Load Switch Technology has a Vital Role in Managing Power

Load switches are being adopted to play an important part in the management of power and protecting loads in systems large and small

By: Bryson Barney, Applications Engineer, ON Semiconductor

Power is the lifeblood of the technology that drives our modern world and, increasingly, we are reliant on high-tech products that assist us in our busy lives both in and away from the workplace. Managing and controlling power is an important topic for high tech, low-power applications. Whether it is developing a sophisticated multi-rail power system for a larger device, or utilizing the very last bit of energy from a battery powered device, power management is high on the agenda of designers.
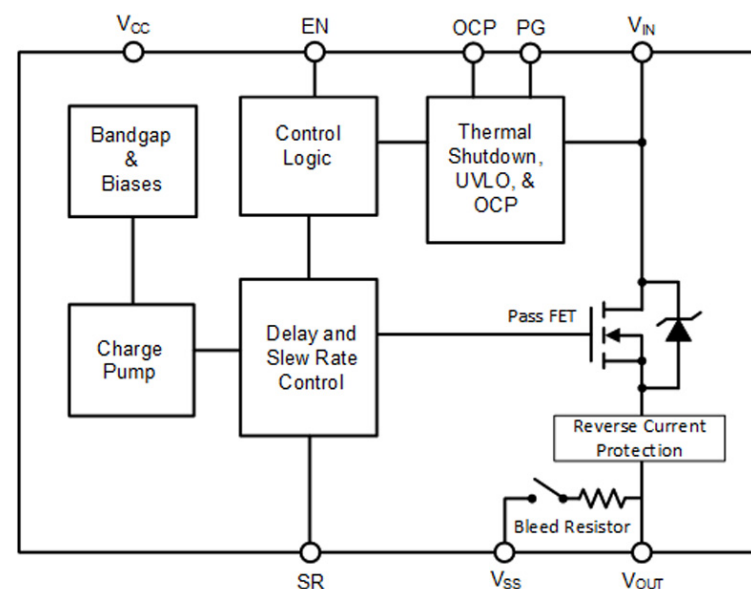
Load switches play an important part in the management of power and protecting loads in systems large and small. There are several considerations when selecting a load switch for a particular application and, in addition, several new devices with improved performance and capabilities are now available.

Integrated load switch devices
The principal function of any load switch is to connect / disconnect power to a load. This function can easily be achieved with a discrete solution using just a simple pass

Figure 1: Block diagram of a typical integrated load switch device

MOSFET; however, fully integrated load switch devices are generally smaller than discrete solutions, reduce component count, and offer far greater functionality including protection features such as detection and protection for over-temperature, under-voltage, and over–current fault conditions. A further protection that is sometimes included is reverse current protection where any current trying to flow from the load to the source is blocked. This is particularly useful for the latest USB-C standard

where power is delivery is used for many applications.

All integrated load switches include a minimum of four pins – V_{IN}, V_{OUT}, GND and EN (Enable) although other pins are often added to support additional functions and provide system outputs for the protection features as shown in **Figure 1**.

In addition to providing simple on / off control and protection, load switches are also able to control

the speed at which the load is turned on through controlling V_{OUT}. By controlling the charging of the FET gate, in-rush current is controlled, as is the rise time of V_{OUT}. This soft startup protects the load from current spikes that can be created by an uncontrolled connection of the load to the power source, especially if the load is not purely resistive.

Some load switches also incorporate a bleed resistor that allows for rapid discharge of any energy stored in the load, eliminating a floating node on the load's supply pin when the load switch is turned off.

Load switch system uses and configurations
One of the most common applications for load switches is managing separate power domains within a system. This control is particularly useful in battery-powered devices where preventing any unnecessary energy dissipation is critical to obtaining the maximum runtime from the battery.

Load switches can be used to control power to various sections of the system that are segmented into logical domains as shown in **Figure 2**. In practical use, sections that are only required for a brief amount of time such as sensors or transmit / receive circuitry would only be powered on for the short periods of time they are required to be active.
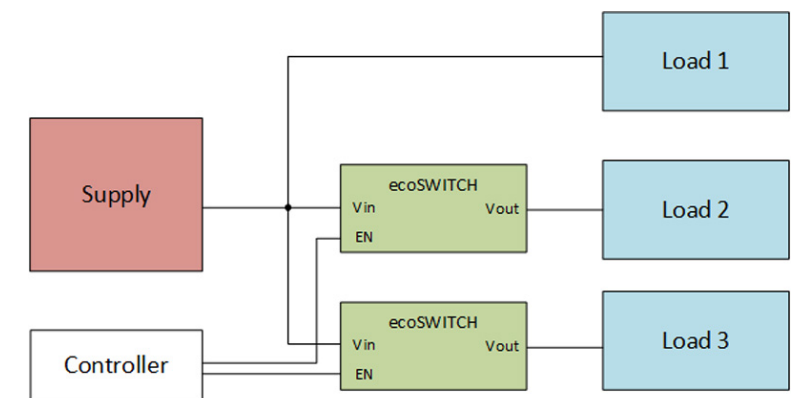
Additionally, load switches can be

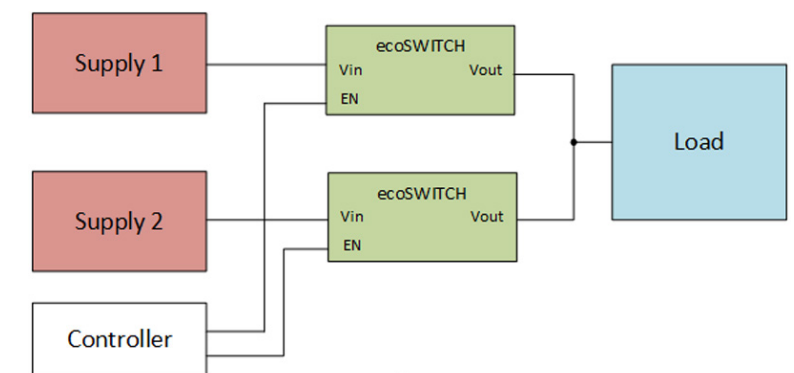*Figure 2: Load switches can manage power delivery across multiple load*

Figure 3: Power multiplexing allows a single load to benefit from multiple supplies

used in systems where there are multiple power sources for a single load as shown in **Figure 3**. Load power can be controlled in such systems to be delivered, for example, from either a main supply or a battery back-up supply.

Complex systems often require multiple power rails and, in many cases, these must be brought up in a certain sequence to facilitate proper operation of the system. For example, it may be necessary for a core processor to be fully booted up before the radio transmitter is enabled to avoid confus-

ing or unintelligible transmissions.

While power up sequencing can be achieved using an external microcontroller to enable the load switches with the correct timing, load switches can also provide sequencing stand-alone with use of a 'power good' output as shown in **Figure 4**. Multiple load switches can be 'daisy chained' by linking the Power Good pin of one load switch to the EN pin of the next. If a greater delay between phases is required, a capacitor can be added from the control line to ground to increase the delay.
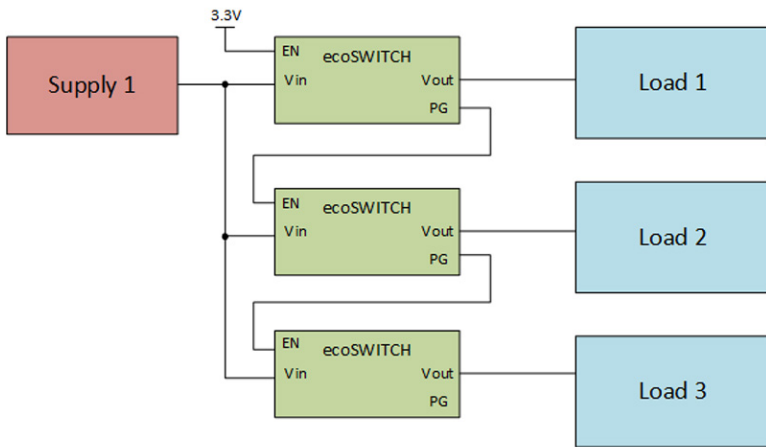
Figure 4: Load switches can facilitate self-driven power sequencing

Selecting the correct load switch for an application

There are many types of load switches currently available, giving designers a wide choice when selecting a device for a particular application. While at first the choice may seem daunting, by considering six primary parameters it is a relatively simple task to assess the options and find the best device.

Energy efficiency is important and often a key reason for employing a load switch in an application. Designers should pay close attention to the R_{ON} resistance of a device under consideration. The lower the switch's resistance, the lower the voltage drop from V_{IN} to V_{OUT} when operating and, consequently, the lower the power loss and heat dissipated in the load switch.

The device needs to be correctly rated for the application in terms of the maximum permissible load current and the input voltage (V_{IN}) range. While ensuring that the current rating is adequate for the application, care should be taken not to over-specify this rating as larger FETs have higher gate capacitance, requiring more energy to turn on. In addition, a higher rated device is also likely to be larger and more expensive.

The quiescent current (energy used when the load switch is on) should be as low as possible as should any leakage current (current from source to load while the load switch MOSFET is off).

Finally, for certain applications the response speed is critical in terms of the time taken to switch on / off as well as for the timing of any fault protection operation. This response time is affected by the size of the MOSFET with larger devices requiring more charge and consequently being slower to operate. Again, over designing with too large of a FET could lead to poorer transient performance.

ecoSWITCH - A comprehensive range of load switches

The ecoSWITCH series of load management devices from ON Semiconductor provide best-in-class R_{ON} resistance currently available to designers. The series comprises of over 20 different offerings and is continuing to grow as ON Semiconductor releases new load switch devices.

The NCP45560 device is just one example of the performance available from the ecoSWITCH series. The device is housed in a space-saving 3 mm x 3 mm DFN12 package yet is capable of switching currents up to 24 A continuously and efficiently with R_{ON} values as low as 4.1 mΩ. Ideal for power management and hot swap applications that require a small footprint solution, the NCP45560 incorporates a number of protection features while offering a significant space and cost saving over discrete solutions.

Summary
As power requirements become more complex and the need to operate small, portable battery powered devices as efficiently as possible grows, load switches are becoming more popular, allowing designers to implement highly efficient and sophisticated power schemes even in the smallest of devices.

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Burst-Mode Operation: A Double-Edged Sword

Smart strategies can avoid adverse, and often unforeseen, effects on RF emissions and end-product compatibility

By: Dylan Howes, Applications Engineer, TT Electronics

In response to ever evolving power supply efficiency standards, power supply manufacturers are using burst-mode operation (amongst a sea of other energy saving strategies) to decrease the standby power consumption of external power adaptors. Efficient conversion techniques do not come without some cost. Burst-mode operation can have adverse, and often unforeseen effects on RF emissions and on end-product compatibility. This article will provide a brief overview of the potential issues and some possible solutions.

When the Department of Energy (DoE) put its now familiar Level VI efficiency requirements into place in 2016, electronic equipment manufacturers around the globe needed to react – adopting new strategies designed to meet stringent new requirements for average-active-mode efficiency and for quiescent power consumption. Now, as Code of Conduct (CoC) Tier 2 legislation nears adoption in the European Union, a similar industry trend is taking hold.

The new legislation will require no-load input power for some external adaptors to stay below a mere 75mW, and will also specify a challenging efficiency target for operation at 10% of rated load. Meeting either of these mandates is no small feat for a power supply, and utilization of burst-mode operation will continue to prove essential in designs going forward.

Burst-mode is an operational mode whereby the power supply control circuit and switching circuit (and sometimes additional features) are intermittently disabled when the direct current (DC) load is particularly light, or absent. The feature can be thought of as a gating signal with a duty cycle that is proportional to the load
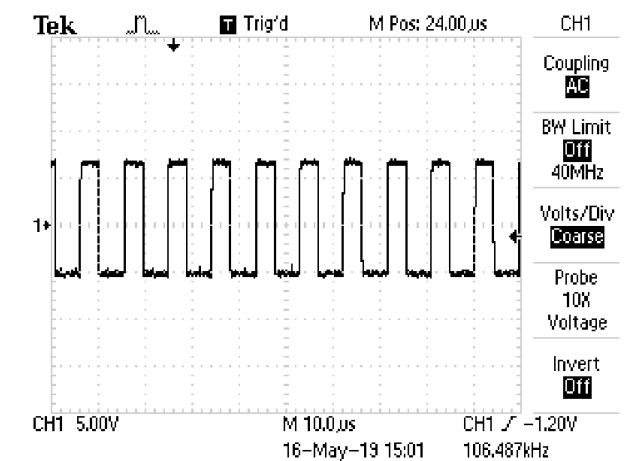

Figure 1: The Vg waveform under relatively heavy, resistive loading. (f=100kHz)

superimposed upon the standard pulse-width modulation (PWM) switching signal, which itself is essentially a pulse train with an on-time that is proportional to the instantaneous DC load. The burst-mode "gating signal" simply has a much longer period, such that several of the PWM pulses occur during a single "burst." Relatively speaking, a lot of energy is lost when a metal-oxide semiconductor field-effect transistor (MOSFET) switches states, which happens during every cycle of standard switch-mode power supply (SMPS) operation. These losses