August 2018 | V2 N3

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In this issue

Audi Crankcase Ventilation and Secondary Air Injection

By: Peter Caro
Redds Automotive

The combination valves are usually located in a tight low access position!

Vehicle emissions control devices have been in use for more than half a century. The crankcase ventilation system was one of the first emissions systems used on cars.

Every modern vehicle on the road has a crankcase ventilation system. This is a critical system used to contain blowby gasses during engine operation. Blowby gasses from combustion can cause engine damage if not properly vented from the crankcase.

Positive Crankcase Ventilation

To control these gasses, most manufacturers use positive crankcase ventilation (PCV). This system is designed to keep a slight vacuum in the crankcase. The vacuum pulls the crankcase gasses out of the engine and recirculates them back into the intake to be burned. On older vehicles, these gasses were vented into the atmosphere. By not venting crankcase gasses externally, vehicle hydrocarbons and emissions can be greatly reduced, with no detrimental effect on engine performance or fuel economy.

The positive crankcase ventilation valve is actually a relatively simple mechanism. By using a lightweight spring design behind a rubber diaphragm, crankcase vacuum can be controlled. Crankcase vacuum is at its highest when idling or under decel. To control this, the PCV valve limits flow under high vacuum. At higher engine speeds, less crankcase vacuum exists, allowing the PCV to flow more crankcase gasses into the intake.

With forced induction engines, such as the Audi 2.0t, the crankcase ventilation system has a lot of additional pressure to deal with. The crankcase breather valve is a high-failure item on modern Audi engines.

On the 2.0t engine always properly torque the fasteners securing the crankcase ventilation valve to the cylinder head. The cover is aluminum and will strip out if installed incorrectly.

Too much internal pressure can cause several issues. Seal damage is quite common on Audi vehicles from a failed crankcase ventilation valve. The rear crankshaft seal, unfortunately, takes the brunt of the damage on Audi engines. Increased engine oil consumption is also an indicator of a failing valve.

Much of this oil ends up in the intake tract, which only makes things worse. On Audi turbo vehicles, this means the intercoolers may have excessive oil in them. The sensors on the intake can also suffer from oil contamination. Most commonly damaged are MAP sensors, if equipped. Additional oil in the intake tract also has the effect of increasing carbon buildup. The direct injection engines already have carbon buildup issues, and this can quickly exacerbate the issue.

Excessive crankcase underpressure can cause a multitude of issues as well. The most common symptom of a failed PCV valve on an Audi vehicle is rough running or random misfires. Seal damage is quite common from excessive vacuum as well. In extreme cases, the engine may not even start or continue to run after excessive vacuum builds.

A quick check for a failed PCV valve is to try to remove the engine oil cap while the vehicle is running. Under normal operations, the oil cap is easily removed. The engine will stumble after removal; this is normal. If the PCV valve fails, the oil cap is almost impossible to remove. This is an example of the extreme vacuum the crankcase may contain. Whistling from the engine may also be heard with a failed PCV valve. Don't blame the turbo!

Audi vehicles are generally good at storing faults for crankcase ventilation issues. However, the codes stored may not directly fault the PCV valve. Faults range from fuel trim bank faults, idle higher than expected faults, as well as random misfires. It's important to check fuel trim values in measuring blocks. This will lead toward a definitive diagnosis.

If using a factory based scanner, access group 32. These measuring blocks reveal fuel trim values stored in the engine computer. Additive and multiplicative fuel trim values are the primary values the ECU uses to control and monitor proper fuel injection. Without the correct amount of air entering the engine, the fuel injectors will not be able to determine how much fuel to inject.

Additive fuel trim values are the primary concern when diagnosing a suspected failed PCV valve. This is the fuel trim value at idle. Proper specification is +/-10 percent. The higher your additive value, the more fuel is being injected to compensate for an air mixture that is too lean.

False air leaks and failed crankcase vent valves are the primary culprits here.

A failed PCV valve is most obvious at idle due to higher engine vacuum levels while idling. An excessive negative additive value indicates a rich condition at idle. This can usually be traced to leaky fuel injectors. A good way to test for a failed valve is to clamp off the primary line leaving the vent valve. This should be the large line leading to the intake manifold.

With older engine models, use coolant line clamps to cut valve flow. On newer engine models, you may need to use vacuum caps to seal it off. If additive fuel trims pull back closer to specification with this line clamped, you definitely have a bad vent valve. Do not drive the vehicle with the line clamped! Use this only for testing in the bay.

Multiplicative fuel trim values are used to control fuel injection under load while driving. Specification for multiplicative values should stay under +/-10 percent as well. An extremely high value, such as +20 percent, indicates the computer is adding fuel to adapt for a fuel mixture that is too lean. This is generally a vacuum leak causing unmetered air to enter the engine. On older 1.8t engine Audis, the MAF or mass air flow meter was a common culprit for high multiplicative values.

Multiplicative values in the negative indicate too much fuel is being injected under load. Often fuel control issues are the root cause here: leaking fuel injectors, fuel pressure too high, etc.

When diagnosing a suspected issue with the crankcase ventilation system, an automotive smoke machine is an absolute

Having a smoke machine can make the difference between diagnostic darts and a definitive diagnosis.

This vacuum line appears OK, however it is torn underneath the cloth covering. It's smart to replace every piece of older cloth vacuum line you may come across.

New rubber lines leave no guessing if there are leaks present.

This is a clear sign of a leaking rear crank seal. This will lead to vacuum leaks and poor engine running if left too long.

The crankcase valve assembly is quite large on the newer V-6 engines. Be careful during installation not to damage the sealing edge.

necessity. These PCV systems must be completely leak-free to operate properly. Any small leak or damaged breather line will affect fuel trim values. Due to the complex routing of breather lines and connections there are many possible failure points. A smoke machine makes it easy to pinpoint leaks in almost any system.

Hook the smoke machine to the intake boot or any accessible point on the intake manifold. This lets the smoke travel through the entire intake tract as well as the vehicle's crankcase. During inspection, pay close attention to any lines or connections that appear particularly oily or damaged. Even small leaks can cause a check engine light!

Use of an inspection mirror under the intake manifold may be necessary to locate leaks. Don't forget to inspect ALL of the lines fed off of engine vacuum when looking for leaks. Brake vacuum lines are notorious for degrading as well as the power brake booster.

The booster can leak engine vacuum causing a false air leak with no appreciable braking loss. On new Audi engines, many of the breather lines are constructed from a corrugated plastic line. These are quite thin, and the retaining clips become brittle with age. During inspection and testing, if you have to remove these lines, be cautious. A preliminary spray with penetrating oil on the retaining clips will aid in safe removal.

Don't forget to inspect engine seals for leaking during the smoke test. Yes, the rear crankshaft seal commonly leaks crankcase vacuum and oil. In most cases, the rear main becomes completely separated, allowing extensive unmetered air to leak past.

On most Audi models, it's possible to see smoke leaks from the passenger side upper bell housing area after removing the side access cover on the transmission. Oil leaks from below are also a dead giveaway at a failed rear crankshaft seal. It's also possible to spray carb cleaner into the bell housing while the engine is running to watch for fuel trim changes to determine a leaking rear main. But this is not recommended. Smoke testing is much safer and more reliable. The rear main seal is a common failure. Aftermarket upgraded solutions are available for the rear crankshaft seal.

Always replace the crankcase ventilation valve if a rear crank seal is being replaced. This is the number one culprit for rear main seal failure on many 2.0t Audi engines.

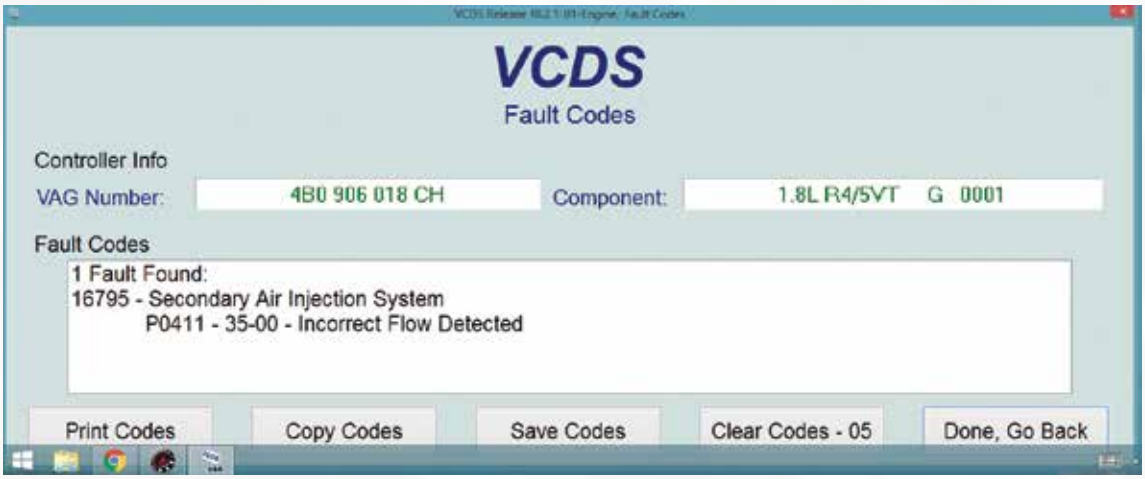
On many Audi VR6 engine models, the crankcase ventilation valve is built into the valve cover assembly. If the valve diaphragm has failed, it will leak through a weep hole that is visible in the corner of the valve cover assembly. These will show smoke leaking out as well as making a whistling sound while running.

On the VR6 engines, the entire valve cover must be replaced to remedy a bad crankcase vent valve. This requires intake manifold removal as well as fuel rail removal on direct injected engines. Always replace intake manifold gaskets as well as fuel injector seals. You do not want to have a damaged fuel injector o-ring on a direct injected engine. It's a big job to fix the crankcase valve!

Many 2010-2016 V-6 models suffered from crankcase valve failures, and updated valves have been implemented. These commonly set rich faults when they fail. On the Audi 3.2 V-6 engine, the crankcase ventilation valve is located deep in the

valley under the intake manifold.

Due to space constraints, the valve assembly is quite literally buried. It requires intake manifold or supercharger removal, followed by fuel rail removal, to fully access the crankcase valve. In V-6 engines equipped with variable intake runners, these must be removed as well. When re-installing, be sure to clock runner position correctly and run basic settings on them to verify proper function.



Always start with a scan for faults.

Secondary Air Injection

Air injection has long been a part of many vehicles' emissions systems. The secondary air injection system plays an important role in modern Audi vehicles emissions systems. In the system used by Audi, an electrically driven air pump is used to supply fresh air to the exhaust stream. This is primarily used when the vehicle starts up, at which time it runs rich, producing more emissions until reaching normal operating temperatures. The air injected into the rich-running exhaust stream helps to quickly heat up the catalytic converter to operating temperature, which lowers hydrocarbon emissions.

Without belly pan protection from the elements, this air pump stood little chance of survival.

The secondary air injection system relies on few components for proper function, the air pump being the primary workhorse of the system. Air pump location varies by engine model but is most often mounted in the lower forward fender area. Air pumps require a clean air supply and often have an intake tube going to the air box. This line must be connected to ensure good air flow.

In many higher-mileage Audi vehicles, the air pump eventually fails. Often they suffer from water ingress from broken inlet or outlet lines and rust or short out internally. On many air pumps, the casing begins to separate with age. This allows air to leak out of the pump casing. The pump may sound fine when listening but is not producing enough pressure for proper activation.

The secondary air pump can be activated via scan tools in Basic Settings group 077. After clicking Go, the air pump should be audibly heard. Always check for power at the air pump as well. If the air pump seizes, often the fuse goes as well.

The check valve, or combination valve, also plays a role in secondary air injection. It is used to control air flow from the air pump to the exhaust stream. Without the combination valve, exhaust flow would be allowed to travel up into the air pump housing.

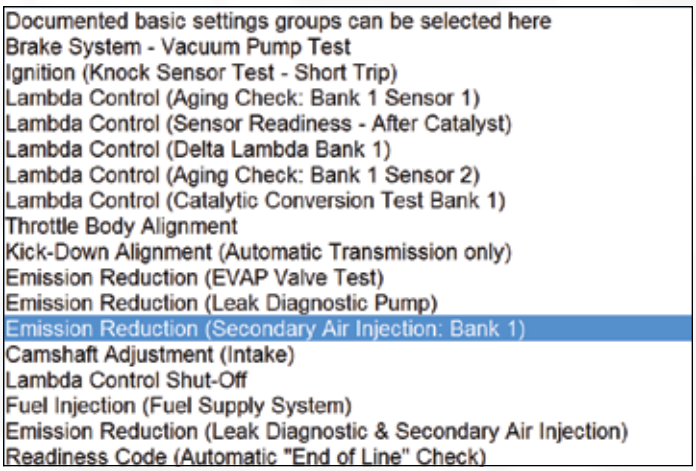
This happens occasionally when check valves become seized in the open position. More often when the combination valve fails, it becomes seized shut, preventing air flow into the exhaust stream. This is usually caused by rust buildup on the check valve from water intrusion. These valves are exposed to extreme heat from the exhaust system and can damage other components if problems arise.

Most combination valves can be tested by using a hand-held vacuum gauge. Vacuum leaks are the enemy here. Very small vacuum lines feed the check valves. On models with electronic combination valves, activation through scan equipment is necessary.

Always thoroughly inspect air injection lines for damage. This system is exposed to extremes due to exhaust heat and suffers from it, creating brittle plastic lines everywhere.

The ECU relies on input from oxygen sensors to determine proper air pump activation. If it is unable to see a change in oxygen sensor voltage quickly enough during the warm-up phase, it may set a fault for secondary air. This means the primary oxygen sensor must be working properly to identify voltage fluctuations. A lazy oxygen sensor may not always set faults immediately, making accurate diagnosis more difficult.

In most engine applications, the secondary air ports must be built into the cylinder head assemblies. This is due to packaging limitations as well as the necessity to provide maximum efficiency in the air injection process. Keeping the air injection ports as close to the exhaust manifold ports as possible ensures even temperature distribution.



Setting Readiness On emissions monitors is a necessity to verify repairs.

The biggest problem with moving the secondary air passageways into the cylinder head is the possibility of passageways becoming blocked. Because exhaust gasses are able to travel through secondary air ports in the head, they eventually become clogged with buildup.

This has become an issue on the 3.2 and 3.0 V-6 FSI engines with air injection. Blocked air ports are also an issue even on lower mileage engines, as low as 50K miles. Common faults stored are P0491, 0492, secondary insufficient flow b1,b2.

It's possible to run a readiness monitor to test the secondary air system for proper function on these models. Via scan equipment, enter the Engine Control Module, then Basic Settings. Test 77 under Basic Settings will run the air pump monitor. If the air pump and connecting hoses both appear to be functioning properly, the ports in the cylinder are likely clogged and require cleaning.

Secondary Air Ports

Cleaning clogged secondary air ports is not a quick job. Unfortunately, to even complete the cleaning process, specific tooling is required. Audi recommends a special power washer that uses regular water for cleaning and specific right-angle spray heads to directly clean the air ports. The power washer Audi recommends operates at more than 1,500 psi. Be careful!

Secondary air ports can be accessed at the front of the engine by removing freeze plug covers that block off the air passageways. These can only be accessed after putting the vehicle's front end in service mode and removing the coolant transfer pipe and water pump pulley on the V-6 engines. By running the power washer wand down each air port, the carbon buildup will be washed away.

During the port cleaning process it is necessary to drop the exhaust system just past the catalytic converters. This allows the water runoff from cleaning to drain out. After cleaning is completed, always pull the spark plugs, and crank the engine over a few times to clear any residual water from the chamber. Its a messy, laborious process to unblock the secondary air ports on this engine. Always make sure to properly protect yourself and the vehicle from damage. ■

Understanding Porsche 9A1 Oiling Systems

By: Mike Bavaro
Bobymotion, Inc.

The 9A1 architecture is the current engine Porsche uses in their Cayman/991/GT3 & 4 platforms. It encompasses many models but generally refers to model years 2009 through the current 2018 models, although designations now also include the 9A2.

All are six cylinder, flat or boxer opposed cylinders, and all are direct fuel injected, producing in most cases 100 horsepower and more from each liter of displacement.

The oiling or lubrication systems go beyond the "lifeblood" terminology. The oil supply not only keeps metal to metal contact in check, but cools the engines from the inside out, including via piston cooling jets.

The other function of the high pressure oil system is the hydraulic component. The engine oil pressure is used to activate different functions such as intake and exhaust camshaft control and activation, primary and secondary lifter function and control, and hydraulic tensioning of timing chains. All of these demands have different requirements for oil pressure, volume and cleanliness.

We will cover the oil pump both pressure and scavenge, return and supply and oil aeration in the next installment. For now we can look at the oil pan itself.

These engines have been very reliable, but have suffered occasional failures. As mentioned the oil pumps and controls have had many updates that will be covered in depth. However there may be a specific contributing factor or direct cause for loss of oil pressure.

Data acquisition in race cars is a wonderful technology, and can monitor just about everything from steering angles and chassis roll, pitch and yaw, to wheel speeds, throttle position, engine rpm, Lambda, and oil pressure, all at speed.

Observation of the data in several blown racing engines has shown that the oil pressure on some corners was dipping below the demand. The demand is determined in a complicated algorithm that the engine ECU uses, which then sends the request for pressure to the oil pump. Engine rpm, throttle position, and temperature are all factored in.

But the data shows that these engines were not responding to the full demand — not enough to bring a pressure warning signal to the driver. In some instances, after a shut down and restart, the problem went away for a while, but such partial oil pressure losses can lead to a catastrophic engine failure. How? You would expect to find in almost all of these cases a common denominator.

The photo (upper left) shows an undamaged, stock 9A1 lower oil pan. Inside that pan is a bulkhead or oil control baffle. It surrounds the oil pump pickup screen. It holds sufficient oil by

surrounding the oil pump intake screen to prevent air from being sucked in or aerated oil being drawn into the suction side of the pressure pump.

The bulkhead consists of two strips of material that are flexible and act like a door on a hinge. These "one way " doors, sometimes referred to as trap doors, allow oil to flow into one side while restricting the oil from leaving through the opposite side. This center "collector" is a reserve supply of the least aerated oil.

Look at it this way: in a hard right hand corner, the baffles on the left or driver's side of the engine will close and hold the oil from escaping while the right or passenger side of the pan allows the oil to flow into, and thus refill, the center collector. This is not a new idea, but is an effective one that Porsche has done a great job of engineering.

However, and this is the good part, the photo on the bottom left of the previous page shows the collector door and how it is attached. The baffles or doors are made of flexible material that is perforated and hung onto posts shaped like a "T."

In engines that have failed due to lack of lubrication, observation has shown that baffles had come loose on several of these posts and were partially obstructing the oil intake. Thus as the driver negotiated a turn the loose baffle would partially obstruct the oil suction screen.

When the car was shut down the baffle could simply be released and float back to its normal position. If the baffles reach the center pickup, this can obstruct the suction side of the oil pump. And once the low oil pressure warning light comes on it is too late.

Here, in the above right photo, you can see an oil baffle that has almost completely broken free from its mounting. At this point the baffle would almost certainly completely block the oil suction inlet screen. The oil pan gets a shiny rub mark on it where the suction screen is located.

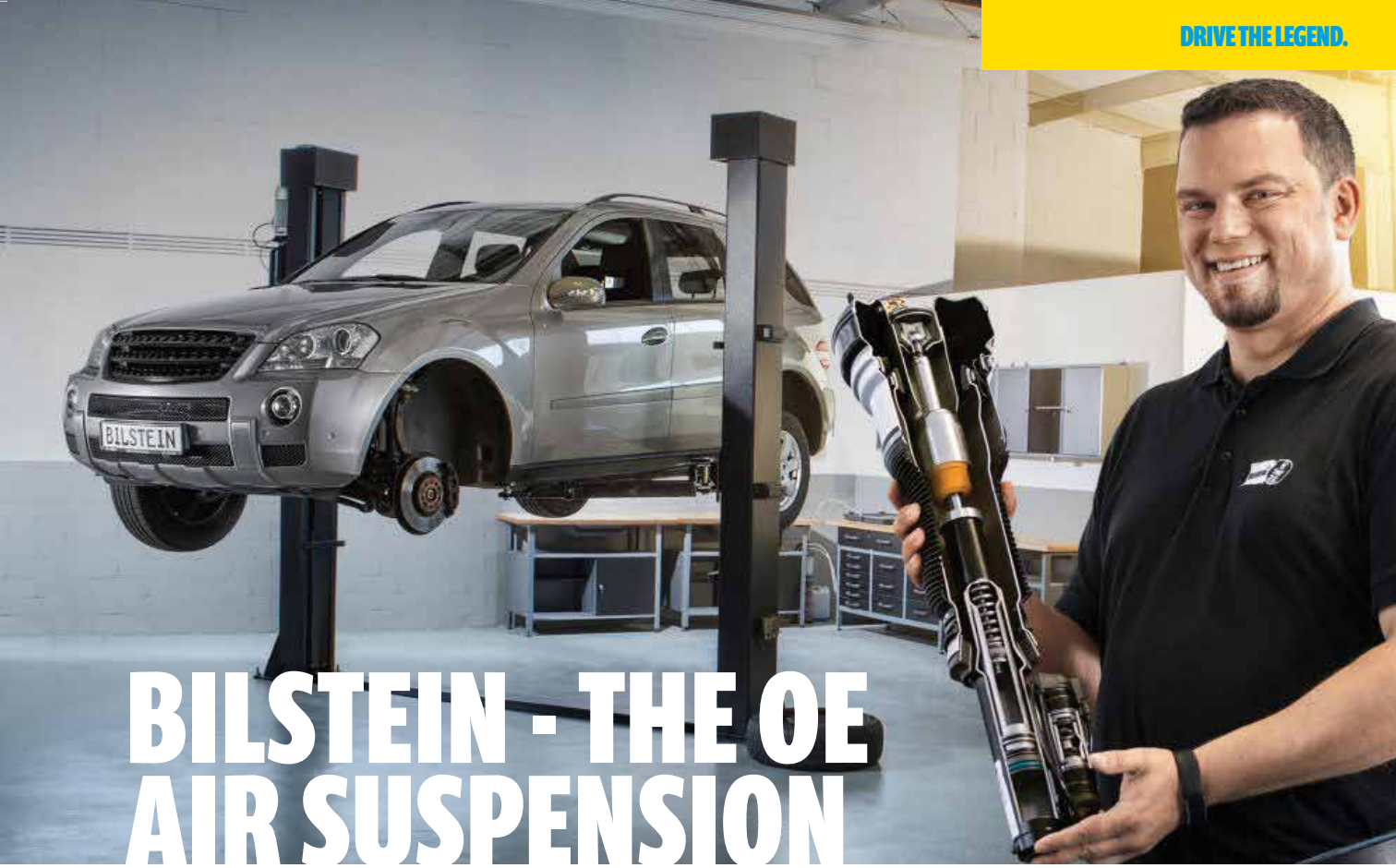
In the next photo you can see a mocked up pump and you can see how the baffle can get sucked into the screen. It happens very quickly and the resultant damage is almost always catastrophic.

Careful inspection of the baffles reveals some interesting information. Apparently the material used for the flexible doors is somehow affected by heat and, possibly by race fuels migrating into the oil supply. It is believed that the holes that the "T" posts go throughcan swell, causing the baffles to come loose.

As a result, some shops are now recommending that all 9A1 engine customers allow them to remove the pan and examine the doors. If only one or two holes are not connected it is possible to use aircraft safety wire on each end of the baffle.

The previous part number for the bulkhead was 9A1 107 243 75. Earlier in model year 2018 the Porsche part number changed to 9A1 107 243 01. A more comprehensive repair includes replacing the bulkhead with the new, upgraded part. ■

DRIVE THE LEGEND.



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Aftermath: Getting Those VW Frame Dimensions Exactly Right

By: Frank Walker

You can only do this with the proper information and the best fixtures and equipment.

The PointX Diagnostic Measuring Tool from Car-O-Liner measures length and height using laser and inclinometer technology respectively, and transmits the data wirelessly to the computer.

Three dimensional measurement

A head-on collision at 30 miles per hour may typically result in the engine compartment being compressed by approximately 30-40 percent, while the passenger compartment is reduced by only 1-2 percent of its length. Engineers design a vehicle's structural components to absorb collision energy, but also to divert some energy around and away from the passenger compartment. For example, a hard frontal impact often causes secondary and hidden damage including buckles in the roof area and upward distortion of some rear structural components.

Your pre-repair damage analysis must find everywhere that excess energy was re-directed to on the vehicle. That requires three-dimensional (3D) measurements — length, height from datum plane and width from centerline, plus access to factory specifications for comparison. Volkswagen-approved professional measuring and collision alignment (damage repair) systems from Car-O-Liner, Celette and Spanesi all use dimensional specifications from either OEM information or data bases built from real-world measurements of new (known-good) vehicles.

A Volkswagen Position Statement on Unibody Alignment and Repair states: "Collision repairs to correct structural damage and body panel replacement should only be conducted on VWoA-approved straightening and measuring equipment. Any and all welded structural panels, parts, pieces and components must only be replaced while properly mounted to VWoA approved straightening and measuring equipment."

OEM information

The fact that OEM dimensional specifications are current may save you from relying too much on past experience. This is important because new Insurance Institute for Highway Safety (IIHS) safety specifications often lead to rapid vehicle structural changes. To prevent poor performance in IIHS crash tests, OEM engineers may modify a given model's structural design as quickly as within the same year that new IIHS safety specs are published. They may add new components or reinforce structural elements to either absorb or redirect crash energy.

You must do three-dimensional measuring to ensure that you identify any damage to these new components. You cannot rely on past experience with a given model to point you to hidden damage. It is no longer the same model under the skin, and that means there may be damage outcomes that your experience would fail to predict.

Another reason you must check the OEM information before planning a pull is that the measurement may have unusual parameters. For example, the point-to-point length may be different if two different variations of a given component are allowed on the same vehicle model. If Version A is specified to be 1.85 mm longer than version B, that certainly affects your pull.

Below: Volkswagen-approved collision straightening and measuring systems feature state-of-the-art technology and sophisticated software to make measuring accurate and fast. And despite — strike that — because of all its built-in high-tech wizardry, the VAS_6528 bench and measuring system shown here is a breeze to use.

In another example, the tolerance around a measuring point may be tighter on one side of the point than the other. If a point-to-point distance cannot exceed a certain length, but is allowed to be slightly shorter, the tolerances may be +0 for the maximum, and -1.40 mm for the minimum. For a hypothetical component length of 210 mm, the specification may be expressed as 210.0 +0/-1.40 mm. These examples may not occur often, but when they do you need to know before you pull.

Measurement Accuracy

A well-known collision repair instructor has reported that he often would start his hands-on class by asking several technicians to manually measure a point-to-point dimension on a structural component of a vehicle. Even with a measuring tape or a tram gauge, different technicians in his class would often fail to record the distance between two points as exactly the same amount. Sometimes, the same technician would record different dimensions in repeat measurements of the same point-to-point location.

Twenty-five or thirty years ago you could hold a tape measure to a point on a vehicle and assume, without looking between your thumb and forefinger that the mark on the tape was within the desired tolerance around the point. The tip of your thumb covered about 1/4 inch of the tape, or just over 6 mm, which was close enough for the +/-3 mm tolerance that was standard at the time.

Many point-to-point dimensions involving Volkswagen structural components today have tolerances of +/- 2.0 mm or less. That 4 mm range equals 5/32 inch, or approximately 1/6th inch, which is a fifty percent reduction. Add the fact that you have to measure in three dimensions in order to locate the correct position of a measuring point, and you triple the potential for error.

Measurement Speed

A thorough analysis will assess the vehicle front, middle and rear looking for out-of-specification measurements that affect structural integrity, suspension and steering, body panel fit, and safety sensor positioning. Even if we are confident in our ability to measure accurately, we cannot perform the great number of measurements needed anywhere near as fast as computerized measuring systems.

Even the old tram gauge is now computerized. The Volkswagen-approved PointX Diagnostic Tool from Car-O-Liner uses laser technology to measure length, and an electronic inclinometer to calculate height.

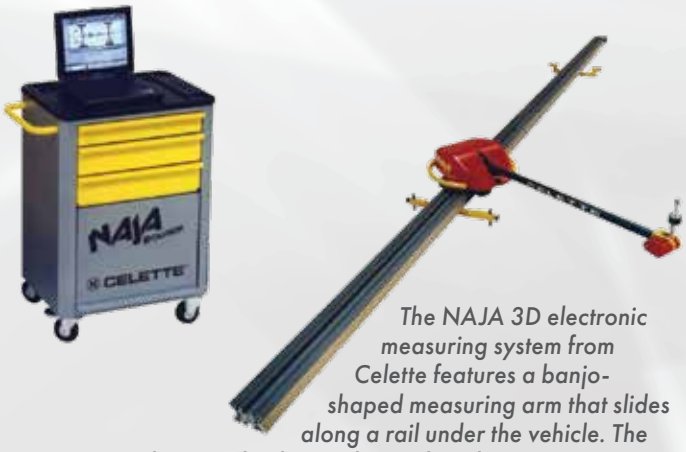
Enter the vehicle year, make and model, the VIN, and other model-specific information, and PointX will ensure that you access the correct data sheet and vehicle specifications. Tell the system whether you are measuring the vehicle on wheels

A powerful magnet holds one end of the PointX Diagnostic Measuring Tool onto the reference point. It is a one-man job to then swivel the other end 360 degrees to quickly measure the distance from one reference point to many different potential damage locations, without repositioning the magnetized end.

The PointX Measuring Adapter includes a display so you can see the measurement at the point you are targeting. Pressing a button near the display provides live, continuous monitoring of the measurement as you move from one point to the next.

or on a support, and whether the engine is in or out of the vehicle. Go to "Select Reference Point" in the PointX measuring tool menu. Select two symmetrical measuring points from the database, one on each side of the vehicle, from an area that on the actual vehicle is undamaged and accessible for later measurement. This centers (calibrates) the tool so the software knows where the vehicle is relative to the laser and inclinometer. You are now ready to measure.

A magnetized tip on one end of the tool snaps into the reference point. Place the other end, called a measuring adapter, on the point you want to measure. The magnetized end remains locked onto the reference point, allowing you to swivel the measuring adapter 360 degrees horizontally to whatever point you need to measure next.



The NAJA 3D electronic measuring system from Celette features a banjo-shaped measuring arm that slides along a rail under the vehicle. The arm transmits data wirelessly via Bluetooth to the computer. It can be mounted on the VW-approved Celette straightening bench, or on a mobile support that is suspended from a two-post lift.

When you touch a point on the vehicle and press a button on the end of the articulating arm, the VW-approved Spanesi Touch electronic measuring system emits an audible chirp to let you know the point has successfully been measured.

3D Point Measuring Systems

Point systems use a base that sits under the vehicle, plus an arm that touches or points to a specific location on the vehicle. The arm may be hard wired or wireless.

The arm transmits the location data to the measuring system's computer, which is typically located in a separate base unit. The base can be bolted to the floor or portable so the arm can be moved to reach any point on the vehicle. Articulated probes or overhead hanging frames allow the measuring arm to reach points located along the upper body and roof.

The computer software calculates the distance between the location on the vehicle and the base and, using geometry, determines the distance between the reference point and the measured point. It then compares that distance to specifications in the database for the vehicle. If the measured point is not in the correct position on the vehicle, the software shows how much and in which direction to pull. Similarly to the PointX tool, 3D point measuring systems can make live measurements as you pull, and send the data in real time to the computer so you can see them on the display.

Volkswagen has approved several different choices of state-of-the art systems for measuring collision damage. What's your choice? ■

The VW-approved Car-O-Tronic electronic measuring system with Vision2 X3 software sends 3D measurement data to your cell phone, a tablet, or a computer.

CAN analysis with a J2534 application

By: Augie Ferron

Ockham's razor: This principle can be interpreted as stating,

"Among competing hypotheses, the one with the fewest assumptions should be selected."

CAN analyzer

If there is an assumption and you believe a control module "wakes up" and/or remains awake for no reason, this article may help the learning technician. If there is a suspect control module and misbehaving/depleting battery voltage, there is another option if there's access to a J2534 device.

Another tool in your tool box

When measuring a parasitic draw, the modern technician would use an amp clamp on the ground side to accurately measure total current draw. The method is to measure the current draw and investigate if the actual measured value is within manufacturer specifications.

Another test measurement is using a multi-meter to measure the voltage across the fuses. It is possible to find the one specific circuit that is active. Part of the challenge occurs when that one circuit has multiple functions.

Another part of the challenge is when the electrical system is disturbed by disconnecting the power supply via battery or circuit protection. At times, disturbing that connection may re-start or re-boot that one controller or device. And in some cases, that re-start/re-boot may temporarily fix the problem.

Note: There are many other examples of network analysis tools, but if the CarDAQ Plus, Plus 2, ISO CAN or MFC Pro are available, put them to use besides on-line programming.

Experiences

This particular article shows the CarDAQ Plus and also the CarDAQ Plus 2. This tool has multiple purposes — Flash, Diagnostics, and CAN analysis.

The interest is to measure CAN activity with a great tool that offers well-made analysis software that can be acquired from Drew Technologies.

The oscilloscope will indicate activity of any type but the interest is, in the simplest terms, "who is it."

Tools needed
DrewTech CarDAQ Plus w/WiFi & a scan tool of your choice
90 amp clean and stable power supply
Split DLC "Y" cable
DLC breakout box and a few salvaged DLC connections
60 ohm resistor or decade box
Screen capturing software

Method to test 1

The first of many tests can be performed on the test bench. A series of strip connector blocks can be used to create a stable, safe and identifiable system to connect multiple salvaged controllers into a DIY network. Two blocks can be used and fixed together to create one long connection. The connections can be identified and tagged so that connections such as B+, B-, K-Line, CAN High, CAN Low, and anything else required, are easily legible.

You can attach a salvaged DLC and also connect a clean 12 volt power supply. This experiment has been performed many times for many reasons and with used VW Group controllers (VAG). What the network is comprised of:

An Audi A4 (RB4) instrument cluster	(vintage 2002)
A VW Passat 2.8L engine controller	(vintage 2002)
A Porsche Cayenne air bag controller	(vintage 2006)
A VW Jetta comfort control module	(vintage 2003)

Strip block

This makes a Frankenstein network that can be connected to various scan tools. Proof is the connection to the DLC and verified with the Ross-Tech VCDS with an OBD II tool.

Note: This is an active bench test and everything is hard wired with an on/off switch at the B+ supply, but also at each controller. A real world test is to measure network activity and with the vehicle prepared in a different fashion.

Method to test 2

Requirements are: a controller, connections, and the schematics that fit the controllers for bench testing. With the controller connections and proper fitting "eye" connections to the connector block, an active and safe network is operating.

With a little thought, nearly anything from any make, model, or year can be active. This choice is VW Group (VAG) controllers. A DLC breakout box can also be used to help identify the active connection via diagnosis. That connection can be CAN, "K," or "L" line, depending on the controller. The DLC box also offers a connection for an oscilloscope.

DLC breakout

Connect the breakout box cable to the DLC of the Frankenstein network and scan tool to the DLC box. With an active network, there will be "chatter" on the affected communications circuit when it's alive and/or communicating. With the added BNC cables into the active port of the DLC box, measure the "chatter" with an oscilloscope. Simple diagnostics are accomplished within this configuration.

Method to test 3

For this experiment, be aware that you can accomplish this task with one laptop and open multiple screens to view the data with multiple USB ports for tool connectivity. That would mean multiple windows that display the oscilloscope (if desired), a scan tool if PC based, with the J2534 analysis software. Using two laptops is identical for these tests, one to diagnose and another to "listen" or sniff network packets. The choice is yours. Note that many laptops have only one USB port and choose that setup for speed, image recordings, and screen captures on both machines.

Note: The CarDAQ Plus also has a LAN port, and that port can be used for connectivity to the PC. A LAN port has advantages such as SPEED!

The CarDAQ Plus 2 is USB connected. Newer versions of the Plus 2 will connect via Bluetooth.

Preparation

With or without the Frankenstein network, make sure a stable and clean power supply is applied. Ensure the scan tool can

Splitter cable

communicate with the vehicle systems with one connection at the DLC splitter cable. The other (identical) end is attached to the J2534 device.

1. Using the other laptop (if available), make sure the correct CarDAQ J2534 software and drivers are installed and operating.
2. Acquire the J2534-1 API version 1.07 or higher from Drew Technologies and install the application.
3. Know exactly the DLC configuration for the model, which pins are communicating, and what communication protocol the controllers use.
4. Adjust the J2534-1 API for the correct J2534 device and communication protocol you're interested in.
5. If this is a real world and non Frankenstein diagnosis, prepare the vehicle in this fashion:
    - Any open doors, hood or trunk must be latched.
    - A DLC breakout box is a consumer (parasitic load), so be aware.
    - The vehicle, in theory, is in sleep mode for a correct measurement.
    - The scan tool itself can wake up a network and be a consumer.
    - The scan tool is a network, so be aware.
    - The key or wireless fob cannot be active with the vehicle.
    - Do not set the alarm, just wait for sleep mode.
    - If the alarm sets, use the mechanical key to unlock twice to disable.

NOTE: If you want to test a possible CAN controller that is active and awake on the network, a 60 ohm resistor or decade box MUST be attached to CAN High (16) and CAN Low (4). If you're working on another type of network, i.e.: Ford medium speed CAN, attach to CAN High (3) CAN Low (11).

If that resistor is NOT connected, NO messages will be displayed.

For this test, a decade box was attached to the DLC breakout box and set to 60 ohms.

The resistor is added to eliminate the echo when the CarDAQ Plus (or Plus 2) is "sniffing" for CAN messages. If a scan tool is used to "sniff" test or view CAN messages, the resistor MUST be removed.

Either way, with the scan tool and J2534 device, the application will record an active network with or without a scan tool.

What can be found in the experiment?

The Porsche Cayenne air bag controller is nearly identical to that in the VW Touareg. The controller uses B+, B-, CAN High and CAN Low, air bags and seat belts can be simulated (but not necessary), and VCDS is able to interrogate that controller and view live data. With the scan tool disconnected, the air bag controller is active in this test because it is directly wired to B+ and B-.

Depending on what you want from this experiment (the interest was the active address the analysis software is listening to), you may find some interesting bits and pieces that should allow a simple perspective of what the CarDAQ J2434 is capable of, instead of just a "flash tool."

When the application is started at the Connect tab, the J2534 is to be loaded and the Protocol is chosen. The analyzer is now active. (View Load and Filter Screen images below.)

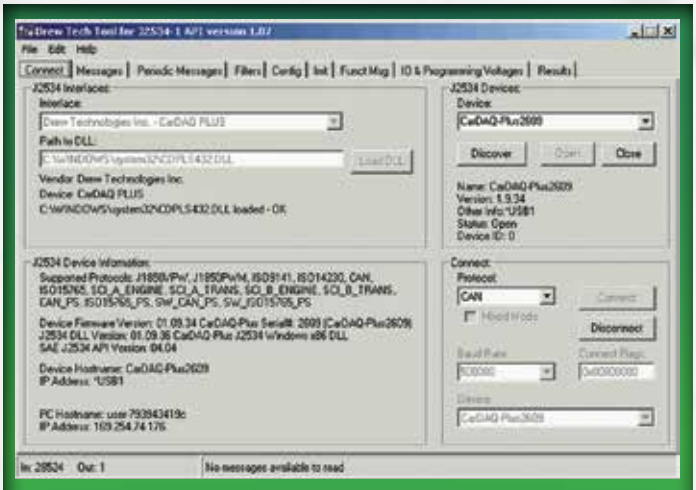
NOTE: The VCDS cable is a CAN Transmitter/Receiver and the J2435 analyzer WILL display data with NO connection to any controller.

Therefore with only a CAN cable connected, the message 1F is repeating.

A network is active and being recorded.

On the Messages tab and if a scan tool is not used with the correct resistor in place, the air bag controller will constantly send data via CAN.

That network address is 05. The scan tool address is 15. Note that!

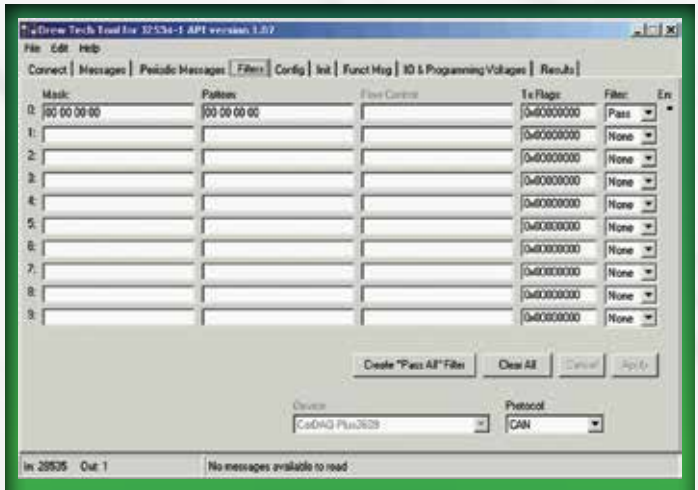


Load screen

In the correct order

- Interface: Choose CarDaq Plus (in this case)
- Path to DLL: Click Load DLL
- J2534 Devices: Click Open
- Connect Protocol: Choose correct protocol
- Click Connect

The next adjustment is at the Filters tab.

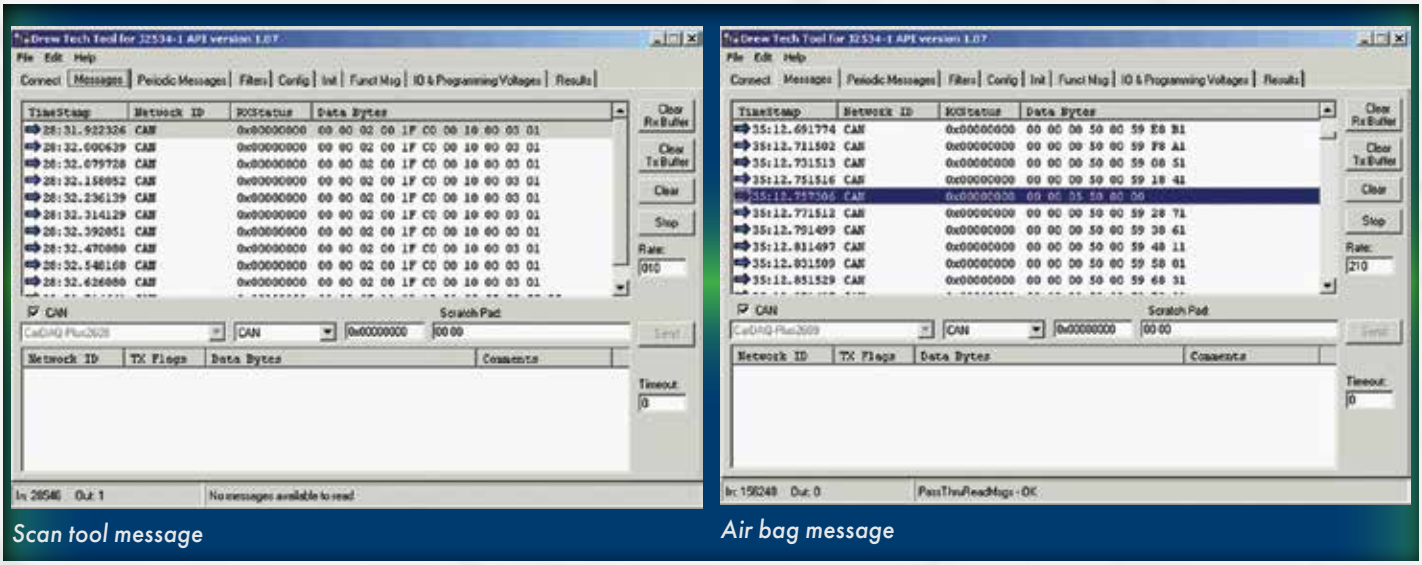


Filter Screen

In the correct order

- Click Filters Tab.
- Click Create "Pass All" Filter.
- The protocol was chosen from the primary screen.
- Click Apply when done. The screen should look like this if correct.

Click the Message Tab.



Scan tool message

Air bag message

Increasing the "Rate" will slow the messages for easier viewing. The Start/Stop buttons allow data to be read in the window at a different rate.

When viewing data or starting the read again, click Stop, and clear all (TX and RX). Click Start to look at fresh data.

The Clear/Start/Stop buttons can be used at any time to "flush" data and start the recording at any time.

The Frankenstein network has multiple controllers attached as mentioned earlier. With VCDS connected, the next controller to be interrogated is the instrument cluster. Remember that the 60 ohm resistor has to be removed to measure and record the CAN address when using the scan tool with the J2534 application.

This next image (*Instruments Message*) is the recording of the Instrument Cluster and that CAN address is 07. The VCDS address to request Instrument Cluster Electronics is address 17. Note this as well.

What does this all mean?

Simply put, for relevance and drawing from the earlier paragraph, a network controller that is actively transmitting data because it is awake will produce specific addresses and be recorded via the J2534 application.

How far can the technician go with this knowledge?

The limit is the installed controllers, and if the controllers are active.

This setup is only as complex as the installed network. Depending on year, make, and model, a competent technician should be able to search the available systems with the correct protocol using two methods as a test.

First, complete and save the autoscan.

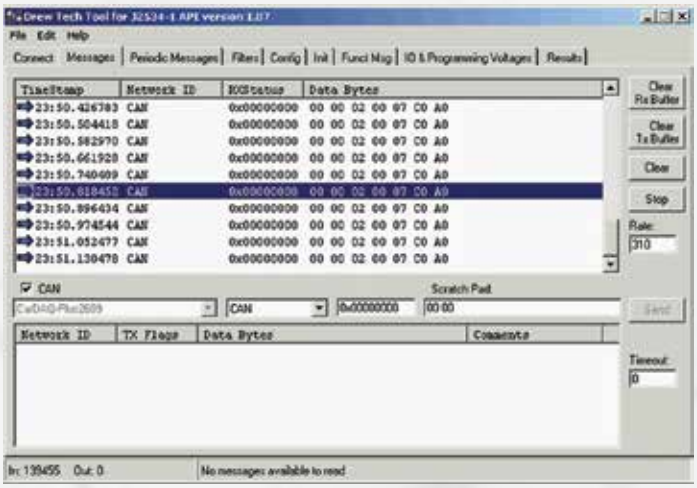
Second, access a schematic and look at the 16 pin DLC connection and identify which controllers are on which data lines.

Note the installed controllers with the scan tool address and also note the CAN address as described earlier.

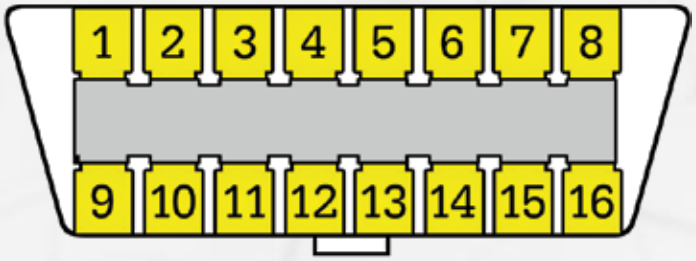
This partial scan is from a full CAN vehicle:

Scan tool address	CAN address 1F
01-Engine	CAN address 01
02-Auto trans	CAN address
03-ABS brakes	CAN address
04-Steering angle	CAN address
08-Auto HVAC	CAN address
09-Cent. elect.	CAN address
15-Air bags	CAN address 05
16-Steering wheel	CAN address
17-Instruments	CAN address 07
19-CAN gateway	CAN address
22-AWD	CAN address
25-Immobilizer	CAN address
42-Door elect, driver	CAN address
44-Steering assist	CAN address

46-Central conv.	CAN address
52-Door elect, pass.	CAN address
53-Parking brake	CAN address
56-Radio	CAN address
62-Door, rear left	CAN address
72-Door, rear right	CAN address



Instruments Message



Pin	Signal	Description
2	J1850 Bus+	
3	Not in use	
4	CGND	Chassis ground
5	SGND	Signal ground
6	CAN High	J-2284
7	K-LINE	(ISO 9141-2 and ISO/DIS 14230-4)
10	J1850 Bus-	
11	Not in use	
14	CAN Low	J-2284
15	ISO 9141-2 L-LINE	(ISO 9141-2 & ISO/DIS 14230-4)
16	+12v	Battery power

There are 101 entries with all known VW/Audi/Bentley/ Lamborghini addresses (most shared) and not including the LT3 (Mercedes VW).

The homework is to fill in an Excel spread sheet with the needed addresses when "pinging" or accessing each controller. The J2534 application is more than happy to write messages on the screen until all the addresses are investigated.

What can be done with it?

Think about the possibilities if a complete record was created and saved for all VAG addresses. Think of the possibilities of recording other manufacturers' addresses. If the controller is awake and sending data to the DLC, wouldn't that be an "epiphany" when applying the Ockham's razor principle and the KISS factor all at once?

The illustration and guide is the most common VW setup known at the moment. Other manufacturers will have slight variations and NOT all communications are CAN.

A little deeper and outside the box.

So what if a more direct approach is needed, meaning a "direct to the controller harness" connection via back probe. It would be a very good test because the approach is identical to using the vehicle DLC.

What is the approach?

Some communications are still "in front of the DLC" and other modern vehicles are behind the gateway.

All that's needed is a sub harness connected to the DLC connection of the J2534. You can use a scavenged DLC with all 16 pins populated. The DLC may have a twisted pair NOT connected to pins 6 and 14 of the vehicle DLC. That twisted pair may have the 60 ohm resistor attached close to the DLC and high quality back probes attached to a meter length of the twisted pair.

Now bring that connection anywhere in the vehicle and test the theory directly. Remember, the J2534 device must have B+ at PIN 16 and B- at both PINs 4 and 5.

Why all the trouble?

So that the vehicle is left completely undisturbed, in its original configuration and the fault theoretically still active. ■

Porsche Brakes
Lessons Learned from the Race Track

By: Tim Pott

One of the hallmarks of Porsche cars has always been their reputation of having excellent brakes. Superior braking is one of the features that, in the earlier years, helped to earn Porsche's reputation of being a "giant killer" at the race track. Lightweight vehicle platforms and monster brakes made up for what Porsches lacked in sheer horsepower.

Over the years, Porsche began to build street cars with engines that had been purposely built for racing and produced significant horsepower. Many of the gains in power have found their way into Porsche's lineup of street cars, but braking systems have never taken a back seat in Porsche cars, and to this day they are a leader in advanced braking systems.

The Porsche Club of America has been hosting high performance driver education events at race tracks around the country for many years now, and more and more Porsches are showing up at these PCA sponsored events as well as independently sponsored high speed events. The Porsche specialist repair facility plays an important role in preparing these extraordinary cars for being pushed to their limits.

Measuring and noting pad thickness is important but it is one of many steps of a thorough brake inspection.

Opposite Page: While center lock hubs are cool to look at, did you know they are limited to a specific number of times they can be removed and re-torqued before the entire assembly needs to be replaced?

Extreme care, diligent maintenance and attention to detail are the keys to success when it comes to preparing and maintaining a vehicle for even the friendliest of competition. There is no worse feeling for a shop owner than to hear that one of your customers had an unfortunate incident during a high speed event.

There are specific challenges to be met when evaluating a vehicle for track use, and it is imperative to maintain the inherent safety engineered into braking systems while addressing normal functionality. In simpler terms; things that look bad may be acceptable and things that look good may not. Brake systems always require careful scrutiny and this applies doubly when a vehicle is being driven at a race track.

Brakes are easy, right? It is true that braking systems have been engineered for ease of service but that doesn't mean things can't go wrong or the systems don't have complexity. It is a recipe for failure as well as a huge legal liability to not follow best practices when servicing any vehicle's braking system, let alone one that will be pushed to its limits. Be certain to read any technical service bulletins before starting the work. Make sure you are aware of critical fastener torque values as well as recommended torque cycles (how many times a bolt can be reused) and sequences.

Brake inspections!

All brake jobs should begin with a thorough evaluation of all the components. Most shops have their own brake inspection form. If you don't have one, get one and customize it for your specific needs. Always start with a road test and note any pulling conditions, unusual noises, firmness of the pedal, pedal effort and vibrations or pulsations coming through the brake pedal. Once on the hoist be certain to remove all wheels. Estimating brake pad wear by looking through the spokes of wheels will not necessarily give you an accurate assessment of brake pads and rotors.

Pay special attention to the surface of the rotors and note any cracking that might be developing. Most modern rotors are now cross drilled which aid in cooling and the release of gasses that burn off brake pad binding material. The holes are also a great place for cracks to being to propagate. However just because a crack is developing does not mean the rotor should wind up in the recycling bin, especially on street-driven cars.

There are technical service bulletins that specifically describe the allowable depth, length and location of any cracks that might be developing. Always follow the specifications while

determining the suitability for re-use of rotors and inspect the drilled holes themselves to make sure that they haven't become blocked with rust or pad debris. Clearly, the function of the holes will be negated if they are packed closed.

Porsche rotors are thicker than its "grocery getter" low-performance cousins used for daily commutes. This additional material may allow for machining and re-use of this relatively expensive brake component. The problem is that many, if not most, shops have abandoned the practice of machining brake rotors and for good reasons. Brake rotors in service on "everyday" cars are typically not intended to be resurfaced. Conventional brake lathes are often crude and too lightweight to do a proper job and leave a professional, non-directional surface. How often has a well-intentioned technician attempted to machine a rotor only to wind up with a finished surface that has been compromised by a harmonic "chatter" as the result of ineffective equipment?

Rotors leave the manufacturing factory having been ground using a hard stone as opposed to being turned on a lathe with a metal bit. During the grinding process the rotor is rotated and the grinding stone contacting the surface is spinning as well. Grinding a metal surface is much better than turning due to two reasons; the aforementioned non-directional surface it leaves, and a more even surface without removing unnecessary amounts of material. Rotor grinding provides a better break-in surface for the new brake pads. Consider either finding a local machine shop with a proper rotor/flywheel surface grinder to resurface these rotors properly as opposed to risk ruining them on a dedicated brake lathe.

Some cracking is permissible! Refer to service bulletins for assessing whether a rotor with some cracking can be re-used. Standards are higher for cars used in competition.

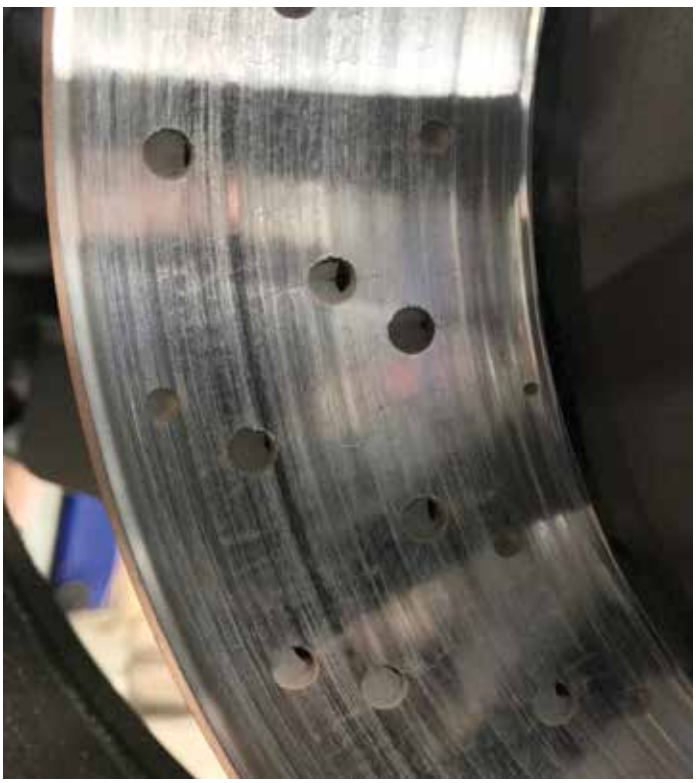
Cross drilled rotors

Drilling holes through the surface of a brake rotor has been a practice now for many years. The purpose for cross drilling rotors is to allow gasses to be released from the friction material's bonding agent to disburse or "gas off" easily. If the gasses can't escape quickly they will interfere with the ability of the brake pad to directly contact the rotor surface.

Another benefit for cross drilling is its ability to aid in cooling as well as the holes providing another pathway for heat to escape the surface of the rotor. The downfall of cross drilling is that often these holes become blocked either from brake pad and rotor material as it wears off the surface, or they can simply become filled with rust.

Once most of the holes are blocked the benefits are obviously negated. Cleaning the holes by running an appropriate size drill through them is an appropriate method for restoring their proper function. This is a simple but time consuming process and it is sometimes challenging to justify its value to your customer.

Brake hoses are an often overlooked component when servicing any brake system, Porsche or otherwise. It is still not uncommon, but it used to be a frequent practice, to replace the factory provided rubber hoses with a racing style "teflon" tube sheathed in stainless steel.



Some of these holes have become completely filled with rust and brake material, rendering them ineffective.

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These were and still are credited with providing a more firm pedal feel due to an advertised resistance to bulging slightly under pressure. Like so many claims made by aftermarket marketeers, however, this and other claimed improvements are typically unsubstantiated. Certainly the stainless steel surrounding the tubing which carries the brake fluid is more durable and resistant to damage from foreign objects or debris one might encounter while racing.

Aftermarket brake hoses appear to be stronger, but are they DOT approved?

A close look at this photo shows the DOT stamp, certifying that it has been tested and meets minimum standards.

It has been witnessed where a wheel, tire, hub and brake caliper, detached from their normal location on a race car as a result of an accident, can be dragged along by nothing more than the aforementioned stainless steel encasing the brake hose. While these may have been proven to be crash resistant in the racing industry, they often have not been tested by the DOT standards that the original equipment rubber hoses were subjected to.

Any repair facility installing such a critical component as the hose providing pressure from the master cylinder to the caliper had better be certain of its integrity over the long run. Brake hoses don't often develop a leak from the material itself, but more frequently will fail where the flexible member (hose) interfaces with the threaded steel component that either threads to the steel line feeding it or the brake caliper itself.

Unless you are preparing a car dedicated for track use, a vehicle where brake hoses and all safety components are carefully monitored in an ongoing basis, it is better to stick to original equipment rubber style hoses that were provided when the car left the factory. These have been tested for long term use and often fit better than aftermarket counterparts. This also has the benefit of mitigating any liability issues as well. Any improvement in the pedal "feel" obtained by using a "racing" brake hose is often imagined by the end user.

The stock rubber hoses should be considered for replacement based on inspection as well as service history or aging. Any abrasion or cracking of the outermost rubber layer is reason for replacement. Inspect carefully the area where the rubber connects to the steel, threaded component as this is a common failure point.

If there is a complaint of a spongy pedal feel, have a second technician apply the brakes firmly while watching all of the rubber hoses for any bulging. Bulging can occur as a result of a structural breakdown of the hose's internal reinforcing material. The innermost rubber lining of these flexible hoses can occasionally swell up and restrict the flow of brake fluid. Having an extreme amount of pressure available at a driver's foot in the form of a power assisted master cylinder, a driver can push fluid through this restriction.

The return pressure, on the other hand, is not nearly as great, and the result is that an internally restricted brake hose can mimic a seized brake caliper. A simple means of diagnosing such a condition is to open the bleeder valve at the dragging wheel. If the wheel begins to turn easily as fluid flows from the caliper then the brake hose can be pinpointed as the culprit. If, however, the wheel is still reluctant to turn, it is likely that a piston is seized in the bore of its corresponding brake caliper.

Most Porsche specialists know the importance of flushing a car's brake hydraulic system. Manufacturers generally specify that the brake hydraulic system be flushed about every two years. Due to the hygroscopic nature of brake fluid, mileage is not a factor, only age.

If a vehicle is being prepared for a track event the officiating club may have a more stringent interval for renewing brake fluid, with some clubs requiring the renewal of the brake fluid before each event. The more frequent interval is required due to the fact that the brakes will likely be used more aggressively than they ever have before. This hard usage can be especially true of a novice driver. Even a tiny amount of moisture in a vehicle's brake fluid can dramatically lower the boiling temperature which can then result in dramatic brake pedal fade.

It is incumbent on the repair facility which is preparing the car to be certain to use a high quality brake fluid that meets the highest boiling temperatures while also meeting or exceeding the manufacturer's specifications. It is also important to adhere to the sanctioning club's requirement, which should be defined on the tech inspection form provided by the club itself.

ABS braking systems have been around a long time and require no special care during normal service. Proper maintenance is nothing more than inspection of the sensors and tone rings at each wheel and a bit of additional care during bleeding procedures.

The majority of problems arise as the result of a speed sensor being unable to "read" a tone ring. This can be caused by an internal sensor failure or dirt buildup in the form of rust at the tone ring. Rust can occasionally be the cause of a tone ring cracking. Be certain to look closely at these items and clean any debris or rust that might be accumulating.

During bleeding procedures it is also best practice to flush fluid out of the ABS valve body itself using a proper scan tool to actuate the valves which modulate brake pressure. There is very little fluid volume in the pump module valve body itself, so one need not necessarily account for additional fluid.

Many technicians have developed a bleeding technique which relies solely on using the pump and control module. This method does not require either a second technician or the use of a pressure bleeder and addresses the issue of bringing fresh fluid through the pump. ABS function is monitored through the system's control unit and will illuminate a warning light if the system is not working properly.

Repairing brakes, either to be used at a track or "normally," is an area that exposes a facility to significant liability. Utmost care and attention to manufacturers' procedures is the key to keeping your customer as well as your business safe. ■

An Inside Look at Audi Turbochargers

By: Peter Caro
Redds Automotive

The wastegate is impossible to see without separating the exhaust.

Audi has historically been at the forefront of emerging engine technology. The main goal while designing and manufacturing a drivetrain has been to increase power and efficiency while minimizing exhaust emissions. By using forced induction, it's possible to have smaller engine displacement and still retain or even increase available engine power.

Audi has used turbocharging on their vehicles since the 1970s. The Audi Quattro was the most widely known turbo Audi from that time period. The Quattro model was also well known then for using Audi's four-wheel drive system. With a turbocharged powerplant and four-wheel drive, Audi rally cars were untouchable in the racing series.

Wastegate/Diagnosis

Most Audi turbochargers have a mechanical wastegate valve to release excessive turbo pressure. It's extremely important to have a proper operating wastegate to protect the engine. Excessive boost pressure can damage the turbo assembly and, in the worst case, may cause engine damage.

Through use of an electronic boost pressure sensor, the engine computer monitors and shuts down boost if excessive pressure is noted. The boost pressure sensors are generally trouble free unless they become soaked in oil or blocked with debris.

Audi uses an internal wastegate design on their turbochargers. The primary advantage to this design is a smaller turbo package and simpler installation. The disadvantage of this design is, if a problem develops with the wastegate itself, the entire turbocharger may have to be replaced.

It's turbo time!

Wastegate "rattle" can also be an issue on certain models. Customers may complain of an engine rattling sound when starting the vehicle or during deceleration. This is usually caused by wear at the connection from the actuator rod to the wastegate arm. This allows exhaust gas pulsations to move or "rattle" the wastegate seal. In extreme cases, the wastegate seal itself can become worn, allowing boost pressure to escape as well as creating a "rattling" sound. A worn wastegate can even set low boost faults.

Audi has released an updated securing clip for the wastegate arm connection. If diagnosing a rattling turbo, check to see if the clip has been updated, as this newer version will address most rattling issues.

Depending on the engine model, a vacuum or pressure-operated wastegate actuator may be used to operate the wastegate itself. If diagnosing a low-boost complaint, this is a good first step in solving the problem. By applying vacuum or pressure with a small vacuum pump at the actuator connection, it's possible to visually watch the wastegate arm for proper movement. Arm movement should be smooth through the entire range to the end stop.

On many 2.0t models, the wastegate actuating arm can actually seize at the turbo housing pivot, not allowing proper movement. This is becoming more common on higher mileage vehicles and generally requires turbo replacement. It may be possible to free up the wastegate arm by using penetrant at the pivot point if it seizes. However, this is not a permanent fix and should only be used for diagnosis.

Often, on older turbos, the rubber actuator diaphragm may fail as well, causing a loss of vacuum supply. This is easily tested by

The actuator arm is only visible with a mirror or from underneath the vehicle when installed.

using a vacuum gauge. This will cause a low boost condition if the diaphragm is damaged.

On newer Audi turbochargers, an electronic wastegate actuator is used. Using an electronic actuator allows for much tighter control over wastegate function. Electronic control is generally more robust than a standard pneumatically controlled valve. This also allows for limited diagnosis and testing of functions. It's possible to run a test of the actuator itself to verify proper movement as well as via scan equipment. These actuators fail from time to time, generally due to a sticking or rusted arm.

If replacing an electronic wastegate actuator, it must be adapted to the turbo, as most wastegate rods are adjustable. Failure to properly adjust the actuator and run adaptations will result in problems!

Electronic Diverter Valves

Audi uses an electronic diverter valve on their turbocharged vehicles. The diverter valve is used to "divert" excessive boost pressure to the intake tract during vehicle deceleration. If boost pressure continues to build with a closed throttle plate, this can cause damage to the turbo itself. It creates a fluttering sound during deceleration if not diverting boost properly. Audi diverter valves rarely cause over-boost conditions. However, due to programming, the engine will go into fail safe mode if unable to safely control the boost pressure.

The diverter valve used by Audi has gone through many revisions. The early valves had a large, visible rubber sealing diaphragm. Many 2.0t diverter valves suffered from premature failure of this rubber diaphragm used to seal the valve piston. When this fails, the valve is unable to maintain a pressure seal. This can cause fluctuating boost pressure under acceleration and is the most common complaint from customers experiencing problems. The updated valves have a more robust sealing area as well as additional fluting on the piston seal, ensuring a tight fit under boost conditions.

The diverter valve is easily removed and inspected from underneath the vehicle.

Eventually, a failed diverter valve will set a low-boost pressure fault. A failed diverter valve will not set a fault specifically pertaining to a torn diaphragm. During diagnosis, the only way to check a valve is to remove and carefully inspect it for damage. Checking the diverter valve for proper function is an important step when diagnosing low-boost faults or complaints.

Intercooler Assembly Damage/Inspection

All Audi turbocharged engines have intercoolers. These are necessary to lower boost pressure temperatures and increase efficiency. Lowering the air charge temperature increases the air density, allowing for more powerful, complete combustion. Without an efficiently operating intercooler, "heat soak" can become an issue, degrading power output.

Most newer model Audi vehicles have a large front-mount intercooler. This is the optimum design as it allows for the maximum surface area to be cooled efficiently. Smaller "sidemount" intercoolers are common on older 1.8t engine models. These work best for smaller displacement engines as they have much less cooling area available.

Audi intercoolers are generally trouble free. They do suffer occasionally from bumps and scrapes, which can cause boost

This boost pipe is commonly damaged during removal.

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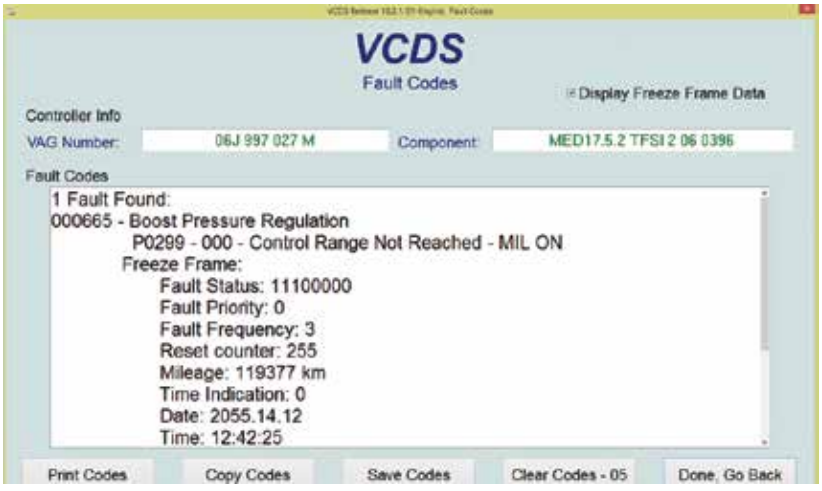


Always begin any diagnosis with a vehicle scan.

Turbo access from the top of the engine is limited.

issues. The most common damage is from parking blocks. Because of intercooler size and plumbing locations, these are susceptible to impact damage. Most models have plastic intercooler end tanks and boost tube connections. These will break if damaged. Usually a broken intercooler or connection can be heard. Loud whistling and low power are a guaranteed boost leak.

Another commonly damaged component is the charge air pipe connected to the throttle body on 2.0t engine models. This is a plastic charge pipe with multiple mounting points. If removed improperly or haphazardly, damage and boost leaks occur.

Replacement/Inspection

Turbochargers live a very difficult life. They must endure both extreme heat and high speed while operating correctly. Most modern Audi turbochargers can be expected to last between 100–150K miles before needing replacement. This lifespan can be drastically shortened by dirty oil or lack of oil pressure. Turbo impeller damage can even be caused by a contaminated air filter.

Inspecting the turbo for damage can be difficult due to tight access. However, it's still possible to visually examine the turbo to aid in diagnosis. A borescope is a necessity for this job, particularly to be able to see the turbo impeller and wastegate.

Impeller damage hurts boost performance. Shaft play is also a clear sign of a worn turbo. This can be felt by any excessive side-to-side "wiggle" to the impeller assembly. Too much play can damage impeller blades and the turbo housing. This can be accompanied by a screeching sound as the impeller grinds through the turbo housing.

On an Audi fitted with the 2.0t engine, turbocharger access can be accomplished by removing the air box assembly. This

Access is particularly tight for the lower inner manifold bolts.

will improve access for separating the exhaust as well as the exhaust manifold bolts.

When removing the exhaust manifold securing hardware, keep a few things in mind:

- Only the upper securing nuts must be fully removed. The turbocharger assembly sits on a supporting bracket held in place by the lower exhaust manifold bolts.
- Loosening the lower manifold bolts slightly will allow the turbocharger assembly to be lifted off its supporting bracket to be removed.

From under the vehicle, removal is straightforward. Remove all boost tubes connected to the turbo. Remove the turbo support bracket. Remove all coolant and oil feed and drain lines. Always replace all sealing rings and gaskets during this process. With the use of metal gaskets in certain applications,

It may be necessary to heat stubborn exhaust hardware to aid in removal.

Be careful not to kink or damage any feed lines during turbo removal.

you may be tempted to re-use these gaskets. Do not. Even metal gaskets can leak, particularly when re-installed.

After replacing the turbo, you may need to clear any relevant stored faults as well as re-adapt the electronic wastegate if so equipped. It's always wise to change the engine oil as well during turbo replacement. Any amount of debris, no matter how small, can restrict turbo oil supply. Clean oil will ensure a long service life. ■

VW 01M Transmission 65535 Error

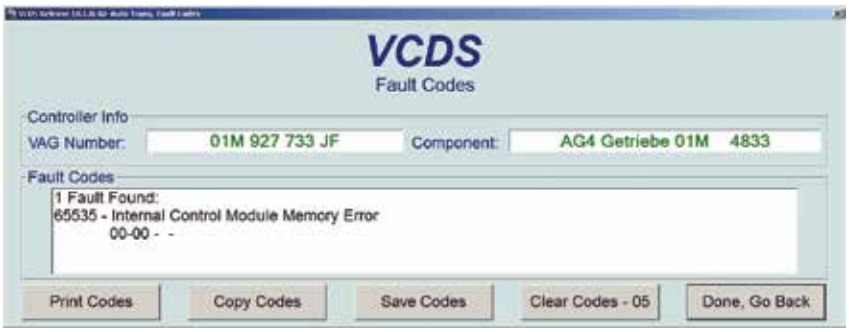
By: Augie Ferron

Alternator connection

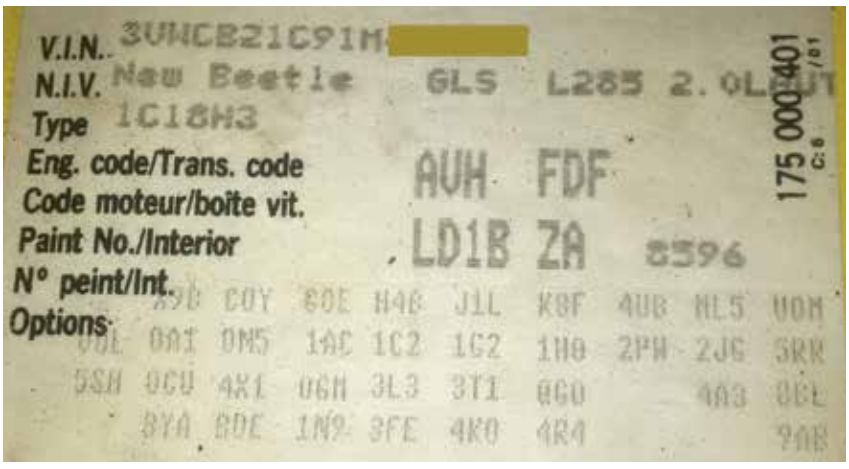
Refer to the previous article "The VW 01M Speed Sensors" as additional information. Consider this article as a resource and guide to test speed sensors, but equally an article as to "what can possibly go wrong." For the learning and uninitiated techs, read the prior version.

On occasion there will be situations when a vehicle owner requests help and/or repair that another repair facility has previously diagnosed. This is one of those times when "a deeper look" leads to repairs beyond the scope of the original diagnosis.

Special tools used besides hand tools.
90 amp power supply
Ross-Tech VCDS
Fluke multi-meter
Wiring schematic
Additional hand-made harness attachments
Camera and lots of patience
Force feed transmission oil fill



65535 error



PR code

The 65535 error is a "data corruption fault code" and can also be attributed to a hardware malfunction. The list of possible causes is endless but for all intents and purposes, can narrow this fault down to these possibilities in the automotive field:

Alternator/generator internal malfunction or harness damage.

Vehicle harness/control unit malfunctions such as B+ or B- connections.

Voltage spikes from vehicle boosting, reverse polarity, or stray secondary ignition voltage.

Caution: Test/repair that assumption before installing any control units.

The 65535 error in most cases will never delete and if that fault was previously recorded, will return quickly if deleted. In this specific situation, the 65535 error will also mask other errors that would not be generally recorded. Consider 65535 as a fatal controller fault and requiring replacement. In some and not all cases "Internal Control Module Memory Error" may not even record any errors; therefore consider 65535 as one of multiple suspects.

Customer complaint: You may encounter a situation where a previous shop diagnosed the 65535 error but the owner noticed the transmission not shifting correctly and stuck in a higher gear when driving their Beetle.

Have a look first before any assumptions

Scan and save the entire network as a primary baseline. Delete all faults and set basic settings for throttle. Measure and test the alternator output and perform an AC ripple test.

Road test if desired but contemplate the 65535 issues as described.

Give the customer the "what if" because of the 65535 issues.

Determine the correct model, transmission code and sales code with the PR tag. The tag is found the trunk and a copy is in the maintenance manual.

Identify the vehicle and look at the TCM data within the scan (next page):

Address 02: Auto Trans	Labels: User\01M-927-733.lbl
Part No: 01M 927 733 JF	
Component: AG4 Getriebe 01M 4833	
Coding: 00000	
Shop #: WSC 00000	
VCID: 7DFA6B3E7785D9ADDE-0958	

2 Faults Found:

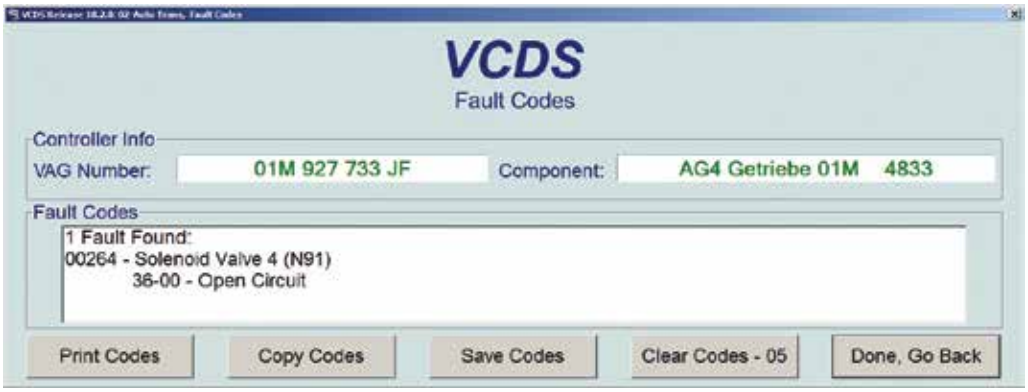
00300 - Transmission Fluid Temp. Sensor (G93)
34-00 - No Elaboration Available
65535 - Internal Control Module Memory Error
00-00 - What else might you find?

You may find indications of previous sub-standard repair. For instance, here Marette connections were never used to attach the harness to the voltage regulator. The possibility of the wires connected to the incorrect positions was 50-50. The correct repair is performed by using "crimp and shrink" connectors.

The battery, alternator and regulator tests typically prove within specifications. The final test is for a parasitic draw and is also usually within specification.

The next step

The 65535 error will not offer proper/correct/valued data during a road test and the possibility of "limp mode" can also be quite high.



Solenoid 4 fault

A replacement TCM (Transmission Control Module) is required to achieve any form of proper diagnosis.

Cleaning of the inner plenum is vital only because of the potential for rodents making a nesting bed. So replace the cabin filter in these cases at all times because of bacteria and other bodily fluids.

On to the road test.

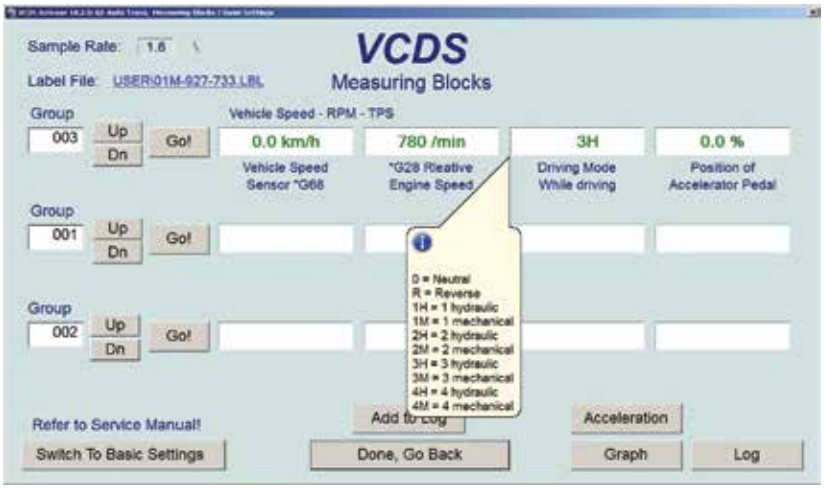
Prepare the scan tool to either record or have another technician drive the vehicle and get the transmission to shift in city and highway driving. Attempt to look at TCM and ECM faults during the road test and record all faults. In this case you may note TCM fault 00264 "solenoid 4 open circuit," and fnote that the transmission does not shift correctly. This fault will delete with the TCM temperature far cooler than driving temperature. Another road test may produce the same fault. The hotter the transmission fluid, the longer the open circuit fault will remain.

Is there another test? To test limp mode with VCDS and stopped safely, look at the next image. Notice the relationship of where the transmission will begin its driving range.

At 0.0 mi/hr, idle rpm and the Driving Mode in 3H with NO throttle applied, is definitely Limp Mode. Apply this to similar transmissions.

Another test can be accomplished by measuring the solenoid harness on top of the transmission case. Solenoid 4 measures open circuit when hot. Use this image with a schematic to measure each solenoid. Refer to the 01M Speed Sensor article as well.

Check Solenoid 4 at pins 1 and 6. Specification: 4.5 to 5.1 ohms.



Limp mode

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- Range of spare parts for cars and commercial vehicles
- High-performance universal sealing compounds: Dirko™ grey and AFD

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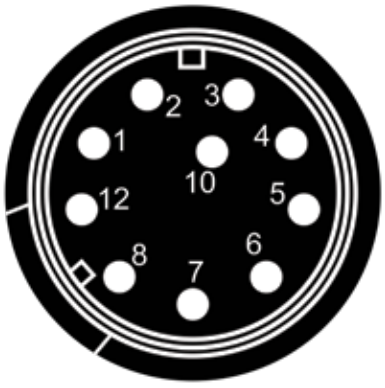
Since 65535 errors can mask other errors, a working TCM is the only option to move forward. In this specific situation, the working TCM provides one more piece to the complaint of "not shifting" correctly at times.



TCM connection

Note: Any vehicle of this vintage and with many miles should be suspect to oil, harness, and solenoid degradation.

A replacement solenoid pack, harness kit, with gasket and filter is recommended in this case.

Onward and upward!

The harness connections to the solenoids will self destruct with plastic particles jammed within the solenoid attachment. Therefore a new kit supplied includes:

- Filter
- Solenoid kit (7 solenoids in total)
- Harness
- Gasket

Not so fast!

Solenoids 4 and 6 are measured at 4.5 to 5.1 ohms.

Solenoids 1, 2, 3, 5 and 7 are measured at 55 to 65 ohms.

Paying attention now?

The transmission cooler requires removal/lifting off the portion of the hidden harness. Four seals are required to remount the cooler.

Draining and keeping clean.

On this type of system, the drain plug can be removed (replace the gasket) and the plastic spill port is removed as well. Generally, measuring the volume of oil is a good idea and saved for later inspection with the customer.

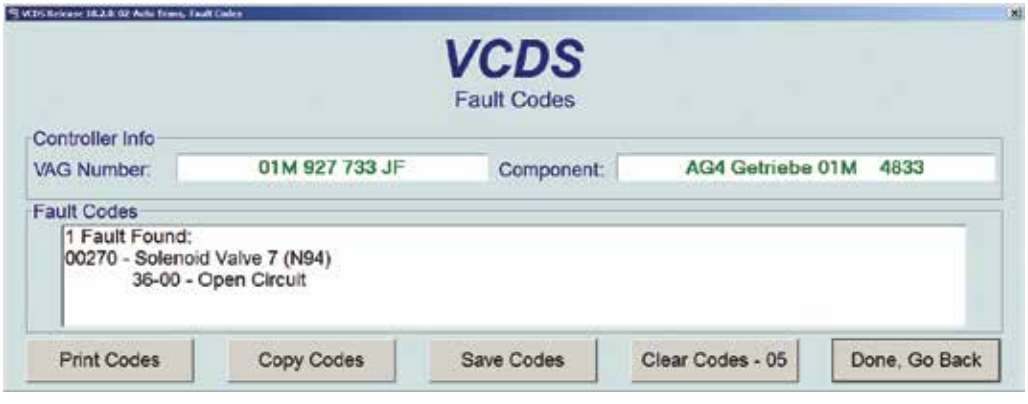

Drain and fill

If the decision is to remove the valve body, remember to set the manual valve. If the decision is to replace the solenoids in-vehicle, either way make sure there are photo images and place the correct valve in the correct bore.

Install the new harness and route it correctly, install the transmission cooler with new seals and finish by installing the oil pan with a new seal.

Thread the oil spill port gently and attach the plug. The oil fill tube can be gently unlocked for access to fill the transmission.

That is why the fluid is measured; the correct volume can be added quickly.



Solenoid 7 fault

Proper filling is with VCDS and measuring the fluid temperature at 95 degrees F (35 degrees C) maximum (check your specs) while the engine is running and drain plug removed. When the fluid spills/drips from the open port, the level is correct. Insert the plug. Simple enough? Not quite!

What if the car is still on the hoist and solenoid 7 has an open circuit?

Solenoid 7

Back to step one

Pin 1 = B+ supply to solenoids 1, 2, 3, 4, 5, 7 and Temperature Sensor
Pin 2 = B+ supply to solenoid 6
Pin 3 = B- signal to solenoid 1
Pin 4 = B- signal to solenoid 2
Pin 5 = B- signal to solenoid 3
Pin 6 = B- signal to solenoid 4
Pin 7 = B- signal to solenoid 5
Pin 8 = B- signal to solenoid 6
Pin 10 = B- signal to solenoid 7
Pin 12 = Temperature signal return

Pins 1 and 10 are measured and the value is open circuit, so a replacement harness and solenoid are the fix here.

The tests and learning lesson – for the uninitiated.

Measure twice, cut once!

1. The drain plug and spill port is removed, capturing the fluid.
2. Pan removed and harness disconnected at solenoid 7.
3. Measured from the transmission end harness to the solenoid harness.
4. Found an open circuit in new harness.
5. Solenoid 7 is the one in white. (See image *Solenoid 7* on the left.)

Harness test 2

Harness test one

Note the temperature sensor attached to the foil strip below solenoid 7.

Double check

Measure the replacement harness and ensure connectivity by using a snug fitting pair of wires (female) and correctly sized male end to the solenoid ends of replacement harness.

Using the TCM Connection image and PIN location description, the harness and solenoids can be measured in-vehicle to determine if all the solenoids are connected and the harness is intact. Follow the next series of steps to double check the replacement components before assembly.

Using a high quality multi-meter, measure the entire harness according to the wiring schematic to confirm that the replacement harness passes the continuity test.

Since the two blue female wires fit the round pins, the next test is after the assembly onto the valve body. The test can be done in-vehicle using the same pin layout described earlier. Measure with an ohmmeter or with 12 volts.

Note: These are 12 volt solenoids and can be tested with a voltage supply to the correct B+ and B- connections. Audible clicking should be heard by applying power or ground intermittently to the individual solenoids.

Hint: By increasing or decreasing resistance with a decade box, the TCM can be fooled into different temperature variances at pins 12 and 2. That test would prove out a defective transmission oil temperature sensor within the transmission strip harness.

Replacement harness under test with made up harness to fit both ends.

Install in the reverse order and ensure the harness is tight and routed correctly. Refill the transmission again and, with VCDS, setting the correct oil level, against transmission oil temperature.

How many ways to fill transmissions of this style? Gravity feed tends to be a bit slow, a hand pump is too much work but this one is air regulated with two ball valves.

That will also mean that, with the correct adapter and coupler, different styles of fill ports can be fitted to one basic tool. 5 psi is enough pressure and the ball valves control the volume of fluid when force feeding through small ports.

The control of each ball valve also allows the fill side to remain closed but the spill side open to watch for the drip at the temperature with VCDS. ■

Harness test two

Transmission filler

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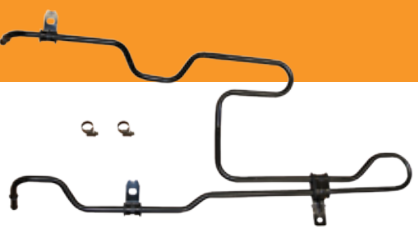

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