Reliability and Cost-of-Ownership Optimization in Industrial Power Supplies

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Industrial power supplies
Continuous operation in demanding conditions

• **Reliability** – Continued uninterrupted operation with no failures
• **Robustness** – Demanding ambient conditions and harsh line / load conditions
• **Efficiency** – Lowest losses to optimize operational cost and cabinet cooling
• **Power density** – Save system cost and cabinet space in challenging installations

... all affecting cost of ownership!
Industrial power supplies
Scalable solution portfolio

GaNSense™ Integrated controllers
GaNSense™ Half-bridge / single switches
GaNSense™ single switches

Flyback
• ACF/QR

PFC / LLC
• Bridgeless Totem-Pole or Boost PFC
• LLC / LCC / FB

10W 100W 800W 2kW >4kW
Industrial power supplies
Application block diagram – key benefits

- Massive reduction of switching losses → much smaller / no heatsink → improve efficiency by ~1...2%
- High switching frequency now easy to do → much smaller PFC inductor (size and losses) → smaller, easier EMI filter
- Bridgeless totem pole PFC → remove input rectifier and improve efficiency by ~2...3%

- Optimum ZVS operation with lowest losses → much smaller / no heatsink → improve efficiency by ~1...2%
- High frequency now easy → much smaller inductor / transformer (size and losses) → enable planar inductors
- Very small and linear output cap → improved resonant operation and control loop performance
# Industrial power supplies

**Navitas GaN power ICs unlock the next level of performance**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Impact</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low switching losses,</td>
<td>Reduce losses by &gt;20% over SiC, &gt;50% over Si</td>
<td>Small / no heatsink, easier thermal design, higher reliability</td>
</tr>
<tr>
<td>Very high switching frequency possible</td>
<td>Very small / planar magnetic components</td>
<td>Reduced size and system cost</td>
</tr>
<tr>
<td>Precise switch timing with low latency and dead time</td>
<td>Improved control loop performance, low EMI</td>
<td>Smaller EMI filter → system cost improvement</td>
</tr>
<tr>
<td>High voltage ratings</td>
<td>High robustness against transient over-voltages</td>
<td>Lower field failure rate</td>
</tr>
<tr>
<td>Integrated gate driver and voltage regulator</td>
<td>Excellent reliability through precise gate drive conditions</td>
<td>Improved lifetime and low field failure rate</td>
</tr>
<tr>
<td>Integrated lossless current sensing and temperature sensor</td>
<td>Excellent robustness through very fast and precise action</td>
<td>Robust, protected application and low failure rate</td>
</tr>
<tr>
<td>High level of integration – less components on PCB</td>
<td>Very compact size and higher reliability</td>
<td>Reduced system size and cost, and very easy to use</td>
</tr>
</tbody>
</table>
GaNSense™ Half-bridges / Single switches

Key benefits for industrial power supplies

- High, stable and repeatable performance $\rightarrow$ reduce design margins
  - Very low prop delay for best control loop performance
- Controlled gate drive conditions enable outstanding reliability
- Much reduced component count $\rightarrow$ system size and cost reduced, increasing power density
- Easy to use $\rightarrow$ fast time to market
- Lossless current sensing removes shunt resistors $\rightarrow$ cost, size, reliability and performance improvement
- Fast and precise overcurrent protection $\rightarrow$ improved system robustness
- On-chip temperature sensing for better thermal design margin
- Precise overtemperature turn-off $\rightarrow$ improved system robustness

GaNSense™ offers highest performance, integration, robustness
Industrial power supplies

GaNSense™ Product Family

- Many family members
  - From 45 to 450mohm Rdson
  - Singles and half-bridges
- 650V continuous voltage rating
  - 800V transient, tested at 900V
- Monolithically-integrated gate drive
  - Lateral GaN process to minimize EMI
  - Full ESD protection 2kV
- Very low switching losses
  - Zero reverse recovery charge
  - Negligible parasitic capacitance
- GaNSense features
  - Integrated loss-less current sensing
  - Short-circuit protection
  - Over-temperature protection
  - Autonomous low-current standby mode
  - Auto-standby mode input
  - UVLO function
- Suitable for all topologies
# Industrial power supplies

**GaNSafe™ Product Family**

<table>
<thead>
<tr>
<th>Part#</th>
<th>$V_{DS}$ (Cont, Max) (V)</th>
<th>$V_{DS}$ (Dyn, Max) (V)</th>
<th>$R_{DS(ON)}$ (Max 25°C) (mΩ)</th>
<th>$I_D$ (Max) (A)</th>
<th>Package</th>
<th>Evaluation Kit</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV6515</td>
<td>650</td>
<td>800</td>
<td>35</td>
<td>57</td>
<td>TOLL 10x10 Bottom-cool</td>
<td>Power Board, Full Bridge Daughter Card, and FanSink/TIM ~ configurable for DPT or Half-Bridge testing</td>
</tr>
<tr>
<td>NV6513</td>
<td>45</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NV6512</td>
<td>55</td>
<td>34</td>
<td></td>
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<tr>
<td>NV6511</td>
<td>98</td>
<td>22</td>
<td></td>
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<td></td>
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</tbody>
</table>

**TnR Ordering**

- Mini-Reel (7” dia) Qty500 Pcs "-MR” suffix
- Standard (13” dia) Qty2,000 Pcs

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1. Samples and collateral available immediately to qualified customers

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**GaNSense™ Control product family**

*Highest power density and lowest component count*

**HFQR Control**
- HFQR controller
- CCM and QR hybrid mode
  - High-frequency, up to 300kHz
- High-voltage startup
- Frequency-hopping for EMI reduction
- X-cap discharge
- SCP, OCP, OTP, LPS protection

**GaN Power FET**
- 170mΩ, 260mΩ, 450mΩ
- Ultra-low gate charge
- Zero reverse-recovery charge
- Low output charge
- 650 / 800 V continuous / transient voltage rating
- Integrated current sense

**Small, low-profile SMT PQFN**
- 5x6 mm footprint
- Minimized package inductance
- Large cooling pad

Ultracompact aux PSU 12V/3A
Industrial power supplies
Programmable Current Sensing Using $R_{SET}$

- No need for external current sensing resistor
  - High efficiency, lower component count, better reliability
- Adjust system OCP level using $R_{SET}$
Industrial power supplies
Autonomous Over Current Protection (OCP)

- Autonomous OCP
- Fast-acting self-protection
- Cycle-by-cycle protection
- Excellent robustness
- GaN FET on-time gets truncated at each OCP event
- OCP latch gets reset at next PWM rising edge
Industrial power supplies

**Autonomous Standby Mode**

- Autonomous standby mode
- Enters STBY after no PWM for 75usec
- Fast wake-up at next PWM edge (15nsec)
- Reduces system standby power (-17%)

<table>
<thead>
<tr>
<th>PIN (no load)</th>
<th>115 V&lt;sub&gt;AC&lt;/sub&gt;</th>
<th>230 V&lt;sub&gt;AC&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV6136</td>
<td>33 mW</td>
<td>33 mW</td>
</tr>
</tbody>
</table>
Industrial power supplies

Over-Temperature Protection (OTP)

<table>
<thead>
<tr>
<th></th>
<th>T_{OTP+}</th>
<th>OTP Shutdown Threshold</th>
<th>160</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTP Restart Hysteresis</td>
<td>T_{OTP,HYS}</td>
<td></td>
<td>60</td>
<td>°C</td>
</tr>
</tbody>
</table>

OTP fault set at T_j > 160°C, GaN IC stops switching

OTP fault clears at T_j < 100°C

System V_{CC} charges up and down during OTP fault
Improving Industrial power Supplies

• Trends in industrial power supplies:
  • Improved energy efficiency
  • System cost and TCO reduction
  • Meet EMI regulations
  • Lowest no-load consumption
  • Size and weight reduction
  • Improved performance and reliability

• Challenge to reduce design time / effort

Navitas’ GaNSense™ and GeneSiC™ offer convincing solutions for industrial power supplies – the next level of performance and integration
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