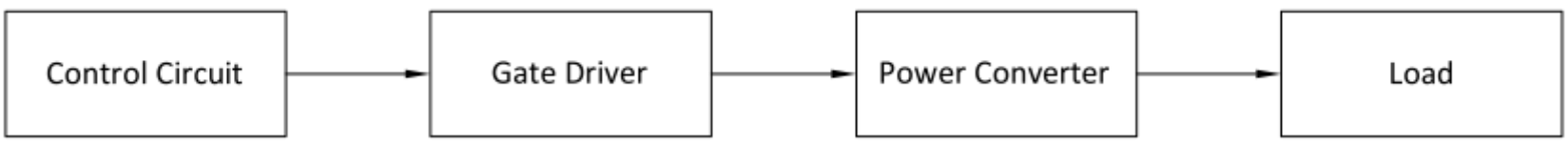
Gate Drivers for Power Electronics

In high power applications, the gate of a power switch can never be driven by the output of a logic IC (PWM controller). Because of the low current capabilities of these logic outputs, charging the gate capacitance would require an excessive amount of time, most likely longer than the duration of a switching period. Hence **dedicated drivers must be used to apply a voltage and provide drive current to the gate of the power device.** This can be a driver circuit and it may be implemented as dedicated ICs, discrete transistors or transformers. It can also be integrated within a PWM controller IC.

A **gate driver** is a power amplifier that accepts a low power input from a controller IC and produces the appropriate high current gate drive for a power device. It is used when a PWM controller cannot provide the output current required to drive the gate capacitance of the associated power device.

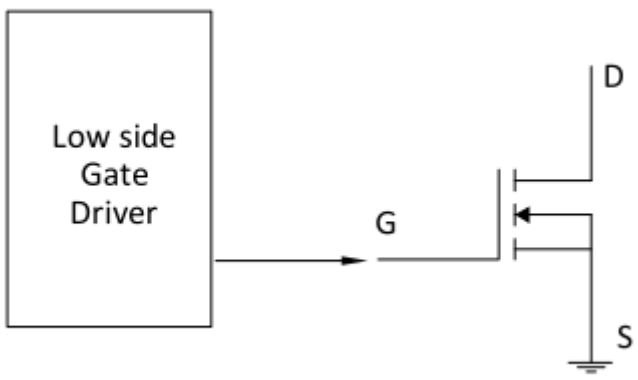


Generalized layout of power electronic system

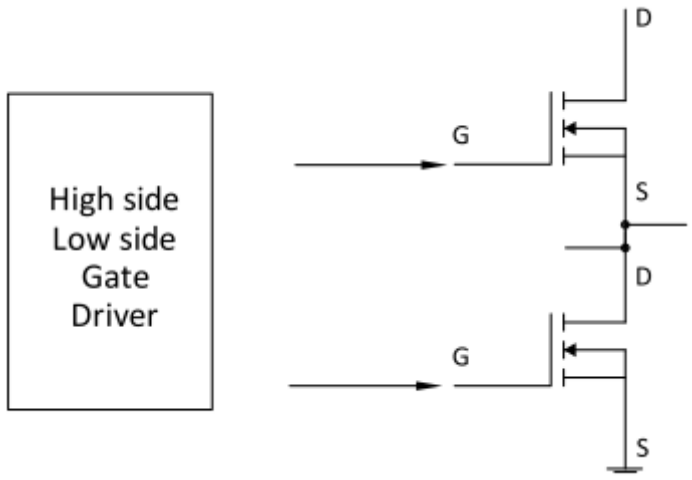
The gate driver circuit is an integral part of power electronics systems. Gate drivers form an important interface between the high-power electronics and the control circuit and are used to drive power semiconductor devices. The output of DC-DC converters or SMPS mainly depends on the behavior of gate driver circuits, which means if the gate driver circuit doesn't drive the gate of a power device properly, the DC-DC converter output will not be according to the design requirement. Therefore, the design of the gate driver circuit is critically important in the designing of power electronic converters.

Types of Gate Drivers

Low-Side Drivers — Used to drive ground referenced switches (low side switches).



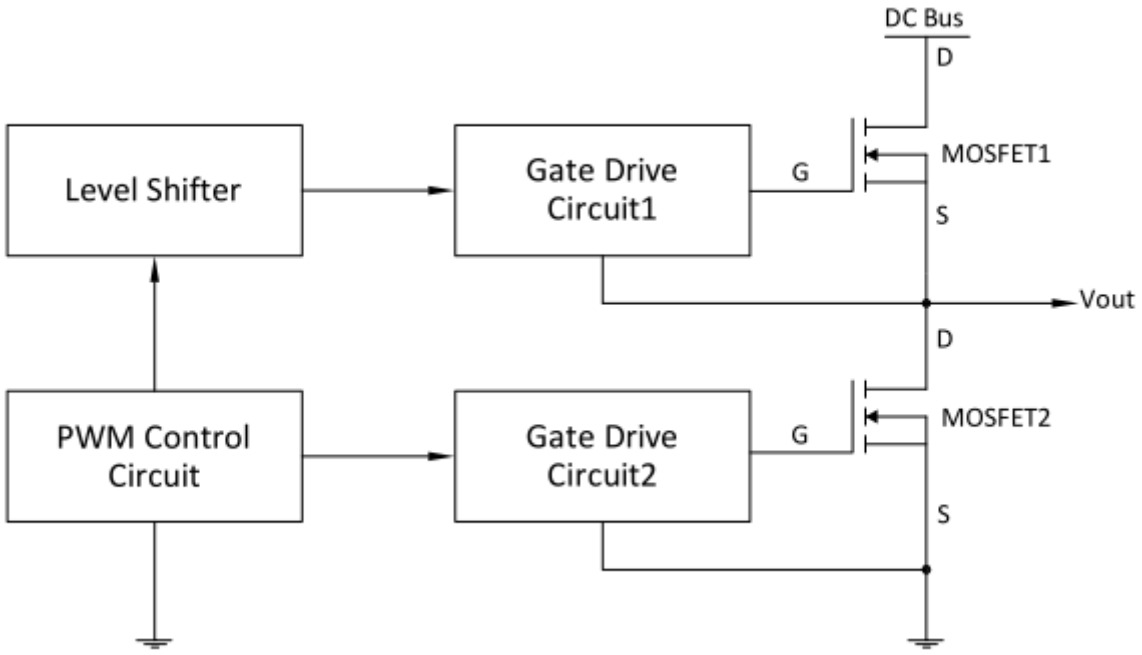
High-Side-Low-Side Drivers — Used to drive two switches connected in the bridge arrangement (both floating & ground referenced switches).



Gate Driver Isolation

Gate drive circuits for power inverters and converters often require electrical isolation for both functional and safety purposes. Isolation is mandated by regulatory and safety certification agencies to prevent shock hazards. It also protects low voltage electronics from any damage due to faults on the high power side circuit and from human error on the control side. The electrical separation between various functional circuits in a system prevents a direct conduction path between them and allows individual circuits to possess different ground potentials. Signal and power can still pass between isolated circuits using inductive, capacitive or optical methods.

Many applications of power devices (e.g., converters where high power density and high efficiency are required) require an isolated gate drive circuit. For example, in power converter topologies such as half-bridge, full-bridge, buck, two-switch forward, and active clamp forward, there are high *and* low switches because low side drivers cannot be used directly for driving the upper power device. The upper power devices require an isolated gate driver because the source and emitter of the upper devices are not sitting at the ground potential (floating).



In a simple bridge topology structure with a driving circuit as shown here, the source terminal of switch 1 can be floating anywhere from ground to DC bus potential. Therefore two things are needed for driving high side switches:

1. **Floating supply** — to provide power to any circuitry associated with this floating midpoint potential.
2. **Level shifter** — to convey the PWM control signal to the floating driver circuitry.

Isolation Techniques

Basically, there are two popular techniques available to implement isolated gate drivers: **magnetic** (using gate drive transformers) and **optical** (using an optocoupler). Our next few articles will focus on the magnetic isolation technique, specifically the characteristics and design requirements for gate drive transformers.