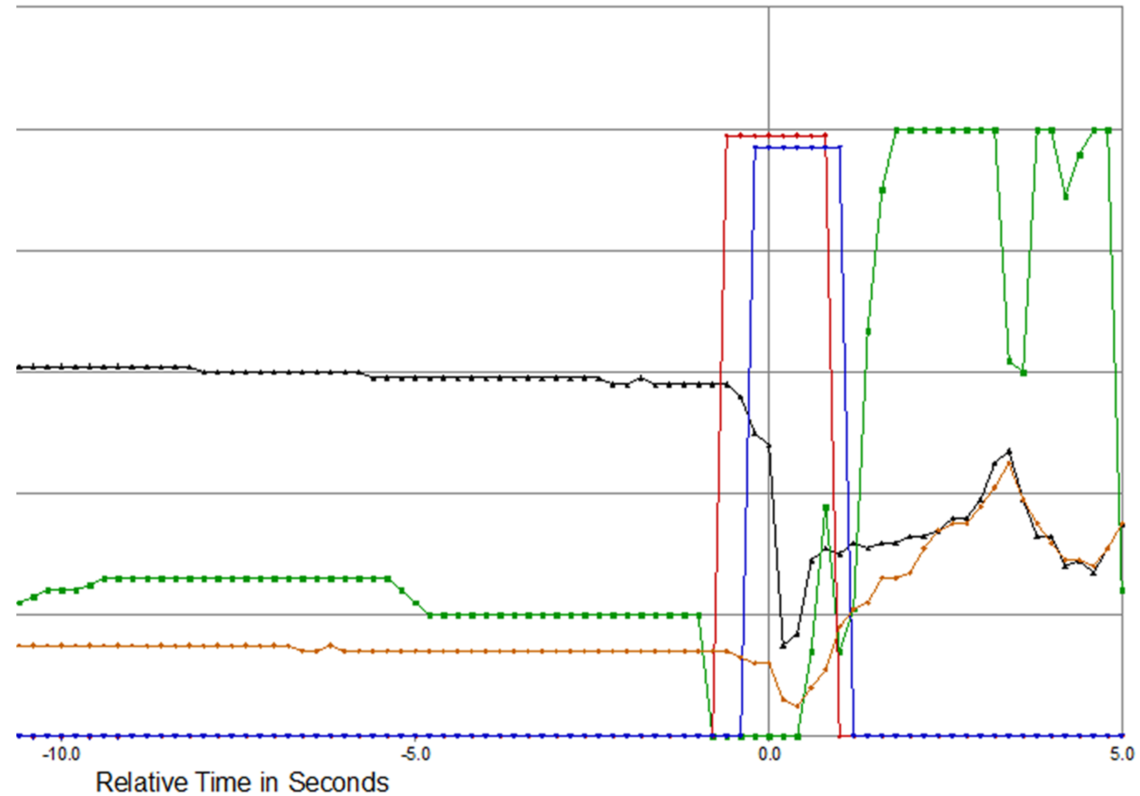
Ford calls its airbag control modules (ACMs) Restraint Deployment Modules (RDMs). For many Ford products, data of certain operational parameters are stored in the Powertrain Control Module (PCM). In a crash in which there was a deployment, the RDM was supposed to send a Restraint Deployment Signal (RDS) to the PCM, which would lock 20 seconds of pre-crash data and 5 seconds of post-crash data in the non-volatile memory of the PCM. That data could be extracted later using the Bosch Crash Data Retrieval (CDR) toolkit. Without the RDS, the PCM kept a sliding record of 25 seconds of vehicle operation. If the ignition key was turned off, the recording stopped. If the key was turned on again, the PCM began recording the sliding 25 seconds of data. Without an RDS, leaving the ignition on after a crash or turning the key on later, for instance to check the odometer mileage, would cause any crash data in the PCM to be overwritten with useless data. Many of the early Ford vehicles with this arrangement were plagued by a problem such that the RDS was never received by the PCM, so any crash data which was in the PCM was quickly overwritten by data useless to a crash reconstruction. But one never knew if the PCM had received the RDS until after the PCM was interrogated. Another problem with PCM data was that improper use of CDR hardware could cause the PCM to start recording as soon as the ignition key was turned on to allow interrogation of the RDM; Bosch provided hardware to prevent that problem, but the CDR operator had to use all of the proper hardware to prevent that occurrence. Another "minor" problem was that, if a specific conductor attached to the PCM was severed in a crash, the CDR system, even when properly used, could still cause data in the PCM to be overwritten by useless data. The best procedure for a vehicle which has been severely damaged in a crash was to completely disconnect the PCM, interrogate the RDM, then separately interrogate the PCM directly from that module. Tedious and possibly tricky, but that's what CDR training is for. There are many other caveats (gotchas) associated with the current CDR system.

With that brief explanation as a background, the image at the top of the column of text to the right shows data imaged from a PCM from a Ford product involved in a crash. The driver said that the brake pedal was depressed but that the engine kept increasing in speed, causing the crash. The PCM records data in 0.20 second increments for 20 seconds before the impact and 5 seconds after the impact, if the RDS has been received. In this case, the receipt of the RDS is marked by a faint gray vertical line in the data. I have truncated the output from the PCM to allow the ten seconds before the crash and the five seconds after to be presented in more detail. The horizontal line at or near which the red, blue, and green lines peak near and after zero represents 100, usually percent; the black line represents speed in mph; the horizontal line about which most of the pre-crash speed indications appear represents 60 mph. The green line represents the position of the throttle pedal; the red line indicates brake switch status (0=off, 100=on); the orange line shows engine rpm/100; the blue line represents functioning of the vehicle's ABS. The faint gray line representing the receipt of the RDS actually occurs after the crash; when changes of acceleration from an impact are high enough to deploy one or more restraints, those restraints are deployed, then the RCM sends the RDS. In the case of the crash in which this vehicle was involved, the crash occurred roughly 40 milliseconds (1000 milliseconds in one second) before the RDS was



received. Note that the throttle pedal was released 120 milliseconds before the RDS was received, while the brake was applied approximately 20 milliseconds after the throttle pedal was released. What I find most interesting in this PCM data is that, after the crash was over, the throttle pedal (green line) was pumped while the brakes (red line) and ABS (blue line) remained at zero. The driver was pumping the throttle pedal, apparently believing that it was the brake pedal. We have all seen cases where evidence has been able to show that a driver had confused the brake pedal and the throttle pedal, and some cases where there was no remaining physical proof, just the knowledge that brakes are stronger than the engine of the car on which they are installed. In the latest iteration of crash data storage, Federal regulations require that crash data be stored in the ACM. I hate to see the loss of PCM data, because that data could reveal much more about a crash than what is typically contained in an ACM. There are still many Ford products on the road with data in both the ACM and the PCM.

We may be getting 48-volt vehicle electrical systems after all. Continental (the company, not the car line by Lincoln) has built a demo Volkswagen Golf TSI with a 1.2-liter gasoline engine and their 48-volt system. The primary components are a 48-volt starter/generator (which they describe as an "E-machine with integrated inverter;" a 48-volt DC to 12 volt DC converter (to operate the many 12-volt components and accessories, which is essentially everything electrical we have and use in today's personal vehicles); and a large 48-volt lithium-ion battery. The engine is shut down immediately upon pressing the brake pedal. When the foot is removed from the brake pedal, the engine restarts immediately. When called upon by hard acceleration, the system goes into E-boost mode, in which the motor-generator provides an additional 14 kilowatts to the powertrain, allowing for significantly higher acceleration. (One kilowatt is approximately 1.3 horsepower; 14 kilowatts is approximately 19 horsepower—not a lot, but it can provide a significant boost to a small, light vehicle.) The same physical assembly charges the battery when the engine is running and provides the additional power when called upon. Another advantage of this system is regenerative braking: when coasting down without applying the brake pedal, the vehicle's inertia helps recharge the battery pack while the engine consumes virtually no fuel. The concept of using the same assembly as a starter motor and a generator is not new, but it is not nearly as practical with an entirely 12-volt system, due to the necessarily increased size of the battery pack. Electrical power is a function of both voltage and current; for a given level of electrical power, increasing the voltage by a factor of four reduces the required amperage by a factor of four. For a given battery, the voltage is relatively fixed; the battery delivers more power by providing more amperage as called for by the demand; it takes fewer/smaller batteries of higher voltage to provide the same amount of electrical power, reducing the weight of the battery pack. A significant detriment to current hybrid and electric vehicles is the large size and/or quantity and associated mass of 12-volt batteries necessary to provide the starting and/or driving power. For a given mass (weight) of a vehicle, the acceleration provided by a specific power source is greater when the object has less mass. (Newton's second law still applies to modern vehicles, regardless of the power source.) In general, lighter vehicles get better fuel mileage from an engine or greater distance from electric motors than their heavier counterparts.

Here is a brief explanation of mass and weight, which I've probably provided before. Mass is a quantity of matter; weight is the force acting upon a quantity of matter by some external, unbalanced force. On earth, weight is caused by gravity which is essentially constant (with minor variations) everywhere on the earth's surface. However, in the absence of gravity or any other unbalanced, external force, a quantity of mass has no weight but is still the same amount of mass. On earth, weight and mass are directly proportional; weight is equal to the mass times the acceleration of gravity. In this country, most "mass" is sold by weight. A pound of butter is not the mass of that butter but the force exerted by gravity on that mass. A "pound" of butter in stable earth orbit would have no weight; on the moon, it would "weigh" a little over five ounces, but it is still the same mass. In the SI system, mass is a fundamental component; in our system, force is a fundamental component. Therefore, it is easy to get confused about the distinction between mass and weight. Sometimes, that distinction is irrelevant. In physics, the distinction is often critical. Newton's first and second laws are expressed in terms of mass, not weight, but the second law allows us to calculate the weight of a quantity of mass when given a value for the acceleration provided by gravity.

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