Application Brief

Enabling Ultra Low Quiescent Current Through LM74912-Q1 Sleep Mode While Powering Always On Loads

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Introduction

With the increase in demand for more feature-rich infotainment and ADAS subsystems in automotive applications, the complexity of electronic control unit is increasing every year. Ideal diode controllers that drive N-channel MOSFETs are selected over traditional P-channel MOSFETs for automotive reverse battery protection designs, with benefits such as thermal efficiency, smaller design size, and robust performance under various automotive transients defined by automotive standards such as ISO7637-2, ISO16750-2.

With back-to-back connected N-channel MOSFET control, additional functionalities such as inrush current limiting, overvoltage, and overcurrent protection can be realized to provide complete power path protection. Ideal diodes also feature a low-power shutdown mode which allows the system designer to turn off the controller to meet the low quiescent current budget requirements while the automotive system is in sleep mode (when the vehicle is turned off or parked). However there are always on loads which must be powered even when ignition is off. Monitoring and supervisor microcontrollers and surrounding power management components such as low dropout regulators, DC/DC converters, and memory devices are some of the examples of such loads.

This primarily helps monitor key system parameters when the system is in sleep mode, and faster system wake up when the system transitions from low power sleep mode to active mode. This application brief highlights the LM74912-Q1 sleep mode feature which powers Always On loads with system-level protection such as overvoltage and overcurrent protection, which helps maintain an ultra-low quiescent current consumption of 5 µA.

Typical ways to power up always on loads in sleep mode

Figure 1 shows typical ways to power up always on loads when the vehicle or automotive systems are in sleep mode.

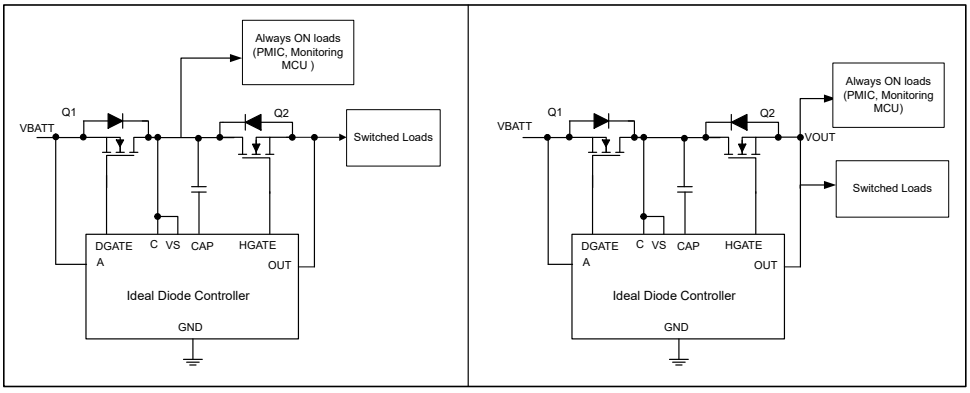

Figure 1. Typical Ways to Power Up Always On Loads

One of the simplest way to power up an always on load is to connect the load from common drain point of back-to-back connected MOSFETs. In this case, the ideal diode controller remains in a low-power state when in sleep mode, which disables both the DGATE and HGATE gate drives. Always on loads are powered through the body diode of an ideal diode MOSFET Q1. Although this technique can power an always on load, the technique does not offer any system-level protection such as overvoltage protection (in case of a vehicle jump-start) or overcurrent protection (in case of fault on the load side.)

Some of the automotive systems contain always on loads connected at the output of back-to-back connected MOSFETs. The sleep mode of LM74912-Q1 is specifically designed to power up an always on load connected at the output of back-to-back connected common drain topology MOSFETs.

LM74912-Q1 SLEEP Mode Functionality

The LM74912-Q1 supports low IQ sleep mode operation. This mode can be enabled by pulling the $\overline{\text{SLEEP}}$ pin low (EN = high). In sleep mode, the device turns off the internal charge pump and the software switch and disables the DGATE and HGATE drives, and as a result, achieves a low current consumption of 6 µA (typical). At the same time, the device powers up always on loads connected on the OUT pin through an internal low power MOSFET with a typical on-resistance of 7 Ω. In this mode, the device can support a peak load current of 140 mA.

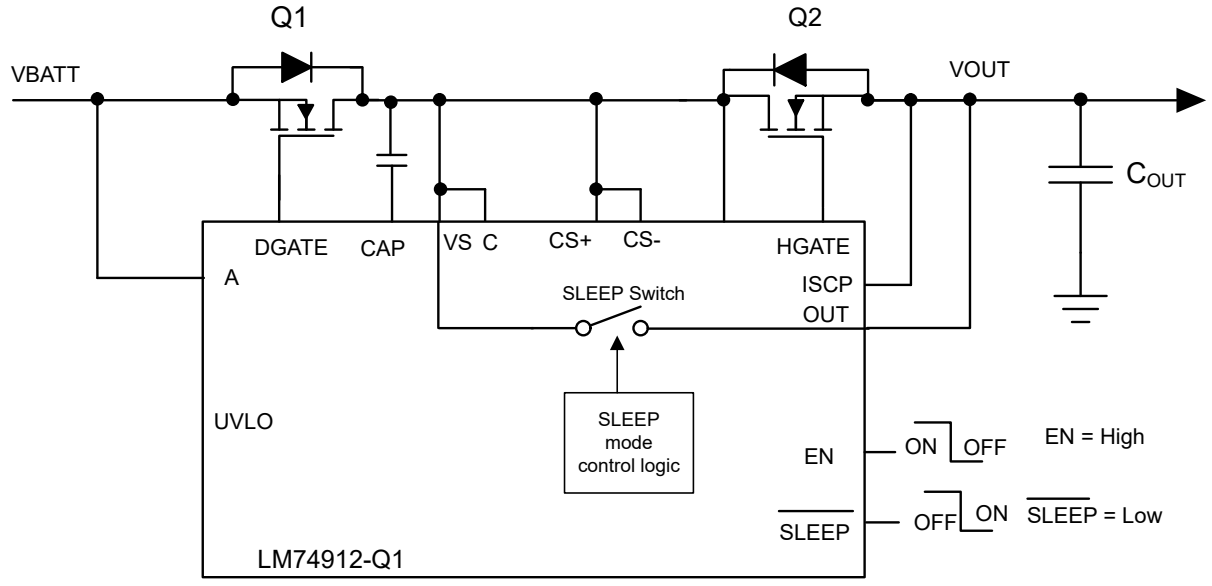

Figure 2. LM74912-Q1 Sleep Mode Typical Application Circuit

When the LM74912-Q1 device is in sleep mode, the device can provide the following types of system-level protection.

Overvoltage protection

In sleep mode, the LM74912-Q1 offers protection against input overvoltage events. The device can be configured in either overvoltage cutoff or overvoltage clamp mode with a default overvoltage threshold of 21 V (typical). In overvoltage cutoff mode (SLEEP OV pin connected to C), the bypass switch inside the device remains turned off unless VIN falls below the OV threshold. In overvoltage clamp mode (where the SLEEP OV pin is connected to the OUT pin), the output voltage is clamped around the overvoltage set point by hysteretic on and off control off the SLEEP mode FET.

To achieve a higher overvoltage threshold for sleep mode, add an external Zener diode between the SLEEP_OV pin to the OUT/C pin as shown in Figure 3. This feature is useful while configuring the overvoltage threshold for 24-V or 48-V powered systems.

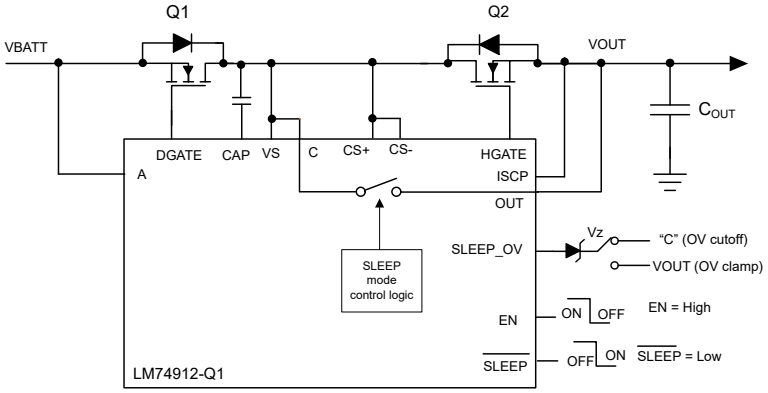

Figure 3. Adjustable Sleep Overvoltage Threshold using an External Zener Diode

Overcurrent protection

The LM74912-Q1 offers overcurrent protection during sleep mode with typical overcurrent threshold of 250 mA. In case of an overcurrent event during sleep mode, the device protects the internal FET by disconnecting the internal MOSFET switch and latching off the device.

Thermal shutdown protection

As an additional layer of protection, device also features thermal shutdown with a latch-off feature in sleep mode in case the device overheats in sleep mode. To turn off latch mode, the user must toggle the SLEEP or EN pin.

Conclusion

For applications that require accurate overcurrent protection with circuit breaker functionality, current monitoring output, and sleep mode, the LM74912-Q1 can be used to realize complete power path protection with sleep mode features. For additional information, Table 1 lists device recommendations.

Table 1. Alternate Device Recommendations

Device	Description
LM74900-Q1	Automotive ideal diode with circuit breaker, undervoltage, and overvoltage protection with fault output.
LM74910-Q1	Automotive ideal diode with circuit breaker, 200-kHz ACS, undervoltage and overvoltage protection.

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