Tech Note

Understanding and Comparing Peak Current Capability of Gate Drivers

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This tech note explains how to evaluate the gate drive strength (peak output current) of different gate drivers, factors affecting the peak source and sink current, and how it affects the performance of the system.

Gate drivers are used to drive power switches such as MOSFET, IGBT, and GaN, mostly in circuits where controllers are not capable of directly driving these power switches due to lack of peak source and sink current. Most gate driver datasheets specify typical drive current capability in a simple manner as shown in table below.

PARAMETER	CONDITION	MIN	TYP	MAX
$I_{Peak\ pull\text{-}up}$	V_O= 0V		1.6A	
$I_{Peak\ pull\text{-}down}$	V_O= 12V		1.6A	

This is helpful for general understanding, but comparing two or more gate drivers only based on these typical values may not yield optimum system performance or even optimum cost of the design. It is important to note at what test condition this peak current is specified. Some gate drivers yield higher typical drive current at higher bias voltage. Thus, a gate driver that is specified as 2.5A at 12V cannot be compared directly with a gate driver that specifies 3.5A at 16V. It should also be noted that the switching losses will increase with higher bias voltage, and thus even though the drive current is higher, the system efficiency may reduce.

Power supply design engineers need minimum and maximum values of most parameters across the operating temperature range to optimize their designs. When drive current is specified as a typical value, the $R_{DS(on)}$ of the output stage of the gate driver may be used to estimate drive current variation and may also be used to compare multiple gate drivers. When comparing $R_{DS(on)}$, care should be taken that the test conditions are the same. $R_{DS(on)}$ is either specified directly or can be derived from the output voltage and test current specification as $R_{DS(on)} = V_O / I_O$, from the valuse show in the table below. Here it should be noted that only two same types of output structures can be compared this way.

PARAMETER	CONDITION	MIN	TYP	MAX
V_{OL}, Low level output	I_O= 100mA		0.1V	0.4V
V_{OH}, High level output	I_O= 100mA		0.1V	0.4V

Similar to bias voltage, the ambient temperature also affects the drive current of the gate driver. To understand and optimize the system performance it is also important to evaluate the output voltage variation across bias supply and across temperature. As can be seen from Figure 1, $R_{DS(ON)}$ of the output stage of the UCC27282 does not get affected by bias voltage irrespective of the operating temperature. It means that even at lower bias voltage the drive current capability does not change significantly. Good drive current capability at lower bias voltage results in reduced switching losses and therefore better efficiency.

$$Psw = Vbias \times Qg \times Fsw$$

Where,

Psw = Gate driver switching loss per channel

Qg = Total gate charge of power MOSFET

Fsw = Power stage switching frequency

Good drive strength at lower bias voltage also enables increase in switching frequency of the power stage, which in-turn will reduce the size, weight, and cost of magnetics in the system.

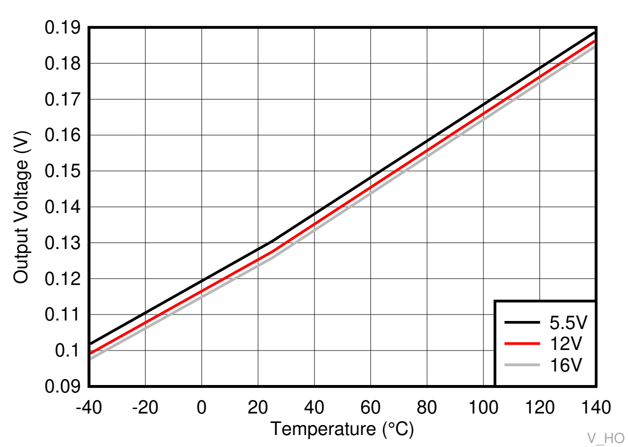

Figure 1. UCC27282 Output Voltage

It is also important to note that even at high temperature, the drive strength is not reduced significantly. At high temperature, power MOSFET internal gate resistance increases which can slow down the turn-on and turn-off. Slow turn-on and turn-off of power MOSFET may result in increased switching losses. Therefore, when comparing two gate drivers, it is important to note the drive current capability at maximum recommended operating temperature.

As mentioned earlier, the primary purpose of the gate driver is, to turn-on and turn-off the power device efficiently. The direct measure of this capability is the rise and fall time specification of the gate driver. Therefore, when comparing multiple gate drivers, it is necessary to compare this specification more so than to compare the typical peak pull-up and pull-down current specification. The test condition needs to be the same for all the gate drivers being compared.

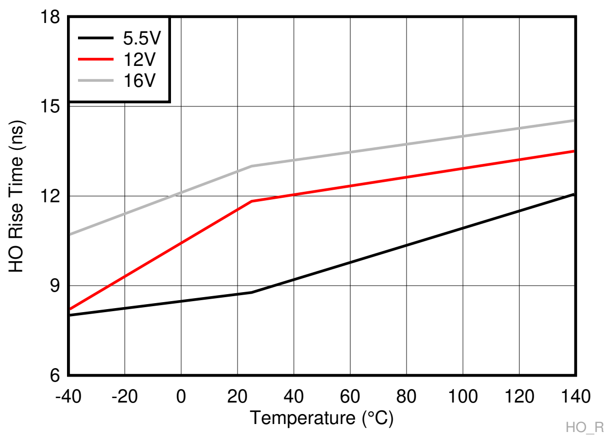

Figure 2. UCC27282 Rise Time (C_L=1800pF)

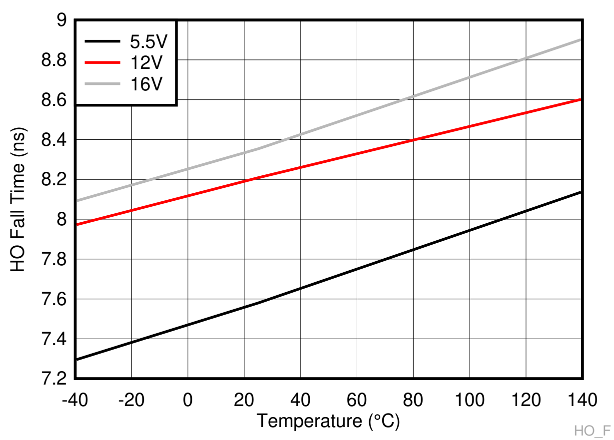

Figure 3. UCC27282 Fall Time (C_L=1800pF)

Power device gate charge is not a perfectly linear load. In other words for different gate charge devices the rise time and fall time may not scale linearly for the same drive current. This is shown in Figure 4 below. The rise time and fall time at 100nF load is different than the linearly scaled values. Therefore, when comparing multiple drivers for drive current, it is important to closely look at the rise and fall time of the gate driver at the load of interest.

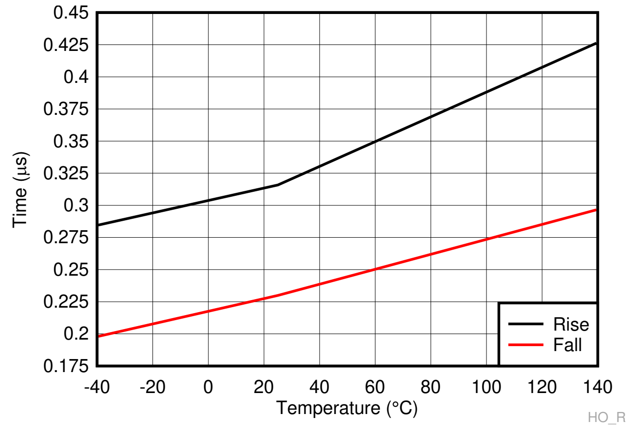

Figure 4. UCC27282 Rise/Fall Time (C_L=100nF)

The better way to compare the performance of the multiple gate driver ICs is to test them in the same application board. But, many times it is not possible and therefore all the elements that affect the turn-on and turn-off of the power device need to be understood. One key element that has not been discussed so far is an external gate resistor that is used between the output of the gate driver IC and the power device. The value of this gate resistor greatly affects the performance of the system. For example, if the system uses a 20Ω external gate resistor then the performance of the system might not be significantly affected whether a 2A or 3A gate drive is used at 10V of bias voltage. It should also be noted that even if there is a difference in system performance due to relatively big difference in the drive current capability, this difference can be compensated by adjusting the gate resistor value. For example, 10Ω gate resistor for a 3A driver can be changed to a lower value resistor for a 2A gate driver or higher value resistor for a 4A driver, to achieve the same rise and fall time of the power device.

In summary, design engineers need various factors to compare multiple gate drivers' drive strength. These factors are type of switching power device, gate charge of the power device, external gate resistor, test conditions, bias voltage, and operating temperature.

Related UCC2728x devices

Device	Interlock	Enable	Diode	UVLO
UCC27282	Yes	Yes	Yes	5V
UCC27284	No	Yes	Yes	5V
UCC27288	No	No	No	8V
UCC27289	No	No	Yes	8V