Turn-on performance comparison of current-source vs. voltage-source gate drivers
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2. Gate driver boards
3. Double pulse test result
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What does “current-source” and “voltage-source” gate drivers mean?

<table>
<thead>
<tr>
<th>Current source</th>
<th>Voltage source</th>
</tr>
</thead>
<tbody>
<tr>
<td>› Current sources have a high resistive output by default.</td>
<td>› Voltage sources shall be as low resistive as possible.</td>
</tr>
<tr>
<td>› Any additional voltage drop in the gate drive loop has no influence on the gate current $I_g$ (inside limits).</td>
<td>› Any additional voltage drop in the gate drive loop has immediate influence on the gate current $I_g$.</td>
</tr>
<tr>
<td>› Supposed to damp oscillations</td>
<td>› Prone to oscillations</td>
</tr>
</tbody>
</table>

![Current source diagram](image1)

![Voltage source diagram](image2)

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### Comparison of gate driver IC functions

<table>
<thead>
<tr>
<th>Current source (1EDS20I12SV)</th>
<th>Voltage source (1ED020I12-F2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>› Isolated gate driver</td>
<td>› Isolated gate driver</td>
</tr>
<tr>
<td>› Current source control for turn-on integrated</td>
<td>› 2 A output capability</td>
</tr>
<tr>
<td>› Adjustability of switching speed from input side on-the-fly</td>
<td>› Adjustability of switching speed by manual change of $R_g$</td>
</tr>
<tr>
<td>› DESAT</td>
<td>› DESAT</td>
</tr>
<tr>
<td>› Current sense input</td>
<td>› ---</td>
</tr>
<tr>
<td>› Optional Two-level turn-off</td>
<td>› Optional Two-level turn-off</td>
</tr>
<tr>
<td>› Soft turn-off</td>
<td>› ---</td>
</tr>
<tr>
<td>› Precise output side monitoring</td>
<td>› Limited output side monitoring</td>
</tr>
<tr>
<td>1</td>
<td>Introduction</td>
</tr>
<tr>
<td>2</td>
<td>Gate driver boards</td>
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<tr>
<td>3</td>
<td>Double pulse test result</td>
</tr>
<tr>
<td>4</td>
<td>Summary</td>
</tr>
</tbody>
</table>
Driver boards for FF1200R12IE5
1200 A / 1200 V power module

- The same design and layout philosophy applies to both designs
- Approximately the same number of components per board
# Agenda

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Test bench and test pulse timing

- Capacitor bank
- Wide bandwidth Pearson probe
- Power Module FF1200R12IE5
- Gate driver board under test

![Diagram of the test bench and pulse timing](image)

- \( V_{IN} \)
- \( V_{G2} \)
- \( T_{off} \)
- \( T_{on1} \)
- \( T_{on2} \)
- Gate driver board under test
- Capacitor bank
- Wide bandwidth Pearson probe
- Power Module FF1200R12IE5

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Switching waveform comparison

\[ V_{DC} = 600 \text{ V}, \ I_C = 120 \text{A}, \ T_{vj} = 25^\circ\text{C} \]

<table>
<thead>
<tr>
<th>Current source (1EDS20I12SV)</th>
<th>Voltage source (1ED020I12-F2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slow (3 V/ns)</strong></td>
<td><strong>Slow (3 V/ns)</strong></td>
</tr>
<tr>
<td><strong>Level 1</strong></td>
<td><strong>R_g = 4.7 \ \Omega</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Normal (5 V/ns)</strong></td>
<td><strong>Normal (5 V/ns)</strong></td>
</tr>
<tr>
<td><strong>Level 5</strong></td>
<td><strong>R_g = 2.2 \ \Omega</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fast (9 V/ns)</strong></td>
<td><strong>Fast (9 V/ns)</strong></td>
</tr>
<tr>
<td><strong>Level 11</strong></td>
<td><strong>R_g = 0.4 \ \Omega</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Stronger tendency</strong></td>
</tr>
<tr>
<td></td>
<td><strong>for oscillations</strong></td>
</tr>
</tbody>
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Commutation speed \((dv_F/dt)\) comparison

Current source (1EDS20I12SV)

- Low load \((dv_F/dt)\) ≈5 V/ns @ level5
- Hi load \((dv_F/dt)\) ≈5 V/ns @ level5

Current source IC keeps \(dv/dt\) constant over load range!

Easy to obtain test results due to simple change of speed from input side

Voltage source (1ED020I12-F2)

- Low load \((dv_F/dt)\) ≈5 V/ns @ 2.2 Ω
- Hi load \((dv_F/dt)\) ≈2.2V/ns @ 2.2 W

Speed is a decreasing function because \(R_{gint}\) reduces driving voltage, thus the gate current

Manual change of \(R_g\) for every branch of diagram
Turn-on energy $E_{on}$ comparison

**Current source (1EDS20I12SV)**

- Starting with <30mJ@120A
- Ending with 140mJ@1200A

**Voltage source (1ED020I12-F2)**

- Starting with <30mJ@120A
- Ending with 320mJ@1200A

- Turn-on energy is a linear function
- Turn-on energy is a non-linear function

Current source method has much lower turn-on losses over load range when starting at the same low load condition!
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The design effort of schematic and layout is equal for current source and voltage source gate driver boards.

$E_{\text{on}}$ at full load ($I_{\text{nom}}$) is less than 50% for the same $dv_F/dt$ condition at low load ($1/10 I_{\text{nom}}$) when using the current source gate driver.

Current source gate drivers such as 1EDS20I12SV overcome parasitic effects which influence the gate drive loop.
Part of your life. Part of tomorrow.