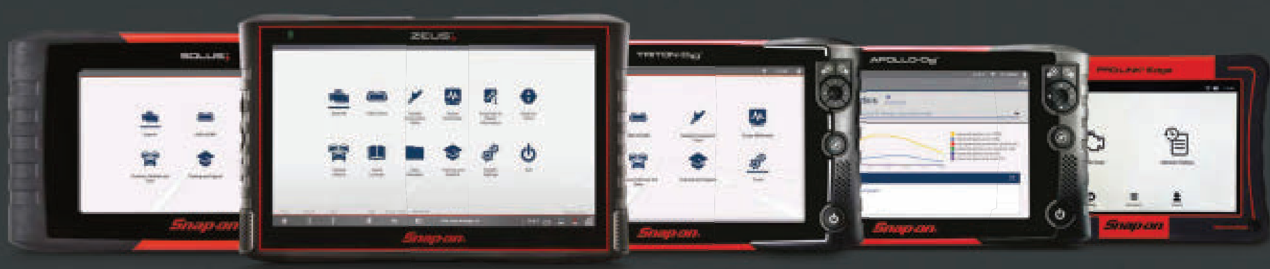
ADVERTISEMENT

MOTOR AGE

JUNE 2023
VOL. 142, NO. 5
VEHICLESERVICEPROS.COM
ENDEAVOR BUSINESS MEDIA

FIND YOUR FASTEST PATH TO FIXED.



Snap-on has a range of diagnostic products to suit every Technician in the shop. From maintenance and repair tasks to complete testing and verification, we have a solution that fits your needs.

No other company can match our product quality, data or our customer service, and no other company has a complete product range that is so fast and easy to use. Bring more “flow” to your diagnostic work, and choose the perfect diagnostic product for you at **snapon.com/diagnostics**.

CHOOSE THE MOST POPULAR BRAND OF DIAGNOSTIC PRODUCT THERE IS.

Snap-on®

MOTOR AGE

JUNE 2023
VOL. 142, NO. 5
VEHICLESERVICEPROS.COM

ENDEAVOR
BUSINESS MEDIA

FARADAY'S LAW: THE FOUNDATION OF IGNITION COIL FUNCTIONALITY

Ignition event acquisition and waveform analysis didn't go away with the distributor.

MOTOR AGE

Talk Shop Anytime

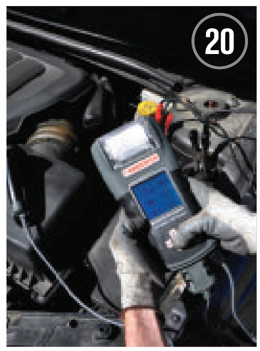
JUNE 2023

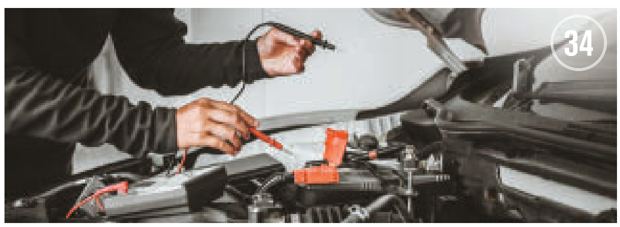
VOL. 142, NO. 5 //

VEHICLESERVICEPROS.COM

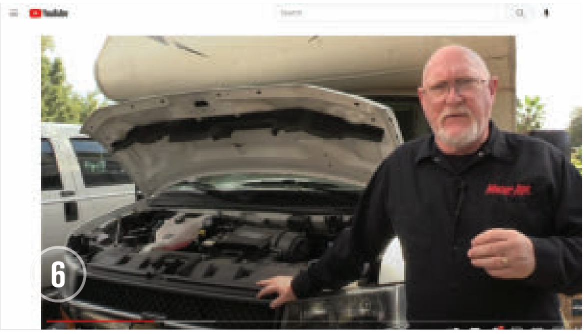
OPERATIONS

TECHNICAL





IN EVERY ISSUE



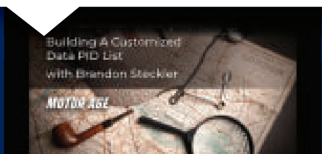
VIDEO

MOTOR AGE SERVICE DONE RIGHT #19 -

EXPERT TIPS ON SERVICING AUTOMOTIVE HVAC SYSTEMS!

In this video, we'll be discussing the best practices that every service technician should follow when dealing with a poorly performing automotive HVAC system. Learn best practices to service modern A/C systems.

WEB EXCLUSIVES



MASTERING DIAGNOSTICS WITH BRANDON STECKLER: PART 4

Sharpen your diagnostics with better data analysis.

The idea behind data analysis is not to fix the vehicle but to determine what is working properly. This will allow you to focus on far fewer possible faults to perform your hands-on testing. The data captured should be arranged to tell a story that any properly trained technician should be able to evaluate and make a diagnostic decision. Here, Brandon Steckler shows you what made him successful!

MOTOR AGE

VEHICLESERVICEPROS.COM

Endeavor Business Media, LLC

1233 Janesville Avenue, Fort Atkinson, WI 53538. Phone: 920-563-6388

EDITORIAL STAFF

JAY SICHT
MANAGING EDITOR
jsicht@endeavorb2b.com

PETE MEIER ASE
CREATIVE DIRECTOR, TECHNICAL
pmeier@endeavorb2b.com

BRANDON STECKLER
TECHNICAL EDITOR
bhsteckler@gmail.com

RHONDA COUSIN
ART DIRECTOR

CONTRIBUTORS

JEFF COX
CHRIS FARLEY
CHRIS MARTINO
TOM RINGLE
JOHN ROGERS

PRINTED IN U.S.A.

SUBMISSIONS:
Motor Age welcomes unsolicited articles manuscripts, photographs, illustrations and other materials but cannot be held responsible for their safekeeping or return.

Connectiv
The Business Information Association, a division of SIIA

MEMBER OF:

ENDEAVOR BUSINESS MEDIA

CEO – **CHRIS FERRELL**
PRESIDENT, CRO/CMO – **JUNE GRIFFIN**
CFO – **MARK ZADELL**
COO – **PATRICK RAINS**
CHIEF ADMINISTRATIVE AND LEGAL OFFICER – **TRACY KANE**
CHIEF REVENUE OFFICER – **REGGIE LAWRENCE**
EVP, TRANSPORTATION – **KYLIE HIRKO**
VP, ACCOUNTING – **ANGELA MITCHELL**
VP, FINANCE – **JESSICA KLUG**
VP, DIGITAL BUSINESS DEVELOPMENT – **MONIQUE LEIJA**
VP, PRODUCTION OPERATIONS – **CURT PORDES**

BUSINESS STAFF

CHRIS MESSER
VP/GROUP PUBLISHER
MICHAEL WILLINS
BUSINESS DEVELOPMENT DIRECTOR, MOTOR AGE TRAINING
LESLIE BROWN
CUSTOMER MARKETING MANAGER
SHEILA WARD
PRODUCTION MANAGER
MELISSA MENG
AD SERVICES MANAGER
TRACY SKALLMAN
AUDIENCE DEVELOPMENT MANAGER
JILLENE WILLIAMS
SALES COORDINATOR

SALES STAFF

MATTIE GORMAN-GREUEL
Associate Sales Director
mgorman@endeavorb2b.com
CORTNI JONES
Director of Business Development
cjones@endeavorb2b.com

Account Executives:

DIANE BRADEN
dbraden@endeavorb2b.com
MARIANNE DYAL
mdyal@endeavorb2b.com
CHAD HJELLMING
chjellming@endeavorb2b.com
LISA MEND
lmend@endeavorb2b.com
BOB MARINEZ
rmarinez@endeavorb2b.com
MICHAEL PARRA
mparra@endeavorb2b.com
MARTHA SEVERSON
mseverson@endeavorb2b.com
KYLE SHAW
kshaw@endeavorb2b.com
SEAN THORNTON
sthornton@endeavorb2b.com
KENZIE VERSCHOOR
mverschoor@endeavorb2b.com
JAMES HWANG
Brand Manager,
ASE Study Guides
jhwang@endeavorb2b.com

REPRINT SERVICES
reprints@endeavorb2b.com.

CUSTOMER SERVICE
Subscription Customer Service
877-382-9187; 847-559-7598
MotorAge@omeda.com
PO Box 3257
Northbrook IL 60065-3257

Motor Age (USPS Permit 925560), (ISSN 1520-9385 print, ISSN 1558-2892 online) is published 10 times yearly (Jan/Feb, March, April, May, June, July, August, September, October, Nov/Dec) by Endeavor Business Media, LLC. 1233 Janesville Ave., Fort Atkinson, WI 53538. Periodical postage paid at Fort Atkinson, WI, and additional mailing offices. POSTMASTER: Send address changes to Motor Age, PO Box 3257, Northbrook, IL 60065-3257. SUBSCRIPTIONS: Publisher reserves the right to reject non-qualified subscriptions. Subscription prices: U.S. ($77.00 per year); Canada/Mexico ($117.00 per year); All other countries ($117.00 per year). All subscriptions payable in U.S. funds. Send subscription inquiries to Motor Age, PO Box 3257, Northbrook, IL 60065-3257. Customer service can be reached toll-free at 877-382-9187 or at MotorAge@omeda.com for magazine subscription assistance or questions.

AD DEADLINES: Insertion orders–1st of month preceding issue date. Ad materials–5th of month preceding issue date.

O'Reilly FIRST CALL

DEDICATED TO THE PROFESSIONAL

IMPORT DIRECT®

OE REPLACEMENT PARTS

PREMIUM BRAKES FOR FEWER COMEBACKS

IMPORT DIRECT® BRAKE PADS

Designed to match OE formulations for a variety of import applications.

On select applications, Import Direct® brake pads have

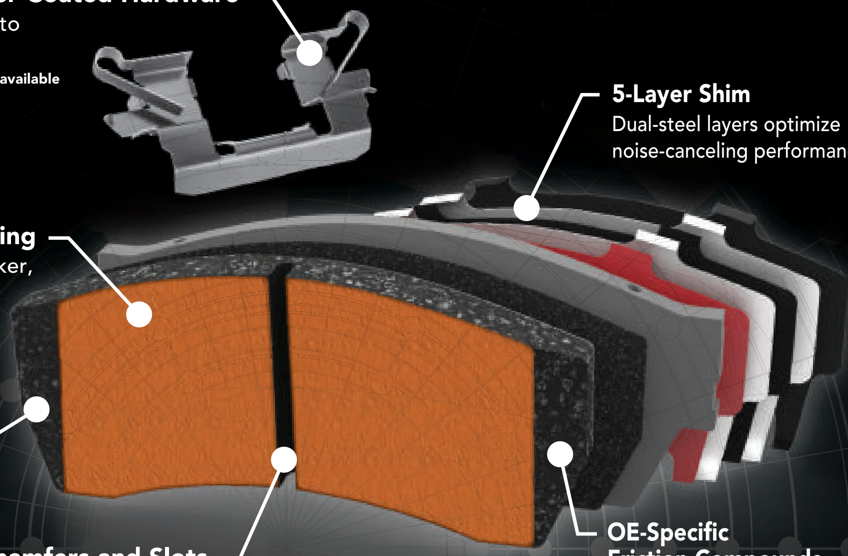
R90

APPROVED FRICTION FORMULATIONS

PTFE & Rubber Coated Hardware
Reduces friction to prevent binding*
*On applications where available

5-Layer Shim
Dual-steel layers optimize noise-canceling performance

Break-In Coating
Promotes a quicker, more effective break-in



OE-Style Chamfers and Slots
Helps dissipate heat and minimize noise

OE-Specific Friction Compounds
Application-specific formulations; ECE-R90 certified friction formulations on European applications*
*On applications where available

What is ECE-R90?

ECE-R90 is a legal requirement in all European countries that specifies design, performance, and testing protocols for replacement brake pads. Aftermarket ECE-R90 brake pads are certified to be a direct replacement to European OE brake pads.

ECE-R90 aftermarket certified brake pads are designed to meet the following test standards:

- Friction behavior
- Cold performance
- Speed
- Shear
- Sensitivity
- Compressibility
- Hardness

AVAILABLE EXCLUSIVELY AT

O'Reilly FIRST CALL

DEDICATED TO THE PROFESSIONAL

FIRST CALL ONLINE

MAKING IT FASTER AND EASIER THAN EVER TO ORDER PARTS

FIRSTCALLONLINE.COM

Visit our website for a complete, internet-based catalog designed exclusively for the Professional.

ADV 1843

TECHNICAL TRAINING

MOTOR AGE YOUTUBE CHANNEL CELEBRATES MILESTONE OF 100,000 SUBSCRIBERS

Of all the auto repair channels available, only *Motor Age*, with more than 10 million views and 618 videos (and counting), serves to advance the automotive professional with accurate and up-to-date technical information.

Motor Age, the nation's oldest automotive trade publication, was formed in 1899 and has had a YouTube channel since 2010. Of all the auto repair channels out there, we think it's the only one that has been, as we say, "Advancing the automotive professional with accurate and up-to-date technical information." Its popularity with viewers was recently proven as it surpassed 100,000 subscribers.

It's through the hard work of Pete Meier, who began his tenure with *Motor Age* as technical editor and later transitioned to the position of creative director, technical, as his time became more consumed by video projects, that the YouTube channel and other social media channels have been able to flourish.

"As a working technician prior to joining *Motor Age*, I knew how hard it was to access the training I needed to stay current," Meier said. "I wanted to do everything I could as the technical editor to make training and related resources available to the men and women trying to earn their living as professional automotive techs. That gave birth to our social media efforts; Facebook, Instagram, Twitter and, of course, YouTube."

So, what makes *Motor Age* video content different?

"Over the past dozen years, I've tried to produce video content (for YouTube and in our live webcasts) that would help our viewers tackle the challenges of the rapidly changing technologies they face," Meier continued. "And rather than focus on fixing a certain problem on a certain model vehicle, like so many other YouTube channels do, I wanted to focus on the underlying skills and knowledge needed to accurately diagnose and fix whatever rolled into their bays. Simply put, 'Give a man a fish, and you feed him for a day. Teach a man to fish, and you feed him for a lifetime.' On our channel, I prefer to teach our viewers the why behind the how-to."

Staying engaged with readers and viewers is another area where Meier has differentiated himself...and the YouTube channel.

"I want our readers and viewers to know that I am committed to their success, and I spend each morning answering their questions and comments. And I will continue to do so, even as my role changes here at Endeavor Business Media. Finally, thank you to everyone who subscribes to our channel. We wouldn't be where we are without you!"

Check out content from Pete Meier, Technical Editor Brandon Steckler, Contributing Editor Scott Brown, and more, at https://www.youtube.com/@MotorAgeMagazine.

Duralast®

DIFFERENCE

REPAIR WITH DURALAST. REPAIR WITH CONFIDENCE.

100% NOISE-FREE GUARANTEE

SHOP EXCLUSIVE BRAKE BUNDLE*
PRICING ON AUTOZONEPRO.COM/BRAKES

OE SLOTS AND CHAMFERS | OE FRICTION FORMULATIONS | OE STYLE SHIMS

SEE THE DIFFERENCE TODAY

AutoZone®

*Brake bundle and noise free guarantee requires the purchase of any set of Duralast, Duralast Gold, Duralast Elite pads, 2 Duralast or Duralast Gold rotors and hardware (when available) on the same invoice. Guarantee covers parts and labor for 90 days when professionally installed.

REPAIR LEGISLATION

ASA CALLS ON TEXAS LEGISLATURE TO OPPOSE HB 3297

The bill would end Texas vehicle safety inspections and make roads less safe, according to the association.

The Automotive Service Association (ASA), the largest not-for-profit trade association of its kind dedicated to and governed by independent automotive service and repair professionals, has called on the Texas State Senate to oppose House Bill (HB) 3297. This legislation would eliminate the state's vehicle safety inspection program for non-commercial vehicles. Yesterday, the State Affairs Committee passed HB 3297 on a 8-3 vote. However, earlier this legislative session, the Texas Senate Transportation Committee rejected SB 684 – a similar bill – by a vote of three in favor and five against. Research, including a study commissioned by the legislature in 2017, unequivocally demonstrates that regular testing of a vehicle's tires, brakes, windshield wipers, lights and beams, seatbelts and other components plays a critical role in preventing injuries, deaths, and loss of property.

The Automotive Service Association is a long-time supporter of vehicle safety inspections and opposes this bill in addition to legislation that would decrease the required frequency of inspection. Bob Redding, ASA's Washington, D.C. representative stated, "The Texas Senate has an opportunity to do the right thing for their constituents by not advancing this bill. Texas has a successful vehicle inspection program that protects the motoring public. This private-public partnership program should not be eliminated. Instead, the legislature should heed its own study's recommendations and consider adding additional inspection items to the program."

The Automotive Service Association thanks its Texan members and allies who contacted their state legislators to educate them on this issue and urge them to oppose the bill. ASA continues to encourage Texas residents to email their State Senators by visiting https://www.votervoice.net/ASASHOP/campaigns/105053/respond. MA

RECOGNITION

MOTOR AGE TAKES HOME ASSOCIATION HONORS FOR VIDEO TUTORIAL AND WEBSITE

Motor Age and our portal website, VehicleServicePros.com, have won two awards from the American Society of Business Publication Editors in the 2023 Azbee Awards of Excellence contests. According to the association, the awards "celebrate the highest quality reporting, editing and design in business-to-business, trade, association and professional publications."

Pete Meier's "Service Done Right #8 - Don't Replace the Fuel Pump Until You've Checked THIS!" won a National Bronze Award in the Online - Video -Tutorial category.

Meier's tutorials explain complex topics to readers/viewers in language that technicians understand. His knowledge comes from decades of field experience and keeping current on the latest topics affecting diagnostics and proper repairs of cars and light trucks. He takes great care in his production and editing to present content that resonates with our readers and viewers, as evidenced by the explosive growth of the *Motor Age* YouTube channel, which now has over 104,000 subscribers.

Vehicle Service Pros provides 619,000 automotive professionals with exclusive content they can't find anywhere else, technical training resources, the latest product information, technology trends, exclusive videos, podcasts, and expert voices across all segments of the aftermarket. The content portal serves as the backbone of VSP's outgoing engagement with readers, from newsletters and magazines via QR codes to internal pages and social media outlets. Entries for the Website of the Year category are judged based on quality of writing, reporting, and editing; value and usefulness to the reader; layout and design, especially consistency in style throughout the website; use of web technologies; and interactivity. MA

8 TIPS to make your shop successful with inventory management

BY TOM RINGLE // Contributing Editor

For a shop owner, inventory management is essential to ensure that your auto repair shop has the necessary parts and tools to complete repairs efficiently and effectively. Implementing an inventory management system in an auto repair shop can be complex, but several steps can help ensure success. An accurate inventory system with effective management allows parts usage to be more responsive to your operational demands.

What is inventory management?

Inventory management is the process of overseeing and controlling the inventory of a business and includes the purchase, storage, and use of materials, parts, and products. The goal of inventory management is always to maintain the right inventory level so that the business can operate efficiently and effectively. Executed properly, it can help streamline inventories to avoid stock overages, helping you identify how much stock to order and when. Parts inventory management is a balancing act of spending resources on the right mix of parts and supplies and minimizing the risk of overstocking surplus goods while securing the parts that add value.

In an auto repair shop, inventory management involves managing parts and tools used in the repair process, including everything from oil and filters to complex engine parts and diagnostic equipment. Proper inventory management in an auto repair shop can help ensure that the right parts are always on hand so the shop can complete repairs quickly and efficiently.

ADOBESTOCK

Why auto repair shops need inventory management systems

Let's explore why auto repair shops need an inventory management system and how a good system can impact your workflows and overall efficiency.

IMPROVES WORKFLOW

Effective inventory management system designs improve the workflow of an auto repair shop by ensuring that the right parts and tools are available at the right time. For example, when a technician must stop working on a vehicle to search for a part or tool, this can cause delays and decrease productivity. With an inventory management system, parts and tools are tracked and stored in an organized manner, making it easier to locate them quickly when needed. This helps to keep the workflow moving smoothly and ensures that customers are not left waiting for long periods.

INCREASES EFFICIENCY

An inventory management system can help increase efficiency by automating many of the processes involved in inventory management. For instance, when inventory levels are low, the system can generate alerts, notifying the manager to order new parts. This can help reduce the risk of stockouts, ensuring that the necessary parts are always available. Additionally, an inventory management system can help track inventory usage, which can help managers identify trends and optimize their inventory levels accordingly.

REDUCES WASTE

Auto repair shops often deal with a wide range of parts and tools only used for specific vehicles. This can lead to overstocking and waste if the parts are not used within a specific timeframe. With an inventory management system, auto repair shops can track the usage of parts and tools, only ordering what they need, thus reducing waste, obsolescence, and unnecessary expenses.

IMPROVES ACCURACY

Manual inventory management can be prone to errors, such as misplacing parts or ordering the wrong parts. An inventory man-


ROTARY LIFT
ROTARY LIFT
RECHARGE YOUR SHOP
ROTARY
R³AC60
R1234yf
ROTARY
R134a
ROTARY
R³AC80
DualGas

agement system significantly reduces the risk of these errors. The system can track inventory levels and usage, making it easier to reorder parts when needed. This ensures that the correct parts are always available, leading to more accurate repairs and increased customer satisfaction. Improving accuracy will result in your team spending less time looking for parts and more time completing tasks that focus on improving the operations of your business and increasing profits. Does internal shrinkage sound familiar? An inventory management system will help you identify inventory that slips through the cracks and fails to make it on the repair order.

BETTER CUSTOMER SERVICE

Customer service is essential to any business, and auto repair shops are no exception. Customers expect quality repairs to be completed within a reasonable timeframe. With an inventory management system, auto repair shops can ensure that the necessary parts and tools are always available, reducing repair times and improving customer satisfaction.

Employ these 8 tips:

1. CONDUCT REGULAR INVENTORY AUDITS

It's important to know what parts and tools you have in stock at all times. Conducting regular audits of your inventory will help you identify any discrepancies and ensure that you have accurate records. Conducting bin or shelf checks is a simple task. Assign team members the responsibility of counting or spot-checking a small number of what you consider the fast-moving parts each week or at least once per month.

2. USE INVENTORY MANAGEMENT SOFTWARE

Many inventory management software programs can help you track your inventory, automate reordering, and generate reports. These tools can save time and reduce the likelihood of errors. For example, consider using a barcode inventory system that you synchronize with a management system.

3. CATEGORIZE YOUR INVENTORY

Categorizing your inventory can help you quickly locate the parts and tools you need. You can categorize by type of part or tool, manufacturer, or even by the make and model of the car.

4. SET PAR LEVEL

Par levels, or periodic automatic replacement, are the minimum quantities of parts and tools you should always have in stock. By setting par levels, you can ensure you always have the parts and tools you need on hand.

5. MONITOR YOUR SALES

Tracking your sales can help you identify which parts and tools are most in demand, which can help you make more informed purchasing decisions.

6. BUILD RELATIONSHIPS WITH SUPPLIERS

Building strong relationships with multiple suppliers can help ensure that you get the parts and tools you need in a timely manner. Minimizing wait time for technicians and improving customer satisfaction.

7. TRAIN YOUR TEAM

Make sure you train your team on inventory management processes and procedures. Training helps reduce errors and ensure everyone is on the same page when managing inventory. You can't expect your team to follow processes and procedures dealing with parts management if they are not properly trained to do so.

8. IMPLEMENT A PARTS RECEIVING PROCESS

Check all parts deliveries and shipments upon arrival, received items versus invoice – cross-check part numbers and quantity. Suppliers and delivery drivers can make mistakes; immediately spotting an error will prevent the possibility of the wrong parts getting to the technician, impacting productivity. Likewise, verify the correct parts arrive in the right quantity.

Inventory management is a critical aspect of your auto repair shop's operations. When done right, your customers will trust your shop to provide the services and tools needed to fix their problem. In addition, the inventory management system will improve workflow, increase efficiency, reduce waste, improve accuracy, provide better customer service, control costs, manage vendor relationships, and generate valuable insights through reporting and analytics. By implementing an inventory management system, auto repair shops can streamline their operations, increase profitability, and ensure they provide high-quality services to their customers.

Auto repair shops are busy and complex businesses that require proper management of various resources, including inventory. Therefore, a proper checklist for all your operations, such as **ATI's Leader's Operations Checklist**, is essential for auto repair shops to provide quality services to their customers while ensuring they are profitable. To receive your copy, go to **www.ationlinetraining.com/2023-06** for a limited time.

TOM RINGLE, CEC, PFP, and ATI executive coach first made his way into the automotive industry in 1983, working in a local dealership in his hometown of Annapolis, Maryland, while he was attending school part-time. He spent many years managing the service and parts operations of GM dealerships and then transitioned to an executive coach role for the Automotive Training Institute (ATI). Independent repair shops provide Tom with new challenges and a way to help both intermediate and large shops realize their true potential by showing them a pathway to get the results they desire. ATI's 34 full-time, certified coaches have helped ATI's members earn over $2.8 billion in return on their coaching investment since ATI was founded.

SCAN THE QR CODE TO READ THIS AND RELATED ARTICLES ONLINE

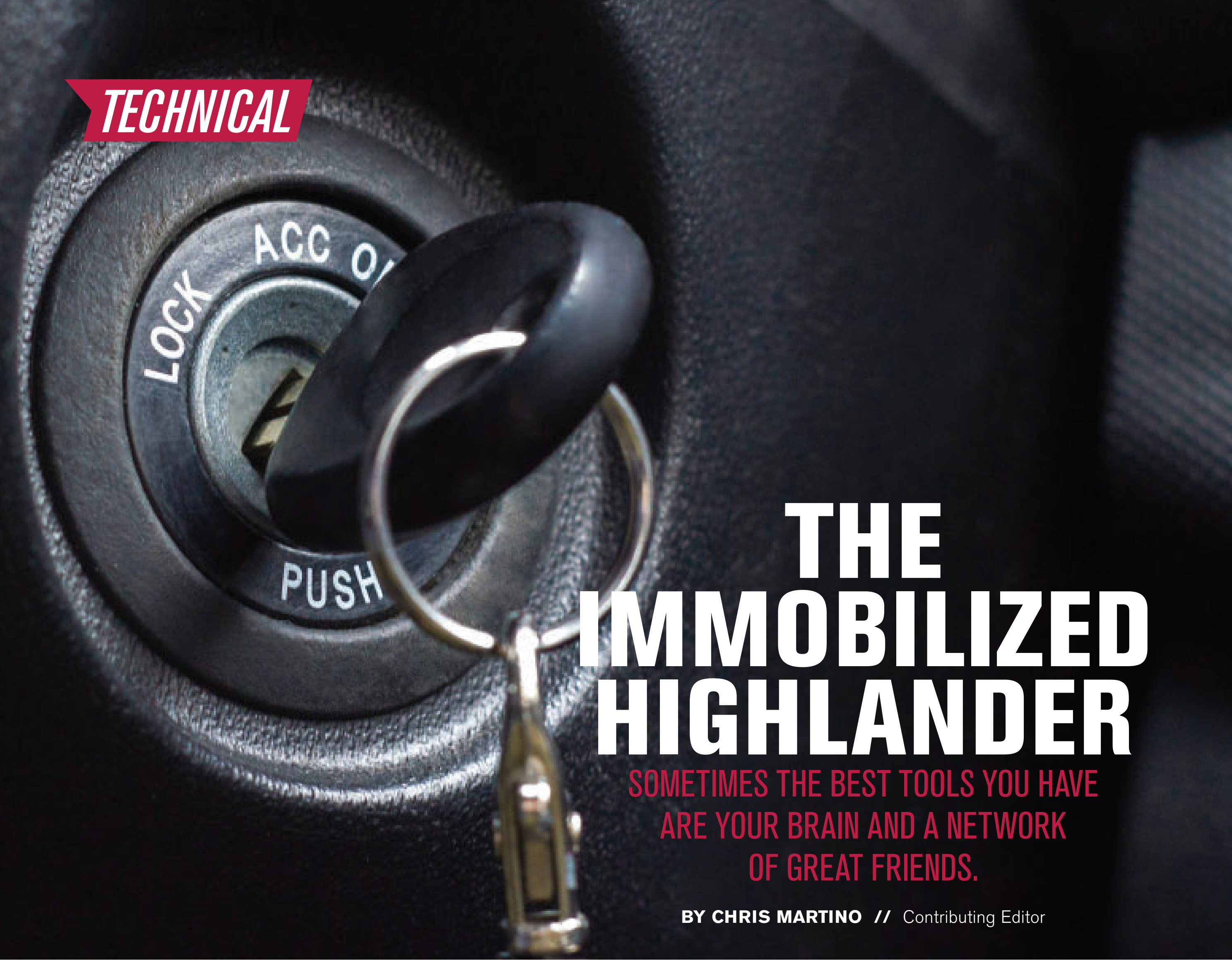
Continental
The Future in Motion

TIMING BELT KITS

To Do the Job ***Right***

Continental's Import Program is specifically designed for European and Asian applications. The Program provides complete coverage for nearly all import applications marketed in the U.S. and Canada.
Turn to Continental for your automotive aftermarket products and Fix It Right.

www.continental-engineparts.com/na



THE IMMOBILIZED HIGHLANDER

SOMETIMES THE BEST TOOLS YOU HAVE ARE YOUR BRAIN AND A NETWORK OF GREAT FRIENDS.

BY CHRIS MARTINO // Contributing Editor

I'm a pretty decent diagnostic tech. But like many of us, there are certain things I cannot seem to get my head around. For me, it's immobilizer systems on Asian vehicles. Yes, laugh and giggle; I don't understand it myself. Immobilizer systems on German vehicles are far more complex and convoluted, but for whatever reason, I just understand them.

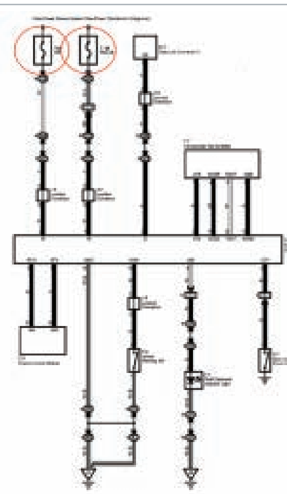
I operate an ADAS, diagnostic, and programming shop with a mobile service. I cater to collision repair shops and try to be the complete answer to their needs. My usual day-to-day consists of finding the broken wires, programming new modules, and explaining to body shops that the radar in the front of their vehicle does indeed need to be calibrated – even though the light isn't on. But occasionally, something truly "fun" drives through the door.

The problem child

The "fun" vehicle was a 2005 Toyota Highlander. I was called to diagnose a crank/no-start condition. The shop already threw plugs, coils and a MAF at the vehicle and then decided to call me.

I started by cranking the vehicle over. It started for a split second and died. It then just cranked and cranked. This sounded like a security/alarm type issue to me, so I hooked up my scan tool and performed a vehicle scan. The only code that showed was B2799 – "Immobilizer ("immo") system malfunction."

When scanning the vehicle, I noticed that the immobilizer module stopped communicating after a few minutes. That made me curious, but I was trying not to "get lost in the sauce." So, I thought, what does a module need for communication? Voltage, ground, and a proper infrastructure. So, I figured let's start with something simple. According to the diagram for the immobilizer system, the transponder key ECU (immo box) is powered by the 10A IGN fuse and the ECU-B fuse **(Figure 1)**.



1

THIS OEM DIAGRAM shows the transponder ECU being powered by the 10A IGN fuse and the 7.5A ECU-B fuse. Both of them checked out fine.

SCAN CODE

CUT THROUGH THE RED TAPE

YOUR TRUSTED PARTNER FOR AUTOMOTIVE PARTS, EQUIPMENT, AND SUPPLIES.

We're a family owned and operated business, so we get it - your time is valuable. As your trusted partner for automotive parts, equipment, and supplies, FMP helps you cut through the red tape so you can focus your time on growing your business and profits, now and in the future. We understand, our success depends on yours.

Let us help supply your success. Visit FactoryMotorParts.com/no-red-tape.

FMP

FACTORYMOTORPARTS™

WE SUPPLY YOUR SUCCESS.

Slow down to speed up

I sensed myself going a little too far without enough background information. Why was the computer flagging this DTC? According to code-setting criteria, this DTC sets when the ECM detects an error in communication with the immo box **(Figure 2)**. Armed with this info and the no-comms issue that I was experiencing, I needed to get access to this box. This immo box is located "conveniently" up in the dash, mounted upside-down and backward, and right under the windshield **(Figure 3)**. I had the shop remove the glove box so I could access the wiring. Once I had access, I was able to inspect the wiring. I pulled the immo box down and was able to see the issue; it was full of water **(Figure 4)**. I made the call to replace the immo box after confirming good voltage and ground supply to it.

It's fixed, right?

The customer called back two days later with the new immo box installed. This is where my palms began to sweat. Like I mentioned before, Asian immobilizers and I do not get along. The service information outlines the registration procedure for the immo box and the keys. It involves putting the vehicle in registration mode and following the prompts on the scan tool. After the registration process is over, you "handshake" the modules by jumping DLC pins 4 and 13 for 30 minutes **(Figure 5)**. After this, the vehicle should start.

I started the procedure and was quickly booted from it, as the keys were already registered. The Toyota dealer was down the street, and the keys were cheap, so I had the customer get me a new key. With the new key in hand, I was able to complete the registration process. Next came the handshake. So, I jumped DLC pins 4 and 13 for 30 minutes. However, the vehicle did not start. I scanned for codes and saw the ECM still had the B2799 code stored.

Research, research, research...

One of the great things about Toyota service information is they give you pinout values and known-good scope patterns when applicable.

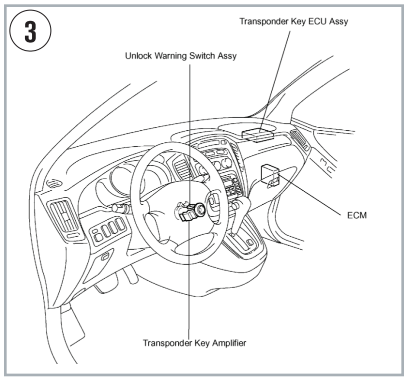
Going back to the immobilizer system diagram, the code refers to an issue on the EFIO and EFII lines between the ECM and the immo box. A deeper dive into service information showed us known-good waveforms for these signals **(Figure 6)**.

These two signals go between the ECM and immo box to communicate

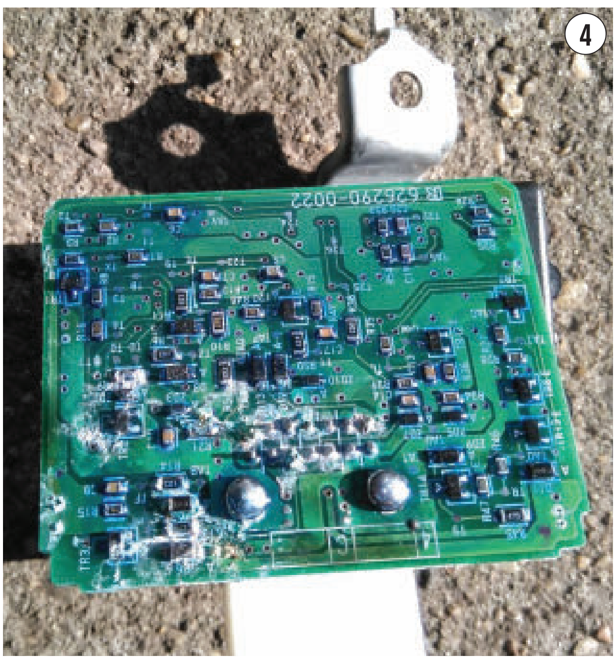
2

DTC No.	DTC Detection Condition	Trouble Area
B2799	☐ Error in communication between ECM and transponder key ECU assy, and in communication line ☐ Communication ID is different during communication with transponder key ECU	☐ Wire harness ☐ Transponder key ECU assy ☐ Transponder key amplifier ☐ ECM

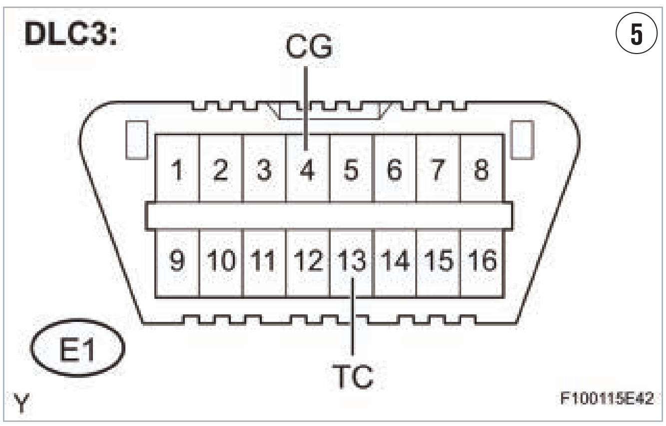
CODE-SETTING CRITERIA STATE the ECM will flag this code if it detects an issue between itself and the transponder ECU or if the key data is different from what is stored.



THE TRANSPONDER ECU is "conveniently" located under the passenger airbag, above the ECM, behind the glove box, and first In line to get wet from a leaking sunroof drain or leaking windshield.



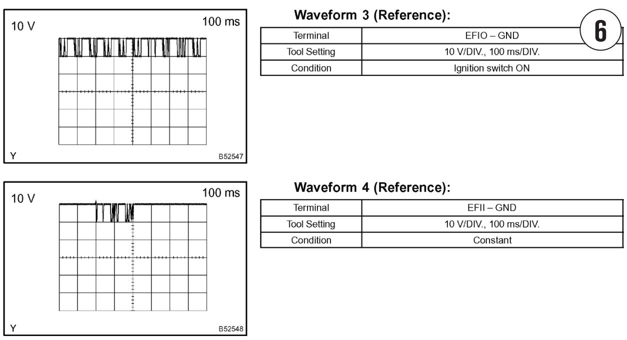
TRANSPONDER ECU is covered in corrosion.



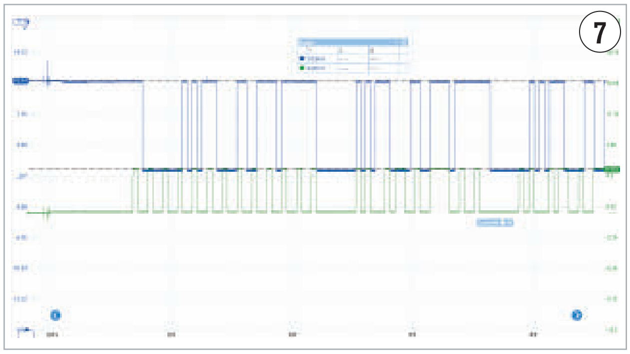
THE "HANDSHAKE" PROCEDURE involves jumping pins 4 and 13 (CG and TC) at the DLC.

that a valid key has been inserted to allow the vehicle to start. It sounded simple enough, so I hooked up my scope to the EFIO and EFII wires and got a pattern **(Figure 7)**. This pattern told me the communication lines were up and working and were not shorted.

According to this, it looked like the ECM did not like what the immo box was saying. I knew I had good keys; they took the registration, and I knew the immo box was talking and sending a signal to the ECM. I had no other choice than to condemn the ECM. The ECM is bolted directly under the immo box, so it is feasible that it could have gotten wet. I told the customer to get another ECM and I would be back to marry it to the vehicle. The customer called me back the next day when the used replacement ECM arrived. I hooked it up, performed the registration process, and I still got the B2799 in the ECM. I went through all the data; the keys were registered and there were no inhibitors preventing the engine from starting. I asked the customer to have it brought to my facility, where I could spend all the time I needed with it, without having to keep an eye on the clock.



TOYOTA SERVICE INFORMATION includes known good waveforms on many computer signals, including the two lines in question.



AFTER SCOPING THE EFIO and EFII lines, they seem to match the known-good waveform in figure 6.

Calling in the reinforcements

Once it was at my location, I decided to use one of my lifelines; I needed to make sure I was not missing something. My good friend Tomi Oliva is my go-to guy for all things immobilizer and EEPROM. He owns SJ Auto Solutions in Chicago and has gotten me out of many jams. I had him walk me through the registration process to make sure I was not missing anything, but it turned out I wasn't. He went through the data PIDS with me and observed that this vehicle should start. He waited on the phone with me while we did the module handshake multiple times, and still nothing.

He then offered to marry the modules on the bench. He told me that sometimes these older Toyota immo systems need a little help. I gladly packed up both ECMs, all the keys, and the new immo box and sent the package to him He called me after a few days and informed me that my original ECM was corrupted and would not read any immo data, but he was able to read and input data into the used replacement. A few days later, I got the modules back. Tomi said they were married on the bench and should start right up. I installed all the modules, but this B2799 code would not go away.

An oversight, perhaps?

I had to be missing something. According to service info, this vehicle should start. I decided to use another phone-a-friend lifeline to P.J. Walter, a former Toyota dealer tech who just left the dealership and opened his own mobile ADAS, programming, and diagnostic company in Pittsburgh. He is awesome for helping me out when any kind of Toyota rears its ugly head. P.J. went through the registration process and module handshake with me, and all seemed fine. He kept returning his attention to the EFIO and EFII wires, because that was what the ECM was "complaining about." He went through his collection of service information, and it showed the same results I had: there should be a square wave signal riding on those two wires, and it should look like the known-good examples in the service info.

We did notice an issue, though. The known-good patterns did not have a usable voltage scale on them. Luckily, P.J. (being the amazing tech that he is) had a known-good scope capture from Toyota with real values in it. IMO and IMI are the same lines as EFIO and EFII, just at the ECM.

This is where we noticed a discrepancy. The known good values for these signals were all at 12V. One of my signals was at 5V; this made no sense. I went up and down a bunch of years in service info. and saw no change in patterns, and P.J. did the same on his side. There was no change in information. The part numbers on the ECM and immo box were the same as well, but I had a theory.

That 'lightbulb' moment

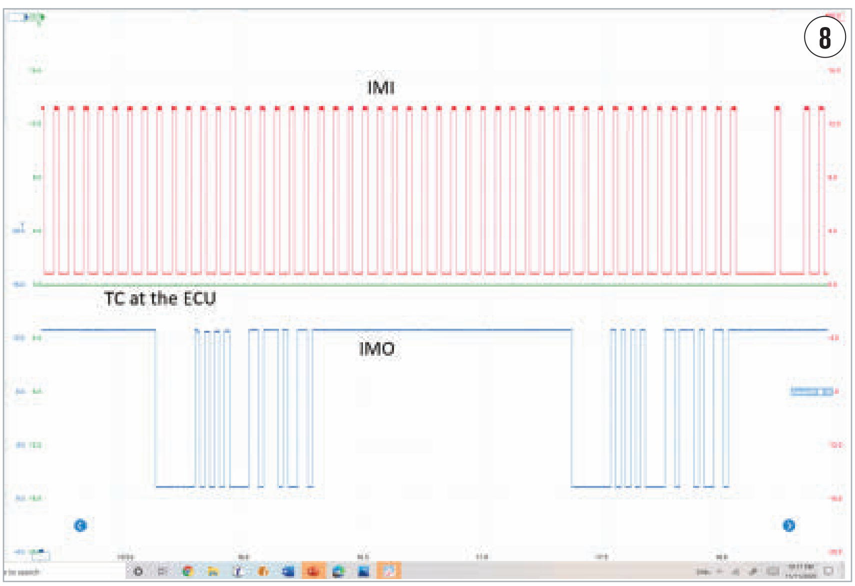
The computer was flagging a B2799 because it did not like what it saw coming from the immo box. What if the ECM was expecting a 12V signal and the immo box was only producing a 5V signal? If this was the case, the ECM would never see the signal because it was looking for a much higher voltage.

Computers must see a voltage cross a threshold. If the voltage never reaches a threshold, it never happened. Therefore, its only recourse is to flag a B2799 and not allow the vehicle to start. Unplugging the modules and reading what came out of them was inconclusive. The only answer we could come up with is we needed a known-good same vehicle. This is where P.J. had to use one of his lifelines.

He had a friend who just so happened to have the same year Highlander. He asked him to scope his EFIO and EFII lines. I got the text the next day that the 05 had a 5V pattern on both lines **(Figure 8)**. That was enough to confirm the diagnosis for me. P.J. and I talked it out and realized that the EFIO and EFII lines are only between the ECM and immo box. If I were able to get a matching set of computers out of a running vehicle, it wouldn't matter if it were 12V or 5V; the modules were already matched and would work fine.

He shoots, he scores

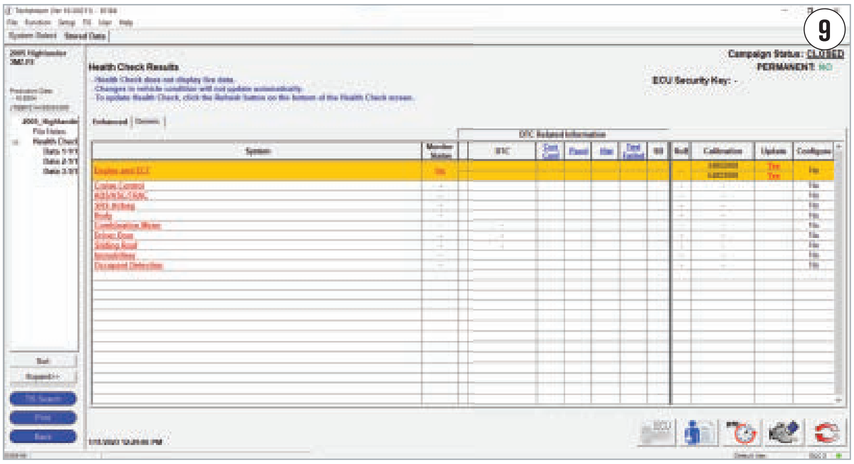
I happened to find a pair of modules in a salvage yard from a known-good running vehicle. I bought them, installed them, registered the keys, wrote the VIN into the ECM, and successfully



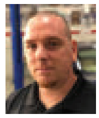
THIS KNOWN-GOOD WAVEFORM from P.J. Walter gave me the correct voltage values that the Toyota service information is lacking.

started the vehicle with no DTCs stored (**Figure 9**).

What is the moral of the story? Well, there could be a couple. One could be that you should not be afraid to try new things; just do your research and go over all the steps. The second thing, and what I would call most important, is no one person is an island. There is help out there. We all have friends. There is always a chance that they or someone they know may have information that you are lacking to get to the next step in a diagnosis. Use all the tools available to you, even some unconventional ones. There is a meme out there that says, "Is it stupid if it worked?" Sometimes that rings true.



AFTER REPLACING THE MODULES with matching units, the troublesome code went away.



CHRIS MARTINO is a member of Trained By Techs and co-owner of ADAS LI, and ADAS diagnosis, calibration and programming solutions provider on Long Island, NY. He spends his days analyzing challenging and problematic vehicles and spends his evenings working to better the automotive service industry with his fellow Trained by Techs members. His specialty is electrical fault diagnosis using advanced efficient troubleshooting techniques but with a focus on the basics.

SCAN THE QR CODE TO READ THIS AND RELATED ARTICLES ONLINE

ADOBESTOCK

UNDERSTANDING THE BASICS OF THE 12v SYSTEM

CONFIDENTLY TROUBLESHOOT THE MOST COMMON ISSUES WITHIN THE STARTING/CHARGING SYSTEM.

BY JEFF COX // Contributing Editor

With so much focus on electric vehicles (EVs) and high-voltage batteries, we must not forget that the 12-voltage system is still the most common battery type and will remain a critical component on many vehicles in the future.

It will be important to build upon what we learned regarding the testing, servicing and replacement of the components within the vehicle's starting and charging system so we can accurately test and diagnose issues on today's vehicle. But what has changed and how does it affect how we service a vehicle?

The vehicle has three main components: The battery, which is an electrical storage device; the alternator, which charges the battery and supplies operating voltage to all the circuits while the engine is running; and the starter, which is an electrical motor used to start the engine.

The battery is the lifeblood of the electrical system

The battery is the lifeblood of the electrical system. Although they may come in a variety of sizes and outputs, the battery technology has remained relatively the same. What we consider a 12-volt battery is actually a 12.6-volt battery. It consists of 6 cells, each 2.1 volts. The most traditional type of battery is the flooded lead acid battery. The construction of this battery consists of positive and negative plates with separators to prevent the plates from touching. The plates are partially submerged in the acid, which creates a chemical reaction that generates electricity. The electricity flows in and out of the battery through the posts, which can be top posts or side posts. In addition to the flooded lead acid battery, there are a few other styles. The enhanced flooded battery (EFB) is similar to the flooded lead acid style, but carbon additives dramatically improve the cyclic durability. This design is great for applications that are equipped with a start-stop feature. The next tier of batteries is an AGM, or absorbent glass mat battery. This style of battery uses an ultra-thin glass mat as the negative plate. Because of the ultra-thin plate, you can have more plates in the same size case, which dramatically increases its performance. The last style and newest technology is a lithium-ion battery. These batteries use lithium manganese oxide as an electrode. The use of lithium has several advantages over the aforementioned batteries. Each cell can deliver 3.6V, which makes for higher voltage applications. They also have a far extended cycle life and the ability to put out 100 percent of their rated capacity, regardless of the rate of discharge. Lead-acid batteries typically provide less usable energy with higher rates of discharge. Lithium-ion batteries have a slower rate of discharge and recharge at a faster rate than a conventional battery.

Battery testing is critical to help motorists avoid being stranded. Batteries often fail during cold winter months, but that is not the only time you should test a battery. Summer heat plays a big role in the degradation of a vehicle's battery, which can be detected with just a few tests. A common test is a battery capacity test. If you are using a tester with a carbon pile, you will determine the cold cranking amps (CCA) of the battery and apply half of those CCA for 15 seconds, watching the voltage to ensure it does not drop below 9.6 volts. If you have a conductance tester like the one in the image, you simply choose the capacity test, enter the battery capacity and let the tool do the rest. An important test throughout the system is a voltage drop test. This tests the voltage loss across a circuit. On a top-post battery, you can test the voltage loss between the battery post and the battery terminal with the use of a multimeter. To perform the test, you place the positive lead on the positive post and the negative lead on the positive terminal. Crank the engine while recording the voltage. The specification may vary but is typically no more than .2 - .5V. You can repeat the test for the negative post by placing the negative terminal on the negative post and the positive terminal on the negative terminal. Lastly, it is always important to ensure the battery is clean and terminals are tight. A good inspection can find these issues before they become a concern.

The alternator: turning mechanical energy into electrical energy

The next component in the system is the alternator. The role of the alternator is to turn mechanical energy into electrical energy. The alternator is driven off the crankshaft by a belt and the pulley is attached to the armature. As the armature rotates through windings, electricity is generated as alternating current (AC) which is then converted by the internal rectifier to direct current (DC). This direct current is then sent to the battery to recharge it, along with supplying the vehicle with its operating voltage. Alternators have remained the same in recent years except for nuances such as water-cooled alternators. But a more common trait that has impacted the system is the use of the decoupler pulley. This evolution of the pulley is able to decouple from the engine during deceleration, which puts less of a strain on the belt and the tensioner. Some models incorporate a spring to reduce harmonics.

Testing an alternator is pretty straightforward. The first thing is to ensure the alternator is producing current to recharge the battery. You can do this by placing a high-current amp clamp around the positive cable that connects the alternator and battery. While operating the vehicle's accessories, you should see an increase in amperage produced

COURTESY OF ASSOCIATED EQUIPMENT

ASSOCIATED EQUIPMENT'S 12-2415 BATTERY ANALYSER tests 12V flooded, AGM, Gel Cell, & EFB Batteries from 100 to 2000 CCA, along with 12V and 24V charging systems.

EVAP COOLERS & HUGE CEILING FANS

COOLING SOLUTIONS THAT GO THE EXTRA MILE!

Summer Savings June 1 – September 30, 2023

SCAN TO LEARN MORE
or visit **www.coolboss.com**

COOL BOSS™
A Division of BendPak Inc.

Contact Your Local AutoZone® Commerical Sales Rep!

AutoZone® offers industry-leading coverage and fast delivery on all Cool Boss evaporative coolers and HVLS fans.*

COURTESY OF EAST PENN

"IF YOU HAVE OVER HALF A VOLT, THE ALTERNATOR IS FAULTY."

by the alternator. Another test is a voltage drop test. Similar to the test we did on the battery, you simply put the positive lead on the alternator terminal and the negative on the positive battery post. Run the engine and adjust the carbon pile to the output rating of the alternator. Record the results and compare them to the specification. The last test can be critical as it may affect more than just the charging system. As mentioned earlier, one of the jobs of the alternator is to convert A/C voltage into D/C voltage. If the alternator fails to do this, the electrical system will have too much A/C voltage and could cause all types of issues. The best way to test this is with an oscilloscope. Connect the positive lead to the positive alternator terminal and the negative lead to the battery ground and run the vehicle. You should see less than half of an A/C volt. Your pattern should be a consistent ripple. If you have over half of a volt, the alternator is faulty.

The starter: turning electrical energy into mechanical energy

The starter takes electrical energy from the battery and converts it into mechanical energy so that it can rotate the engine. Modern starters are permanent magnet motors with a gear reduction. This allows a small amount of current to be applied to the solenoid and a large amount of current to leave the battery and turn the armature that engages the flywheel or flex plate.

To test or diagnose a starter, there are a few steps. First, ensure you have battery voltage at the control side (small wire) of the solenoid. With the ignition in the start position, you should have battery voltage. With the ignition off, you should have zero voltage. If you do have battery voltage in the start position, you should check to see if the amperage is flowing from the battery to the starter. If there is no amperage, the starter is faulty. The last test is another voltage drop test. This time, you will place the positive lead of the meter on the battery positive post and the negative on the positive starter post and engage the start position, record your voltage, and compare to the specification. Again, the specification can range from .2V-.5V.

I know we are eager to learn how EV vehicles operate and how to service them, but the 12V system is still overwhelmingly prevalent and will be for years to come. Of course, there are additional tests. But with the tests outlined in this article, you can confidently troubleshoot most issues within the starting/charging system. MA

JEFF COX is the President of the Automotive Maintenance and Repair Association. Jeff has been in the automotive aftermarket industry for 25 years, starting as a technician before transitioning to leadership. Jeff is an ASE Master Technician and holds a bachelor's degree in Automotive Technology from Southern Illinois University. He also holds a master's degree in Organizational Leadership. Jeff and the AMRA team are dedicated to helping build trust between the customers and the repair shop through their Motorist Assurance Program, better known as MAP.

SCAN THE QR CODE TO READ THIS AND RELATED ARTICLES ONLINE


REV UP YOUR
SAVINGS!
Call us! 800-261-7729
WRENCHERS
Top Savings for You
Ingersoll Rand
2135QXPA-2
Impact Wrench
ALL-IN-1
SHOPPING
SUPER DEALS
FREE WITH PURCHASE OF $700 OR MORE
1-800-261-7729 • www.wrenchers.com
Call Now for a FREE catalog!
1-800-261-7729
Ask about our price promise guarantee.
WRENCHERS.com
© 2023 Wrenchers LLC. All Rights Reserved.

FARADAY'S LAW: THE FOUNDATION OF IGNITION COIL FUNCTIONALITY

IGNITION EVENT ACQUISITION AND WAVEFORM ANALYSIS DIDN'T GO AWAY WITH THE DISTRIBUTOR. UNDERSTANDING FARADAY'S LAW MEANS KNOWING WHAT AN IGNITION WAVEFORM CAN DEMONSTRATE FOR A DIAGNOSTICIAN, AND THAT'S A 'HOME RUN' IN THE WORLD OF DRIVEABILITY.

BY BRANDON STECKLER // Technical Editor

I'm frequently asked to analyze many ignition waveform captures from technicians around the globe. This is a skill set that has been hammered into my head since I was a young up-and-coming diagnostician. Why? Because this waveform analysis is the same, regardless of which spark ignition internal combustion engine the waveform was derived from.

Faraday's law

I will be the first to tell you that I'm not one to suggest memorizing these laws of physics. I do, however, recommend becoming familiar with what it is that they are defining. Faraday's law addresses what is known as electromagnetic induction. This is the electrical current that is generated in a conductor (or wire) when a nearby/adjacent magnetic field changes in strength (or intensity). Said another way, we can create electricity in a wire simply by moving/changing a magnetic field near that wire.

I told you that to tell you this...This is exactly how ignition coils function on all spark ignition internal combustion engines regardless of year, make, or model. That's right, at a basic level, an ignition coil operates the same in a 1929 Marmon as it does in a 2022 Bugatti Chiron (Figures 1 and 2). It's plain to see why this was pounded into my mind so many years ago.

During the 19th century, a physicist named Michael Faraday discovered a relationship between a changing magnetic field strength (magnetic flux) and the electromotive force (voltage) that is induced within a wire as a result. This is what became known as Faraday's law.

In a recent article (https://www.vehicleservicepros.com/21293485), I discussed another law of physics known as Lenz's law. While Lenz's law relates to the rate of current flow change in an inductor as it saturates (ignition coil primary windings), Faraday's law relates to the resulting inductive kick that occurs when that current flow ceases and that ignition coil discharges.

And this is the basis for our topic of discussion today (Figures 3 and 4).

Seen here is an experiment to help describe what is to be expected as a magnet is passed through a hollow cardboard tube. Around this tube is an inductor (multiple coils of a conductor or wire). Connected on either end of the inductor are the leads of this Fluke 88 DVOM, set to detect voltage indifference (difference in voltage between the red and black test leads) (Figure 5).

As the magnet (along with its magnetic lines of flux) is passed through the hollow tube, the flux lines cross the inductor coils and induce a voltage indifference, as seen on the DVOM display. In fact, these same principles allow variable-reluctance crankshaft/camshaft position sensors to operate with the signal characteristics they exhibit (Figure 6).

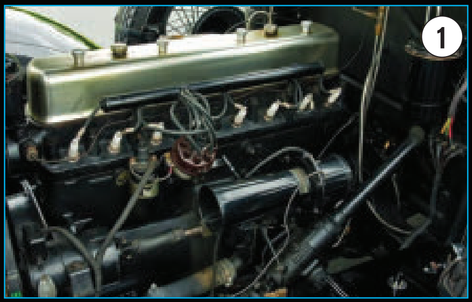
Step-up transformer construction

So, how does this at all relate to the ignition coil, and what is its significance? The ignition coil is a device known as a step-up transformer. It earned that name because an ignition coil operating with only 12-14V can step up that voltage to amplitudes nearing 80,000V on some systems. This is all possible due to the operation of the ignition coil which functions as it does due to Faraday's law.

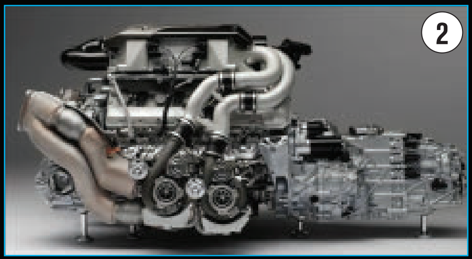
I'll begin by describing an ignition coil as having two distinctive sets of coil windings (inductors). One is known as the primary winding, and the other, the secondary winding. These two sets of windings affect one another through a process called mutual induction (Figure 7).

Mutual induction is described as a voltage being induced in one set of windings because of a change in current (magnetism) in the other set of windings. In other words, a steady current in the primary windings does nothing except establish a magnetic field (https://www.vehicleservicepros.com/21293485). The collapsing of that magnetic field (when the current flow ceases) creates the induced voltage in the secondary set of windings.

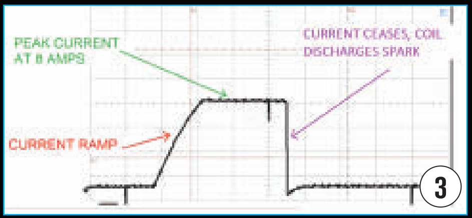
Primary windings - Regarding the configuration of the coil, the primary set of windings is the set that is being controlled or in which



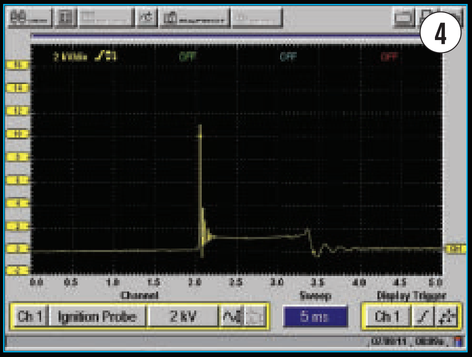
DISTRIBUTOR IGNITION SYSTEM on a 1929 Marmon.



COP IGNITION SYSTEM on the engine of a 2022 Bugatti Chiron.

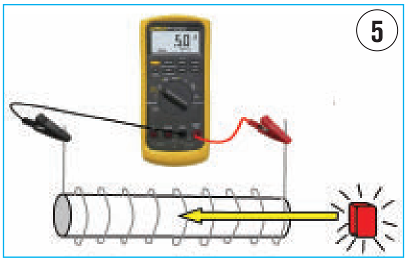


THE ANTICIPATED waveform from a healthy ignition system primary current signature.



THIS SNAP-ON M.O.D.I.S. ignition scope is displaying the associated inductive kick resulting from a healthy ignition primary circuit magnetic field collapsing, then multiplied in the secondary windings. Almost 11kV is displayed in this event.

the current is being manipulated. For that reason, this set of windings is larger in diameter (relative to the diameter of the secondary windings) to allow for higher current flow values. It's common to see primary coil windings carrying 10A or more. However, the length of the primary winding is relatively short (compared to the secondary windings). This allows for only several hundred turns of the inductor.

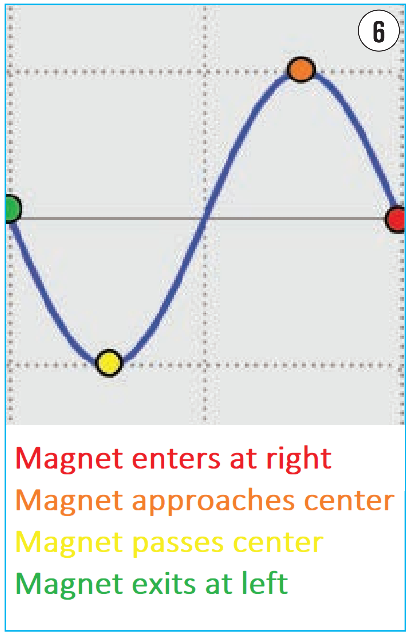


FARADAY'S LAW is displayed in this picture. As the magnetic lines of flux from the magnet pass through the hollow cardboard tube, a voltage is induced in the windings of the inductor wrapped around the carboard tube.

Secondary windings - The secondary set of windings is much thinner in diameter (relative to the primary windings). The secondary windings do not carry much current or for very long (typically less than 2ms). However, the secondary windings are significantly longer (relative to the primary windings) to allow for at least 100 times more turns of the inductor. For every one turn of primary windings, there are typically 100 turns of secondary winding, and that fact holds some significance. I will discuss this shortly.

Coil functionality

It's typical to see the primary set of windings supplied with a source of voltage from a fused source and/or a relay **(Figure 8)**. The control of current flow is then carried out by a switching device on the ground side. These switching devices replaced the points/condenser in older distributor



IF THE RESULTS OF THE previous experiment were plotted on a lab scope, it would appear in this fashion, and for the reasons listed here.

systems when the systems were eventually engineered with electronic control, and they have various names (dependent upon the vehicle manufacturer). Some you may recognize from this list below:

- PCM
- ECM
- Ignition control module (ICM) I
- Ignition control unit (ICU)
- Igniter
- Power stage
- Coil control module

Although the names vary greatly, rest assured they all serve the same purpose, to allow electrical current to flow and then to prevent current from flowing.

When the switching device allows for current to flow through the primary windings, this is known as a dwell period. At that time, the primary coil windings begin to take on energy as they saturate. This energy or current flowing through the looping inductor creates a magnetic field around that inductor.

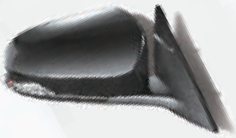
At the time the PCM/ECM decides it's appropriate to induce a spark (at the spark plug gap for a specific cylinder), the PCM/

Expect More. Expect TYC.

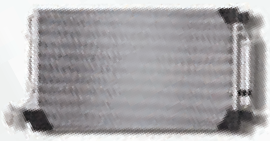
QUALITY, SELECTION, CONVENIENCE

From Headlights to HVAC to Electrical parts, TYC has you covered. With a commitment to quality products that are parallel to the Original in terms of Fit, Form and Function, TYC automotive products provide incredible value for you and your customers.

AUTOMOTIVE LIGHTS

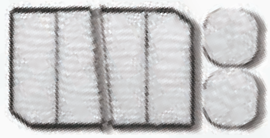


MIRRORS



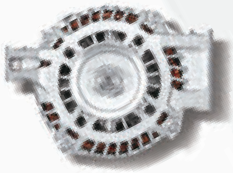
CONDENSERS

COOLING FAN ASSEMBLIES



CABIN AIR FILTERS

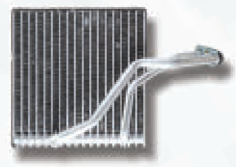
STARTERS



ALTERNATORS

RADIATORS

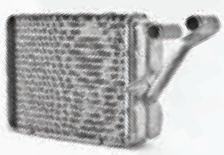
BLOWER ASSEMBLIES



EVAPORATORS

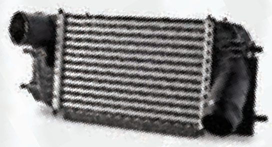
WINDOW REGULATORS

FUEL PUMPS



HEATER CORES

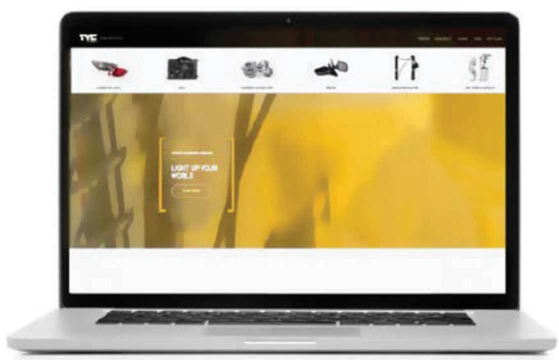
TRANSMISSION OIL COOLERS

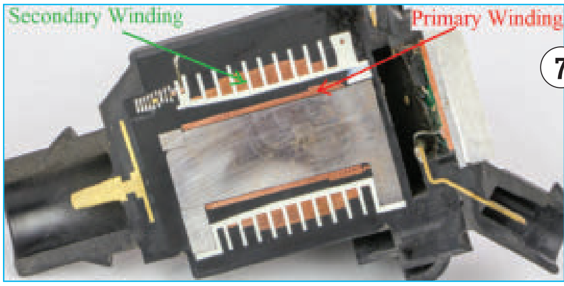


CHARGE AIR COOLERS

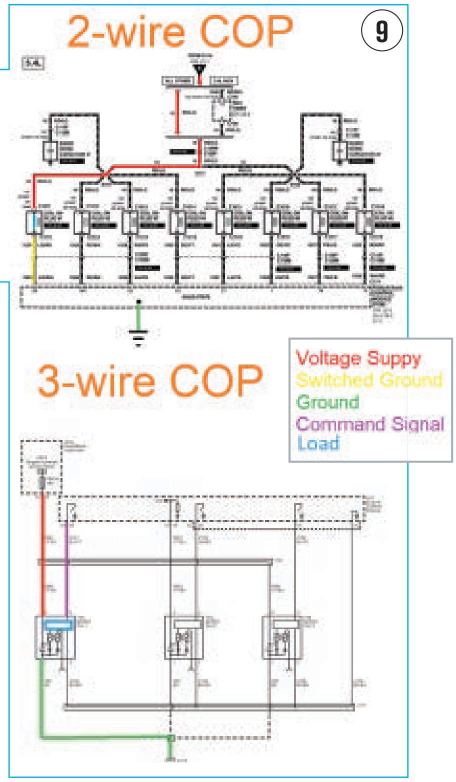
FIND YOUR ONE-STOP SHOP

For more information about our replacement automotive parts and to order TYC parts, please contact Tri-State Enterprises. You can also look up TYC parts in our convenient e-catalog located at www.TYCUSA.com

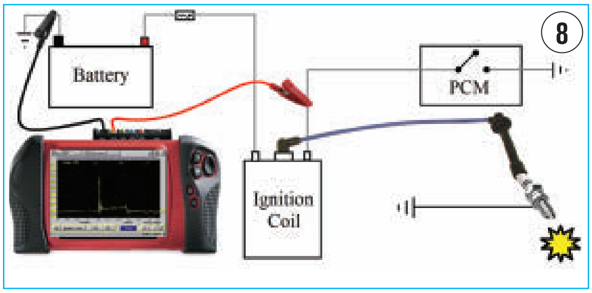




A CUTAWAY VIEW of a COP ignition coil.



THIS ALLDATA WIRING DIAGRAM allows for a comparison of 2- vs. 3-wire coil circuit configuration. The COP in the 2-wire design houses the switching devices internal to the coil.



DISPLAYED is a basic and typical ignition systems configuration for a 2-wire coil. Ignition voltage waveform testing will be carried out by acquiring data from the controlled side of the coil (the side in which the switching device is located).

ECM will end the dwell period by opening the circuit via the switching device. The current that was flowing through the windings no longer flows. As a result, the magnetic field (that built up over the dwell period) collapses.

Electricity and magnetism are very closely related. So, when the magnetic field collapses, that potential energy must dissipate somehow. It does so by transforming from magnetism to electricity within the primary windings.

Keep in mind the several hundred turns of primary windings mentioned earlier. Because each turn of the primary windings multiplies the induced voltage, the 12-14V that was used to energize the primary windings is now several hundred volts as the magnetic field collapses, as displayed on the Snap-on M.O.D.I.S. capture in figure 8.

Because the secondary windings are within close proximity to the primary windings, the several hundred volts we just discussed are mutually induced in the secondary windings. What's more, is the secondary windings have at least 100 times the turns of the primary windings. So, how do you think that affects the induced voltage?

You guessed it; the voltage is multiplied! This now means that the several hundred volts induced in the primary windings becomes tens of thousands of volts induced in the secondary windings. It's this tremendous amount of energy that is required to create and maintain the spark at the plug electrodes in the cylinder under a tremendous amount of heat and pressure. This occurs as much as a billion times over the life of the vehicle.

Applicable to most

So why make such a big deal about Faraday's law? The fact remains that even though technology has advanced (and continues to advance) significantly over the years, it's a common misconception that ignition event acquisition and waveform analysis are dead. I will say it's a dying art, but it is only because techs think the ability went away with the ignition distributor.

It's true that acquisition was much easier with the distributor because it offered a very simple and easily accessible test point (at the coil output) to acquire the secondary waveform. With today's coil-over-plug/coil-on-plug (COP) systems, the secondary waveform is accessible through the implementation of a capacitive pickup, but the COPs are typically heavily shielded to prevent radio frequency interference (RFI). This makes acquisition extremely muted or at times impossible.

However, the primary and secondary waveforms closely mimic each other, meaning the same data can be extracted from either one. An option would be to instead connect to the primary side of the coil. However, unless you are faced with a 2-wire COP, you will have no access to capture the primary voltage waveforms, either. The 2-wire COP is controlled the same as a coil found in a distributor system. The switching device is in one of the controllers in the list mentioned earlier. These systems offer direct access to the primary circuit. Simply connect to the control circuit between the coil and the switching device (Figure 9).

But if you are dealing with a 3- or 4-wire COP, the switching device is internal to the coil, leaving the primary circuit inaccessible. However, there is a solution. Simply pull the COP from the cylinder head and connect a **high-tension extension lead** between the coil and the plug. This will offer the same secondary waveform acquisition opportunity as did an old distributor system **(Figure 10)**.

DNJ®

ENGINE COMPONENTS

CHEVROLET & GMC
4.3L OHV LV3 ENGINES

WE GOT YOU COVERED!!!

YOUR ONE STOP SOURCE
FOR ALL YOUR
ENGINE PART NEEDS
www.EngineComponents.com

Viewing combustion through the eyes of the ignition scope

What technicians frequently fail to realize is that the ignition waveform offers a tremendous amount of information, not just info. pertaining to the health of the ignition components. In fact, here is a list of some of what can be derived from ignition waveforms of today's newest vehicles (in combination with other tests and under a variety of different engine operating conditions):

- Low cylinder compression
- Lean air/fuel ratios
- Rich air/fuel ratios
- EGR dilution
- Cylinder sealing issues
- Weak ignition coils
- Loosely fitted spark plug wires or poorly installed COPs
- Poor injector spray patterns
- Carbon-contaminated GDI platforms
- Shorted spark plugs
- Excessive spark plug gaps
- Carbon tracking
- Ignition timing issues
- Primary-circuit voltage-drops
- Poorly functioning switching devices/ Condenser failure

With the ability to detect such potential faults with one simple connection to the vehicle, I have grown to love ignition waveform acquisition and analysis and implement it frequently. I must tell you that it certainly is not the first test I choose to perform.

In fact, as some of you regular readers recall, I always recommend reaching for the "low-hanging fruit." The easiest information to grab that offers the most insight is always my goal (which typically begins with scan tool data). But ignition waveforms can provide another "arrow in the quiver," so to speak. Anytime I can back up my theories about a potential fault with the results from not one but multiple tests, the likelihood of my being accurate in my analysis (or where/what I may choose to test next) is significantly higher.

Take the time to do your diligence. Acquire the tools to perform the analyses on

AESWAVE

THESE PICO TECHNOLOGIES Extension leads from AESWave are used to aid in the Acquistion of secondary ignition waveforms from a heavily shielded COP.

known-good vehicles, and practice often, creating your own faults deliberately and capturing the waveforms for analysis. It's like my mentor (Jim Morton) always says: "If you become comfortable with what 'GOOD' looks like, 'BAD' sticks out like a sore thumb!"

Although these acquisition and analytical skillsets are not a necessity, they certainly will be another tool in your belt for driveability concerns. Having the test results to lean on and analyze can be the difference between being confident in your diagnosis and simply hoping for the best outcome with your fingers crossed.

Keep your eyes open for my upcoming ignition class that is currently under development. It should be available sometime in late 2023-2024 and will cover everything you need to know about the physics involved, ignition theory and operation, the correct tools to have, and how to use them. The class will even teach you how to experiment safely so you can grow your knowledge and expand your horizons as an industry-leading diagnostician. MA

BRANDON STECKLER is the technical editor of *Motor Age* magazine. He holds multiple ASE certifications. He is an active instructor and provides telephone and live technical support, as well as private training, for technicians all across the world.
bsteckler@endeavorb2b.com

SCAN THE QR CODE TO READ THIS AND RELATED ARTICLES ONLINE


RAISING THE
STANDARDS OF EXCELLENCE
AP SERIES™
NEW 360-Degree Automatic Swing Arm Restraint System
Provides the Ultimate In Safety and Vehicle Fall Protection
NEW
ARRIVAL
SHOP NOW
BENDPAK
Model: 10AP
10K lb. Capacity
Two-Post Lift
Certified to meet the standards of ANSI/ALI ALCTV: 2017
LEARN MORE
Bi-Metric Swing Arms
Our 10AP Series offers the convenience of wide or narrow installation wrapped up into one configurable package. This durable, safe, and reliable car lift features an expandable top beam and BI-METRIC™ arms to suit virtually every vehicle lifting requirement – symmetric or asymmetric. The 2-in-1 design gives operators the option of loading vehicles either symmetrically (centerline of vehicle at column) or asymmetrically (centerline of vehicle behind column). The simple, yet highly sophisticated is sure to keep operating costs low and productivity high. Check out the full line of 10AP lift series at bendpak.com/10AP or call us at 1-800-253-2363.
1-800-253-2363 • BENDPAK.COM
©2023 BendPak Inc. All rights reserved.
BendPak®

DREAMSTIME.COM

UNDER-PRESSURE DIAGNOSTICS WITH A MOBILE TECH

THE JOB OF A MOBILE DIAGNOSTIC AND PROGRAMMING TECHNICIAN REQUIRES MAKING QUICK BUT ACCURATE DIAGNOSTIC DECISIONS TO BE SUCCESSFUL. HERE ARE A FEW TIPS FROM WITHIN THE TRENCHES.

JOHN ROGERS // Contributing Editor

2006 GMC Acadia- Breathe deeply

I got called in to look at a 2009 GMC Acadia 3.6L with 93K miles on the odometer that was experiencing a "crank/no-start" symptom. The shop's initial diagnosis was that the vehicle was over-fueling, preventing the engine from starting.

I arrived at the shop and my first course of action was to crank the engine over and listen to it (for clues of a mechanical failure) and also to see if I could detect a fuel odor. The cranking speed appeared to be excessive and the engine sounded like it had low compression (it is no secret that these vehicles have timing chain issues.). I did not smell fuel at this time.

I then connected my GM MDI2 interface and Tech2Win scan tool software to the DLC and monitored the following PIDs:

- Cranking rpm
- Engine coolant temperature (ECT)
- Throttle position (TPS)
- Manifold absolute pressure (MAP),
- Barometric pressure (BARO)

Satisfied with these values, I moved on. I next consulted service information for a wiring diagram and firing order of the engine. I wanted to move quickly and get the most bang for my buck here. I decided to disable fuel (via fuse removal) and go in cylinder #1 with my WPS500x pressure transducer, current clamp, and PicoScope from Pico Technologies. I also placed an amp clamp around the positive battery cable to the starter motor for relative compression. I removed cylinder #1 spark plug and found it was black and fuel-fouled.

I first cranked the engine over with nothing in cylinder #1 and of course cylinder #1 COP unit disconnected. I wanted to try to clear any liquid fuel that may be in the cylinder. I then connected my scope, amp clamp, and pressure transducer to the vehicle.

I took a capture with the vehicle

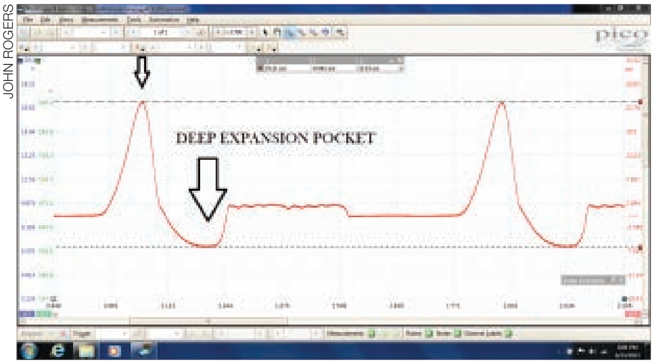
cranking. At just over 25 psi, it was obvious this cylinder had low compression. What stood out to me was the deep expansion pocket on this cranking waveform. Regarding a relative compression (RC) trace (not shown), I noticed that not all cylinders' RC-humps were even. I did not use an ignition synch on the capture. I used my in-cylinder channel as a "synch," so to speak. Remember, I was going for speed and getting the most data in the shortest amount of time. Using the firing order and my in-cylinder "synch," it wasn't pointing towards a particular bank or cylinder.

I then turned my attention to the actual in-cylinder waveform. I isolated the waveform and magnified the waveform **(Figure 1)**. I then added some cursors and could see I had low 25 psi of cranking compression and a deep expansion pocket. The expansion pocket was rounded as well. I like to see quick sharp changes.

I then decided to add some cursors to indicate 720 degrees of crankshaft rotation, or one full engine cycle **(Figure 2)**. I then wanted to see when exhaust valve opening (EVO) occurred. EVO was occurring at approximately 55 degrees before bottom dead center (BBDC). I typically see these vehicles have EVO events in the range of 50 degrees BBDC.

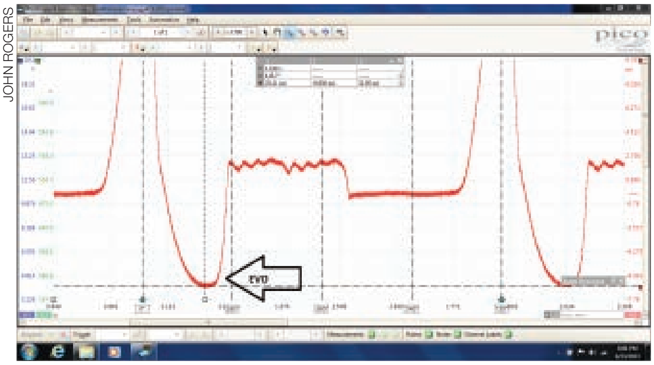
I also compared this waveform with a known-good waveform I acquired from a fellow tech that I trust. This was close enough for me. The leaning compression towers were an indication of compression loss as well. But remember, this vehicle was no doubt flooded with fuel.

I considered the possibility of a restricted exhaust. I ran some horizontal cursors along the waveform and saw close to 2.5 psi of exhaust backpressure while cranking **(Figure 3)**. I should have seen pressure values near atmosphere, or essentially 0 psi of backpressure while cranking.



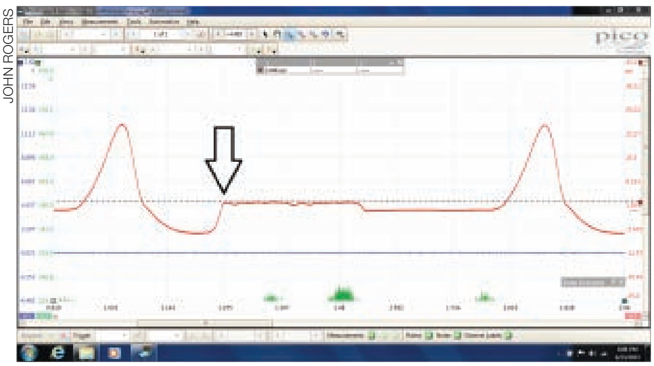
JOHN ROGERS

1 **ZOOMED IN WITH CURSORS SHOWING** EVO and peak compression.



JOHN ROGERS

2 **ZOOMED IN VIEW WITH CURSORS SHOWING** EVO and peak compression.



JOHN ROGERS

3 **ZOOMED IN SHOWING EXHAUST** backpressure.

I then proceeded to perform the same captures on the cylinder next to #1 as a comparison (In this case, cylinder #3) and had the same results. Intake manifold design makes bank 2 in-cylinder acquisition nearly impossible. I felt very confident that this vehicle had a restricted exhaust causing the "flooded" engine, resulting in the crank/no-start scenario.

I informed the shop owner of my findings. He put a tech right on the Acadia to unscrew the upstream oxygen sensors to confirm my findings. Within minutes, the Acadia roared to life and ran quite well with the exhaust restriction alleviated by the removal of the upstream oxygen sensors. At this point, I instructed the shop owner the exhaust needed to be thoroughly inspected and restricted components replaced, along with an oil change and fuel trim checks. A thorough road test to evaluate for any misfires or oil consumption issues that may have contributed to the restriction was also called for.

I returned to the shop a couple of days later to diagnose another vehicle. I inquired about the Acadia and the shop owner told me that they installed new catalysts and changed the oil and filter. I asked if I could do a follow-up on the vehicle, and he obliged.

I first looked at fuel trims at idle. They were within reason and so were fuel trims at 2,000 rpm. I then revisited cylinder #1 in-cylinder compression and relative compression, cranking after disabling fuel **(Figure 4)**; it was totally different from our original capture. Notice the lack of deep expansion pocket, no more leaning towers, and relative compression was much more even. Reinstalling the fuse for fuel, I wanted a running capture as well **(Figure 5)**. It looks good, and notice how even the peaks are. The Acadia was back in action.

2006 Ford van- volumetric efficiency stuffiness

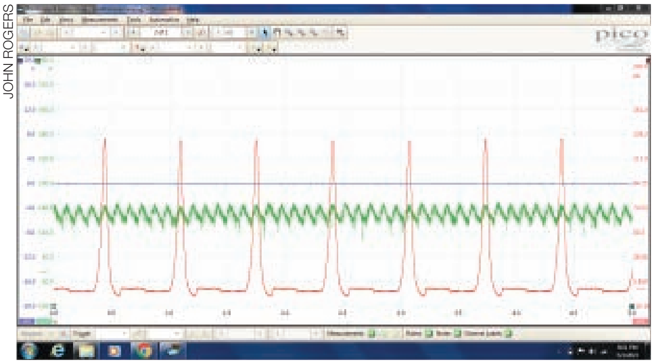
Our next example is a 2006 Ford van with a 5.4L engine and 206K miles. The complaint is "lack of power under load." I road-tested the van and it performed as described. I had a pretty good feel where I was heading.

I connected my Rotunda VCM2 interface along with my Ford IDS to the DLC and decided to run a KOEO self-test, and the vehicle had no on-demand or continuous memory codes. This is not surprising, since the shop that called me in to look at the vehicle had been working on the van and probably cleared codes previously.

I decided to look at a couple of scan data PIDs on a road test. During the road test, I wanted to look at load and enrichment under WOT (wide open throttle). The vehicle had low load percentage but did have enrichment. So, I was pretty confident that we were not dealing with a fuel issue such as low fuel pressure or a bad MAF sensor. The vehicle also didn't have that ignition misfire feel. Again, I had a pretty good idea of where I was heading. I just needed to confirm my suspicions in the shortest amount of time with positive proof.

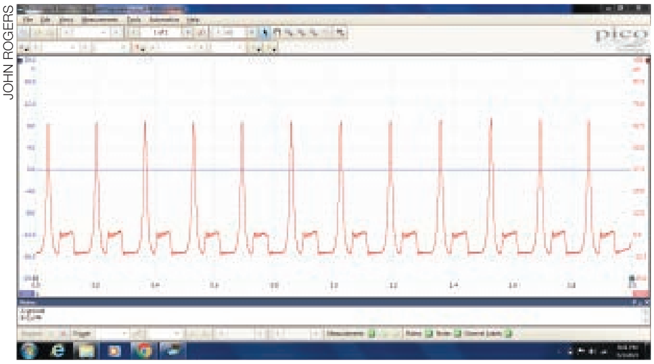
I decided to go in-cylinder with the pressure transducer. I typically will check one cylinder on each bank on these vehicles. I went first in cylinder #4 (on bank 1) after disabling spark and injector pulse for that cylinder. I will typically check at an idle and snap throttle.

I zoomed in and added a horizontal measurement cursor. Again, I'm interested in the pressure rise just after EVO. Ideally, I should see atmospheric pressure at an idle and some low pressure during a snap throttle event. Here we see we have 1.6 psi at an idle **(Figure 6)** and 31.3 psi on a snap throttle **(Figure 7)**.



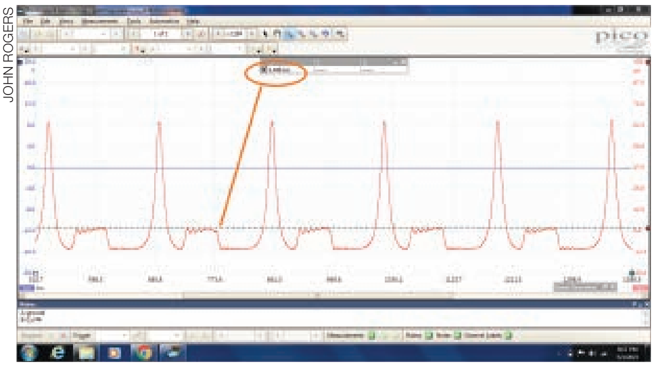
JOHN ROGERS

4 **AFTER CATALYST REPLACEMENT CRANKING** in cylinder and relative compression cranking.



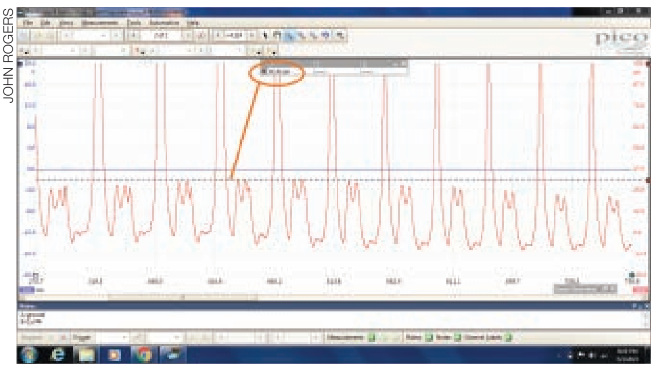
JOHN ROGERS

5 **AFTER CATALYST REPLACEMENT** running in cylinder.



JOHN ROGERS

6 **CYLINDER #4 BANK 1** zoomed showing exhaust backpressure idle.



JOHN ROGERS

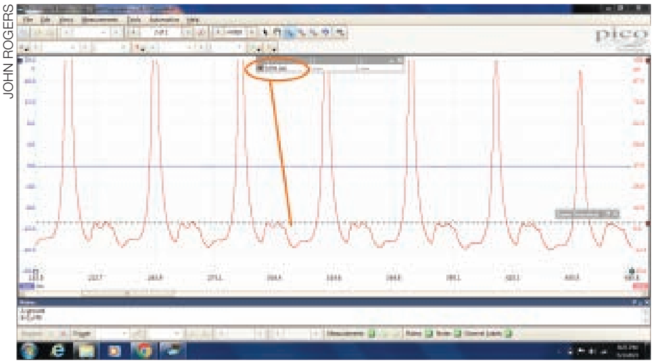
7 **CYLINDER #4 BANK 1** zoomed showing excessive exhaust backpressure snap throttle.

I went in cylinder #5 (on bank 2) with the pressure transducer. Again, disabling spark and fuel injector for that cylinder, I repeated the idle and snap throttle events. Zooming in and adding a horizontal cursor measurement, a very different story was told for this bank's breathability. At an idle, atmospheric pressure was present just after EVO and about 3.5 psi during a snap throttle event **(Figure 8)**. This bank can exhale, whereas bank 1 is restricted.

I informed the shop owner of my findings and showed him my results. I also advised him that catalysts usually don't clog on their own. There are many factors that can cause such failures (such as misfires, fuel trim issues, oil consumption, etc.), and l will need to be evaluated, especially on a high-mileage vehicle such as this one.

I checked in with the shop owner a couple of days later. He informed me that he changed bank 1 catalyst and inspected the rest of the exhaust system. A follow-up road test confirmed that the van had its power back.

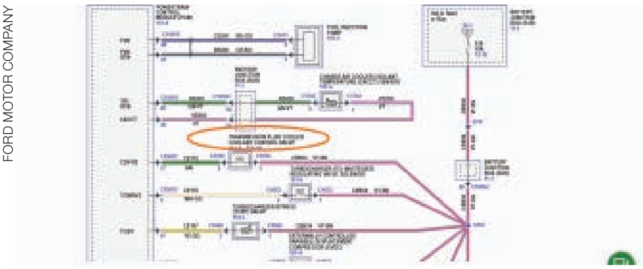
JOHN ROGERS



8

CYLINDER #5 BANK 2 zoomed showing minimal exhaust backpressure snap throttle.

FORD MOTOR COMPANY



9

FORD WIRING DIAGRAM displaying component call-outs.

2017 Ford Escape - When a solenoid circuit code goes sideways

"Cause-and-effect" is one of the many daily occurrences we see in the automotive industry. Neglecting to change your oil or running your engine low on oil undoubtedly will have a negative impact on the engine's lifespan. The effect is a bad engine; the cause was lack of maintenance. But what happens when we see strange cause-and-effect issues? Well, this is one such case.

A 2017 Ford Escape 1.5 L with 205K miles was being addressed. This vehicle is a security vehicle for a local school, so it sees its fair share of idle time. The shop had the vehicle for a check engine lamp illuminated. They scanned for DTCs and diagnosed the fault as a bad coolant bypass solenoid. They ordered one from the Ford dealer, installed it, and still had the same code. They then installed a second one from Ford and visually checked the wiring. After the second installed part, they had the same issue. And that is when they called me.

I inspected the vehicle, and it was in pretty good shape for the mileage it had. I ran a KOEO self-test. The vehicle had a code P2681 on demand for a coolant bypass solenoid. After visually inspecting that the shop changed the correct solenoid, I went to work. Looking at the code description, the code was for an open circuit. Ford pinpoint testing is a series of checks (check this for an open, check that for a short, etc.)I needed to check this circuit fast and efficiently. Looking at the wiring diagram, I could not find an engine coolant bypass valve. I referred back to the pinpoint test.

The engine coolant bypass valve is also called a transmission fluid heater coolant control valve. Lo and behold, I located that component by name in the wiring diagram **(Figure 9)**.

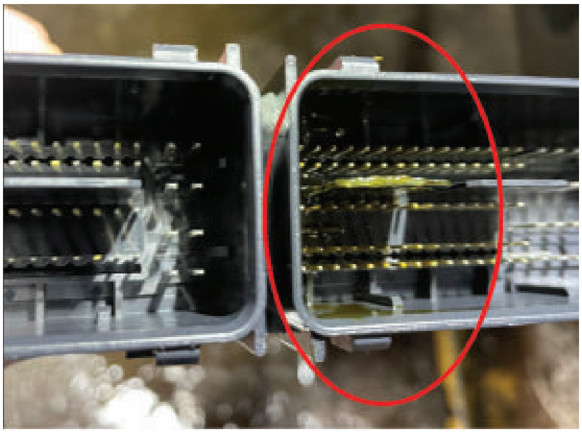
So, 12V is fed through fuse F34 (in the battery junction box) to circuit CBB34 (VT/BN), to solenoid. The control side of the solenoid goes from back to the PCM connector C1551E, terminal #17 (on circuit CE172 (GN)).

I was able to get to the solenoid. I unplugged the solenoid and checked terminal tension at the connector and was satisfied we did not have spread terminals. I then reconnected the solenoid and back-probed the solenoid connector, first on the power feed wire and then on the control side key on, and I had battery voltage on both. This temporarily ruled out S110 being a potential issue for a complete break.

After a visual inspection of the exposed harness, I had to gain access to the PCM and test at the PCM connector to confirm circuit integrity. Getting to the PCM on these vehicles is no easy task. The left front wheel and inner fender well had to be removed. I was then greeted by the plastic box forward of the wheel that houses the PCM. I noticed that the PCM harness going into the plastic PCM housing box was quite oily. I attributed this to the high mileage of the vehicle.

I removed the cover and exposed the PCM. I took off the PCM connectors and was surprised to find oil in one of the PCM connectors and the PCM itself **(Figure 10)**. Now I knew why the

JOHN ROGERS



10

FORD PCM WITH OIL INGRESS from a damaged sensor, wicking oil through the entire length of the engine harness.

11

CONNECTOR OF FAULTY CAMSHAFT position sensor. The damaged sensor allows oil to wick its way into the PCM at the other end if the wire harness.

harness was oily, too. Referencing the wiring diagram again proved this was connector C1551E (the very same connector that housed my problem circuit that I was chasing). I continued to check my problem circuit. I first verified that the circuit was complete. I reconnected my PCM connectors, turned key on and back-probed circuit CE172 at the PCM connector C1551E and measured 12V. This verified a "complete" circuit.

I disconnected the PCM connectors again and powered up F34 fuse in the battery junction box with a jumper wire. This was a necessary step because with the PCM disconnected, that fuse would not be supplied voltage with the key on (as the PCM power relay would not be activated with the PCM disconnected).

I then front-probed terminal #17 at the disconnected C1551E PCM connector and grounded the circuit and listened for an audible click from our offending solenoid. A distinct click could be heard. I then checked the amp draw of the circuit when I actuated it. I was satisfied that the circuit was intact and not drawing too much amperage. I then reconnected the PCM connectors and reran my KOEO self-test and still had a code P2681 on demand. This is always a wise step, as I could have inadvertently moved a harness and temporarily "fixed" the issue.

So, it was pretty clear that this little Escape would need a PCM. But, where was this oil coming from? Looking at the pinout for C1551E, there were a couple of culprits. I was looking for components that spend their lives in oil. There was an engine oil level switch and both exhaust and intake cam sensors. I looked for an oil level switch and was never able to find one. I then looked at the cam sensors and hit paydirt. The exhaust cam sensor connector was nice and dry. The intake cam sensor was wet with engine oil, and there was a pool of oil in the sensor itself **(Figure 11)**.

This was the offender for the oil migration. Over the years, I have seen various liquids such as washer fluid, oil, and coolant end up in modules through capillary action. At times they seem to defy gravity. Sometimes it is quite bizarre.

I advised the shop of my findings and gave some options. After discussing with the Escape owner, they elected to change the cam sensor and pigtail. They hung the harness up for a couple days to get rid of most of the oil in the harness. They cleaned the PCM connector and were going to get a Ford remanufactured PCM. This was the decision between the shop and the vehicle owner.

A few days later I arrived to program the remanufactured PCM. The harness seemed to be pretty dry and oil-free. I installed the remanufactured PCM. I programmed it, ran vehicle theft programming, and other setups as well. The vehicle ran well and had no more codes for the engine coolant bypass valve circuit.

I have no doubt that the oil migration into the PCM caused this failure. It was indeed a strange case of cause-and-effect. With all of those factors applied, is there really anything we are not capable of properly diagnosing? MA

JOHN ROGERS has been in the automotive industry for over 38 years. In that time, he has worked in a multitude of positions, including technician, shop owner, and 11 years on a national automotive diagnostic hotline. He currently operates JWR Automotive Diagnostics and Programming. For the past 15 years, his business has catered to registered repair shops, body shops, and transmission shops in two counties on Long Island, New York, servicing all their diagnostic and programming needs.

SCAN THE QR CODE TO READ THIS AND RELATED ARTICLES ONLINE

TECHNICIAN-INDUCED DIAGNOSTIC DILEMMAS

BLINDLY APPROACHING A FAULT IS LIKE JUMPING INTO AN EMPTY POOL... YOU MAY QUICKLY GET TO THE BOTTOM OF IT, BUT IT'S PROBABLY GOING TO HURT.

BY CHRIS FARLEY // Contributing Editor

I recently encountered two vehicles with technician-induced problems that I believe offer some valuable lessons. Whether we caused the problem or we're there to diagnose it, rushing and jumping to conclusions often costs us more time in the end.

2013 Ford Focus — The customer brought in a 2013 Ford Focus for an intermittent no-crank condition.

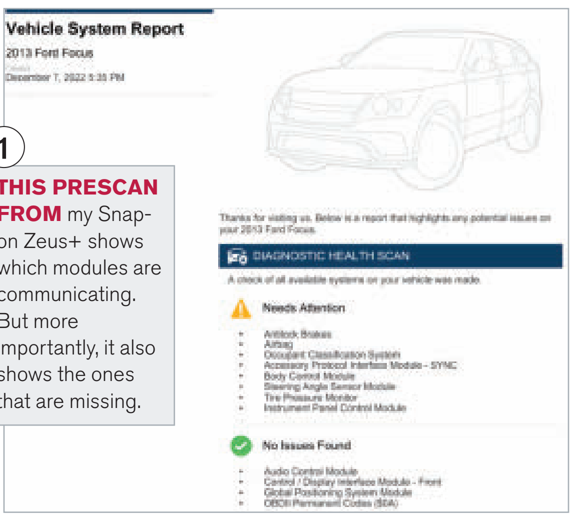
My usual diagnostic routine is a prescan, a quick visual inspection, and an interview with either the shop owner I'm called to assist or the vehicle owner. But as usual, I got only part of the story, even after thorough questioning. I'll never understand why this happens.

The shop tested the car and didn't find anything wrong, so it returned the vehicle to the customer. A week later, the vehicle returned to the shop on the hook of a tow truck. The customer stated that the vehicle had refused to start a few instances, and this time it had died on road. The technician at the shop approached the vehicle and it started right up. The tech believed the starter must be the culprit. This is not a logical direction to head in for a vehicle that suddenly died on the road.

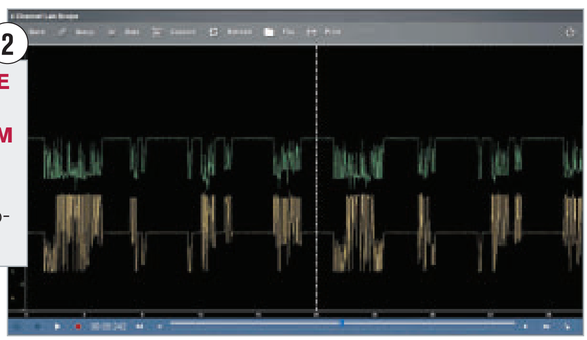
The shop owner told me they installed a starter, lowered the vehicle to verify it started and then raised the vehicle to install the underbody shield. They then lowered the vehicle and it again failed to start. They tried to scan the vehicle and found it would not communicate. They decided to push the car out and give me a call.

Jumping the gun

I connected my **Snap-on Zeus+ scan tool**, and the first thing I noticed was the vehicle did not auto-identify with the scanner. I manually selected the vehicle and reestablished communication with some of



1 **THIS PRESCAN FROM** my Snap-on Zeus+ shows which modules are communicating. But more importantly, it also shows the ones that are missing.



2 **THIS IS THE CAN BUS WAVEFORM** when testing at the DLC with my Snap-on Zeus+.

the onboard modules. Now, this is where I'm guilty of having jumped the gun. Since I received the call, all I could think of was the common fault for the symptom that these vehicles experience, a faulty transmission control module (TCM).

Sometimes we need to be reminded of why we have a diagnostic process, and we need to be humbled when we get lazy or ignore it. Although I followed my process, I wasn't focused because I had already convinced myself the problem was a failed TCM before I even connected my scanner.

It was a rainy day, and I was in a parking lot. But in my head, I believed all I had to do was unplug the TCM and I'd see vehicle communication return. So, I laid down in the rain and unplugged the TCM, but communication had not returned. For the rest of the day, all I had to show for my effort was wet clothes.

Now that my bubble had burst, I got to kick myself and regroup. I went back to my process and I reviewed my scan report **(Figure 1)**. I noticed that the power steering control module (PSCM), the powertrain control module (PCM), and the transmission control module (TCM) are the only modules missing from the bus. At this point I reviewed the system wiring diagrams, and since I already had the TCM unplugged I started my testing there. I tested to verify the TCM had everything it needed to communicate (voltage supply, ground supply and communication signals coming in). The only issue I noted was the signal from high-speed CAN bus low **(Figure 2)**.

The second approach

My next step was to install my **AESWave LineSpi breakout box**. I connected the **Snap-on scope (Zeus+)** and saw the same high-speed CAN low pattern, so then I performed a resistance check on the high-speed CAN network. This test checked the integrity of the circuit and offered me direction.

To perform this test, turn the key off (so the network isn't active) and by connecting my **Snap-on DMM** across high-speed CAN+ and CAN-, you should anticipate a 60-ohm reading displayed. However, that is not the reading we were getting here, which tells us there was an incomplete circuit and one resistor was bypassed **(Figure 3)**. I then retraced my steps to decide on which direction we go:

- The scan report showed the PCM, TCM, and PSCM are offline.
- A resistance test proved a circuit was open in the high-speed CAN network.

A review of the CAN system topology I sourced for this vehicle from **Alldata,** showed the terminating resistors for this network are located in the body control module (BCM) and the PCM **(Figure 4)**. But of those two, only the PCM failed to communicate.

I Looked at the CAN bus network diagram **(Figure 5)**. The communication wires pass through connector C238 to splices S109 and S110. From there, the circuit heads toward the ABS module and to connector C140. The ABS module was communicating, so I realized wiring integrity was good up to that point.

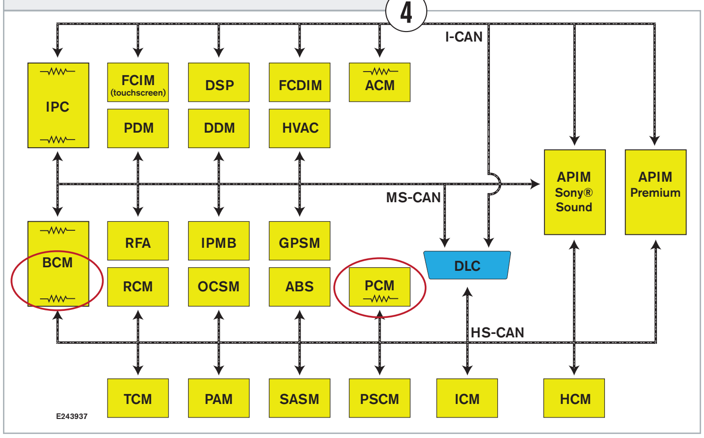
The next best place to check our signal is connector C140, which is located alongside the battery. I've accessed the high-speed CAN- wiring at pins 3 and 4 with my **pierce probes from AESWave (Figure 6)**. The circuit comes through pin 3 to splice S112, which splits the circuit (to the PSCM and back through C140 pin 4/ out to the PCM and TCM).

I performed another resistance test at connector C140 (pins 2 and 3) and measured 120 ohms, but pins 4 and 5 displayed an open circuit. This confirmed the fault was between the two chosen test points.

I jumped pins 3 and 4 and communication returned, and I could talk to all modules. I then knew I would find my circuit issue between S112 and C140.

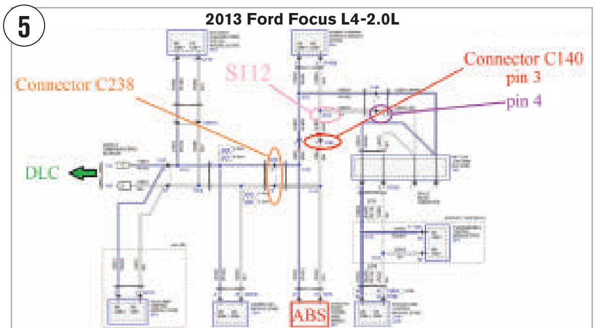
3

RESISTANCE TEST being performed (using my AESWave LineSpi breakout box and Snap-on DMM at the DLC) of the CAN bus.



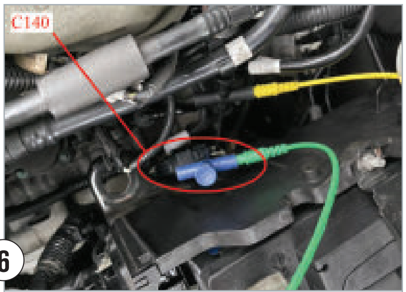
4

THE CAN BUS TOPOLOGY overview found in Alldata shows the location of the terminating resistors.



5

THIS IS THE WIRING DIAGRAM of the high-speed CAN bus wiring, including connectors and splices, which is used to create a test plan.



6 **CONNECTOR C140** is a perfect spot to divide the circuit to isolate the location of the fault.

7 **THE HARNESS WAS CAUGHT** between the mount and bracket.

8 **HERE IS THE DAMAGE** to the harness, visible after it was freed from the bracket.

A step in the right direction

To access that section of the wiring, I removed the battery, covers and tray. Once they were removed, I saw a shiny new transmission mount looking at me. The wiring harness comes out of C140 and goes along this mount before S112. I disconnected C140 and tried to move the harness to gain access for testing, but it was pinched under the mount.

I questioned the shop owner about the new mount. Suddenly his memory came back, and he told me he had replaced the mount after he confirmed the starter was working (I'll never understand why it is so difficult to get the whole story up front).

After removing the bracket, I freed the harness and removed the conduit from the harness **(Figure 7)**. This is the extent of the damage **(Figure 8)**. With only a slight tug on the wires individually, two of the wires instantly pulled apart. The shop let me repair the wiring, which allowed me to test the vehicle again after repairs and confirm everything was working properly at that time. I add the "at that time" reference because I know their repair caused this no-start issue, but I don't think the starter caused the previous issue of vehicle "died while driving." We may never know the root-cause of this vehicle's stalling issue, but time will tell.

2021 Jeep Grand Cherokee — MIL after rear-end collision

I got a call to look at a 2021 Jeep Grand Cherokee with multiple indicators illuminated and a handful of DTCs. It was hit hard in the right-rear of the vehicle and the shop had already replaced a physically damaged module in that area. But when I got to the vehicle, it seemed all the original faults remained.

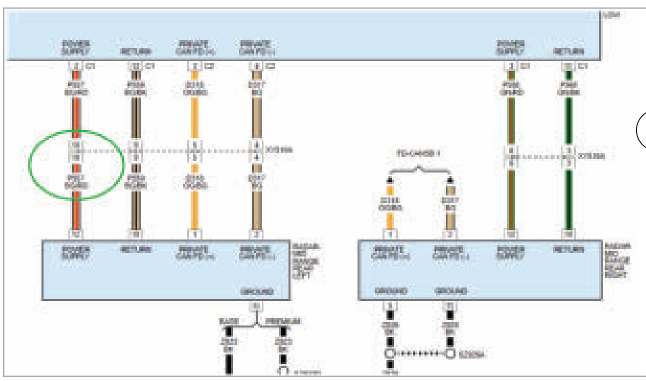
If you can't stand the heat, stay out of the kitchen

The shop owner told me he called another mobile guy first, and when he saw all the codes (63 to be exact), he turned the job down. When I asked about the replaced module, all he could tell me was it was behind the right rear interior panel. There are multiple modules in that location, but they couldn't be any more descriptive. And of course, they threw out all the old parts. The good news is the odometer was flashing (for those of you that haven't seen that yet, it means a module in the network needs a proxy-alignment/configuration). This is a procedure that transfers the vehicle configuration from the BCM into the new module that was installed.

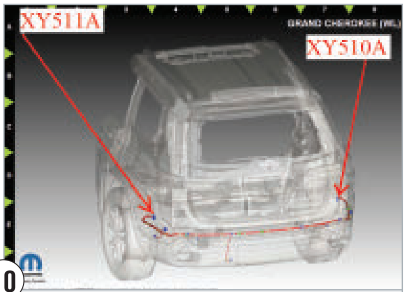
I connected the factory interface (Micropod3) to the vehicle and ran the proxy procedure. The scan tool alerted me that the power liftgate module wasn't aligned, so now I knew which module was replaced. I performed the procedure and I cleared the DTCs. I was then left with only seven remaining DTCs (four for rear parking sensors shorted to ground, two for rear radar blind spot circuits open, and one for private CAN network in the central ADAS decision module (CADM). In a situation like this one I typically choose one code and chase only that one DTC's root-cause fault. In this case, I chose the rear radar module a circuit open (C00C4-13).

First, I asked the shop to remove the bumper so I could gain access to the wiring and modules. In factory service information, the set conditions for this DTC are as follows: "The CADM detects a power supply circuit for the left-rear mid-range radar." A check of the OEM wiring diagram shows voltage coming in through connector XY510A pin 10 (beige/red wire) **(Figure 9)**.

The connector is on the passenger side of the bumper and has plastic covers over both sides, making it nearly impossible to see the colors of the wires. When I



9 **THE RADAR WIRING DIAGRAM** found in the OEM factory service information shows the voltage coming in on pin 10 of the connector.



10 **HERE IS THE CONNECTOR LOCATION VIEW** found in Alldata of the XY511A and XY510A connectors.

removed the covers from the vehicle-side of the harness I found voltage available at pin 10 but no voltage available at the radar unit. I then removed the cover from the harness on the bumper side and I found no wire in that connector cavity. The wires that are present did not match the colors indicated in the wiring diagram.

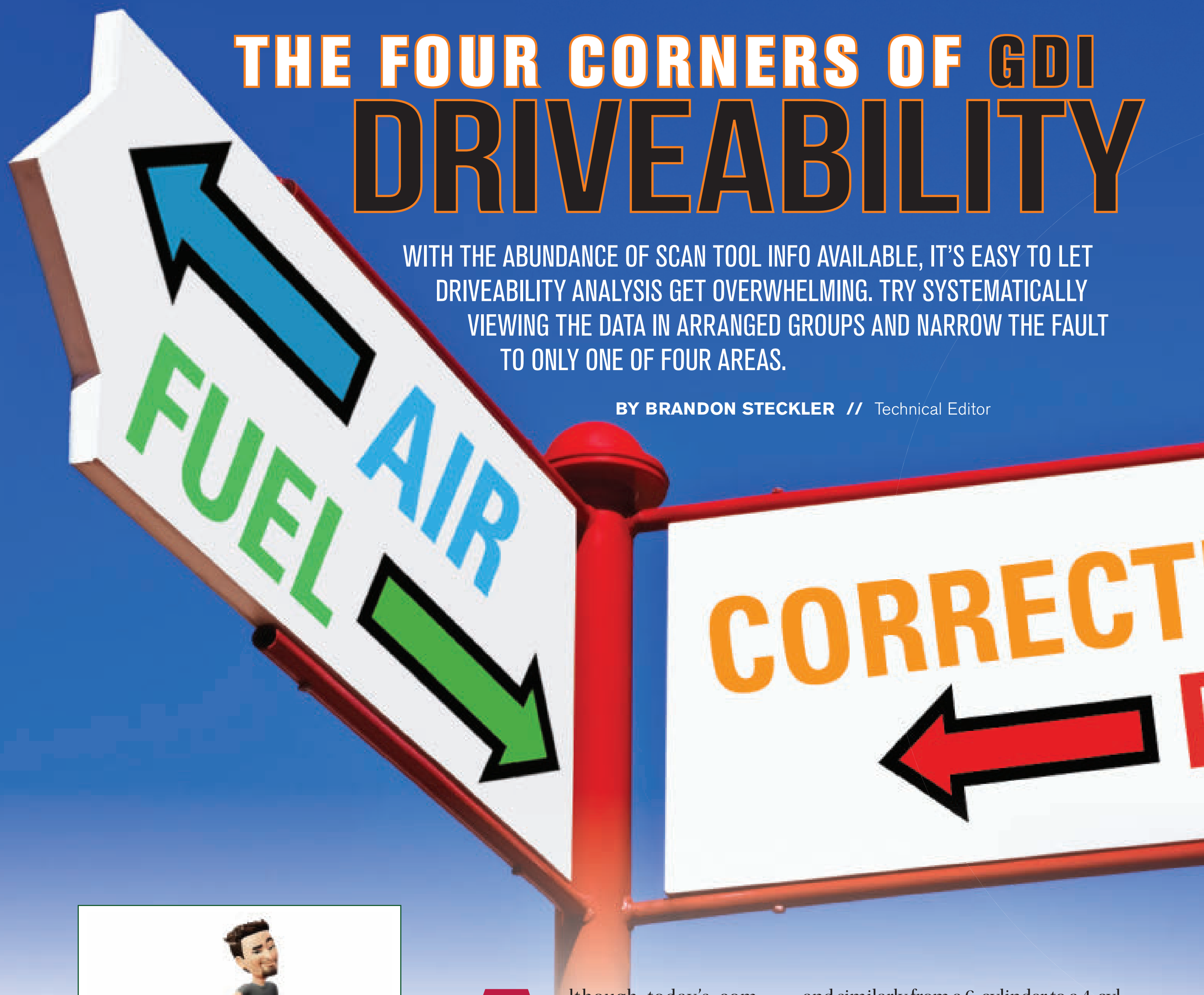
I had another conversation with the shop owner, and he confirmed he had replaced the bumper harness. I decided to inspect the parking sensor wiring and found it's routed through connector XY511A (which is the connector on the driver's side of the same bumper harness) (**Figure 10**). I removed the covers from connector XY511A to inspect the wiring. A beige/red wire at pin 10 on the bumper side of the connector was mated to an empty cavity in vehicle side of harness. I wouldn't have guessed this from the start, but this was a case of the bumper harness having matching connectors on both sides. This allowed it to fit (with all the connectors going across the bumper, for parking sensors) with the wire in either position. Strangely enough, there were no fitment issues and the only way you could tell there is a difference is if you looked at the terminals in the connectors. A quick swap of the harness, clearing the DTCs, and we had a functioning parking and radar system with a clean post-scan.

Both case studies were shop-inflicted issues that could happen to any of us when rushing to complete a job. Whether it is attempting to drive efficiency up or the pressure we get from impatient customers to get their car back, spending a few extra minutes on either of these jobs would have prevented these issues. They also show how following a diagnostic process and not jumping the gun saves time in the end, even if you are up against 63 DTCs!

CHRIS FARLEY is a 25+ year veteran of the industry and the owner and operator of Automedic LLC, a mobile programming and diagnostic business servicing both auto body and repair shops in central New Jersey.

SCAN THE QR CODE TO READ THIS AND RELATED ARTICLES ONLINE

THE FOUR CORNERS OF GDI DRIVEABILITY



WITH THE ABUNDANCE OF SCAN TOOL INFO AVAILABLE, IT'S EASY TO LET DRIVEABILITY ANALYSIS GET OVERWHELMING. TRY SYSTEMATICALLY VIEWING THE DATA IN ARRANGED GROUPS AND NARROW THE FAULT TO ONLY ONE OF FOUR AREAS.

BY BRANDON STECKLER // Technical Editor

WELCOME BACK TO ANOTHER EDITION OF "THE DATA DOESN'T LIE," A REGULAR FEATURE IN WHICH I POSE A PUZZLING CASE STUDY, FOLLOWED BY THE ANSWERS TO THE PREVIOUS ISSUE'S PUZZLE.

Although today's computerized fuel injection strategies still shoot for the same goals as the ones from years past, how they go about reaching that goal and maintaining fuel control (especially in response to faults) is far different. If you aren't aware, I suggest you pay attention.

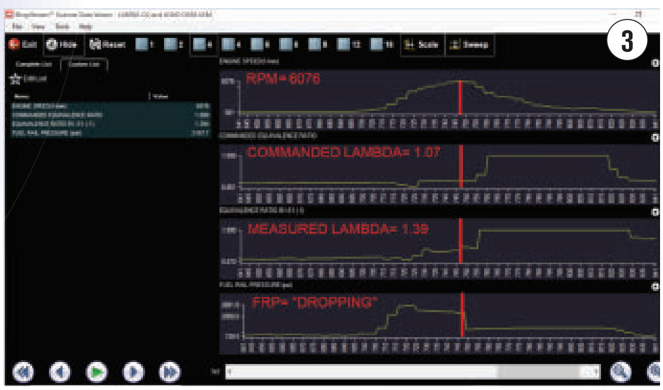
When coupled with other newer technologies (like turbo/supercharging, Atkinson cycling, VVT/VVL, DoD) the benefits of the GDI fuel injection system are tremendous. The ability to extract the energy output of a big 8-cylinder can now be accomplished with a small 6-cylinder, and similarly from a 6-cylinder to a 4-cylinder engine. Moreover, they are far more fuel-efficient and emit far fewer contaminants from the exhaust stream.

But that technology comes at a cost to technicians faced with driveability issues. The components used to monitor and control these systems are more complicated and require a slightly more involved analytical skillset.

My good friend Caleb Mohler, of European Service Center in Houston, Texas, was faced with a 2014 BMW X6, with a DOHC V8. This vehicle is turbocharged and includes two independent GDI fuel injection systems (two MAF sensors,

THIS FIRST DATA SET demonstrates a struggle for the engine to breathe. This information guides the diagnostician to determine the cause of the breathability fault. A different set of data parameters will serve as a steppingstone, bringing the diagnostician closer to the fault and right from the driver's seat.

THIS SECOND DATA SET explains why the engine is experiencing a breathability fault. Although the throttle pedal is being depressed (not displayed here), requesting acceleration, the throttle position sensor show the PCM has other plans. It appears that the PCM commands the throttle blade closed, limiting the amount of incoming air. The MAFs appear to be reading differently from one (bank-to-bank) another as well.



DISPLAYED IS THE REASON the PCM may be commanding the throttle blade closed. The measured exhaust content is 30 percent leaner than the PCM desires. This is because of a fuel rail pressure loss. So, next is to determine why the fuel rail pressure dropped.

two camshaft-driven high-pressure fuel pumps, and two separate fuel rails.) The vehicle presented with a P0303-Cylinder #3 misfire and would set the DTC only above 4,000 rpm.

Initial approach

Using a Snap-on scan tool and the Snap-on upload website ShopStream Connect, Caleb gathered some basic graphical driveability data at the time of the fault, which he collected for analysis **(Figure 1)**. What can be seen is the primary WRAF sensor is reporting Lambda 1.36. The secondary (post-cat) HO2 sensor signal is not included in this capture but is reporting below .074mv. (Lambda 1.36 = 36 percent-lean-of-stoichiometry). Both sensors tell the same story, and the engine is operating in a very lean state. Although a DTC for a cylinder-specific misfire has flagged, we have to consider a globally lean condition to be the root-cause.

The next step is to determine why the engine is underfueled. Reviewing a different data set shows that the MAF sensors (responsible for reporting engine load to the PCM for calculation of proper fuel delivery) indicate an inability for the engine to pump air adequately. It should be clear that if the PCM sees a lack of incoming air, it would deliver less fuel (because the fuel isn't required). That begs the question "Why is the engine failing to breathe correctly?"

Reviewing yet another set of data PIDs reveals that answer quite clearly **(Figure 2)**. Paying mind to the engine rpm value, it continues to climb (indicating acceleration). However, the throttle position sensors show that the throttle is being commanded to close, even though the accelerator pedal is being depressed (not displayed in the capture).

A diagnostics path was chosen

Considering what was stated in the beginning (how GDI platforms respond differently to faults), we can see in the data above that the PCM responded to the lean condition by closing the throttle. This means the apparent breathability fault was simply an effect of the throttle blade being commanded closed. So, the next question to be answered is "Why is the PCM delivering such a lean fuel charge?"

Caleb viewed a third set of data parameters **(Figure 3)**. These were based less on "breathability" and more on "fueling." The PIDs show that under heavy acceleration, the fuel rail pressure began to drop. Although only one of the FRP PIDs is displayed in the capture, this occurred on both independent fuel rails/both banks of the engine.

For clarity, I've compared fuel rail pressure to rpm and load **(Figure 4)**. My goal in this data set is to see if the load dropped before the fuel pressure (cause or effect). It's clear that the rail pressure dropped first, meaning this fuel rail pressure drop did not occur in response to a change in measured absolute load.

SEEN HERE, the fuel rail pressure dropped before the measured incoming air (absolute load). That means the rail pressure loss is the cause of the problem, and not the effect.

The data doesn't lie

With all the information in front of us, we wer e faced with deciding how to proceed. Here are some bullet points of what we know to be factual, and I will ask all of you, diligent readers, for your input:

- P0303 is occurring, and it's always under heavy/sustained load
- All four primary/secondary exhaust gas oxygen sensor report lean conditions for both banks during fault
- Both fuel rail pressure sensors report a loss over time leading up to the fault
- The apparent breathability issue is simply an effect of the adaptation to correct for a lean condition

Given this information, what would you recommend doing next?

- Gather more information about the commanded rail pressure and low-pressure fuel delivery system
- Replace in-tank low-pressure fuel supply pump
- Replace GDI fuel injectors
- Replace both high-pressure fuel pumps

Be sure to read next month's Motor Age issue for the answer to this month's challenge and what was discovered! MA

SCAN THE QR CODE TO READ THIS AND RELATED ARTICLES ONLINE

SOLVED: (May 2023, *Motor Age*) 2014 Ram ProMaster 3.6L, overheating

What would you recommend doing next, given the data bullet points in last month's challenge?

1) Replace head gasket for suspect bank
2) Defer to a different test due to inaccurate results from this test
3) Repeat the test and place the pressure pulse sensor in the exhaust system and/or dipstick
4) Replace head gasket and recondition cylinder head due to poorly seating intake valve

For those of you who chose answer #3, congratulations! This is likely the most logical approach. Although I always suggest deferring to tried-and-true tactics when current test results do not instill confidence, answer #2 would be acceptable as well. However, if you chose answer #1, replacing only the head gasket will correct the overheating /coolant loss concern but doesn't answer the question about to where most of the compression was lost. Answer #4 is incorrect, as the cranking-intake pulse captured didn't prove where the compression loss occurred but did prove the leak was not to the intake manifold (past a poorly seated intake valve).

LAST MONTH'S DIAGNOSTIC CHALLENGE was an engine with two faults: a failed head gasket and a valve sealing fault. It's all in the captured data, and "the data doesn't lie."

By placing the pressure pulse sensor in the tailpipe, the compression loss fault would have been confirmed to be a poorly seated exhaust valve. After the removal of the cylinder head, the exhaust valve seat for cylinder #2 was displaced and the cylinder head required reconditioning. Even if this pressure pulse information is a current challenge for you to understand, capture it anyway. After the fault is confirmed visually, you can begin to put the puzzle pieces together and learn from them. Learn the techniques properly and practice!

MAXIMUM CRANKING POWER AND RESERVE CAPACITY

Today's automobiles and light trucks require batteries that will start the vehicle in extreme weather conditions and run all of the power-hungry accessories. The FVP Platinum Automotive and Light Truck Batteries from Factory Motor Parts are specifically designed to provide maximum cranking power to start the vehicle and run the electronic accessories when the vehicle is turned off.Each FVP Platinum Battery is engineered to meet exact OE fitment specifications and is backed by a nationwide free-replacement 30-month warranty. A five-year free replacement warranty is also available.

FACTORYMOTORPARTS.COM *SPONSORED*

IDEAL FOR LOW-RESISTANCE TESTING

The MT03A Milliohm and Motor Tester from Pico Technology offers resistance testing of all windings on a three-phase motor in under a minute, producing highly accurate results that can automatically compensate for temperature using the included sensor, says the company. It's designed to meet the needs of technicians in a wide range of industries, including automotive, off-highway, heavy duty, rail, mining, and more. With its earth-bond testing in compliance with UN ECE R100 regulations and a minimum test current of 200 mA, the MT03A has widespread applications, including fuel pumps, air-conditioning motors, regeneration pumps, blower motors, camshaft controls, EGR valves, turbo actuators, and more.

VEHICLESERVICEPROS.COM/53058475

OE QUALITY, ENGINEERED FOR TODAY'S VEHICLES

Metrix climate control and engine cooling products are made to do the job right the first time. With a complete line for automotive and light truck applications, Metrix provides OEM fit and quality to maintain the integrity of the vehicle and restore optimal performance.

Engineered for today's higher performance cooling systems, Metrix engine cooling products are manufactured to do the job right the first time. All Metrix products fit the same as the OE parts with no need to move fittings, drill added holes, or stretch hoses. Metrix climate control products are engineered to deliver superior performance, extended reliability and reduced noise. Metrix products are distributed exclusively by Autopart International and Worldpac.

ADVANCEAUTOPARTS.COM *SPONSORED*

BLUETOOTH-ENABLED BATTERY DETECTION TESTER

The Launch Tech BST-360 Battery Tester is a Bluetooth-enabled battery detection tester. It features depicting battery health, and an overall indicator of the vehicles starting and charging system, enabling the user to identify charging system issues accurately and timely. With Bluetooth technology, the tester is portable and able to sync with smartphones and Launch Tech diagnostic scan tools.

VEHICLESERVICEPROS.COM/21262157

TRANSMISSION TECHNICAL SUPPORT OVER THE PHONE

ATSG AUTOMATIC TRANSMISSION SERVICE GROUP

When you have a transmission issue and want to make sure you fix it right, call ATSG's Pay-Per-Case. Our transmission experts will provide technical support over the phone. The ATSG techs on stand-by will walk you through your transmission questions including diagnosis, repair, parts, rebuilding, replacement, and electrical for only $75/case! To start a Pay-Per-Case, just call 800-245-7722 and provide us details on your transmission issue. One of our experienced ATSG techs will call you within one hour to help!

ATSG.LINK/PPC *SPONSORED*

3-IN-1 PROGRAMMING AND COMMUNICATION DEVICE

The Autel MaxiFlash XLINK is a three-in-one programming and communication device. It's a remote expert-ready device. Connect with module programmers, automotive diagnosticians, and system experts for tasks requiring OE data, software, or tools. The XLINK is a J2534 Pass-Thru programmer. Perform module programming with Windows-based PC and OE subscriptions. It's also an enhanced, multi-protocol VCI. Pair with any Autel MaxiSYS tablet to perform advanced diagnostics with multiple communication protocols including CAN, CAN FD, and DoIP.

VEHICLESERVICEPROS.COM/53060399

DIAMETER OPTIONS RANGING FROM 12' TO 30'

The Big Ass Fans Powerfoil X4 is engineered to improve indoor air quality and occupant comfort. Purpose-built to provide maximum airflow in even the toughest conditions, with diameter options ranging from 12' to 30'.

VEHICLESERVICEPROS.COM/53060108

UPGRADE YOUR SHOP, UPGRADE YOUR AIR

DanAmAir is a fast, flexible, and easy-to-modify aluminum pipe system for compressed air in any shop or garage with optimum flow rate performance. The Press-to-Connect fittings feature a full-bore design for turbulence-free air delivery. This quick, instant connection eliminates the need to thread, solder or glue, for far less installation times than traditional copper or black pipe and allows you to do-it-yourself.

DANAMAIR.COM

SPONSORED

DIAGNOSTIC AND PROGRAMMING TOOL KIT

Diagnose and program import and domestic tire pressure monitoring systems with the new Ranger TruSensor TS58R Universal TPMS Kit. Offering 98 percent global vehicle coverage, the kit includes a portable TS58R tool with color touchscreen, four metal stem sensors, four snap-in rubber sensors, USB interface cable, OBD-II cable, and power cord, all packaged in a durable, padded carrying case. TruSensor TS58R can test tire pressure, temperature, and battery life; read and clear TPMS diagnostic trouble codes; reset warning lights; and accurately diagnose car key remotes and fobs. It supports all 315 and 433 MHz aftermarket and OEM sensors.

VEHICLESERVICEPROS.COM/53059977

CARQUEST DOESN'T CUT CORNERS

The Carquest Premium steering and suspension lineup is engineered for superior performance. Our high-quality professional parts are designed and built by leading OE and OES manufacturers with years of experience in chassis and ride control technology. Each part meets the highest quality benchmarks and matches OE specifications for fit, form and function to ensure your ability to repair and service vehicles at the right price for your customers.

MY.ADVANCEPRO.COM/UNDERCAR

SPONSORED

MARKETPLACE

AD INDEX

THE TRAINER #138: FUEL SYSTEM PERFORMANCE TESTING USING THE DIGITAL STORAGE OSCILLOSCOPE (FEATURING AUTEL DSO)

THERE ARE ONLY FOUR THINGS THAT CAN MAKE AN ENGINE RUN BADLY. ONE IS A PROBLEM IN GETTING FUEL TO THE COMBUSTION CHAMBER.

PETE MEIER // Creative Director, Technical

There are only four things that can make an engine run badly.

One is a mechanical problem that is preventing the engine from sealing the combustion chamber or pressurizing the air/fuel charge.

The second is an inability to breathe – a problem with volumetric efficiency.

The third is ignition; that is, the ability of the ignition system to deliver a good, strong spark consistently and at the right time.

And last, but certainly not least, is fuel.

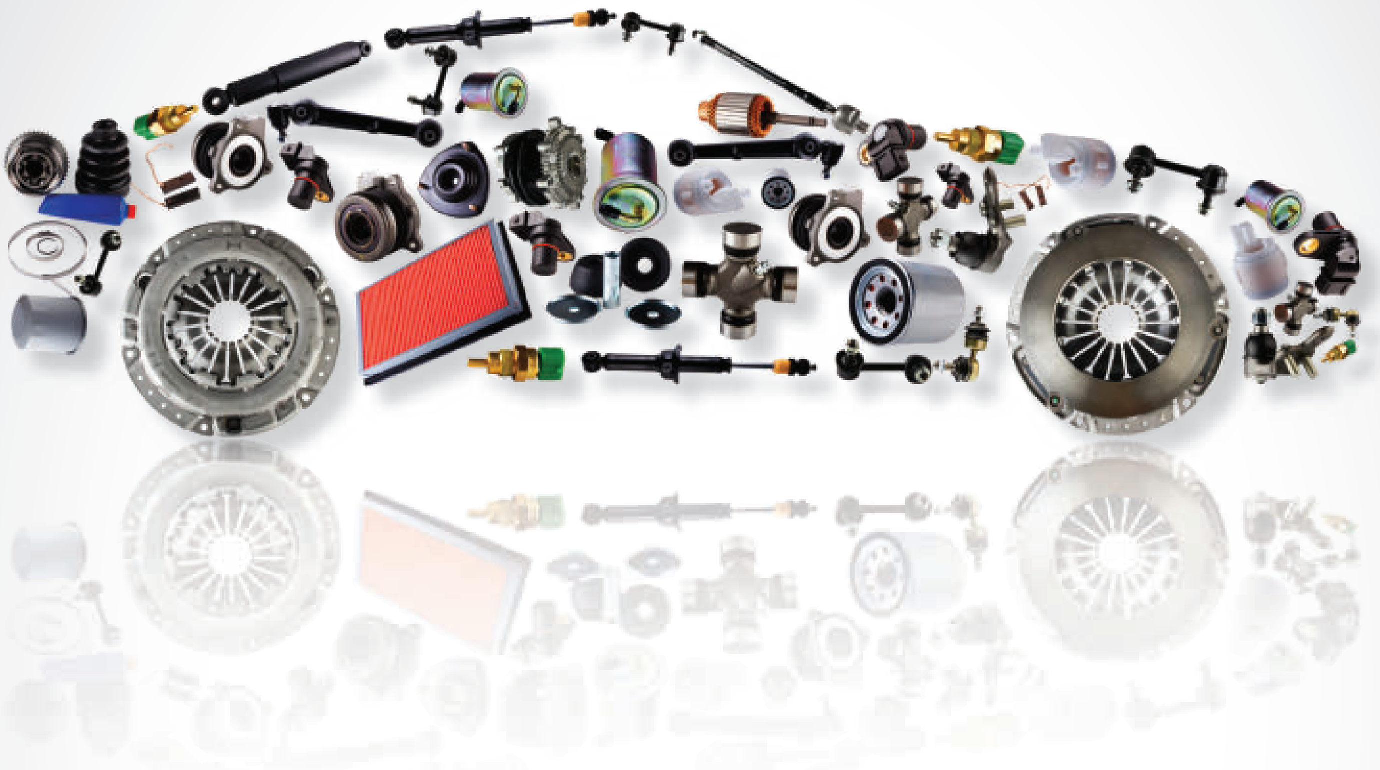
Let's first define what I mean by fuel. This covers everything from the fuel pump to the tip of the injectors and every component related to their proper operation. Critical is the ability of the fuel system to deliver the right quantity of fuel at the right time and in the proper configuration – or spray pattern. And this can be one of the most challenging performance components to narrow down.

But the use of the DSO, or digital storage oscilloscope, can make this task a lot easier. It can also be more efficient and more accurate than many of the traditional testing methods you may be used to. In this edition of "The Trainer," I'll show you how to use the Autel scope module and related accessories to aid you in narrowing down fuel system faults, from a weak fuel pump to a sticking fuel injector. We'll also discuss how the ECM controls this process so you can use that information as your diagnostic pathway. Don't have the Autel scope? No worries - the techniques apply to whatever scope you have at hand.

Let's get started! MA

YOU'RE COVERED

Worldpac gets you the right part at the right time.



aae STEERING SPECIALISTS · ACDelco · ADVICS · AISIN · akebono BRAKE EXPERTS · AP EMISSIONS TECHNOLOGIES · Arnott Suspension Products · Ate · BANDO · BCA BEARINGS by NTN · BEHR

BILSTEIN · BOSCH · Continental · ContiTech · CORTECO · CSF Cooling Experts · Delphi Technologies by BorgWarner · elring · EXEDY EXEDY Globalparts Corporation · FTE automotive · GC Genuine Chemistry

GLYCO · GOETZE · HELLA · ISG · JURID by Honeywell · KYB · LEMFÖRDER · LIQUI MOLY · MAHLE ORIGINAL · MANN FILTER · MAVAL · METRIX

MEYLE · MITSUBISHI · MOPAR · Motorcraft · MOTUL · Nissens · MOTION & CONTROL NSK · NGK THE IGNITION SPECIALIST · NTK THE SENSOR SPECIALIST · OEF³ · OE+ · OES

PEC PRECISION ENGINEERED CHASSIS · PENTOSIN · PETROTEK FUEL PUMPS · PDL PROFESSIONAL DRIVELINE · Pro-STRUT · ProTUNE · REDLINE · rein AUTOMOTIVE · ROWE · SACHS

SCHAEFFLER · SERVICETECH · TEXTAR · TRW · Valeo · Vernet · VSV SHOCKS VSV STRUTS · WORLD SOURCEONE · ZF · Zimmermann Brake Discs · Brake Drums

WORLDPAC®

worldpac.com | worldpac.ca

Access quality brands, business solutions and technical training all in one place.