

# Understanding Peak Source and Sink Current Parameters

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Gate drivers are often confused as continuous current sources because of the  $I_{OH}$  and  $I_{OL}$  specifications in the datasheet. For example, designers looking at the UCC5320SC might read the parameters 4.3-A source and 4.4-A sink and mistakenly believe these devices are capable of providing these currents continuously. Gate drivers do not need to provide constant current because they only have to source/sink current when switching the gate of the MOSFET or IGBT. Refer to [Figure 1](#) for the turn-on waveforms.

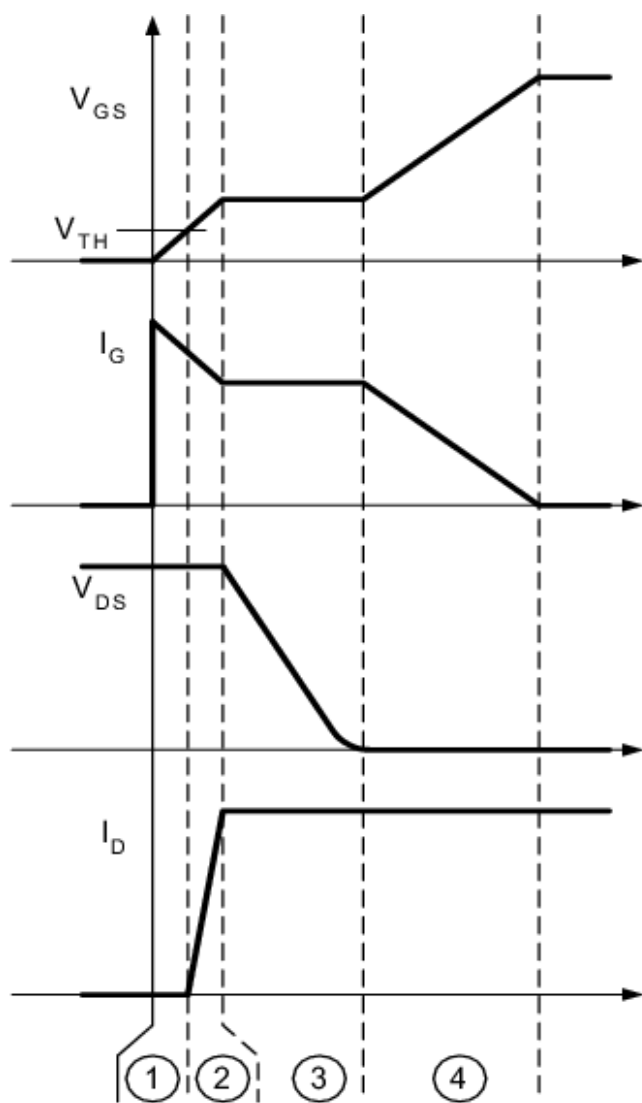


Figure 1. MOSFET Turn-On Time Intervals

In order to understand the  $I_{OH}$  and  $I_{OL}$  specifications, we need to look at the pull-up and pull-down structures inside the device. The output stage of a gate driver typically comes in some variation of [Figure 2](#). UCC5320SC is offered in a split output pinout that gives designers more control of the rise and fall times without adding extra components like schottky diodes.

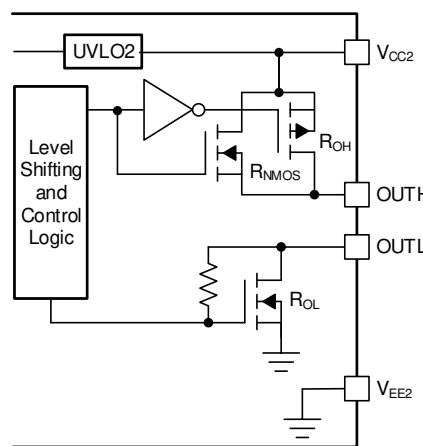


Figure 2. Gate Driver Output Stage

Under a no load condition,  $I_{OH}$  is determined by  $V_{CC2}$  and the parallel combination of  $R_{NMOS}$  and  $R_{OH}$  while  $I_{OL}$  is set by  $V_{CC2}$  and  $R_{OL}$ .  $R_{NMOS}$  helps the pull-up structure deliver the peak current with a brief boost in peak-sourcing current during the Miller plateau region shown as interval 3 in [Figure 1](#). This is done by turning on the N-channel MOSFET during a narrow instant when the output is changing states from low to high.

When driving MOSFETs and IGBTs high, the external gate resistor  $R_{ON}$  and the transistor's internal gate resistance  $R_{GFET\_Int}$ , reduce the peak output current as shown in [Equation 1](#).

$$I_{OH} = \min \left( 4.3 \text{ A}, \frac{V_{CC2}}{R_{NMOS} \parallel R_{OH} + R_{ON} + R_{GFET\_Int}} \right) \quad (1)$$

Likewise, the peak sink current is limited by the external gate resistor  $R_{OFF}$  in series with  $R_{OL}$  and  $R_{GFET\_Int}$  and is determined by [Equation 2](#)

$$I_{OL} = \min \left( 4.4 \text{ A}, \frac{V_{CC2}}{R_{OL} + R_{OFF} + R_{GFET\_Int}} \right) \quad (2)$$

This TI TechNote will use the isolated single-channel gate driver, UCC5320SC and a 100-nF capacitive load to demonstrate different techniques to determine the peak drive current. The first method calculates the expected peak currents based on Equation 1 and Equation 2. Use these equations to estimate the peak drive current when selecting a gate driver for your system.

In order to simulate driving a MOSFET or IGBT before installing it onto the PCB, select a load capacitor that is equivalent to the switch's input capacitance,  $C_{ISS}$ . Determine the input capacitance by looking up the required gate charge from the MOSFET or IGBT's datasheet at the drive voltage condition.

A second technique uses this  $C_{ISS}$  value and the  $dV/dt$  of the switching waveform to determine the source or sink current. Figure 3 measures the  $dV/dt$  using cursors set to a fixed 35-ns interval and swept across the rising edge in order to find the peak  $dV/dt$ . As a guideline, set the oscilloscope's cursors to a time interval,  $\Delta t$  of approximately 10% of the rise time to determine the current through the load capacitor.

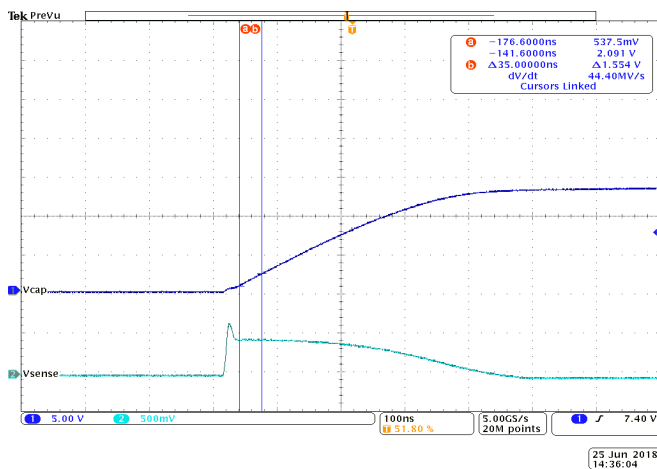


Figure 3. Measuring Peak  $dV/dt$  Across Load Capacitor

Use the measured peak  $dV/dt$  and load capacitor value along with Equation 3 to calculate the peak current.

$$I_C = C \frac{dV}{dt} \quad (3)$$

A third method inserts a 0.1- $\Omega$  sense resistor between the capacitor and ground to calculate  $I_{OH}$  or  $I_{OL}$ . Figure 4 shows the voltage waveform across the sense resistor,  $V_{SENSE}$  and its measurement coincides with the highest  $dV/dt$  value of the  $V_{cap}$  waveform.

The results of the three presented techniques are shown in Table 1. Even with the 0.1- $\Omega$  sense resistor in series with the capacitor, Equation 1 predicts 4.30-A sourcing current. Equation 3 uses the largest measured  $dV/dt$  value in the linear region of the gate drive waveform which gives an estimated 4.53-A. In this same linear region, the voltage across the sense resistor is measured in Figure 4 and Ohm's law is used to determine peak  $I_{OH}$  at 4.29-A.

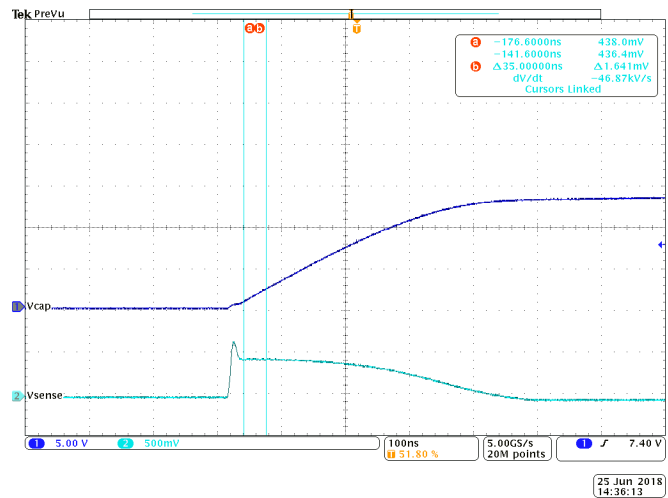


Figure 4. Voltage Across Series Sense Resistor

The first method is a good starting point when selecting a gate driver but it is not an actual measured value. The second method relies on the engineer to accurately measure the highest  $dV/dt$  by using a fixed  $\Delta t$  and sweeping it across the waveform. Lastly, the voltage measured across the 0.1- $\Omega$  sense resistor will give the engineer a value calculated from measurement of the peak drive current using Figure 4 and Ohm's law. The key to the third measurement technique is to select a small valued sense resistor to prevent any limitations in the peak output current. All presented methods are acceptable approximations of a gate driver's peak output current.

To reiterate,  $I_{OH}$  and  $I_{OL}$  are not continuous DC values. The peak current charges or discharges  $C_{ISS}$  in an instant and then reduces in value as the switch begins to turn on.

Table 1. Measurement Comparison

Theoretical vs. Measured	Method	Result
Theoretical	Equation 1: $I_{OH} = \min[4.30A, 4.44A]$	4.30A
Calculated from Measurement	Equation 3: $I_C = 102nF(44.4MV/s)$	4.53A
Calculated from Measurement	Ohm's Law: $I_{OH} = 438mV/102m\Omega$	4.29A

## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Original (June 2018) to A Revision</b>	<b>Page</b>
• Added additional Gate Driver detail. ....	<b>1</b>

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