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.

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.

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.

$$I_{OH} = \min \left( 4.3 \frac{A}{R_{NMOS} \parallel R_{OH} + R_{ON} + R_{GFET\_int}}, V_{CC2} \right)$$  \hspace{1cm} (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.

$$I_{OL} = \min \left( 4.4 \frac{A}{R_{OL} + R_{OFF} + R_{GFET\_int}}, V_{CC2} \right)$$  \hspace{1cm} (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, \( C_{\text{ISS}} \). 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 \( C_{\text{ISS}} \) value and the \( \frac{dV}{dt} \) of the switching waveform to determine the source or sink current. Figure 3 measures the \( \frac{dV}{dt} \) using cursors set to a fixed 35-ns interval and swept across the rising edge in order to find the peak \( \frac{dV}{dt} \). 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 \( \frac{dV}{dt} \) Across Load Capacitor

Use the measured peak \( \frac{dV}{dt} \) and load capacitor value along with Equation 3 to calculate the peak current.

\[
I_C = C \frac{dV}{dt}
\]  
(3)

A third method inserts a 0.1-\( \Omega \) sense resistor between the capacitor and ground to calculate \( I_{\text{OH}} \) or \( I_{\text{OL}} \). Figure 4 shows the voltage waveform across the sense resistor, \( V_{\text{SENSE}} \) and its measurement coincides with the highest \( \frac{dV}{dt} \) value of the \( V_{\text{cap}} \) 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 \( \frac{dV}{dt} \) 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 \( I_{\text{OH}} \) at 4.29-A.

<table>
<thead>
<tr>
<th>Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical</td>
<td>4.30A</td>
</tr>
<tr>
<td>Calculated from Measurement</td>
<td>4.53A</td>
</tr>
<tr>
<td>Ohm's Law</td>
<td>4.29A</td>
</tr>
</tbody>
</table>

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

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 \( \frac{dV}{dt} \) 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, \( I_{\text{OH}} \) and \( I_{\text{OL}} \) are not continuous DC values. The peak current charges or discharges \( C_{\text{ISS}} \) in an instant and then reduces in value as the switch begins to turn on.

Table 1. Measurement Comparison
Revision History

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

<table>
<thead>
<tr>
<th>Changes from Original (June 2018) to A Revision</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Added additional Gate Driver detail.</td>
<td>1</td>
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