APC Electronics

Application Brief - LED Drivers

High-reliability
Power Semiconductors

Designed in Bend, Oregon

Available exclusively from:

LUMINUS

www.luminus.com

www.apowerc2.com

Summary to Selecting & Using SiC for LED Drivers

- **Why SiC is (just) worth it even at 100 W. (GaN is also attractive at power levels <150W)**
  - Although the absolute saving is only ~2 W, that translates to:
  - **+2 % efficiency** → easier ENERGY STAR / DLC qualification.
  - **~35 % lower heat** → slimmer enclosure or passive-only cooling.
  - Better PF/THD margin without extra boost inductance.
  - Component delta cost ≈ US $2.50–3.00 in volume (SiC MOSFET + Schottky barrier diode (SBD)). In outdoor or high-ambient fixtures (-40 °C…+60 °C), the thermal and lifetime gains usually justify the premium

- At 100W~300W 650V SiC MOSFETs and SBDs may be considered
  - LED drivers generally require PFC above 25W to comply with standards like IEC61000-3-2 and ENERGY STAR, ensuring high power factor (>0.9) and low THD.

- Above 300W 1200V SiC MOSFETs and SBDs will start to make sense depending on output voltage. Use the LED Driver Block Diagram for reference part numbers

- Also: Use of SiC reduces heat and allows smaller heat sinks. With LED lighting this greatly enhances the ergonomics but also ROI in energy savings.

Overview - LED Driver Classes & SiC Use Cases

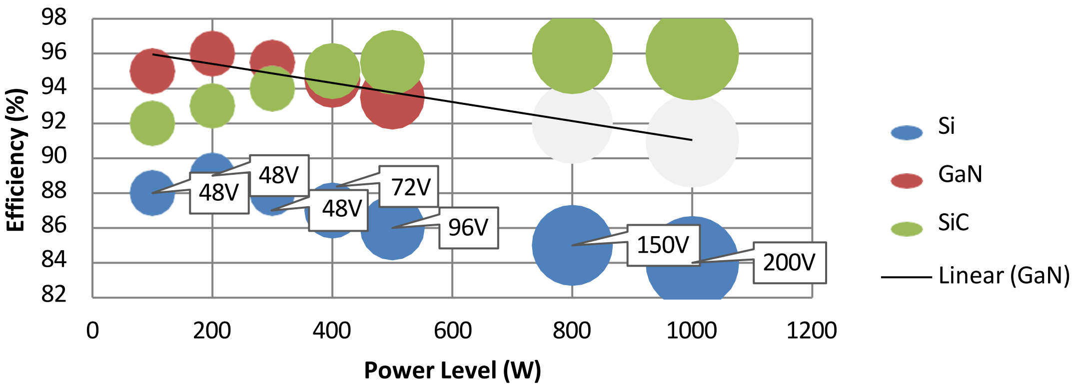
Power Class	Applications	Topology	PFC Required	Does SiC Make Sense?
<10W (Ultra low power)	Flashlights, Indicators, Decorative	Linear, Buck	No	X No – Cost Driven
10W ~ 50W (Low Power)	Residential Bulbs, Desk Lamps	Buck, Flyback	Optional but required above 25W	X No – Minimal benefit
50W ~ 150W Medium Power)	Commercial Panels, Downlights	Flyback, Forward Resonant	Yes	⚠ Might use SiC diode in PFC if compactness & efficiency matter
150W~300W (High Power)	Street lights, floodlights, industrial ceiling lights	Two-stage (PFC + DC-DC), LLC or phase-shifted full-bridge	Yes	✔ Increasingly common – PFC stage benefits from SiC MOSFETs/diodes
300~1000W	Stadium lighting, horticultural lighting, stage/theater lighting	Two-stage with interleaved PFC, resonant DC-DC	Yes	✔ Recommended – lower switching/conduction losses, thermal advantage
> 1000W	High bay industrial, UV curing, LED-based projectors	Modular multiphase architecture, full digital control ala phase-shift full bridge topology	Yes	✔ Strongly preferred – efficiency, thermal handling, EMI control

Overview – Technology Comparison for LED Drivers – SiC vs GaN vs Si

Feature	Si	GaN	SiC
Best Voltage Range	0–400 V	0–300 V (optimal <150 V)	400–1200 V
Switching Loss	High	Very low (at lower power levels <150W)	Low
Conduction Loss	Moderate	Low at low V, increases at high V	Very low (especially >400 V)
Reverse Recovery Loss	High (Si diode)	None (no body diode)	None (with SiC Schottky)
Thermal Headroom	Low	Good (below 300 W)	Excellent (esp. >400 W)
Cost (per device)**	Drops to ~$1–$2 in volume	$3.40–$5.60 in bulk	$2.20–$3.40 in high-volume
Driver Complexity	Simple	Moderate (layout-sensitive)	Moderate
Efficiency Potential	85–89%	94–98%	92–96%
Heatsink Requirements	Largest	Smallest (up to ~300 W)	Medium (but best above 500 W)
Use Case (LED Driver)	Cost-sensitive, <200 W	High-density <300 W	Industrial, >400 W

** 650V, 20A Class Devices

Efficiency vs Power Level (Bubble = Output Voltage)



Key Takeaway - While GaN shows slightly higher efficiency at lower power levels, **SiC provides strong ROI and robust thermal margins in high-power designs (>300 W)** due to better availability, high voltage capability, and solid performance at elevated temperatures.*” At high output voltage (>200V~300V) GaN loses its efficiency advantage to SiC.*

Overview – Technology Comparison for LED Drivers – Tradeoffs vs Crossover points

Power Level	Recommended Tech	Crossover Explanation
100 W	GaN or Si	GaN preferred for small size & 94–95% efficiency; Si if cost matters
200 W	GaN	GaN > Si in both efficiency and size; SiC not cost-effective
300 W	GaN → SiC Zone	GaN still efficient; SiC starts matching if voltage >300 V
400 W	SiC	Thermal and switching loss push Si out; GaN OK at low voltage
500 W	SiC	GaN starts losing advantage at high voltage (efficiency, EMI, thermal)
800 W	SiC	Si is inefficient; GaN costly and thermally stressed
1000 W	SiC	SiC wins on efficiency, reliability, EMI, and thermal management

Key Takeaway – While GaN may have some advantages in lower voltage and lower power applications, SiC has superior Thermal conductivity (3x vs GaN), higher temperature rating (200–225°C vs ~125–150°C), better power packaging, Superior ruggedness (higher short-circuit ratings & voltage capability) and is more tolerant to EMI and layout margin.

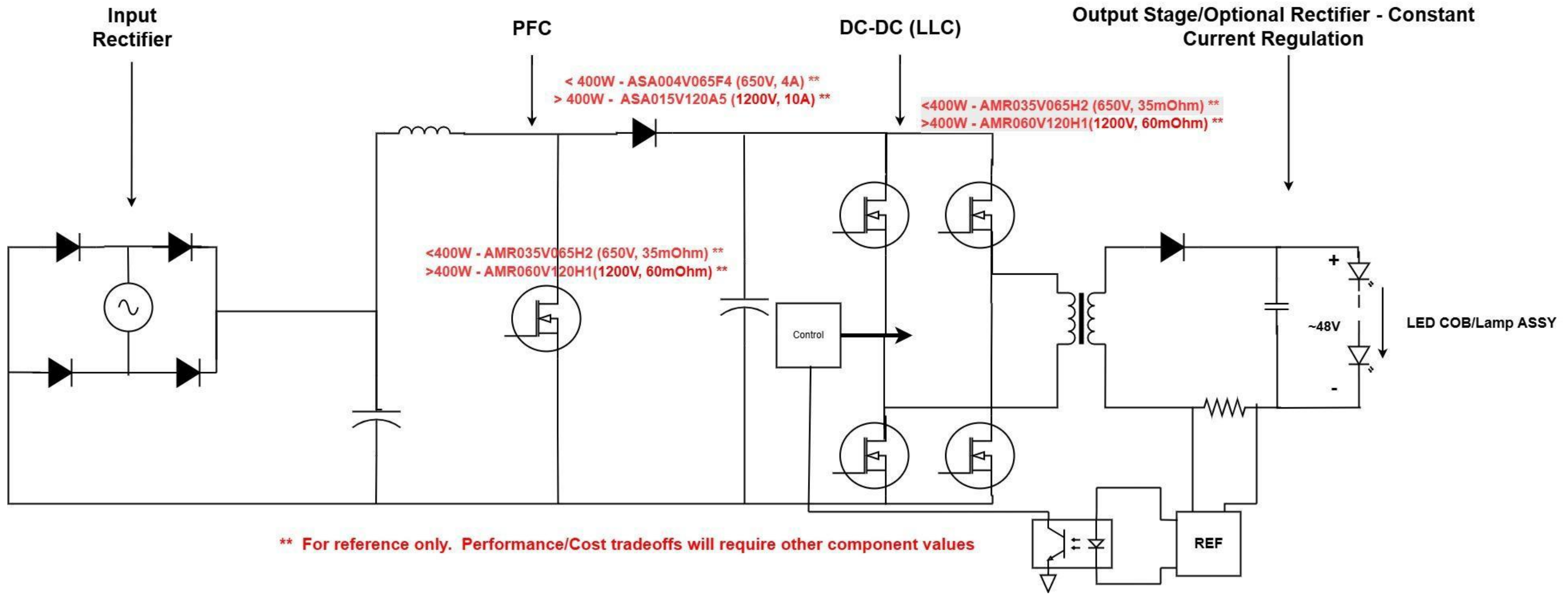
Crossover Points

- ✅ **Si → GaN Crossover**: ~150–200 W
  - GaN becomes more efficient than Si due to lower switching loss, especially <300 V output
- ✅ **GaN → SiC Crossover**: ~300–500 W
  - SiC becomes more efficient and thermally robust, especially above 300–400 V output
  - GaN loses ground due to rising EMI, layout constraints, and cost at higher currents/voltages

✅ Summary Table: Best Fit by Power

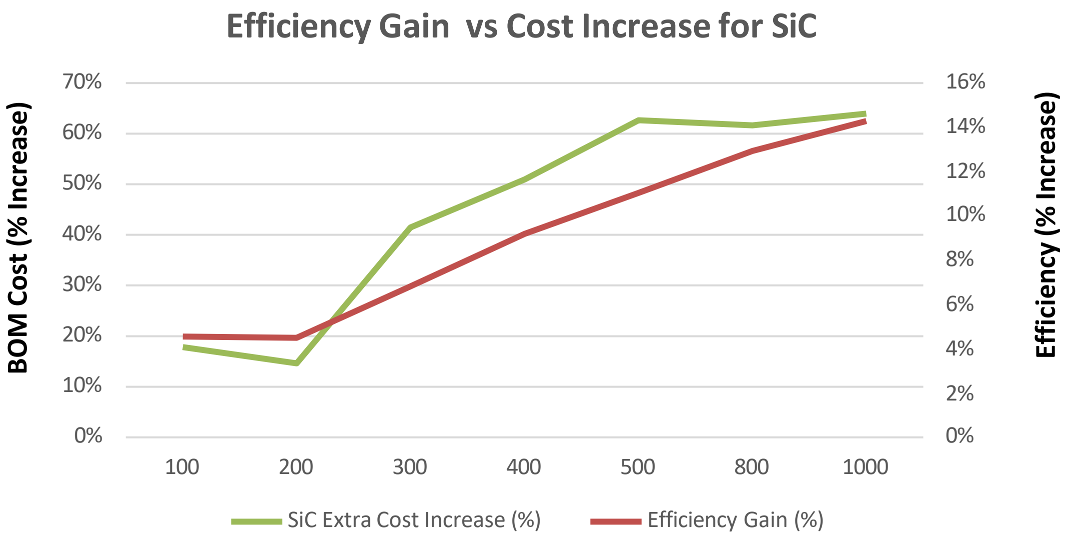
Power (W)	Si	GaN	SiC
100	✅	✅ Best	❌ Too costly
200	❌	✅ Best	⚠️ emerging crossover
300	❌	✅ / ⚠️	⚠️ emerging crossover
400	❌	⚠️ limited	✅ Best
500	❌	❌	✅ Best
800–1000	❌	❌	✅ Best

LED Driver Block Diagram - Component Selection



Power Level	PFC Stage Switch**	PFC Diode**	DC-DC Main Switches**	Output Rectifier**
100W	**AMR050V065H2(650V**, 50mOhm)	ASA006V065F4/**A4**(650V, 6A)	AMR050V065H2 (650V, 50mOhm)	ASA006V065F4/A4(650V, 6A)
200W	**AMR035V065H2**(650V, 35mOhm)	ASA006V065F4/**A4**(650V, 6A)	2x ASA006V065F4/A4(650V, 6A)	2x ASA006V065F4/A4(650V, 6A)
300W	**AMR050V065H2**(650V, 50mOhm)	ASA006V065F4/**A4**(650V, 6A)	2x **AMR050V065H2**(650V, 50mOhm) **AMR075V120H2** (1200V, 75mOhm)	2x ASA006V065F4/**A4**(650V, 6A)
500W~800W	**AMR060V120H2** (1200V, 60mOhm)	**ASA015V120A5 (1200V, 15A)** ASA006V065F4/**A4**(650V, 6A)	2x~6x **AMR050V065H2**(650V, 50mOhm) **AMR075V120H2** (1200V, 75mOhm)	2x ASA006V065F4/A4(650V, 6A)
1000W	**AMR030V120H2** (1200V, 30mOhm)	ASA006V065F4/**A4**(650V, 6A)	2x~6x **AMR060V120H2** (1200V, 60mOhm)	2x ASA006V065F4/A4(650V, 6A)

LED Driver Performance/Cost Tradeoffs Using SiC vs Si

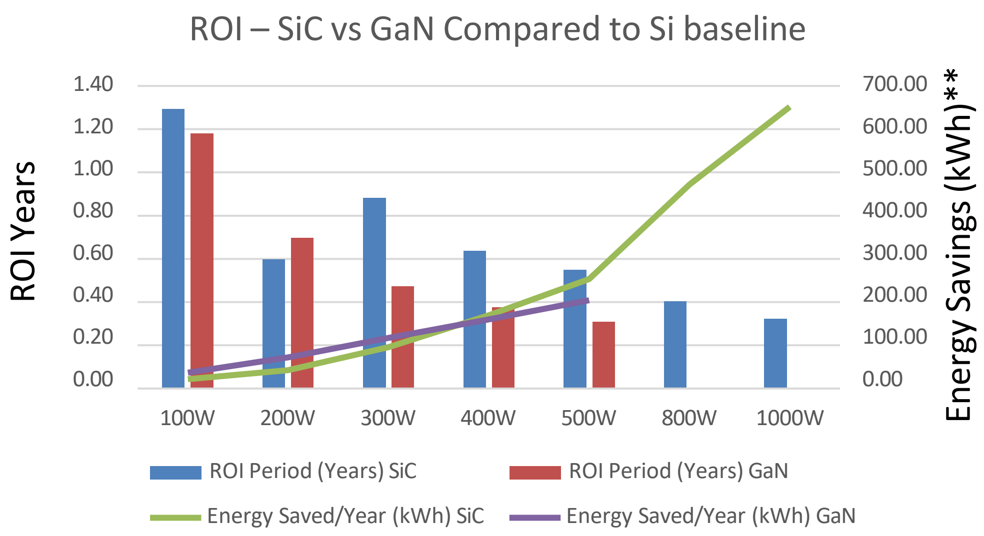


SiC's improved performance & ruggedness helps drive lower PCBA size/costs

Key Points

- Above 500W the percentage cost increase of SiC levels off while the increase in efficiency continues
- At >200W SiC is still competitive against Si based designs
- For compact, high-reliability applications, SiC remains preferred. For purely cost-driven markets, advanced Si can be acceptable

LED Driver ROI Using SiC and GaN vs Si



**Assume Electricity Costs = $0.15/kWh. 12 hours per day operation

Key Points

- ➢ SiC offers highest efficiency above 400W
- ➢ Payback for SiC and GaN is < 1.5 years but GaN doesn't compete above 500W
- ➢ Best value from SiC adoption starts around 200W and up

Summary

- While initially very high cost relative to Si, SiC has experienced severe ASP erosion over the past year making the investment to transition to SiC more commonplace

- At output power <100W, GaN may have better efficiency than SiC but suffers as output power and output voltage increase.

- SiC still has best thermal efficiency, operating temp range and ruggedness of all materials. For LED Drivers this benefit may be a valuable tradeoff due to tight space constraints and operating temperatures such as for high bay lighting and outdoor streetlighting.

- High Level Summary of Tradeoffs
  - **Si** performs worst across the board, especially at low voltages. But is least expensive.
  - **GaN** leads at low voltage, low-mid power.
  - **SiC** outperforms at high voltage and power.