Power Challenges Faced by Vehicle Applications

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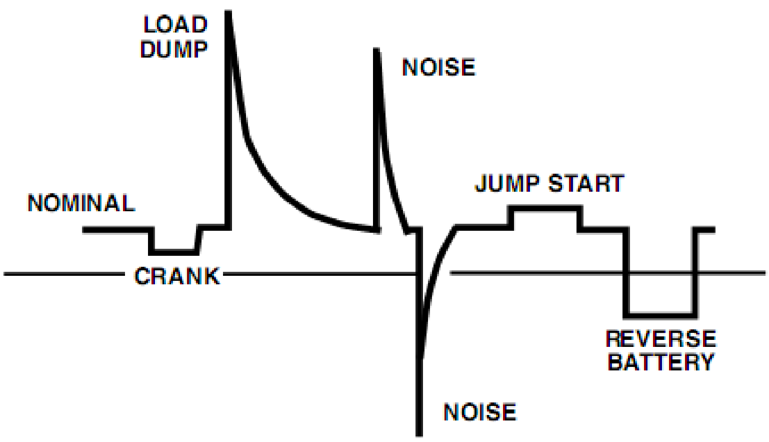
Many challenges are faced when designing in-vehicle computers: temperature extremes, vibration and shock, RF technologies, and so on. The most important one is related to “dirty power”. Standard IT products are not suitable for use in vehicles as transient power conditions may damage equipment or even cause explosions. Therefore, the first priority for the in-vehicle environment is solving the crucial problems presented by dirty power conditions. The automotive environment is fraught with electrical hazards. These hazards, including electromagnetic interference, electrostatic discharges and other electrical disturbances, are generated by various vehicle sub-systems such as ignition, relay contacts, alternator, injectors, and other accessories. These generated hazards can occur directly in the wiring harness in case of conducted hazards, or may affect electronic modules indirectly via induction. The hazards can impact the electronics in two ways - either on the data lines or on the power rail wires, depending on the environment. In determining the kinds of factors that will cause problems, the first priority for the in-vehicle environment is solving critical problems introduced by dirty power sources. In most present-day motorized vehicles, the DC power source is provided by a lead-acid rechargeable battery, and that battery is charged by the engine and a generator or alternator. The DC voltage in such an environment is seriously impacted by ignition signals, motor RPMs (speeding up or slowing down), loading devices (audio system, MOD, PND, lamps, horn, etc).

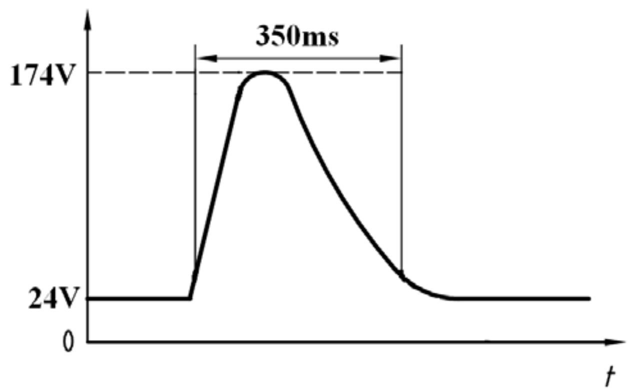


TYPICAL AUTOMOTIVE TRANSIENTS

The severest transients result from either a load dump condition or a jump start overvoltage condition. Other transients may also result from relays and solenoids switching on and off, and from fuses opening.

Load Dump

A load dump condition is caused from a vehicle battery disconnect. When a vehicle battery is disconnected while the alternator is still generating a charging current, the current will raise the voltage to a high level in a short time, causing damage to electronic equipment. The severity of a load dump pulse is determined by the alternator speed and the level of the alternator field excitation at the moment of battery disconnect. Cable corrosion, a poor connection or an intentional battery disconnect might lead to a load dump condition. The image below shows the typical waveform of a load dump pulse and its peak voltage, which could reach 174 volts with duration of 400 milliseconds. Although load dump conditions don't happen often, they are of concern as their high voltage and huge energy surges are unbearable for most transient protection components, and can result in permanent damage to in-vehicle electronic devices.

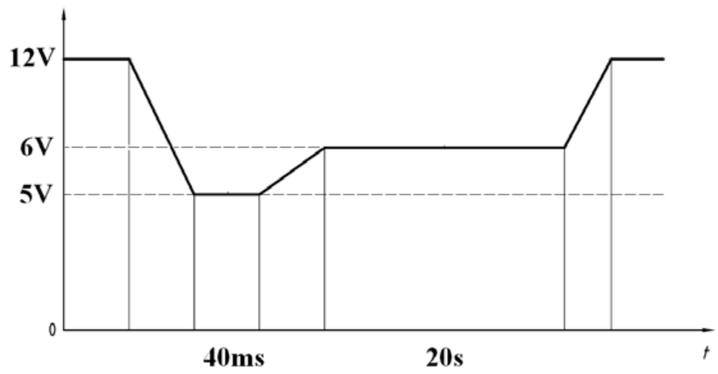


Jump Start

A jump start is a condition that occurs when two batteries are connected in series to provide the higher voltage needed to start an engine when it is cranked in cold weather, and the engine oil is very thick. In a nominal 12-volt vehicle system, the jump start voltage would be 24 volts. If the electronic devices are not designed with this in mind, a jump start condition will lead to damage.

Cold Crank

A cold crank condition occurs when a car's engine is started at cold temperature. Engine oil viscosity is high requiring more current from the battery to start the engine. The large current load will cause battery voltage to drop below 5 volts. The image below illustrates the cold crank waveform. For a general vehicle computing device, especially a PC-based one, 5-volt power is a very crucial power rail, and should remain as stable as possible. When faced with cold crank conditions, maintaining a 5-volt power rail becomes a challenge.

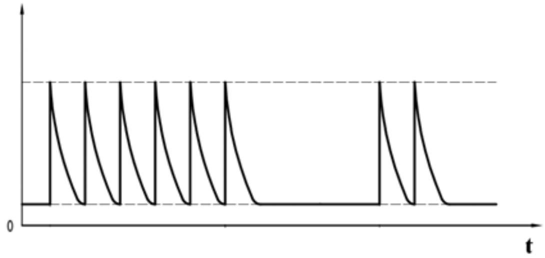


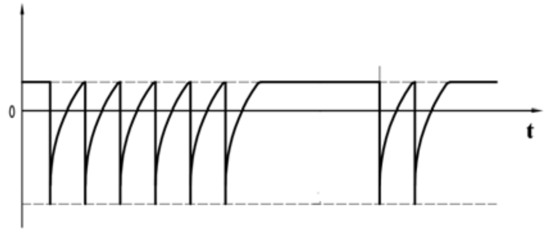
Reverse Battery Connection

Reverse battery connections are common occurrences in the automotive environment. Designing electronic devices with protection against this condition is a basic requirement.

Inductive-load Switching Transient

Inductive-load devices are widely used in the automobile environment for such things as warm-up devices, air conditioners, wipers, sprayers, electrical fans, power doors and windows, and so on. These devices will generate switching transients on the power rail while they are operating. The type of transient can range from -200 to +200 volts, in hundreds of milliseconds, and exceeds the bearable voltage levels for general electronic components. Transient voltage can cause severe damage and failure of electrical devices.





Low Power Consumption During Standby or Power Off

For electronic devices that are connected to a vehicle battery and drain power directly, ensuring that there is enough power in reserve to start the engine is important. In some cases, the user

will operate the electronic devices while the vehicle engine is shut off, and they will consume power without a vehicle charge. If no criterion exists for protection in this circumstance, the vehicle battery will discharge completely. Electronic devices can even consume power while in standby or shut off. To avoid battery discharge, the standby and the quiescent current of electronic devices must be kept as low as possible.

When facing the problems mentioned above, it is apparent that in-vehicle, electronic device design must include solutions to counteract specific power problems that can occur in an automotive environment.

Transient Protection

The first solution is transient protection, designed to handle load dump, inductive-load switching, jump start conditions, and so on. The transient protection circuits should protect electronic devices from over-voltage spikes, and maintain stable power output, to keep the system working even when a transient condition occurs.

Power Noise Filtering

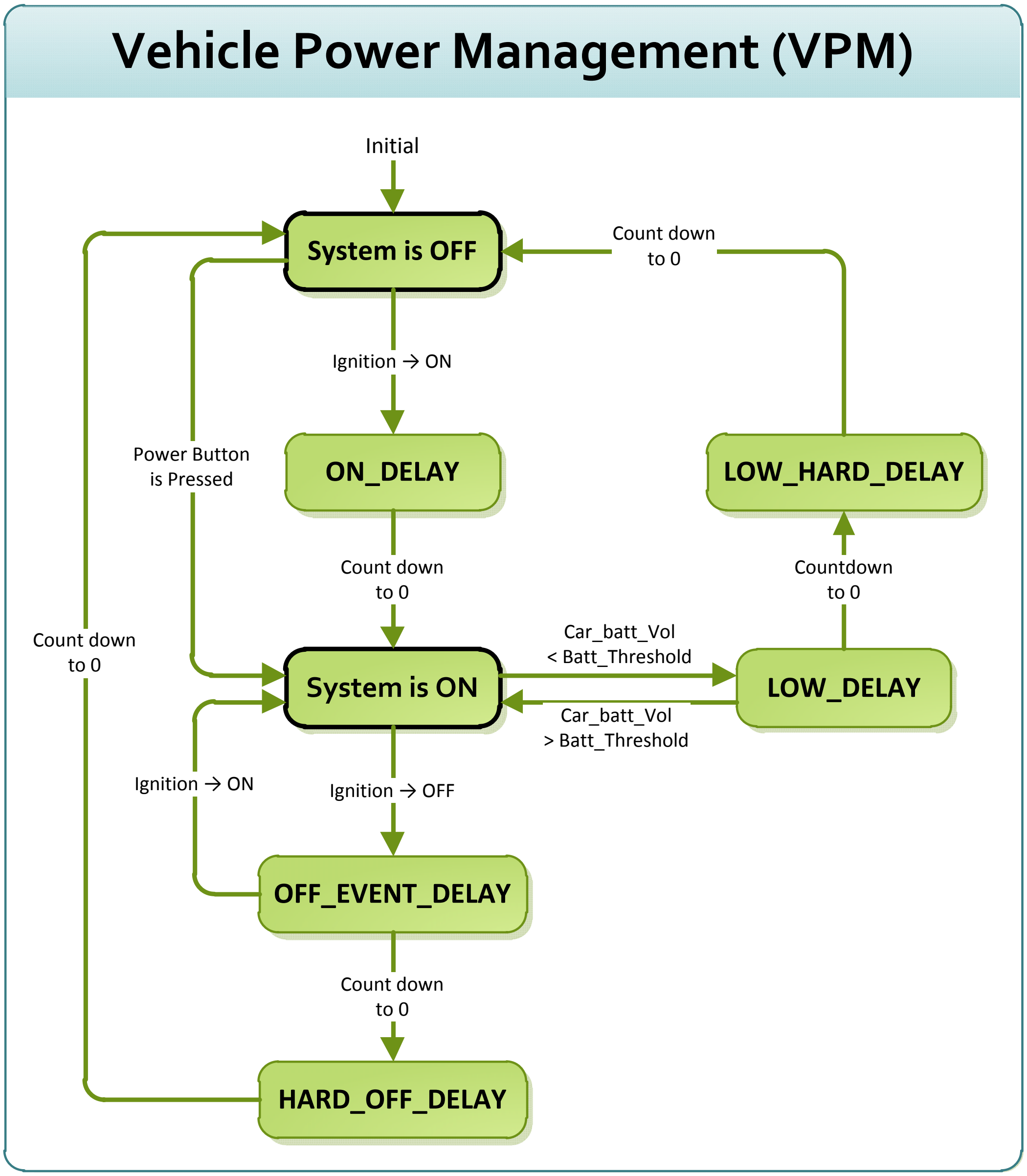
The switching noise from devices on a vehicle's main power rail might be too high even after it is regulated by a DC-DC convertor. This might cause an audible hum in audio output, video or display interference, or even lead to a malfunction of the electronic device. For in-vehicle signage, surveillance, or infotainment applications, this is a critical issue. Power noise frequency ranges are different for different kinds of vehicles, and from different power sources.

Wide Range DC Input

Vehicle power systems supply different voltages with 12-volt, 24-volt and 48-volt being the most common. To ease the installation of in-vehicle applications, a wide input range is necessary. This not only reduces risk from installation mistakes, but also improves resistance against cold crank conditions, jump starts, and load dump conditions.

Vehicle Power Management

Since electronic devices will drain power from the vehicle battery directly, ensuring battery power is enough to start the engine is a top priority. In the real world, electronic devices might hang or malfunction due to unforeseen conditions. Operating system halts, required responses from application programs or outright failures, will leave a device powered on, continuously consuming power until the battery is complete discharged. This is one of the most critical conditions in which an in-vehicle device can cause trouble resulting in a huge loss of time and money. Vehicle power management (VPM) systems must be included to manage the working status of electronic devices to respond to user events (like a change in ignition status) or application programs/operating system activities. The diagram below illustrates how VPM system works.


Vehicle Power Management (VPM)
Initial
System is OFF
Count down
to 0
Ignition → ON
Power Button
is Pressed
ON_DELAY
LOW_HARD_DELAY
Count down
to 0
Countdown
to 0
Count down
to 0
Car_batt_Vol
< Batt_Threshold
System is ON
LOW_DELAY
Car_batt_Vol
> Batt_Threshold
Ignition → ON
Ignition → OFF
OFF_EVENT_DELAY
Count down
to 0
HARD_OFF_DELAY

Certifications

Certification standards have been developed to ensure the power design of electronic devices is robust enough to pass real world trials for different kinds of applications. These standards have strictly defined the test methodologies that simulate the possible hazards in automotive environments. Below are some of the most common certification standards:

- emark: A mark of consistency, governed by European Union Directives for conformity of vehicles and vehicle components. An emark indicates conformity to these standards and directives.

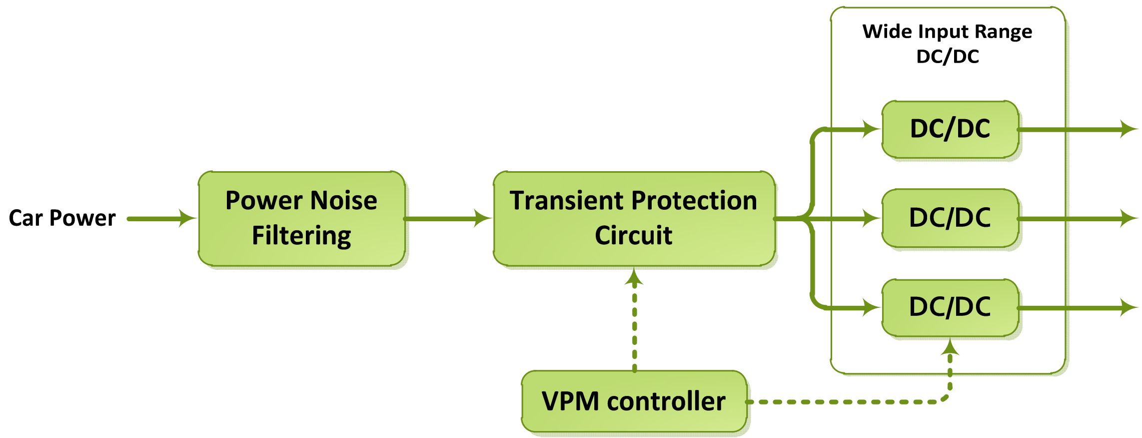
- ISO-7637-2: Road Vehicles – A standard test mechanism to measure electrical disturbances from conduction and coupling; Part 2, is concerned with electrical transient conduction along supply lines on vehicles with a nominal 12-volt or 24–volt supply. The second edition is dated 2004.

- SAE J1455: Recommended environmental practices for electronic equipment design in heavy-duty vehicle applications.

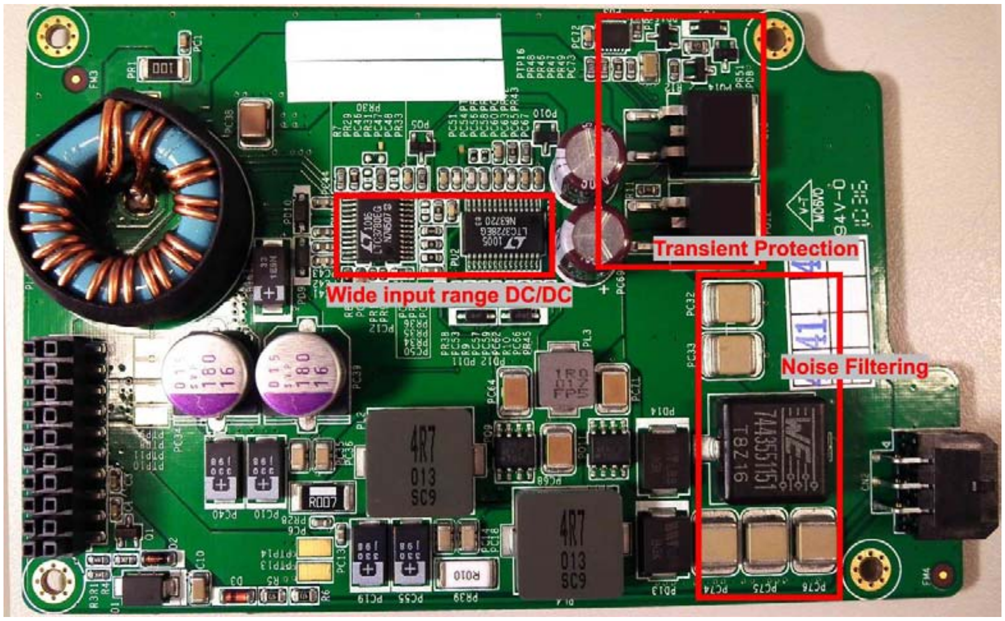
- SAE J1113: Electromagnetic susceptibility measurement procedures for vehicle components (aircraft excluded).

Advantech Solution for Vehicle Power Management

Advantech has implemented a complete solution of vehicle power management on TREK series products; this solution is robust again the severe automotive environment and it also passes the certifications mentioned above. The diagram below illustrates the architecture of this VPM solution.



The image below shows a real case in TREK products.



Advantech Offers Solutions

Advantech industrial mobile computing solutions provide a wide range of products for a variety of vertical markets. Advantech offers integrated solutions for all aspects of industrial mobile computing: systems that work under a wide range of temperatures; certified power systems; x86 and RISC-based architectures; a full suite of RF protocols; standardized vehicle diagnostic tools; rich I/O connectors; vibration and shock resistance; and a comprehensive software developer kit to facilitate application development, speeding up time-to-market for system integrators, and helping reduce costs. For more information, visit www.advantech.com