Power Electronics as Enabler for Modular Luminaires

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Imagination at work.

LED Luminaires Today

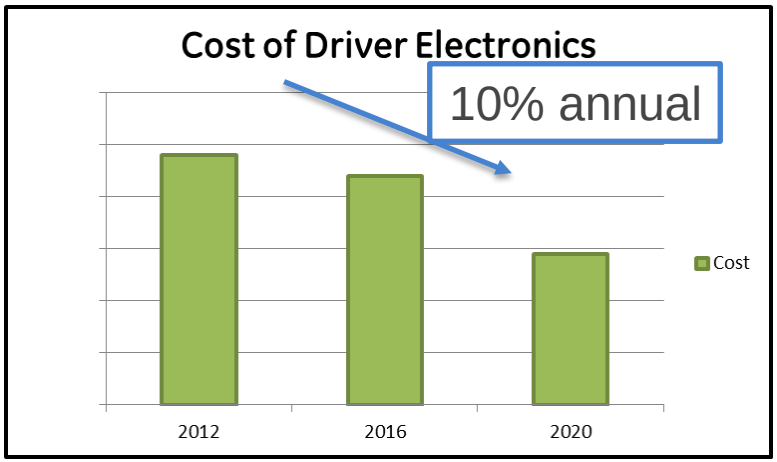
Benefits
- Rapid deployment in indoor commercial and outdoor
- High lumen per watt and decreasing cost per kilo-lumen
- Promise of high reliability, low maintenance

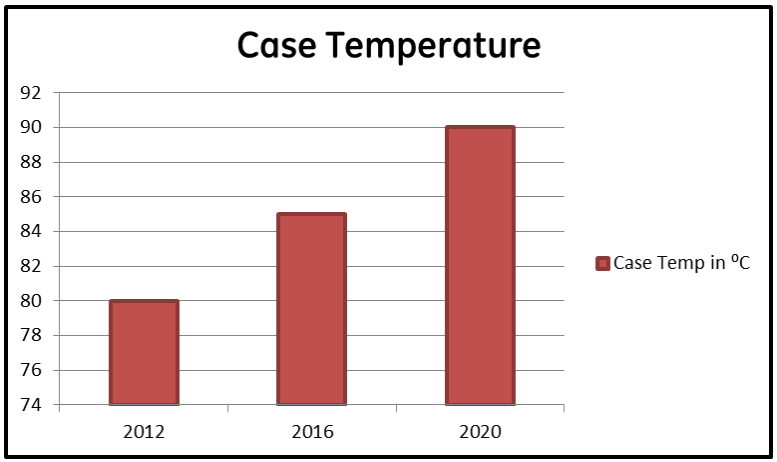
Future trends
- Indoor – IPS, VLC
- Outdoor – Hub for traffic, weather, emergency monitoring
- Key element in smart cities initiatives
- Valuable real estate in crowded outdoor space – application opportunities

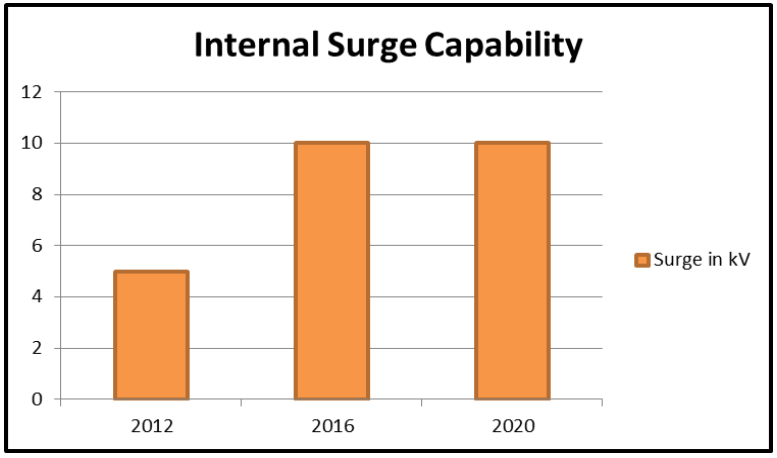
Concerns
- System complexity
- Need for rapid turnaround in manufacturing and deployment
- Increasing pressure on reliability and cost

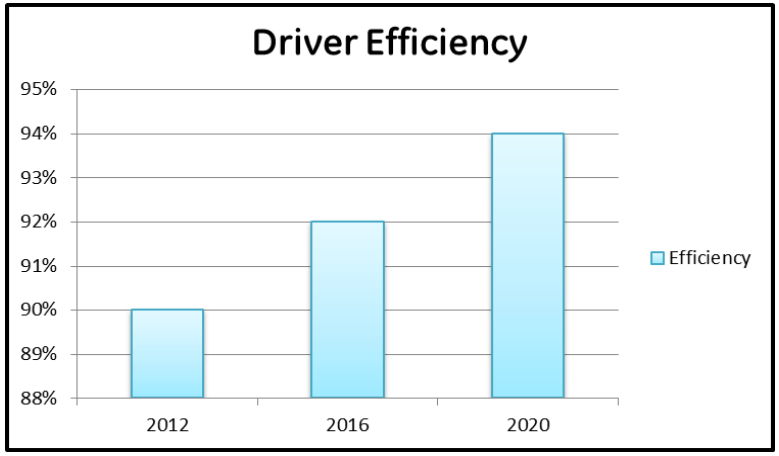
Luminaires are complex systems now- components need to be quickly assembled and deployed

Impact on Driver Power Electronics





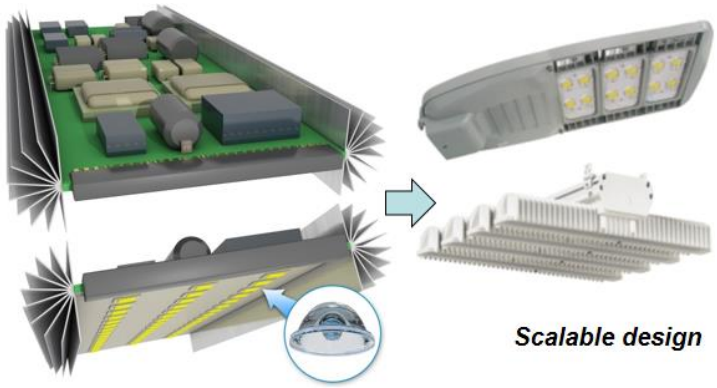




These are directional trends in power electronics requirements to guide development.

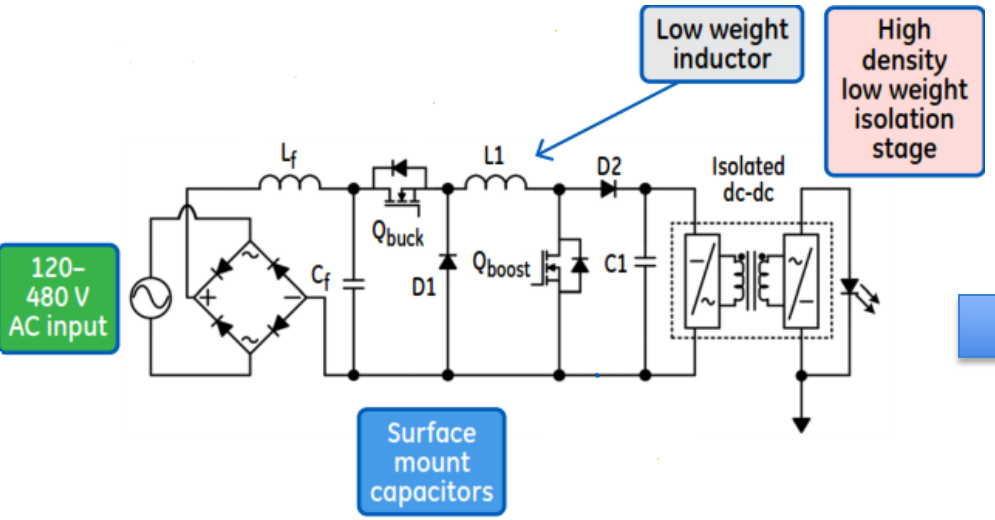
Making Power Electronics an Enabler

- Use wide band gap devices (SiC, GaN)
- Gain Low part count design and Reliability
- Improve surge rating
- Benefits
  - More room for controls
  - Fewer magnetics
  - Higher warranty
  - Easier manufacturing, closer to customer

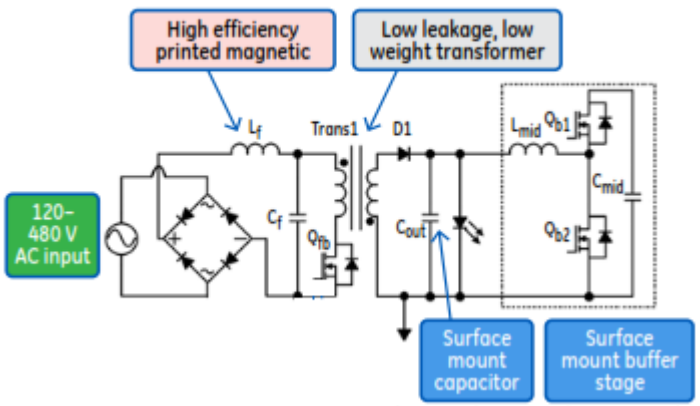


- Make designs scalable and modular
- Reduce total weight and cost to improve adoption
- **Goal: Improve integration, automate assembly**

Step 1: Lower Part Count Designs



Two stage Higher Part Count

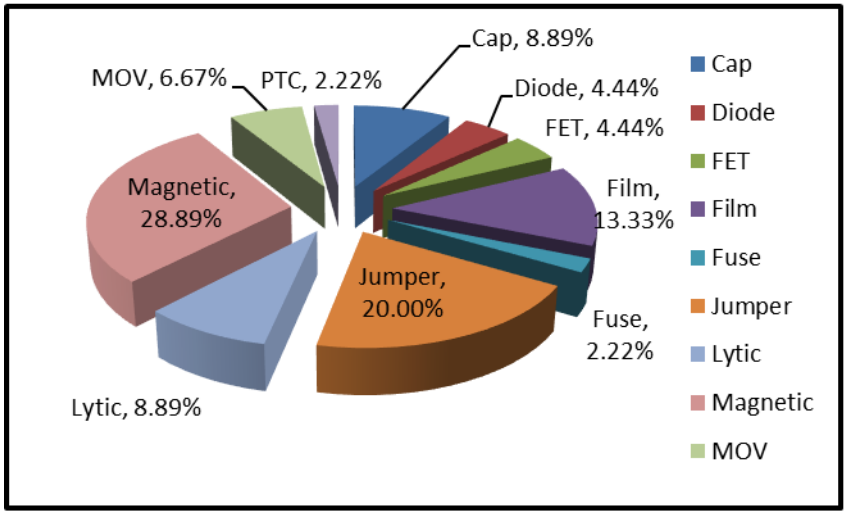


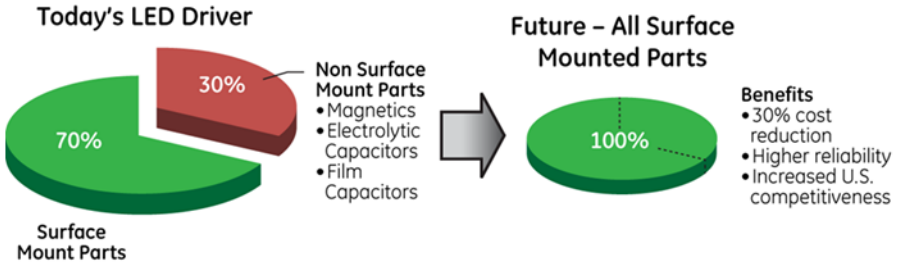
Single stage Lower Part Count

- Traditional two stage designs ideally done with Silicon MOSFETs
  - Capable of dynamic range on input and output
  - Low electrolytic capacitor count but higher magnetic count
  - Good peak efficiency but poor light load efficiency
- Single stage designs with wide band gap devices have high efficiency
  - Needs good high voltage MOSFET
  - Innovations in control needed to increase dynamic range

Step 2: Challenges in Automated Assembly

Non-SMT components distribution





Non-SMT components challenges

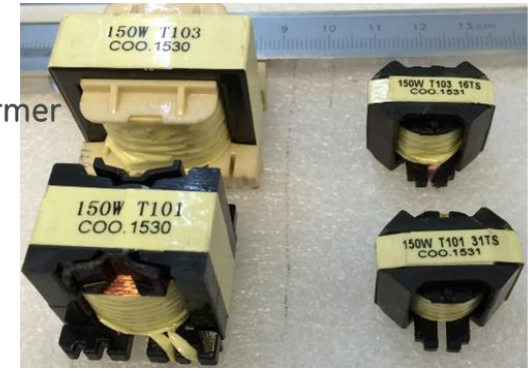
- MOSFET: thermal
- Large film cap
- Large Electrolytic cap
- Larger magnetics
- MOV: 347/480V

- Magnetics-the cost will be increased 15~20% due to increased SMT bobbin cost
- Making FETs SMT require higher efficiency and lower dissipation
- Electrolytic capacitors have to be lower voltage and lower value
- Transformers have to be smaller than EFD20 or equivalent size to be SMT compatibl
- Some parts –Y capacitors and MOVs- are extremely hard to replace in SMT

Addressing Challenges in Magnetics

Typical Transformer

Inductor



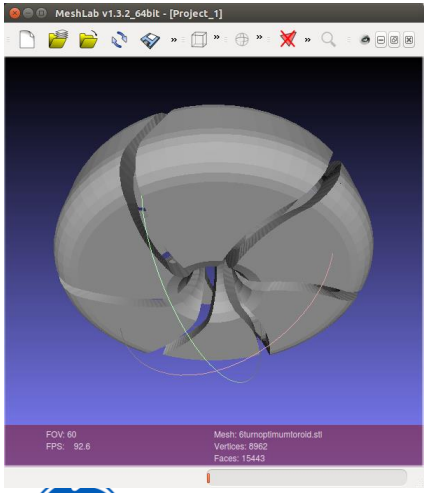
Preferred size

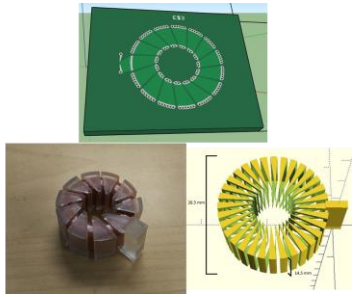
	Today's Design		
	Core	Size(mm)	Weight(g)
Transformer	EE33A	34	66
Inductor	PQ2625	27	47

- Automated pick and place machines have height and weight restrictions
- Area constraints on board with clearance around part for pick and place
- Alternative
  - Additive methods for making more compact magnetics
  - Circuit designs for reducing magnetic count and size

Alternatives to Wire and Bobbin Arrangements

Printed inductors





- Molded scaffolds + electroplating
- 3D printed shapes (metals still an issue)
- PCB + additive part magnetics
- Cost is still a concern

3D printing can be used for smaller filter inductors
PWB embedded magnetics can be used for small transformers and inductors (requires small adder multi-layer board)

Photo courtesy: Prof. Rivas from Stanford

Challenges and Areas for Development

- Cost of wide band gap devices
  - Maintain superior performance but reduce in cost
  - Improve processing and reduce defects
- Reliability of wide band gap components
  - Needs to be proven in application
  - Robust designs with benign EMI signature
- Magnetics manufacturing
  - Still off shore, high labor content, sets performance limits
  - Needs novel manufacturing methods to reduce weight and size
- Critical components need to be surface mount
  - Surge protection
  - Fuses with appropriate voltage rating