks secured a Gateway Control Module. The location of the Gateway Module on this particular truck was located in a lower position at the front part of the center console near the base of the



center dash. I could now see how this could easily confuse a scan tool user. The actual cable hookup screen on the scan tool was just a generic picture of the location of the Gateway Control Module that did not apply to all vehicles, so it was basically up to the user to find the proper location using their repair information.

I just want to clear the codes

I replaced the blown fuse in the engine compartment and had the tech put the vehicle back together. I proceeded to use my Chrysler Wi-Tech factory scan tool,

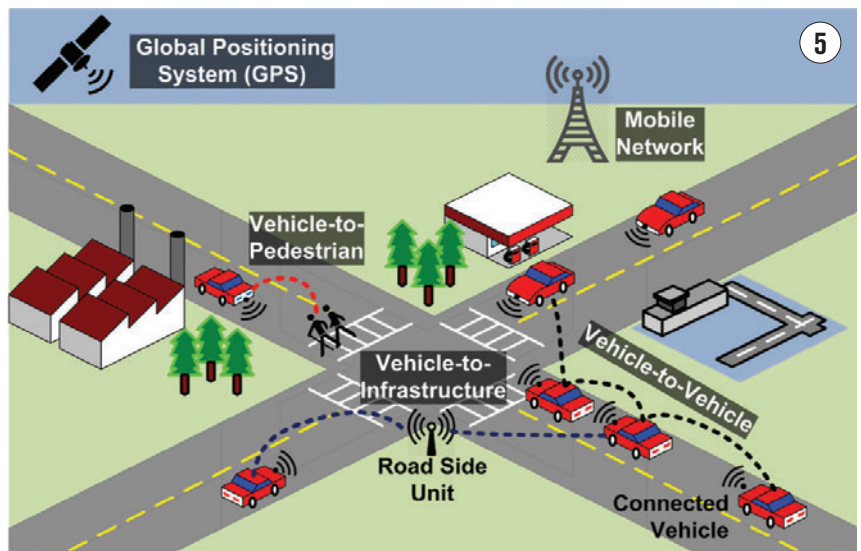
which could command the onboard Gateway Control Module to unlock itself so I could clear out all error codes stored in the network and the shop could finish up the vehicle. If you look at the topology map of this Chrysler vehicle using the Wi-Tech software, you will notice a Secured Gateway Module located in front of the OBD II connector that controls scan tool communications in and out of the network. The diagnostic port is normally open for data acquisition, but it is locked for bi-directional acquisition from scan tool commands. Chrysler holds the authority for you to be able

to access bi-directional controls and through their secured server and the proper credentials, the Gateway Control Module will be unlocked without using a bypass cable that could invite unwanted labor or mishaps.

This all started a few years back when a couple of “friendly hackers” decided to use a late-model Jeep to test the vulnerability of onboard CAN networks to hacking possibilities. They were able to hook a laptop to the diagnostic port and analyze communication protocols being transmitted within the network between controllers. Then they were able to mimic these messages, reproduce them and sent commands into the network to perform tasks like shutting down the engine, applying the horn and wipers and even blasting the radio. It was then taken to the next level by hacking into a Bluetoothed phone that was synchronized with the onboard Telematics Control Module, which in turn was tied to the vehicle CAN network. They were successfully able to remote into the phone and send command messages into the CAN network via the Telematics Control Module while they were a distance away from the vehicle. This all sounds like weird science, but it became a reality. They posted it on YouTube and when Chrysler saw the video, they quickly took action to address the issue to prevent any future terroristic opportunities available to the “dangerous hackers of the world.”

Cybersecurity is a real issue

The Car Spy Study Act of 2017 was implemented by the Federal government and directed the National Highway Traffic Safety Administration (NHTSA) to create standards for automakers to address cybersecurity in automobiles. This would cover building firewalls in the onboard networks to prevent drivetrain access from the Telematics Control Mod-



MASSACHUSETTS DATA ACCESS HEARING DRAWS LARGE CROWD OF SUPPORTERS

In January, the Massachusetts Legislature held the first hearing on legislation that would ensure consumers would have access to the repair data generated by their vehicle. The room was packed with repair shop owners and technicians, as well as representatives from the major parts retailers and tool suppliers — providing a major show of support for the new legislation the auto care industry in the state.

The hearing featured testimony from multiple shop owners who discussed the need for the current Right to Repair law to be amended to ensure that car owners have access to wireless repair and diagnostic data generated by most late-model vehicles. Opponents of the legislation, mainly trade groups representing car and truck

manufacturers, countered that the law was not necessary and it would expose an extensive amount of a driver's personal information. Manufacturers further alleged that making data available would make critical vehicle safety systems vulnerable to cyber attacks.

Legal experts explained to legislators that the bill was specifically worded to only require access to repair and diagnostic data, ensuring that personal information would be protected.

The Legislature now has until May 15 to determine whether to pass the bill and therefore negate the need for a ballot measure that has been filed by the Massachusetts Right to Repair Committee that would mandate access to vehicle diagnostic and repair data.

traffic lights that could send messages to cars that the light is turning red before the vehicle reaches an intersection. Traffic and weather reports can also be sent to vehicles to alter their destination routes. It all sounds so crazy, but we are living in a fast pace of never-ending changing technology.

There are a lot of guys in the field I talk to who will admit that automobiles have gotten out of control and they just want out. Then I pose the question of what they would they do when their passion was always about cars. You need to embrace the new technology as it comes into your bay and find ways to retool your business to accommodate the changes. There is no time to sit back and become stale to the industry. The key is to do a lot of research to learn new technology and be involved in continuous education. Don't resist change or it just may push you out of the industry. It is the best time right now to get in the business, because the diagnostics and services of these new systems could be more lucrative for you.

I'm guessing that by now a lot of you techs out there have moved to register your scan tools with a secured server to unlock the 2018 and newer Chrysler vehicles. Talk to your scan tool dealer for more information; you don't want to be left out in the cold and lose customers because you're unwilling to move forward. My only hope is that this article has inspired you to stay in this business and make newer investments in your shop to keep you going forward. *TL*



JOHN ANELLO owns Auto Tech on Wheels in northern New Jersey, which is a mobile diagnostic service for 1,700 shops, providing technical assistance and remote programming. He is

also a nationally known trainer.

atowscopeit@aol.com

ule. They would also require encrypting language within the networks to prevent easy hacking of shared onboard messaging between controllers. This was soon followed by Chrysler deciding to install a Secured Gateway in front of the OBD II connector on late-model 2018 vehicles and newer to prevent unauthorized access for bi-directional manipulation. The fear is if this is not addressed early, then it would hurt the automotive industry's plans to move full speed ahead in producing Level 3 to Level 5 driverless cars in the close future.

Aftermarket scan tool companies are now slowly migrating to push for wireless access scan tools to link to a secure website where each repair shop will have to register their scan tool along with the names of individuals in the shop and complete a shop information form. These websites will

be working closely with manufacturers and the federal government to allow a registered scan tool the ability to unlock a secured vehicle Gateway Control Module. The manufacturers will now be able to monitor all activity on the vehicles and see who is accessing them and what is being commanded within the vehicle network.

This will be the new norm of the vehicle industry and will create an atmosphere never seen before. It's all about driver security for what is to come. If we are looking to link vehicles to a closely linked network of other vehicles and traffic infrastructures, it is a critical step that has to be taken. Just imagine vehicles being wired into a world-wide web like our home computers. Vehicles can talk to one another and share their locations before approaching the same intersection (**Figure 5**). There would be

ON THE ROAD AGAIN!

MOTOR AGE TAKES ITS “COMMITMENT TO TRAINING” TO NEW LEVELS IN 2020. WILL I SEE YOU AT A TRAINING EVENT THIS YEAR?

PETE MEIER // Director of Training

I am passionate about training. I remember, as a tech, how difficult it was to find decent training and the few opportunities that did come along were, often as not, more infomercial than educational.

My, how things have changed! And that's a good thing!

It's going to be a busy first quarter!

Our friends at AVI kicked off 2020 with their annual Winter Training Conference, held at the AVI headquarters in Ft. Myers, Fla. This month, it's the Mobile Air Con-

ditioning Society Worldwide's annual Trade Show and Training Conference, hosted at the Gaylord Opryland Resort in Nashville, Tenn. In addition to some great management and technical training classes, both events also offer something for the families of the attendees, making it easy to combine the two and get a little family time after classes are over.

Training events really blossom in March, with three leading events taking place. The first on the March calendar is one that every tech and shop owner needs to have on their “bucket list” — the VISION Hi Tech Training and Expo, held at the Overland Park Convention Center, March 5-8. Odds are by now most of

the classes are sold out and hotel rooms close to the convention center are taken, but you may still find a way “in” if you check their website.

If you can't make VISION this year, Overland Park is just too far for you to go or you can't take off that much time from work, there are two other great options coming up for you, both offering the same high quality training and networking opportunities. The first is the TST (Technicians Service Training) “Big Event,” being held March 21st in Tarrytown, New York. The location is easily accessible from the major New York airports, or you can fly in to Westchester and grab an Uber to the



THE BEST TRAINING EVENT is the one you attend! But if you have to pick one that is a “must see,” it has to be VISION.



THE TST BIG EVENT IS UNIQUE among training events. This one-day training event uses tablets rather than printed handouts and packs a lot of activity into a single session. Get some sleep the night before!

hotel. It is an action-packed, one-day event that is known for two distinct features (other than the great training and vendor exhibition) — all handouts are downloaded to a tablet that you get to keep and sponsors of the event provide literally thousands of dollars of giveaway items.

In addition to these two stellar events, let's not overlook what's happening on the West Coast. Also in March, ASA Northwest will host their annual Automotive Training Expo, or ATE. This event takes place in beautiful Seattle, Wash., March 27-29. Both of these events are held over the course of a weekend (three-day weekend in the case of ATE) and that should make it a bit easier to break away from the shop for a bit. As a matter of fact, there are numerous shop owners that truly understand the value of training for their team and they actually close down, bringing everyone to the event of their choice, and use the time to build their internal team.

Shop owners — are you listening?

At-home options

One point I raised with my bosses when I first joined the magazine was the fact that making a living as a technician can be a challenge. According to the Bureau of Labor Statistics, the median income for automotive technicians of all skill levels today is \$39,550. That has only improved slightly from the approximately \$33,500 it was nearly 10 years ago. The best-paid 25 percent made \$53,590, while the lowest-paid 25 percent made \$29,370.

During my last few years in the field, I earned above the industry median but even then, I had other obligations that needed to be met before I could consider spending any of it on training. And the challenges of keeping up with rapidly changing technologies was nowhere near at the pace it is today! So what options do you have when traveling to a national event isn't in the budget?

Motor Age Training has expanded to offer a few. First, of course, is our YouTube channel, where I try to produce

content that offers insights into the repair and service of today's systems while also reinforcing the fundamentals you must master before you can take on more advanced material. These videos are, of course, available to anyone that wants to view them.

And many of you know that we also host technical webinars, where I and my cohort, G. Truglia, host presentations on a variety of topics "live" so that you have the opportunity to interact with us by submitting your questions and comments, and we do it in the shop so that we can make the experience as useful to you as we can. We've also expanded our webinar offerings, including a relatively new series hosted by Jeremy O'Neal of AdvisorFix, aimed at helping shop owners grow their business and close more sales.

Want something more formal that you can fit around your work and home life? Then try out our online Learning Management System, "Motor Age Training CONNECT." This is a self-paced training regimen that allows you



G. JERRY TRUGLIA WILL BE ONE OF OUR FEATURED PRESENTERS at the Commitment To Training LIVE event scheduled for May 9 in Rosemont, Ill. I will also be presenting and our new Technical Editor, Brandon Steckler, will finish off the day with a brand-new class!

to follow a learning path or to select the topics you want to focus on — with a test out requirement before you can move forward. You can try it out for free and there are no contract terms, so if you do decide to sign up for the monthly service you can also cancel at any time. I will tell you that I think the quality of the material is first-rate, but you will have to get around the fact that the steering wheel appears to be on the wrong side of the car! You see, our training partners are based in the “land down under” and they use a little different terminology than we do. More entertaining, I say, and makes learning that much more enjoyable!

One more thing!

If you haven't seen the press releases or the news on social media yet, allow me to share it here! Motor Age Training (along with partners *PTEN* magazine and TST!) takes to the streets in 2020, with plans to host at least two one-day

training events around the country!

The first will be held on May 9, hosted by the Embassy Suites by Hilton Chicago in Rosemont, Ill. Its close proximity to Chicago's O'Hare airport makes it easy to access the venue and the cost of the event makes this opportunity affordable to nearly every budget.

The event will feature three presenters you certainly know; myself, G. Jerry Truglia and *Motor Age's* newest Technical Editor, Brandon Steckler! If you've seen G. or Brandon before, you know how good they are and both will be featuring new and updated material, most never presented before!

In between, enjoy spending time with a variety of industry representatives, showcasing their tools and products. We'll also provide breakfast and lunch, and end the day with an after-training reception, where you'll have the chance to relax your brain cells and interact with the other attendees, vendors and presenters before calling it a day!

As I said at the start, *Motor Age* has a “Commitment To Training.” Whether it's helping other training events get the word out or providing the training directly, it all falls into our mission of “advancing the automotive service professional.” And with the challenges you guys and gals are facing in the next decade, that commitment to you is more important to us than ever!

Will I see you at one of these events or webinars this year? **Y**



PETE MEIER is an ASE certified Master Technician with over 35 years of practical experience as a technician and educator, covering a wide variety of makes and models. He began writing for *Motor Age* as a contributor in 2006 and joined the magazine fulltime as Technical Editor in 2010. Pete believes in the mission of the magazine to “advance the automotive professional” and provides resources to working techs around the country through print, social media and YouTube.

pete.meier@ubm.com

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AVOID THESE COMMON CAUSES OF A/C COMPRESSOR FAILURE

REPLACING AN AIR CONDITIONING COMPRESSOR IS A RELATIVELY STRAIGHTFORWARD TASK, BUT IF YOU DON'T PAY ATTENTION TO THESE KEY AREAS, YOU'LL BE DOING IT AGAIN MUCH SOONER THAN YOU'D LIKE!

PETE MEIER // Director of Training

The air conditioning system on your customers' vehicles has changed significantly over the last few years. Fewer components, lower refrigerant charges, lower oil charges — even a new refrigerant! And with these changes in system design comes changes in the procedures and processes related to repair and service.


These new systems are proving relatively bulletproof. It's not unusual for vehicles to live out their useful lives on the same refrigerant charge they

left the factory with, let alone having needed any major repairs or component replacements. When they do, it can usually be traced to factors that may have been easily intercepted and corrected before the failure occurred.

But failures do occur, don't they? Evaporator core leaks are among the more common and right behind that? Failed compressors.

When compressors fail, they usually leave a mess behind in their wake. If the debris is not completely removed, the new compressor won't stand a chance of lasting very long.

The issue of how to effectively remove the debris and ensure that nothing is left behind to threaten the compressor is a matter of debate. Not only that, the process for prepping and installing the new compressor also varies depending on who you talk to.

In this edition of The Trainer, I turn to the experts to get the facts on the steps you need to take when faced with the aftermath of a failed compressor and the procedures you need to adhere to ensure that the new compressor lasts as long, or longer, than the first! 



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