PowiGaN™: HV GaN For Mass Markets

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HV GaN Benefits

- **High Efficiency vs. Silicon for a given frequency of operation**
  - Near zero cross conduction losses
  - Very low capacitive switching losses relative to $R_{DS(ON)}$
  - Much smaller die size relative to Si for the same $R_{DS(ON)}$
  - Better switching performance than SiC

- **Fundamentally more cost-effective than SiC for <1200 V**
  - With potential for further cost reductions

- **Enables smaller, lighter & more efficient power supplies**
  - High efficiency at higher frequencies for smaller size
  - Low losses eliminate heat sink reducing weight & size
HV GaN Challenges

- **Tricky to drive**
  - Discrete GaN devices are very sensitive to drive voltage
  - Uncontrolled fast switching can cause EMI problems
  - Parasitics can cause VHF oscillation that can be destructive

- **Difficult to protect**
  - Protection circuits have to be faster than the device
  - Very difficult to achieve when devices are separately packaged

- **External current sensing negates the efficiency benefit**
  - Discrete designs use current sense resistors $\geq$ the RDS(ON) of GaN switch!
  - Needed to provide sufficient voltage drop for fast current limit response

- **Continuous voltage rating of 650 V is needed for reliable Flyback operation**
  - Many HV GaN devices are rated at 480 V continuous - only good for HB circuits
  - Voltage spikes due to parasitics could be a problem even with HB circuits

RDSON = 120 m$\Omega$
Rsense = 290 m$\Omega$
The System Level PowiGaN Solution

- Proprietary GaN technology optimized for system level integration
- Co-packaged with controller to guarantee safe operation & ease of use
  - Close coupling greatly reduces parasitics
  - Driver carefully matched to the GaN transistor for safe switching and low EMI
  - Switching waveforms matched to Silicon equivalents
  - As easy to use as Silicon solution but, much higher efficiency
  - Controller + GaN operate from a single 5V rail
- Built in lossless current limit
  - Avoids loss of efficiency due to series current sense resistors
  - Provides very fast response for protecting the GaN transistor
- Rated at 650 V repetitive operation & 750 V non-repetitive for transients
  - Can use simple Flyback topology with external circuit identical to silicon counter parts
Integration is Key To Success Of PowiGaN

- **InnoSwitch3** combines both primary and secondary circuits
  - Very few components compared to discrete solutions—ease of use
- **Provides seamless transition from Silicon to GaN**
  - Circuit operation indistinguishable between Si or PowiGaN
  - Big difference: higher efficiency with PowiGaN

The Ultimate Flyback!

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Taming the GaN Through Integration

- Precisely matched gate drive prevents oscillation, reduces EMI
  - Reduces fast $\text{di/dt}$ voltage overshoot

- PowiGaN switching waveforms indistinguishable from Silicon versions
  - No special EMI issues for PowiGaN

- Loss less current limit preserves the efficiency advantage
  - Also fast enough to protect PowiGaN
Seamless Transition From Silicon to PowiGaN

- RDS(ON) (Ω) – Typical (25 °C)
- Output Power (W)

Legend:
- RDS(ON) - Typical at 25° C
- Power (W) (90-264 VAC)
- Power (W) (PFC - 400 VDC)
InnoSwitch 3: Up to 100 W Without Heatsink!

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<th>Part Number</th>
<th>230 VAC ± 15%</th>
<th>85 - 264 VAC</th>
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DER-747 (65 W, 20 V Adapter): Full-load efficiency is 95% at 230 VAC and 94% at 115 VAC
**PowiGaN –Ready For Prime Time**

- Compelling alternative to Si above ~30-50 W
- Higher efficiency – up to 95% using simple flyback topology
- No heat sink up to 100 W in a low profile surface mount package
- Enables much smaller & lighter adapters compared to silicon

**Already used in many high volume applications**
- Cell phone/Tablet adapters –both aftermarket (30 - 61 W) & inbox (45 W, 65 W)
- TVs, Lighting ballasts (LYTSwitch-6), Wall USB outlets for size/efficiency
- Also being designed in to appliances for efficiency & lack of heatsink

- More than 3 million PowiGaN-based devices sold-to-date!