APPLICATION NOTE

AUTOMOTIVE

Protect and Power Vehicular Asset-Tracking Devices

Figure 1. Asset-tracking/fleet-management applications.

Introduction

Vehicular asset tracking, an important part of fleet management, is a way to know the exact location of physical assets around the clock. Three main benefits of using asset tracking are cost savings, theft protection, and preventative maintenance. Asset-tracking devices are powered by the vehicle battery, typically 12V in cars and 24V in many trucks. As an aftermarket add-on, they must be small enough to fit in tiny places such as under the dashboard, and they face a much harsher power management environment than a well-bounded OEM device. This application note describes how to power the device with a small, efficient power solution and how to properly protect it from electrical stresses in a vehicle environment.

Why Asset Tracking?

Large organizations such as trucking, construction, utility companies, and government offices operate diverse fleets of vehicular assets across multiple jobs sites and on the road. There is great value in knowing where all vehicles are at any given time. Consider the typical responsibilities of a company's fleet manager:

- Monitoring and improving fleet efficiency — tracking and reporting the costs and ROI of each vehicle in the fleet and the fleet as a whole.
- Ensuring the fleet vehicles undergo regular maintenance to improve both the safety and long-term ROI of each vehicle, as well as keeping vehicle operations in compliance with relevant industry regulations and laws.
- Tracking where each vehicle is, preventing theft, or providing a way to recover the vehicle.
- Monitoring and managing driver behavior.

Vehicular asset tracking is a way to know exactly the location of physical assets at all times, along with vehicle telemetries. It represents a set of technologies and processes designed to help capture, transmit, and store data that can improve the performance and ROI of a business's fleet. These technologies have found places not only in cars and trucks, but also in heavy equipment, trains, ships, avionics, and defense applications, as seen in **Figure 1**.

Vehicular Asset-Tracking Power Requirement

Vehicular asset-tracking/fleet-management devices are powered by the vehicle battery, typically 12V in cars and 24V in many trucks. As an aftermarket add-on, they face a much harsher power management environment than a well-bounded OEM device. Most devices also have a rechargeable backup battery, typically 3.6V, intended to last two or three days when the main battery power is lost. From the main battery source, the front-end electronics are protected against transient and fault conditions. The protected voltage is converted to useable, lower voltages (such as 5V, 3.3V, 2.5V, or 1.2V) by step-down DC-DC converters and LDOs to power various digital logic and analog ICs.

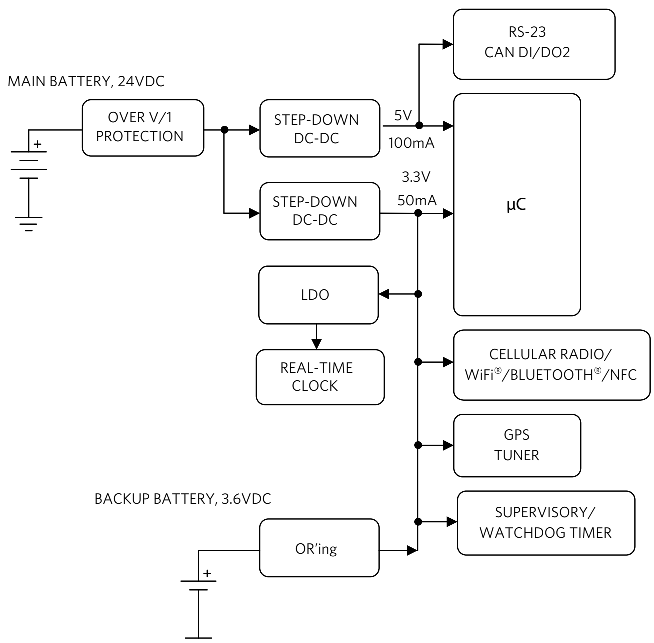

Figure 2. Typical asset-tracking/fleet-management power architecture.

Powering the Device with Modern DC-DC Regulators

Asset-tracking/fleet-management devices must be physically small in order to fit in small places. One typical installation is to the on-board diagnostic (OBD) connector, which is under the dashboard, in such a way that the device does not protrude and interfere with entering or exiting the vehicle or is not located where it could be inadvertently kicked or bumped during vehicle operation.

In such small area, reducing the heat dissipation in a device to keep its temperature within range is a challenge. Fitting the power circuit into a small space requires high integration. Modern DC-DC regulator power solutions that effectively integrate the power MOSFETs, compensation circuit, and other external components help reduce overall circuit size. Combining the small solution size with the efficient synchronous rectification technology helps reduce the power dissipation.

To further increase integration, Himalaya uSLIC™ power modules also integrate the power inductor and other discrete components with the DC-DC regulator. These easy-to-use, easy-to-design, and quick time-to-market power module solutions only require an input capacitor, an output capacitor, and an optional soft-start setting capacitor to complete the power solution. The uSLIC family employs advanced packaging technology to minimize the module footprint. For example, the **MAXM15062**/**MAXM15063** fits a 60V, 300mA power solution into a tiny, 2.6mm x 3mm x 1.5mm power module. This highly efficient synchronous DC-DC buck power module also minimizes the heat dissipation in end equipment. The MAXM15062 has a fixed 3.3V output, while the MAXM15063 is similar but with a fixed 5V output. We use these two modules to power our example asset-tracking/fleet-management device.

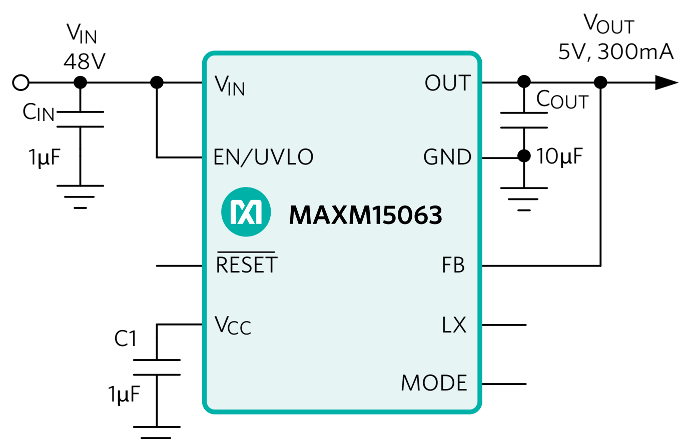

Figure 3. MAXM15063 typical application schematic.

One might use LDOs here for small size since LDOs are generally low cost and very simple to use, but they have high power dissipation if used directly from the main battery voltage, which is a main drawback. For example, a typical asset-tracking device would need 3.3V/50mA to power the microcontroller and 5V/100mA to drive other peripherals. If LDOs are used here, the power dissipation across one LDO would be:

(24V - 3.3V) x 50mA = 1.04W

and for the second LDO:

(24V - 5V) x 100mA = 1.90W

where 24V is the nominal 24V truck battery voltage.

Dissipating this 2.94W power in a small asset-tracking device is impractical and can cause device overheating. We need a solution that can meet both size and power dissipation requirements. Thus, the MAXM15062/63 uSLIC power module fits the bill here. **Figures 4** and **5** show the module efficiency; we can calculate the power solution as follows:

The power dissipation of the 3.3V output is:

Po x (1/n - 1) = (3.3V x 50mA) x (1/72% - 1) = 0.064W

Similarly, the power dissipation of the 5V output is:

(5V x 100mA) x (1/84% - 1) = 0.095W

where 72% is the efficiency of MAXM15062 at 50mA load, and 84% is the efficiency of MAXM15063 at 100mA load.

Total power dissipation using the uSLIC power modules is 0.159W, which is a 18x power dissipation reduction compared to the LDOs solution. Low power dissipation also means lower system operating temperature and higher long-term reliability.

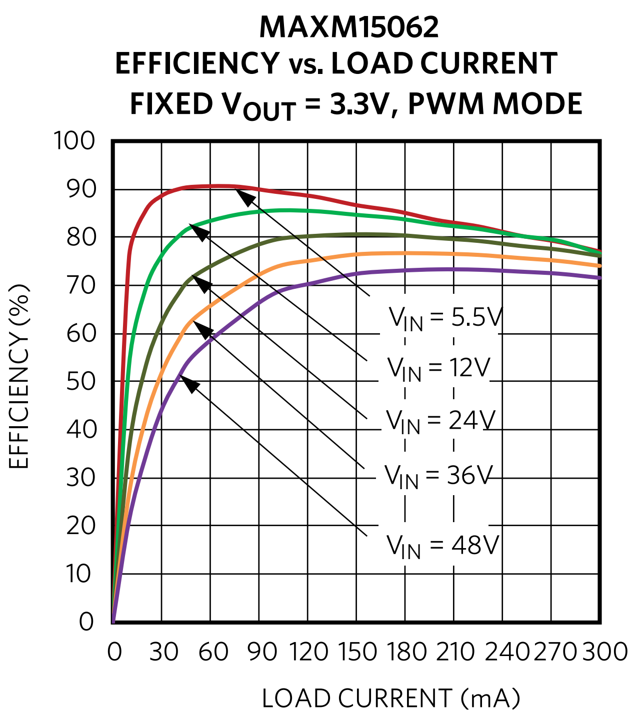

Figure 4. MAXM15062 efficiency vs. load current.

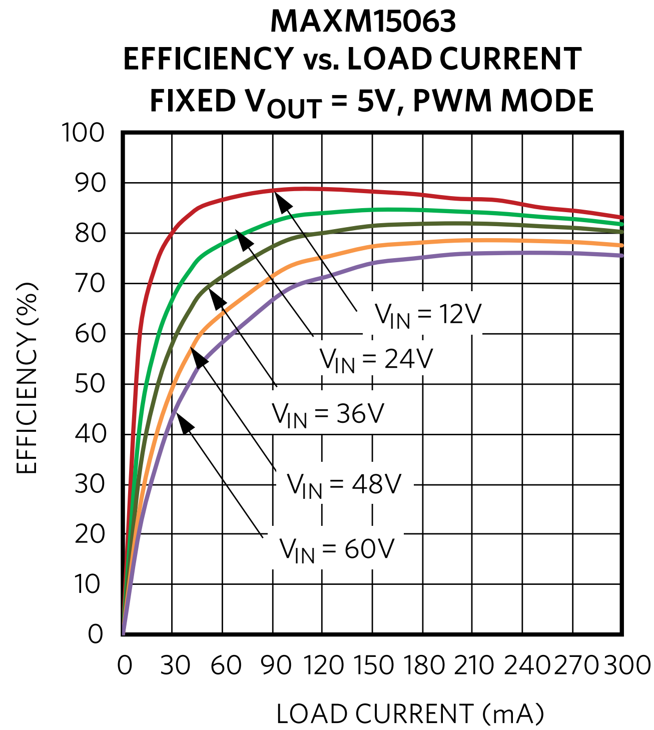

Figure 5. MAXM15063 efficiency vs. load current.

Protecting the Device from Faults

Like many other electronics that draw power from a vehicle battery, the asset-tracking/fleet-management device must be protected from common voltage surges such as load dump, regenerative braking, and long cable ringing. Load dump is an event where the battery cable is suddenly disconnected while the alternator is spinning, putting high energy back to the vehicle power cable where there is nothing to absorb it, causing high voltages that could destroy unprotected electronics. Regenerative braking occurs in an electric vehicle when the driver applies the brake—the vehicle kinetic energy is captured by the motor and sent back to charge the battery. Due to the high energy, high di/dt nature of regenerative braking, there will be high voltage ringing associated with this event.

Long cable ringing occurs when there is a high di/dt event such as plugging in a device to an on-board diagnostic connector. The surge current charging the device's on-board capacitors or backup battery will resonate with the cable's inductance, causing high voltage ringing. Longer cables with higher parasitic inductance will exhibit more severe voltage ringing. The new OBD-II standard dictates that the diagnostic connector be within 2ft (0.61m) of the steering wheel, while the main battery is far away under the hood or on a side of a truck. This new requirement makes the cable from the battery to the OBD-II connector longer and more prone to high voltage ringing.

Cable Ringing Causes High Voltage Faults

Figures 6 and **7** show a lab setup to demonstrate cable ringing. A 24VDC power source is used to represent a 24VDC battery from a truck. A 10-foot cable connects the power source to a 1µF ceramic capacitor to emulate an input capacitance of a fleet-tracking device.

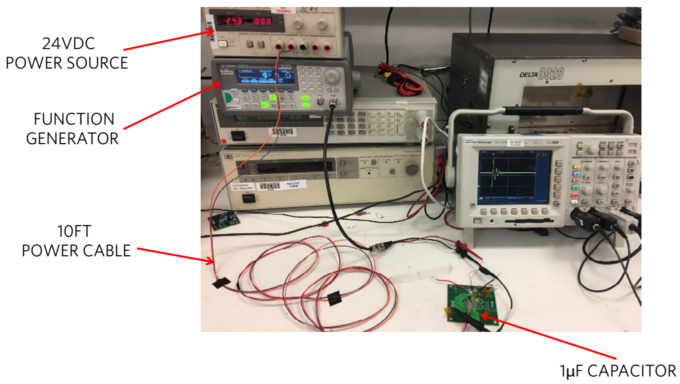

Figure 6. Cable ringing test setup.

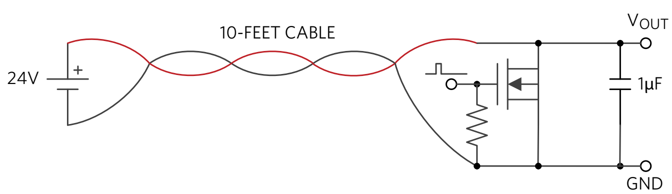

Figure 7. Cable ringing test circuit schematic.

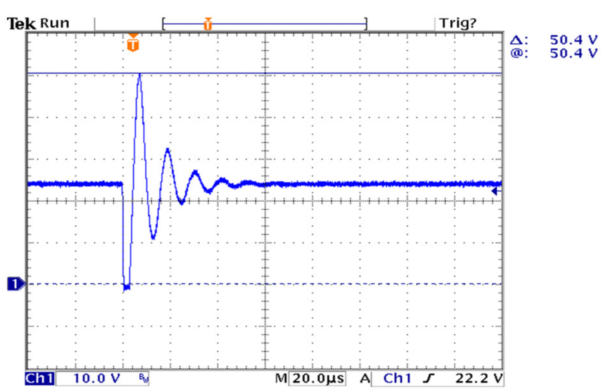

Figure 8. Cable ringing at initial plug-in.

Figure 8 shows our test result, where we emulate a brief short-circuit condition across the cable (commonly occur during a hot plug event) by switching on the power MOSFET at the output for a few microseconds. Once the short is removed, the short-circuit current built up through the cable parasitic inductance resonates with the board input capacitance. The peak ringing voltage is 50.4V, more than doubling the source voltage of 24V.

We use a 10ft cable in this experiment, which is a reasonable estimation of the truck cable length from its battery to an OBD-II connector, to demonstrate that the peak ringing voltage can easily double the input-voltage source. The high peak ringing voltage can occur at different cable lengths and at different device input capacitance. In fact, peak ringing voltage can be calculated as:

$$V_{PK} = I_{PK} \sqrt{\frac{L}{C}}$$

where I_{PK} is the peak short-circuit current, and $\sqrt{\frac{L}{C}}$ is the characteristic impedance of the system.

In this case, L is the cable parasitic inductance and C is the device input capacitance.

Other Faults

Electronic components can encounter short-circuit faults. Short-circuit and/or overcurrent protection circuitry is essential for preventing fire hazards, as well as isolating the power cable from a failed-short device.

When the ambient temperature become excessive or if there is an overcurrent or some other fault, the overtemperature protection prevents permanent damage by either scaling down the power dissipation or shutting down the device completely. Overtemperature protection prevents system overheating and fire hazards, and it ensures that the system operates within its defined temperature limits.

Reverse voltage faults occur when the battery is connected in reverse or the power cable is installed backwards. While unlikely to happen, reverse voltage faults usually cause expensive damage to the power cables and electronic devices connected to the cable without proper reverse voltage protection.

Implementing fault protection circuits with discrete components can be quite tedious, expensive, and not foolproof. The solution is large due to the high number of components. Verifying and guaranteeing the circuit performance over time and worst-case component tolerance can be a time-consuming task.

Figure 9 illustrates a modern protection IC from Maxim's Olympus family of devices, the **MAX17608** 60V/1A current limiter. This highly integrated IC packs all necessary protections into a single, tiny 3mm x 3mm, 12-pin TDFN package. This device is very simple to use, while providing a rugged solution to the asset-tracking device. Some of the MAX17608 features are:

- High input voltage tolerance (+4.5V to +60V operating range)
- Reverse voltage protection (tolerates -60V negative input voltage)
- Reverse current protection

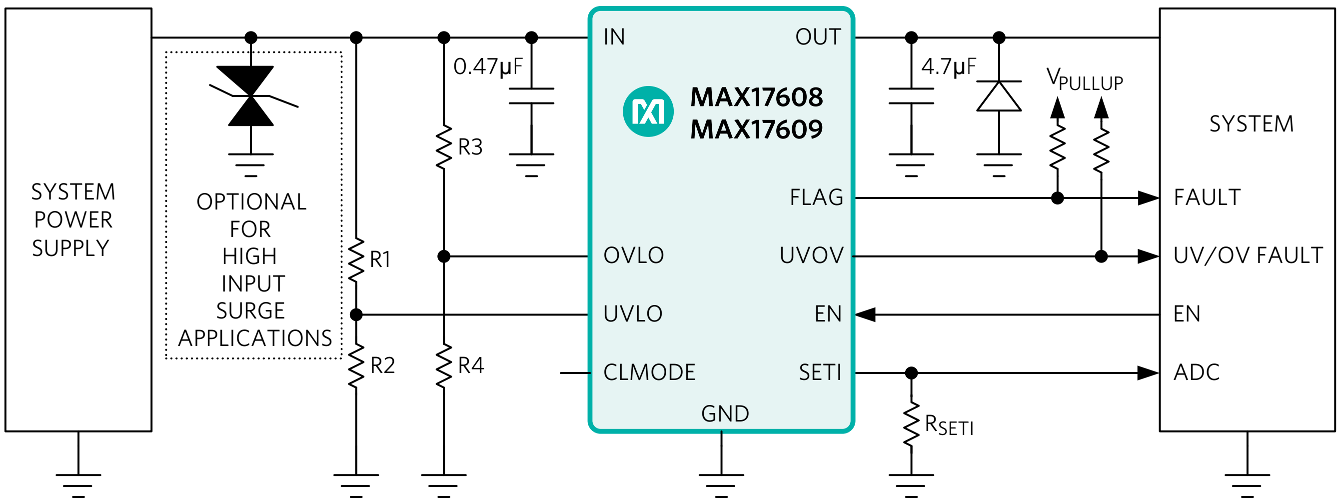

Figure 9. MAX17608 typical application schematic.

- Short-circuit overcurrent protection
- Adjustable OVLO, UVLO, startup current, and forward current limit
- Overtemperature protection

Figure 10 shows our asset-tracking device, powered by the MAX17608 protection IC and MAXM15062 and MAXM15063 uSLIC ICs.

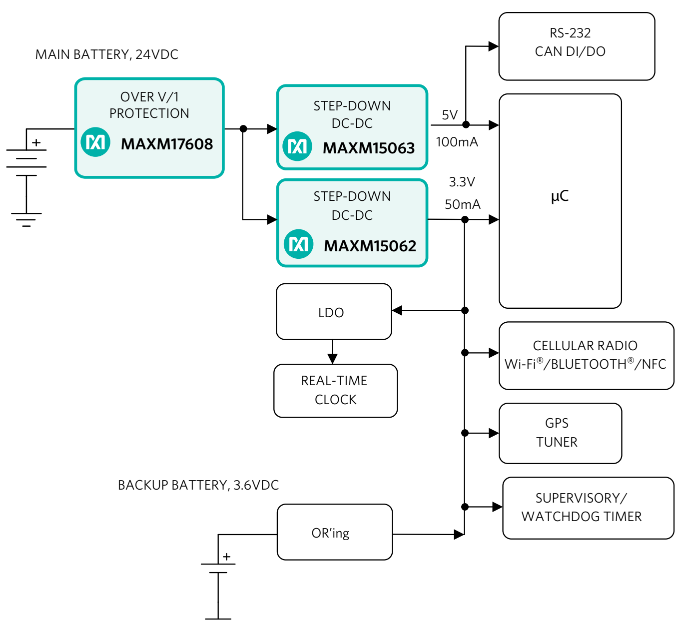

Figure 10. Asset-tracking/fleet-management device power block diagram.

Conclusion

Vehicular asset-tracking/fleet-management devices are designed to operate from the vehicle 12V/24V battery system and must fit in small places. They must be robust against transient conditions such as overvoltage, overcurrent, reverse voltage, reverse current, and overtemperature. Highly integrated protection ICs provide all of the above protections and simplify the design over discrete solutions. Highly integrated and efficient uSLIC power modules ensure fit, mitigate thermal dissipation challenges, and enhance the long-term reliability of the device.

Learn more:

MAX17608 4.5V to 60V, 1A Current Limiter with OV, UV, and Reverse Protection

MAXM15062 4.5V to 60V, 300mA Himalaya uSLIC Step-Down Power Module

MAXM15063 4.5V to 60V, 300mA Himalaya uSLIC Step-Down Power Module

Himalaya uSLIC Power Modules

Design Solutions

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