ADI Isolated Gate Drivers for GaN MOSFETs

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Market Trends in Power Conversion Applications

Higher Efficiency String inverters replace central inverters
• More energy to the grid: conversion efficiency of 98.5% Peak
• 31% to 37% decrease in DC current for the same power

High Voltage Energy Storage Systems
• Faster Charging of EV
• Higher efficiency

Smaller, Lighter auto inverters
• >10% efficiency improvement & ~80% volume reduction

Higher Efficiency compact OBC

Better Motor Control Performance
• Reduced EMI
• Optimise performance vs. load
Why GaN/SiC?

- Decreased gate capacitance means reduced drive requirement which allows for increased switching frequencies
  - typical IGBT systems run at <10kHZ, SiC increases this to 100kHz and GaN even further into the MHz range
- Increased electron mobility means faster switching speeds
  - lowers switching losses
  - allows higher switching frequencies
- Increased bandgap and critical electric field means smaller size for a given breakdown voltage resulting in a lower on-resistance
- Increased temperature support reduces cooling requirements and allows the use of smaller cheaper heat sinks
- Increased switching frequency allows the use of smaller external filter components.
ADI Portfolio addresses the spread of switch technology requirements

ADI Solutions offer the common features required for existing IGBT/MOSFET applications while delivering the performance levels demanded by emerging switch technologies.

Enables Customers to deliver on current solutions while preparing for the future
## Changing Landscape in power conversion

### Table: Comparison of Power Conversion Devices

<table>
<thead>
<tr>
<th></th>
<th>IGBT</th>
<th>SiC</th>
<th>GaN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical working Voltages</strong></td>
<td>600/1200/1700+</td>
<td>1200V, 1700V</td>
<td>100-650V</td>
</tr>
<tr>
<td><strong>Temperature Range</strong></td>
<td>up to 125°C</td>
<td></td>
<td>up to 225°C</td>
</tr>
<tr>
<td><strong>Switching Frequencies</strong></td>
<td>~1 to 10kHZ</td>
<td>~100kHZ</td>
<td>~MHz range</td>
</tr>
<tr>
<td><strong>Turn on/off Voltages</strong></td>
<td>Up to 15V for IGBT</td>
<td>-6V (off) to 17V (on),</td>
<td>-2V (off) to 8V (On)</td>
</tr>
<tr>
<td><strong>Gate Charge</strong></td>
<td>~70nC or more</td>
<td>&lt;30nC</td>
<td>&lt;10nC</td>
</tr>
<tr>
<td><strong>Response Time (delay)</strong></td>
<td>100nS</td>
<td></td>
<td>&lt;30nS</td>
</tr>
</tbody>
</table>
SiC/GaN adoption Technology Drivers for ADI gate Drivers

More Performance
• Higher frequency switching
• Higher CMTI
• Lower Delay

Focus on Safety/ Reliability
• Increased/Faster error detection/reporting
  • Current, Voltage, Temperature

Higher integration/system capability
• Higher level of switch control
  • Advanced turn on/turn off

Focus at a system level (Gate Drive + switch+ sensing) gives more efficient /higher performing solution to these drivers
Addressing the challenges of evolving systems – Higher CMTI

- Traditional IGBT/MOSFET drivers offered Common Mode Transient Immunity of ~30kV/μS.

- Higher Switching Frequencies of SiC/GaN require CMTI of 100kV/μS and higher to avoid issues.
  - iCoupler based gate drivers offer CMTI of 150kV/μS+ to ensure robustness against issues

- CMTI failures can cause unwanted data errors
  - For gate drivers this can result in unexpected channel turn-on!!

<table>
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<tr>
<th>Technology</th>
<th>Gate Driver Typical CMTI Values</th>
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</thead>
<tbody>
<tr>
<td>IGBT/MOSFET</td>
<td>&lt;30kV/μS</td>
</tr>
<tr>
<td>SiC/GaN</td>
<td>100kV/μS+</td>
</tr>
</tbody>
</table>

Higher switching rates cause CMTI related errors on output
Addressing the challenges of evolving systems – Layout issues

- Higher switching frequencies for SiC and particularly **GaN (MHz range)** can complicate system design
  - Trace inductance from gate driver to power switch can result in significant ringing and system issues

- Locating Gate driver as close as possible to power switch minimizes issues
  - Can be difficult with isolated products in bigger packages, especially in multiphase and multilevel topologies

- Small package drivers such as ADuM4120 (6 lead) and ADuM4121 (8 Lead) allow placement as close as possible to the switch
Isolated Gate Driver Roadmap

- **Automotive**
  - ADuM4138
  - Temp sensor support
  - EEPROM
  - Flyback

- **Advanced Gate Drivers**
  - ADuM4135/6

- **½ Bridge Drivers**
  - ADuM3223/24
  - ADuM4224/23

- **Basic Gate Drivers**
  - ADuM4121/4120

- **Dual Gate Drivers**
  - ADuM4220

- **Slew Rate Control Drivers**
  - Controllable On/Off Rates for EMI Control

- **High Working Voltage**
  - 1500V Working Voltage Driver (8/15.1mm Package)

- **SiC Gate Drivers**
  - 6/10A
  - 900V/1500V IGBT Driver

- **GaN Drivers**
  - GaN Driver with integrated isoPower

Availability:
- Released
- Development
- Concept

Calendar Year:
- Earlier
- 2017
- 2018
- 2019
ADuM4121 Isolated Half Bridge GaN

- Next generation inverters will utilize advanced switching technologies like GaN and SiC
- ADuM4121 Isolated Gate Driver meets the needs of these applications
ADUM4221 DC/DC Optimizer Power Stage Eval Board

- **GaN H-Bridge w/ Center Inductor**
  - Four GaN Systems GS61004B, 15 mΩ, 100 V
  - Two Analog Devices ADUM4221 HB gate drivers

- **Bidirectional, 500 W Rated Power**
  - $V_{DC} = 50 \text{ V}$, $I_{DC} = 10 \text{ A}$

- **Four PWM Inputs, max. 1MHz**
  - pre-configurable to Buck- / Boost-only mode
  - fully synchronous, fully isolated

- **Best efficiency > 98.5%**
  - @ 1 MHz, 350 W

- **Applications**
  - Solar PV DC/DC optimizer
  - Bidirectional Chargers

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Thank You!