# Electrical Systems, Part 2

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Look at any car from Porsche's history closely and you'll recognize some constants — like design genius, quality materials, and utilization of leading-edge technology. This is particularly true when it comes to electronic systems. Consider the D-Jetronic electronic fuel injection in 1970's 914-4, the Digital Motor Electronics control unit in 1982's 944, and the tire-pressure monitoring in 1986's 959. These are just a few of the systems that have yielded dramatic improvements in vehicle operation and performance.

In today's Porsches, we see highly complex electronic technologies, such as Direct Fuel Injection, Porsche Traction Management, and PDK manumatic transmissions. These require communication through a multitude of sensors, controllers, and electronic control units (ECUs) that are shared with other systems throughout the car. Communication occurs through specific protocols based on the type, purpose, destination, and priority of the signal.

The control systems that handle all of that information would have been considered science fiction to an automotive engineer of 25 years ago. And things won't be getting simpler from here: The new Type 970 Panamera sedan is so sophisticated that it required the release of a new system tester (dubbed Porsche Integrated Workstation Information System 2, or PIWIS-2) to enable Porsche technicians to communicate with all of the systems in the car and to diagnose any faults.

To Porsche's credit, drivers and passengers are unencumbered by the myriad electronic handshakes and decisions being made on their behalf throughout a modern Porsche. As in a 356, they still get in, start the engine, select a gear, and drive off. However, the exchange of electronic data throughout the car to get it going is nothing short of amazing — and it can be difficult to appreciate how it's accomplished because everything operates so seamlessly.


**Above: This power supply is applying voltage to the car so that the battery can be disconnected and replaced. Remember: For a battery replacement, do not connect a battery charger or a power supply in the charging mode; if you do, the battery charger may shut off when the battery is disconnected—allowing the erasure of volatile RAM memory. As shown, this power supply is providing power to the vehicle rather than the car battery.**

There are downsides, however. With complexity comes the need for strong technical knowledge of all systems as well as an understanding of the procedural requirements for working on them. For the average Porsche owner, greater complexity means that something as simple as a battery change can have an impact.

In "Electrical Systems, Part 1," we took a look at problems relating to the electrical systems in a variety of Porsches, from 356 to 997. In this *Tech Forum*, we'll look at the modern Porsches, how a loss of battery power can affect them in unexpected ways, and how to avoid problems.

## Your Porsche Becomes Aware

No, we're not suggesting that elements of Cyberdyne Systems' Skynet have been incorporated into your Porsche's ECU, even though your car may act like it has a mind of its own from time to time.

The first Porsche to have adaptive capabilities was the 1989 964 Carrera 4. Its ECU learned and could change certain operating parameters as the car was driven.

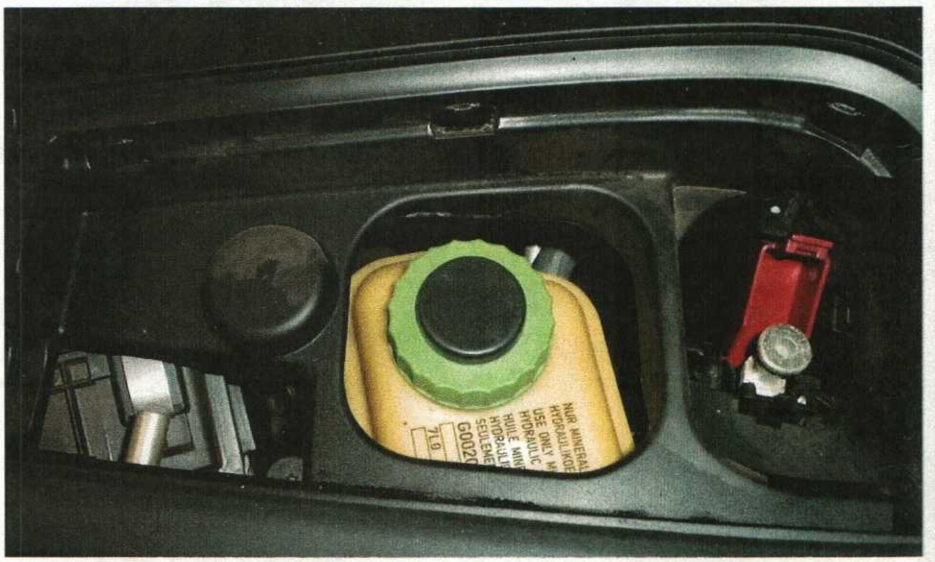
Porsche had updated its Bosch Digital Motor Electronics control system for that first 964, and it could determine the total quantity of fuel needed by the engine at any point in time based on the engine's sensor inputs for temperature, load, speed, and emissions. The DME would then send an electrical pulse to each injector to operate at the appropriate moment relative to engine firing order. This was something new — sequential fuel injection with each injector operating one at a time. All previous Porsche fuel-injection systems operated the injectors simultaneously.

The 964's DME also had the ability to make adjustments to the length of time the injectors were open, meaning a shorter or longer (injector) pulse width. The amount of time an injector is open is known as Time Injected (Ti). DME's adjustments could also be influenced by intake air leaks, incorrect fuel pressure, an input sensor deviation, and multiple other possibilities. To accomplish this, the engine's exhaust characteristics were read by the oxygen sensor. This data was then provided to the DME control unit and analyzed with and against other sensor inputs. If DME detected any deviations between its preprogrammed optimal values and the actual values, it would attempt to optimize the air/fuel ratio by making adjustments to the Ti of all injectors.

These adjustments are called fuel trim, and the quantity of a fuel trim change is known as the adaptation value. Fuel trim adaptation values are broken into two segments: TRA and FRA. TRA is the "idle range" (engine speeds up to approximately 1700 rpm) while FRA is the "cruise range" (engine speeds over approximately 1700 rpm). The adaptation values are stored in the DME control unit's Random Access Memory (RAM) and are lost if the car battery is disconnected or goes dead. We will come back to this, as it is critical.

So what if the engine has a more serious fault and the DME has utilized its entire available range of TRA/FRA adaption without being able to correct for the problem? The DME records a fault, turns on the Check Engine Light (CEL), and reverts to an internal, preprogrammed map to protect the engine and catalytic convertor. This is known as "limp home mode," where engine power and response are significantly reduced. The intent of the limp home mode is to provide a means to get the car off the road. It is not advisable to drive any further than is necessary because something significant is wrong with the engine and/or its management system.

The introduction of the 1992 968 saw further DME upgrades including Vario-

Opposite, top: A good tool to have for finding a parasitic drain is an inductive clamp-on Digital Volt Ohm Meter, or DVOM for short. This can be used for obtaining a reading without having to disconnect any cables. The DVOM shown is connected to a 2002 996 Turbo; the car's Computer Area Network Bus (CAN Bus) system is in sleep mode and the current draw is just 31 milliamps.

Opposite, middle: These are the jumper posts on a late-model Cayenne S, and they're an ideal location to connect bridged power from a power supply while changing a battery. Note that the posts are on either side of the power-steering fluid reservoir.

Opposite, bottom: The power supply cables are connected; this is on the driver's side, between the engine and the fender.

Cam, but it was not until the release of the 1996 993 Carrera that DME really began to change. In 1996, all cars sold in the U.S. had to have On Board Diagnostics 2 (OBD-2) engine operating systems. One of the primary goals of OBD-2 is to protect the central component of a car's emissions system: the catalytic converter. The 1996 Carrera was the first Porsche to offer these more complex OBD-2 capabilities.

## Don't Disconnect the Battery

Can we really be serious? We're afraid the answer is yes, we can. While one of the obvious consequences of disconnecting a car battery — or replacing one after finding the car with a dead battery — is a loss of the radio presets and clock time, each Porsche model has other, more critical potential consequences if battery power is lost, whether intentionally or not. This is something for DIYers to consider, as many of them tend to disconnect their Porsches' batteries when working on anything having to do with the airbags — like seats, door panels, and steering wheels.

In the case of the 964, the engine may not run correctly and could develop a stalling problem on deceleration and/or a possible idling problem. Once the car is up to operating temperature, it takes approximately 20 to 30 minutes of driving for the adaptations to take place. You can, however, aid this process by performing a system adaptation with a Bosch "Hammer" or Porsche factory tool 9268. While running the system adaptation, turn on some "consumers" (i.e. lights, interior fan, etc.) to help raise the idle speed. This is one of those unknown tricks that works very well.

The 993 has an archaic (compared to today) form of misfire monitoring and a fuel trim adaptation system similar to the 964's. Added to the 1996 993 was the adaptive capability of Cylinder Cut Out, where fuel injectors for up to two cylinders could be shut off if DME sensed a misfire. A misfire is incomplete combustion and is detected by a lack of flywheel acceleration during a cylinder power stroke. However, the 993 wasn't always accurate regarding which cylinder was misfiring — an issue Porsche would resolve in the 996.

The adaptations are stored in the RAM section of the 993's DME control unit as volatile memory, and are thus lost if the battery is disconnected. The 993 will also lose all critical OBD-2 monitors, which are mandatory for state-run emissions inspections, if the battery is disconnected. Additionally, cars equipped with the Tiptronic transmission will lose shifting adaptations based on each driver's characteristics.

The 996's more complex control system is also sensitive to a battery disconnection. As in the 993, misfire, fuel trim, and Tiptronic adaptations will be lost. The 996's camshaft position sensors allowed for far more accurate misfire monitoring, and that information is lost when battery power is disconnected — as are throttle body adaptations, which may cause idle speed to surge, as well. The latter applies to E-gas (electronic throttle) vehicles (MY 1999 996 Carrera 4 and 2000 996/986S and later). Issues can be caused by the loss of mechanical and electrical stops stored in the RAM memory, and made worse if the throttle body has carbon buildup — as it will not allow the throttle blade to completely close to its mechanical stop.

Additionally, the 996 Carrera 4 can lose instrument-cluster data, including calibration for the fuel-level indicator, if the battery is disconnected. If the internal battery in the instrument cluster is old and faulty, the information may be lost. This will then require the re-calibration of the fuel gauge.

While issues covered thus far are reason enough not to disconnect the battery in a 964, 993, 986, or 996, the 997-1 is basically the first Porsche that can have substantial issues if the battery is disconnected. In addition to the items previously mentioned, the 997 can experience strange electrical/mechanical issues relating to or between the various control units for systems like seat heaters, exterior mirror control, Porsche Occupant Side Impact Protection (POSIP) air bag systems including the Auto Weight Sensing (AWS) occupancy sensors, Porsche Stability Management (PSM), etc. if the battery is disconnected. A 997 Cabriolet's passenger window auto function may also become disabled. If that happens, you must reset and initialize the right rear quarter window before initializing the passenger window.

The 970 Panamera will also suffer from a loss of adaptations stored in multiple controllers' volatile memory. Unique to the 970 is its rear hatch, which may no longer open or close properly as a result of losing its set points. If it does, you must place the hatch in its most upward position, then hold down the open/close button to reset and initialize the system. Also, the right front window's auto function can be lost. To correct this issue, the car must be driven about a mile and then the right rear window must be calibrated, followed by the right front window.

997s, 987s, and 970s will most likely benefit from performing a "Hand Over" procedure. The Hand Over is essentially a reboot for the operating systems of the car which will realign all the control units and reset functionality to factory original status. This procedure can be performed with a factory PIWIS or PIWIS-2 tester.

## A Possible Bad Day Scenario

So what's the worst that can happen, you ask? Let's look at one example. A 996 has been running somewhat poorly for a few weeks. The owner recalls the Check Engine light came on for a short time, but that it went out, too. Even so, the engine has continued to seem a bit sluggish. The owner assumes that he purchased some bad gas, or that it might be time for a tune-up. Since he doesn't drive his 996 every day, the car ends up sitting for a few weeks.

When the owner returns to his car, he finds the battery is completely dead. He fixes that by disconnecting and removing the old battery before installing a new one. The car starts, but is running quite rough. There are no control-unit fault codes present — as they were erased when the battery went dead or was disconnected — other than low voltage or terminal 30 faults due to the dead battery (these codes will only appear after the car is started).

The owner decides to drive the car anyway in hopes of clearing the rough-running condition with a few full-throttle blasts. At this point, all fuel trim and misfire adaptations have been lost because the battery was dead or disconnected and insufficient time was available for re-adaptation to take place. The engine is running, but a serious problem is taking place.

A problem had developed over the last few weeks the car had been driven, where cylinder misfiring from incomplete combustion was caused by a faulty ignition coil pack. The owner is not aware that the DME had previously turned off the fuel injector for this misfiring cylinder. Until the misfire adaptations are completed or ready, the DME cannot turn off any injectors with Cylinder Cut Out. If there is a faulty condition present, such as a misfire from incomplete combustion, raw fuel will enter the catalytic convertor(s), which could immediately sinter (overheat and melt) the convertor's substrate (stainless steel core).

Bottom line: It is not recommended to drive a catalytic convertor-equipped car unless it's running properly. A CEL should be diagnosed as soon as possible. If a *blinking* CEL is present, the engine should be turned off immediately — as this is the intended warning when the catalytic converter is being damaged.

### So What Am I Supposed to Do?

When changing your modern Porsche's battery, the best way to avoid issues associated with a loss of ECU or DME memory is to apply an external source of power to the car. The best option when changing or removing a battery, although not necessarily the only option, is a clean source of 12-volt D/C (no spikes or A/C voltage) power connected to the car *prior* to battery cables being disconnected and removed from the battery inside the car.

Shops today should utilize a high-quality, purpose-built power supply from companies like Midtronics and Fronious to ensure that clean power remains constant during various procedures including control unit interrogation, coding, and programming. General-purpose battery chargers should not be utilized because they may shut off when they sense the battery has been disconnected. Other options for external power can be from another car battery, a jump-start power pack, or a device intended for maintaining power to the car, not the battery.



Connection for the external power supply can generally be done on a battery jumper post, the battery cables, through the OBD-2 port, or a cigarette lighter. If your model has specific requirements, they must be followed explicitly.

The car battery in a Porsche with computer-controlled systems and adaptive capabilities should not be allowed to go dead. Of course, unanticipated problems can drain a perfectly good battery. Even though some DME adaptations can be relearned, other issues may require a technician's intervention with the use of factory test equipment. The good news is today's high-quality battery testing equipment can evaluate a battery's condition accurately — so checkups during regular maintenance can help prevent battery failure.

If you must disconnect the battery to work on or around sensitive electronics or airbags, be *sure* your car is running properly before doing so. We recommend calling a qualified repair facility to schedule an appointment to check your Porsche before you pull the plug — and to help make sure you bring it back online safely.

### Parasites are Lurking

A common reason for a battery to go dead unexpectedly is from a power drain somewhere within the car. Without using any expletives, these are referred to as parasitic drain (PD). Generally, a PD is something that remains on and draws current from the battery when the car is shut off. This can be as simple as a small light that remains on due to an open trunk, glovebox lid, or dome light. Of course, a PD can be harder to trace. One example might be a horn relay that remains "on," thus drawing the voltage needed to operate the horn even though it is not being used.

The "hidden" PDs are frustrating, both to experience and to diagnose because the problem can often be intermittent. The first thing to check for if a PD is suspected is drain when the car is off. A normal drain on your Porsche's battery should be in the neighborhood of 20 to 30 milliamps (mA). Readings as high as 50 mA can even be considered acceptable. However, PDs in the range of 400 to 800 mA can drain a good battery in a day or two.

There are many electrical components in a Porsche — or any car — that qualify as usual suspects when it comes to PDs. An alternator that has a bad diode can kill a battery in fairly short order. However, there can sometimes be a symptom where the battery or alternator light will stay on, even after the ignition key is removed.

A common PD in 993s results when the Climate Control Unit is faulty. Usually, this causes an intermittent drain. When the PD is present it can be severe, in the 300 to 400 mA range. The only repair is to replace the CCU. Additionally, aftermarket electronic components such as anti-theft and audio systems or the substandard installation of aftermarket products can cause various electrical problems including PDs.

Some of the more complex PDs can be caused by a faulty ECU. Porsches with CAN (Computer Area Network) Bus systems can have issues related to hardware and/or software. CAN Bus is an advanced communication architecture that ties all electronic components together to share data. The first Porsche to use CAN Bus was the 1997 986 Boxster. It was followed by the 1998/1999 996-based Carrera. Since then, all Porsches have utilized CAN Bus.

The CAN Bus system has multiple control units throughout the car. After the car is turned off, the CAN Bus system, including all the controllers, will sense no activity and go to sleep; this can take up to 30 minutes. During the sleep mode, current draw falls to a minimum. If a controller or switch is faulty, wiring is damaged, or a software problem is present, the system may not go to sleep, and the resulting PD can be high. The 997-2 and 970 are generally at more risk for these types of problems due to their added complexity.

Testing for a "hidden" PD can be a fairly involved process. Having special electronic equipment and a thorough knowledge of a particular Porsche's electrical system is required. With older, simpler Porsches, mechanics used a 12V test light in series with one of the battery cables. If the bulb started glowing, there was some level of current flow. On modern, computer-controlled Porsches, mechanics utilize a high-quality inductive DVOM that clamps around a battery cable (or other power cable) to confirm if a PD is present. This allows a check of the circuit without breaking any electrical contacts.

Even with the right tools, isolating the circuit or component causing a PD can take time. If the problem is intermittent, the use of a Parasitic Drain Data Recorder may be required to capture and isolate the problem.

## Conclusions

Porsches of today are highly complex, and there is no doubt they'll get more complex in the future. For owners of 2005-and-later Porsches, diagnosis and repair of electrical problems typically requires access to specialized tools and factory diagnostic equipment as well as specific knowledge of the systems. We hope this *Tech Forum* has provided a few useful take aways: 1) Even a basic repair job like changing the battery can have potential consequences. 2) Porsches have become quite good at self diagnosis and can adapt to issues at hand. 3) If a CEL or other warning comes on, it should be diagnosed as soon as possible. 4) If the CEL is blinking, or if the car begins to run poorly, its engine should be shut off and the car should be towed; it should not be restarted until a diagnosis can be made.

While all of the above may seem drastic, it can head off more costly repairs — and keep you on the road longer in the long run. Enjoy your Porsche.

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