Technical Article

Gate Drive Transformer vs. High/low Side Driver: Which Way to Go for Power Supply Design?

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In a typical close-loop power-electronics system, the gate driver is the key interface between the control system (normally a low voltage like 12V) and the main power stage (normally a high voltage like 400V_{DC}). The gate driver's purpose is to translate the input low-voltage control pulse signal to the power transistor (MOSFETs, IGBTs) in a clean, robust and timely manner.

In this blog series, I'll take a look at two ways to drive high-voltage transistors: the gate-drive transformer and the high-voltage driver IC, and illustrate the strengths and weaknesses of each.

The key specifications defining the performance of the gate driver are:

- Static characteristics: functional voltages ($V_{CC/DD}$, bootstrap function), peak source/sink current and UVLO.
- Dynamic characteristics: propagation delay, delay matching, pulse-width distortion, common-mode transient immunity (dv/dt) and rising/falling time.

You will also need to consider safety standards and compliance – protecting human operators from hazardous voltage/currents higher than 42.4V_{pk} AC or 60V_{DC}. For example, in cellphone chargers, the low-voltage DC output is insulated from the universal AC input (85~265V_{AC}) where double or reinforced insulation is necessary to eliminate the need for a grounded metal enclosure as well as a grounded power plug. Table 1 shows the test voltages requirement (IEC 61010-1 ed. 3.0) for solid insulation in the main circuits of Overvoltage Category II up to 300V.

Table 1. Test Voltages for Solid Insulation in Main Circuits of Overvoltage Category II

Voltage Line-to-neutral (AC rms or DC) (V)	1min AC Test Voltage		1min DC Test Voltage	
	Basic Insulation and Supplementary Insulation (V)	Reinforced Insulation (V)	Basic Insulation and Supplementary Insulation (V)	Reinforced Insulation (V)
⩽150	1350	2700	1900	3800
>150, ⩽300	1500	3000	2100	4200

Figure 1 is a simplified circuit diagram with the controller sitting on the secondary side (secondary-side control). The main power-stage insulation is based on a conventional power transformer. You can use two major types of gate drivers to transmit the gate-drive signals with insulation between feedback control in the secondary-side and primary-side gate driver:

- A gate-drive transformer (see Figure 2[a]) with insulation by magnetic coupling.
- A high- and low-side gate driver with signal-isolator interface (see Figure 2[b]). The signal isolator interface could be an optocoupler (optocoupling) or digital isolator (magnetic or capacitive coupling).

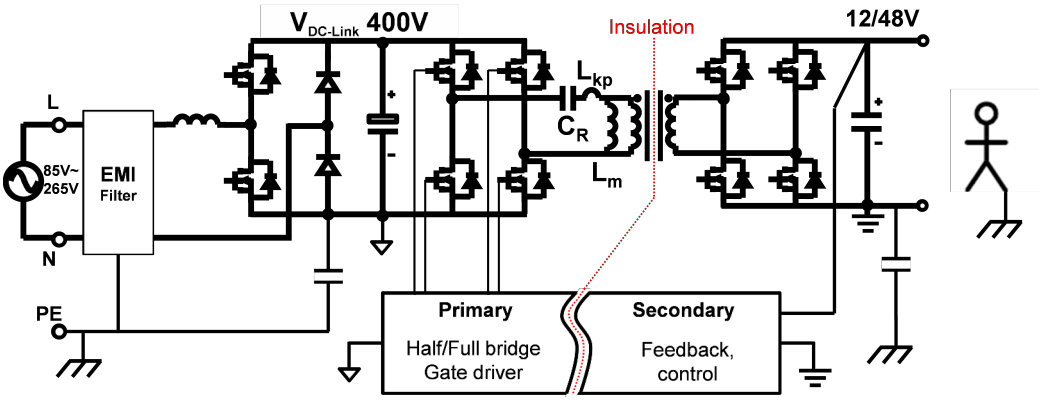

Figure 1. Simplified Circuit Diagram with Secondary-side Control

The gate-drive transformer can deliver both the logic gate-drive signal and required gate driver required peak current/power capability.

A high- and low-side gate driver uses a signal isolator interface to provide the required insulation and uses gate-driver ICs to provide enough gate-drive power/current capability.

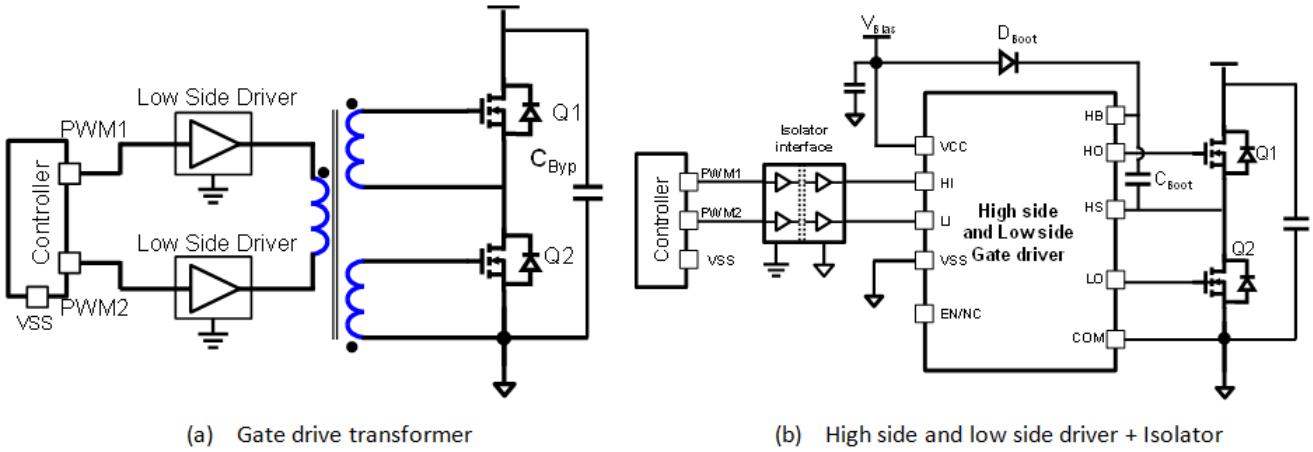

Figure 2. Simplified Circuit Diagrams (a) Gate Drive Transformer (b) High and Low Side Driver + Isolator

Table 2 lists the key components required for each implementation. A gate-drive transformer uses the UCC27324 as the low-side driver with two-channel I_{pk}=±4A capability to drive the gate-drive transformer and the GA3550 from Coilcraft with reinforced insulation. A high- and low-side gate driver plus isolator uses the ISO7520C dual-channel digital isolator to provide reinforced isolation, the UCC27714 as the high- and low-side gate driver, and Vishay MURS360 as the bootstrap diode.

			W (mm)	L (mm)	H (mm)	Area (mm^2)	Vol (mm^3)
Type I: Gate Drive Transformer	1	**UCC27324**	5	6.2	1.75	31	54.25
	2	**GA3550-BL**	17.4	24.13	10	419.862	4198.62
Required PCB Minimum Area for Type I					**SUM**	**450.862**	**4252.87**
Type II: Isolator + High side and low side driver	1	**ISO7520C**	10.5	10.6	2.65	111.3	294.945
	2	**UCC27714**	8.75	6.2	1.75	54.25	94.9375
	3	**MURS360T3G**	8.1	6.1	2.4	49.41	118.584
Required PCB Minimum Area for Type II					**SUM**	**214.96**	**508.467**

Take a look at about the total required PCB minimum area in Table 2: Type II (a high- and low-side driver plus isolator) takes only 215mm^2 , and will save over 50% of PCB space over type I. And the volume savings will be more significant considering the awkward height of the reinforced insulation gate-drive transformer.

Moreover, this calculation is only counting the major components. When considering the signal conditioning circuit, the savings of Type II over Type I will increase.

Stay tuned for the next installment of this series, when I'll discuss the strengths and weaknesses of each driver.

Additional Resources

- Check out TI's new high-speed, 600V high-side low-side gate driver with 4A peak output.
- Check out detailed safety considerations in this paper from IEEE "Safety Considerations in Power Supply Design"

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