

Motor Technology 1: Gate Drive vs. Integrated Driver

TI Precision Labs – Motor Drivers

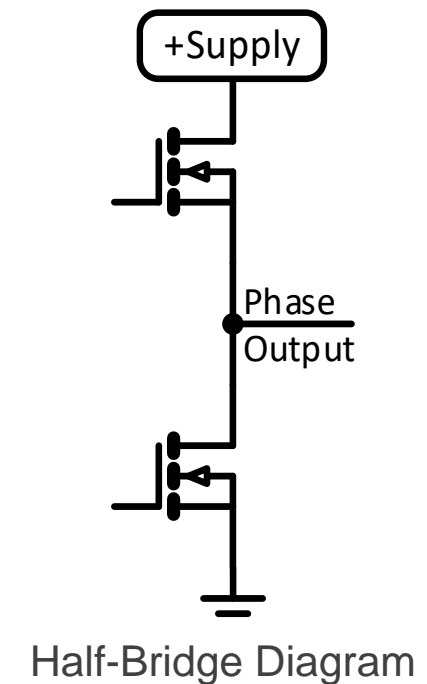
Presented and prepared by Omar Naamani

Introduction

- Brushed, brushless, and stepper motor drivers share many of the same tradeoffs when selecting to use integrated or external field effect-transistors (FETs) for the power stage.
- Full-bridge motor driver topologies:
 - Gate driver external-FET topology
 - Multi-chip module (MCM) integrated FET topology
 - Monolithic integrated FET topology

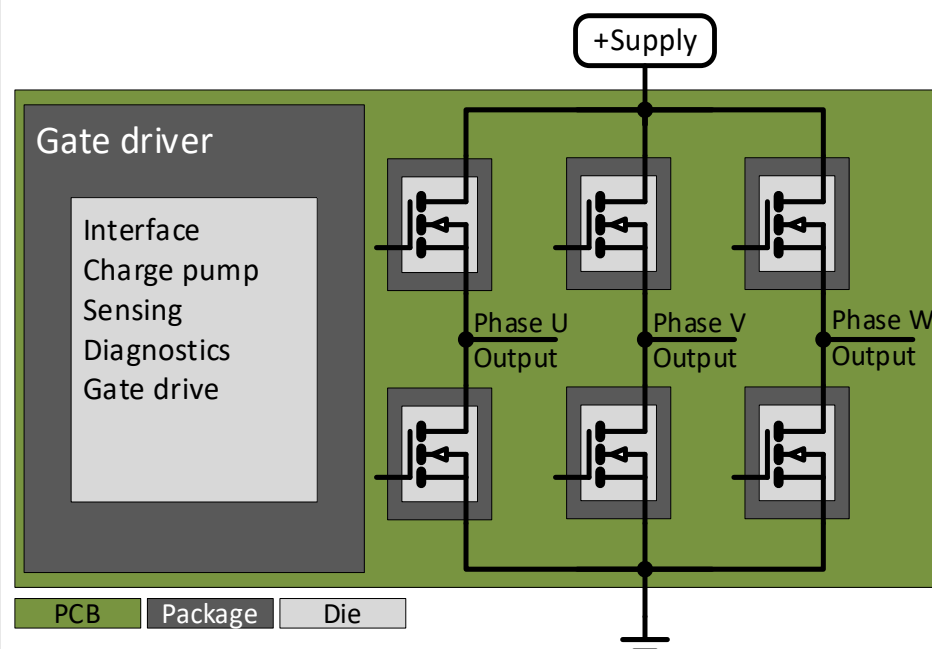
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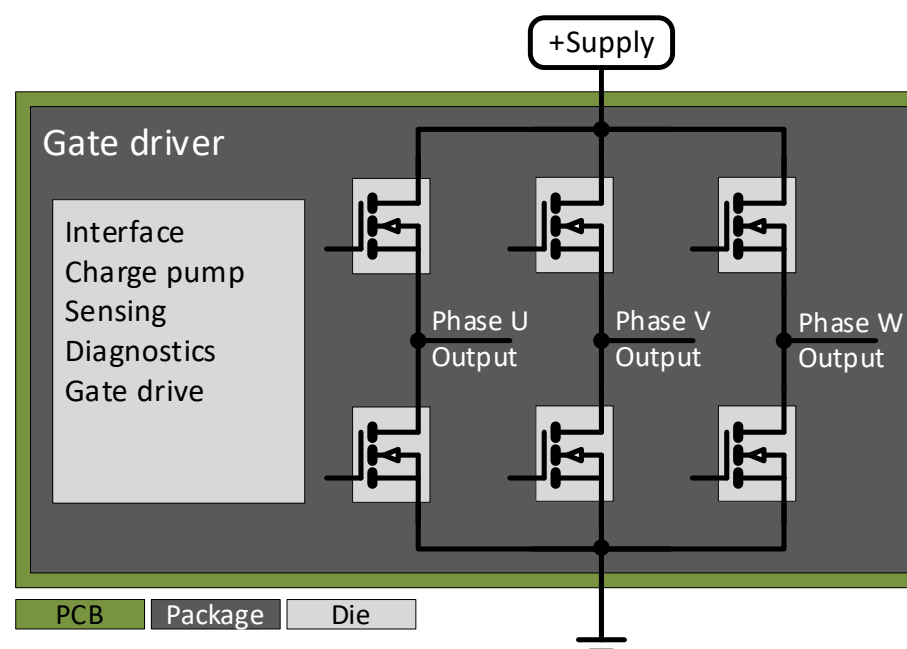
Introduction

External FET



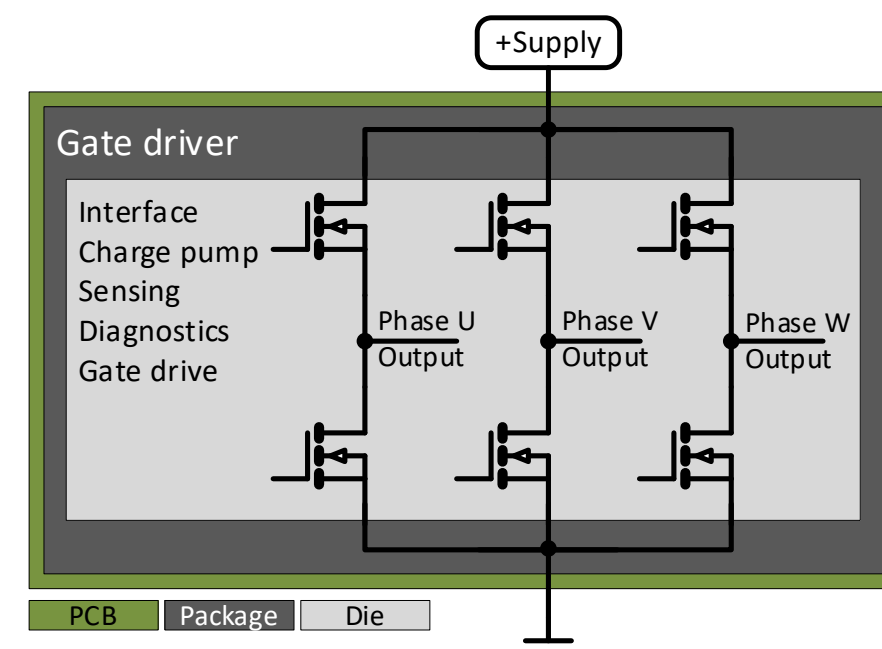
The gate driver and the power stage FETs are contained in separate packages in this topology. The designer can select the driver and FETs independently.

Integrated FET: MCM



The gate driver and the power stage FETs are contained in the same package in this topology. However, the FETs are on separate semiconductor chips.

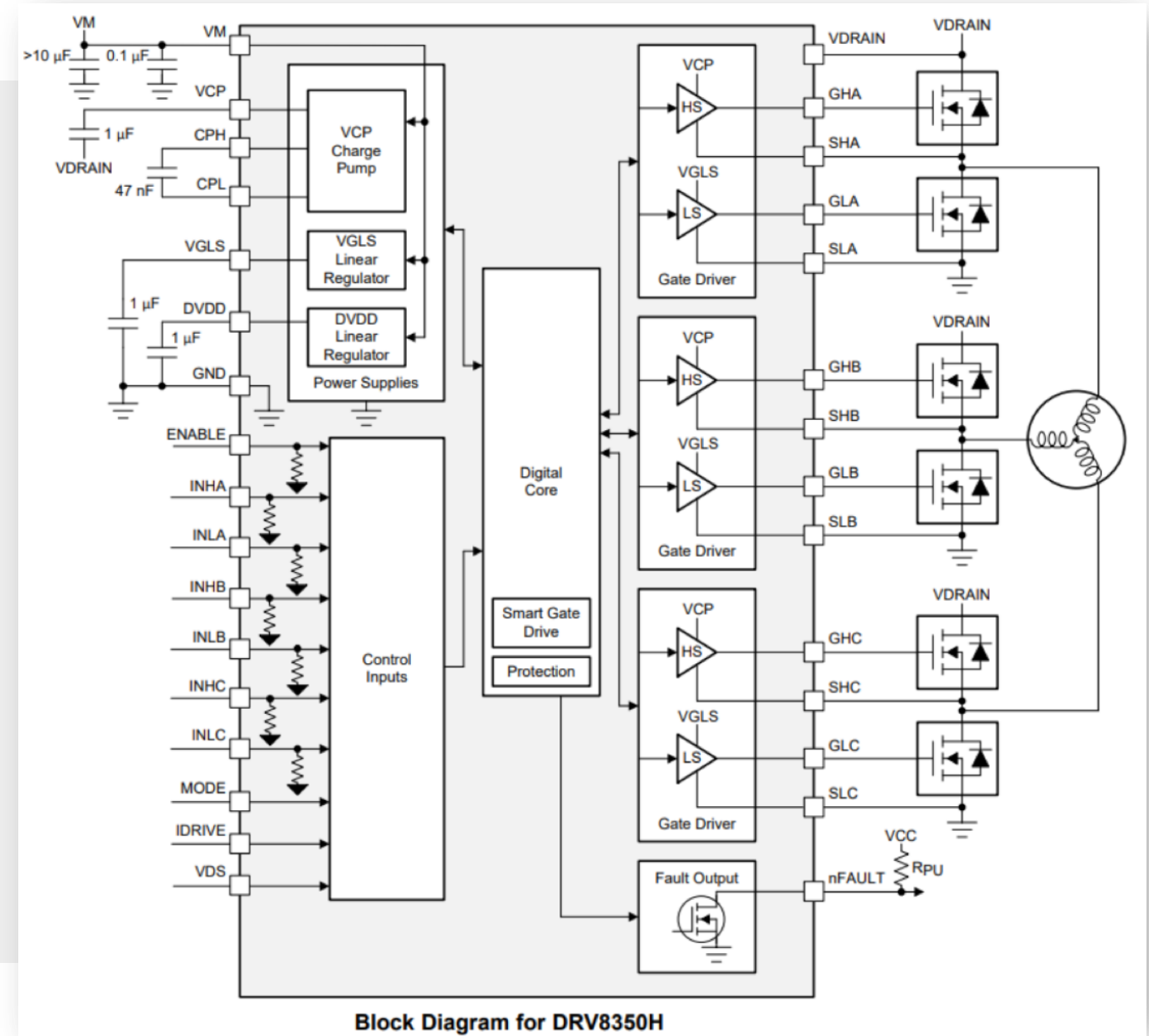
Integrated FET: Monolithic



The gate driver and the power stage FETs are not only contained within the same package in this topology, they also share the same die. (This is usually used for low motor current applications)

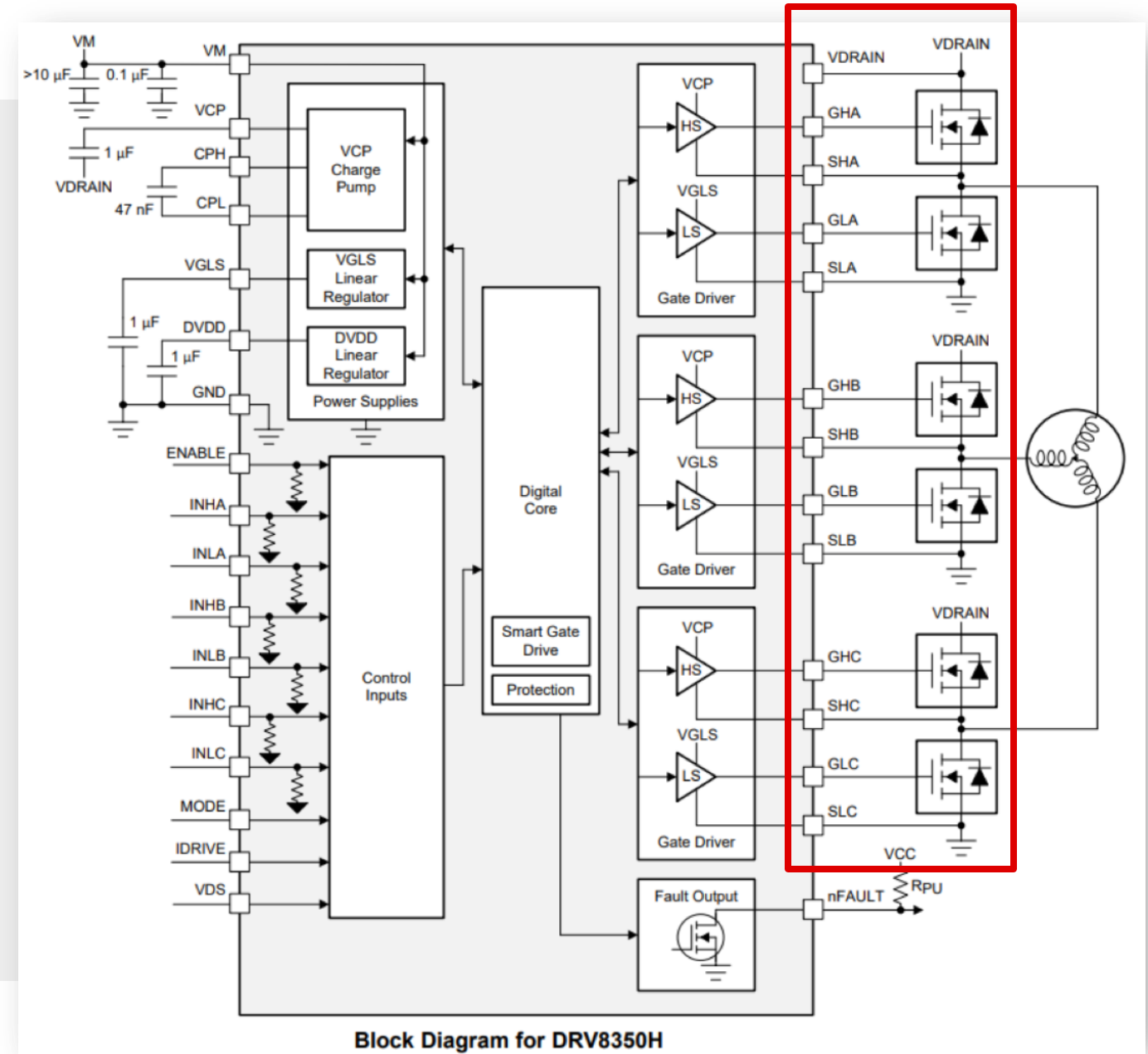
Gate drivers

- *Flexibility*
- Scalable, allows for higher currents
- Power stage FETs are external
- Preferable for >70W systems



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Gate drivers

Benefits

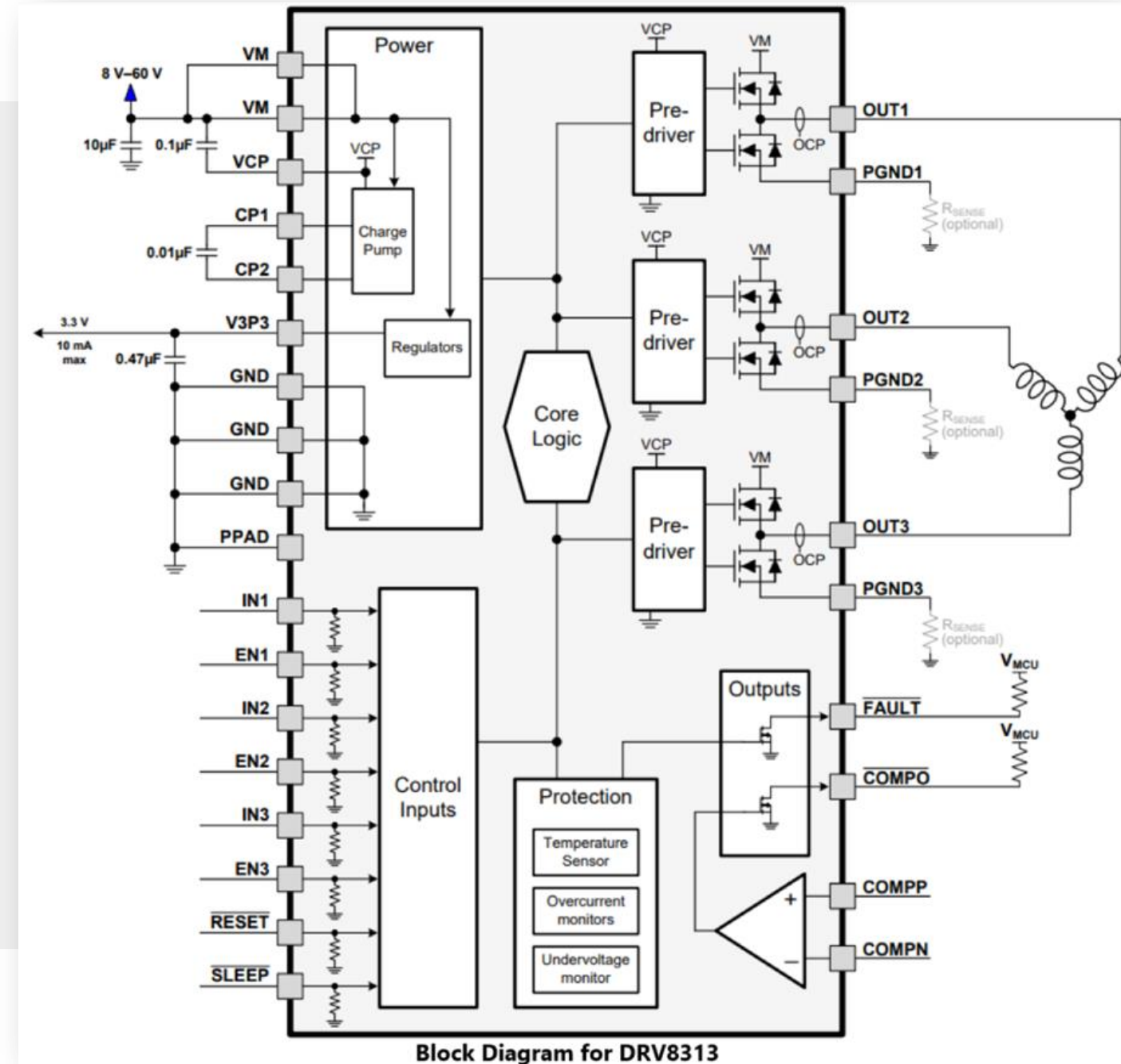
- FETs with lower drain-to-source resistance ($R_{DS(ON)}$) can be chosen to reduce losses.
- The driver integrates necessary charge pumps, diagnostics, and often current sense amplifiers.
- Power dissipation at high current is negligible in the gate driver compared to the power stage FETs.

Disadvantages

- External FET packages can take up a large amount of board space.
- Design complexity is significantly increased.
- FET $R_{DS(ON)}$ and area are inversely proportional.

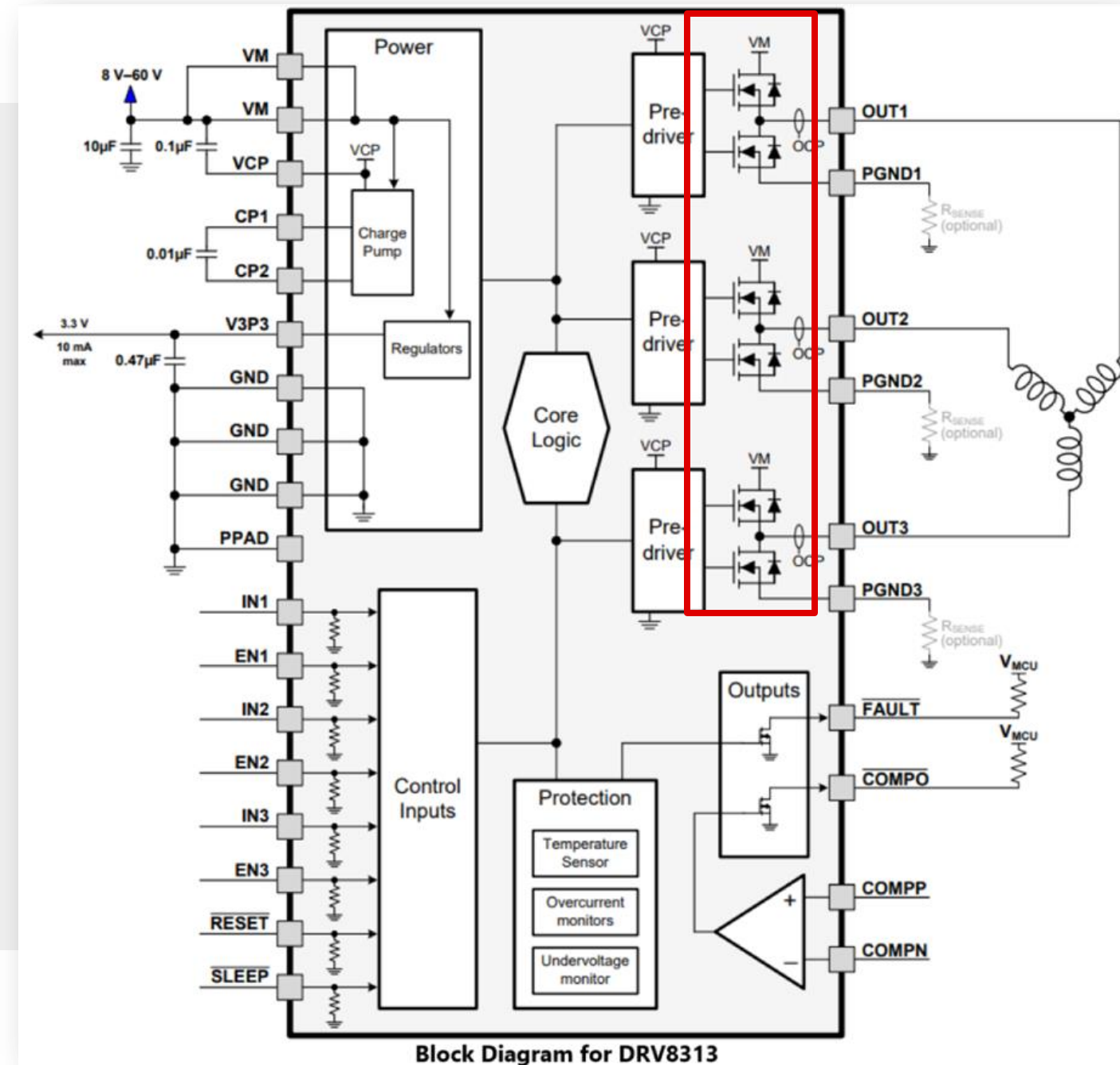
Integrated drivers

- *Simplicity*
- Development time reduced by removing power stage design
- Reduces bill of materials
- TI offers integrated FET motor drivers with peak current capabilities from 1A to 10A+



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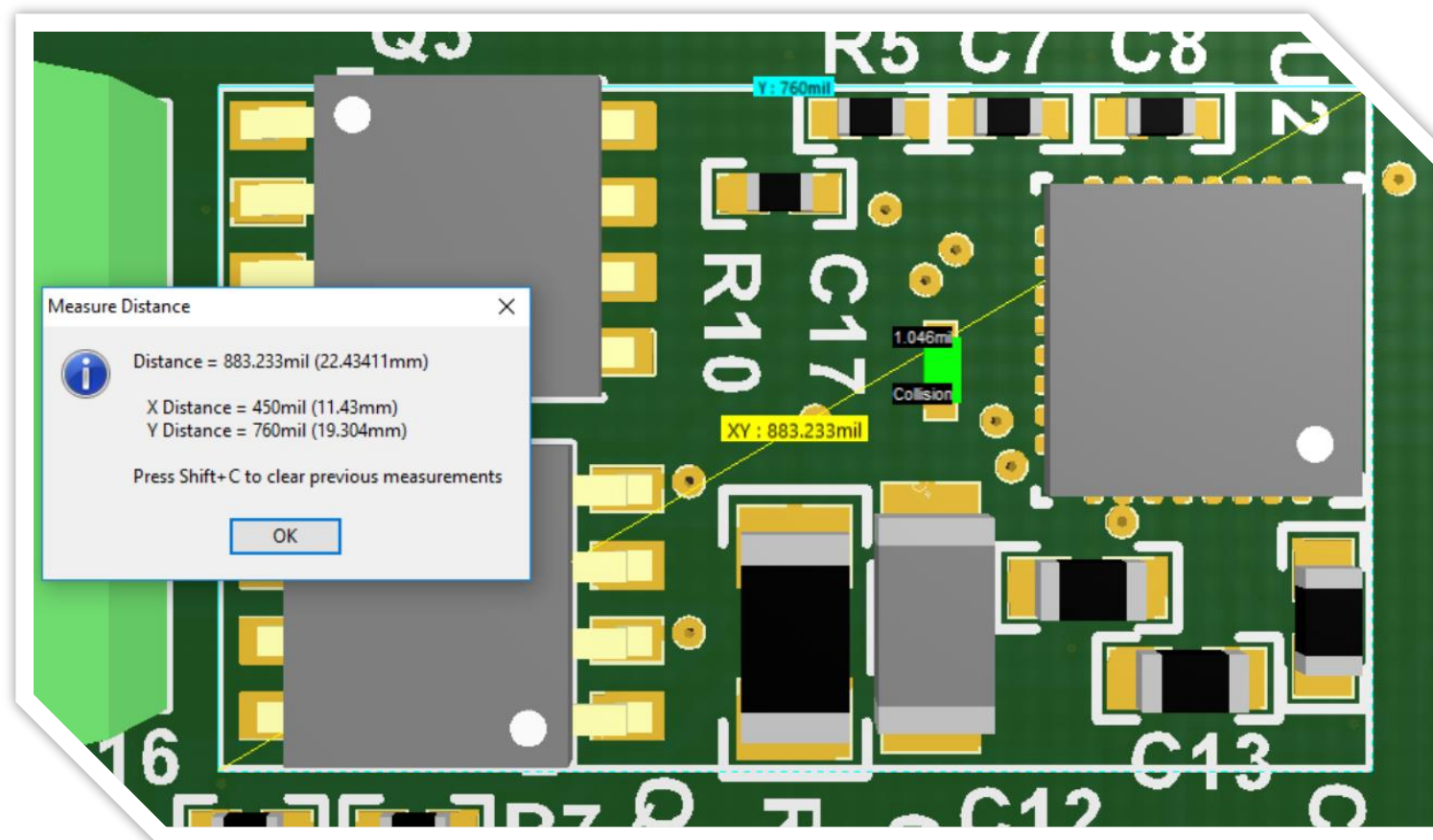
- Testing during production assures proper operation of both the control and power stage of the motor driver.
- Optimal thermal performance and smaller device footprints in low motor current applications (<10A).
- The driver's temperature monitoring is now extended to the power stage.

Disadvantages

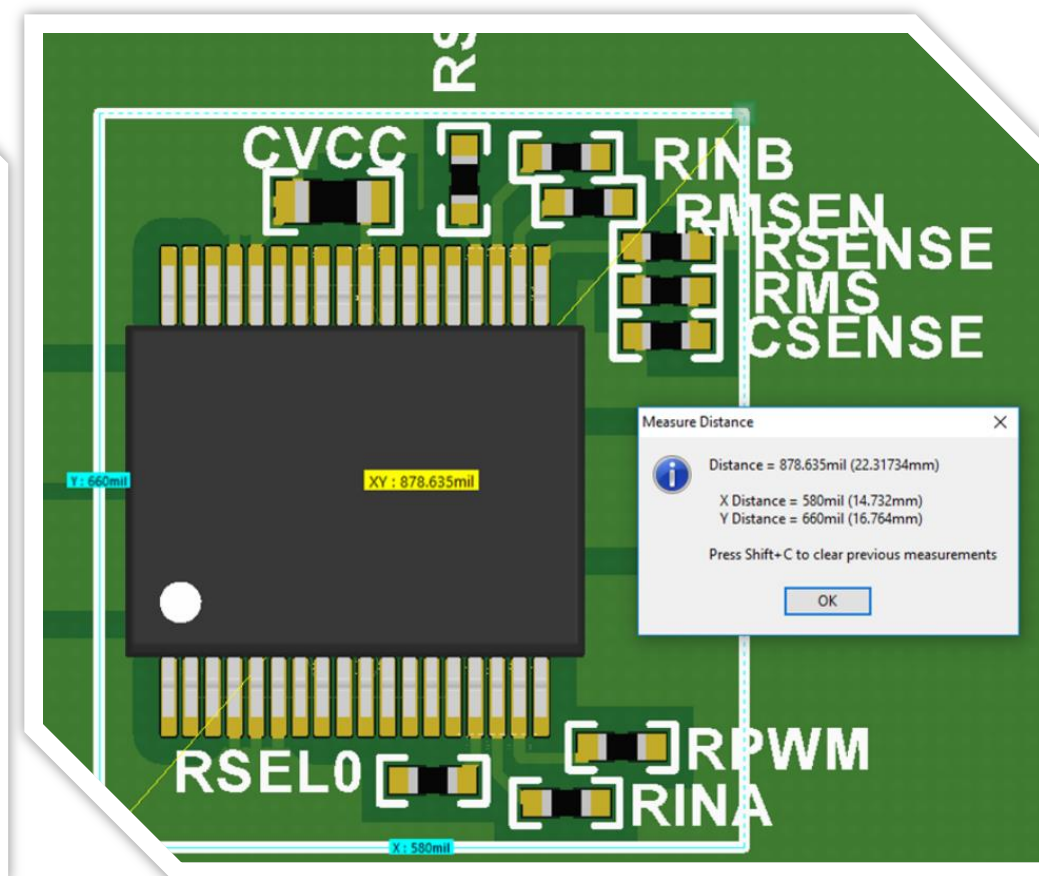
- Since the FETs are contained within the package, size is inversely proportional to $R_{DS(ON)}$.
- Maximum allowable junction temperature of the integrated FET device is heavily influenced by $R_{DS(ON)}$.
- For motor currents greater than 10A, external FETs are more optimal for spreading power dissipation.

Board area considerations

As $R_{DS(ON)}$ increases, both integrated and external FET drivers increase in solution size. The external FET topology may have higher steady state current capability at lower $R_{DS(ON)}$, but integrated FET drivers can minimize board space requirements in low-current applications.



External FET Topology

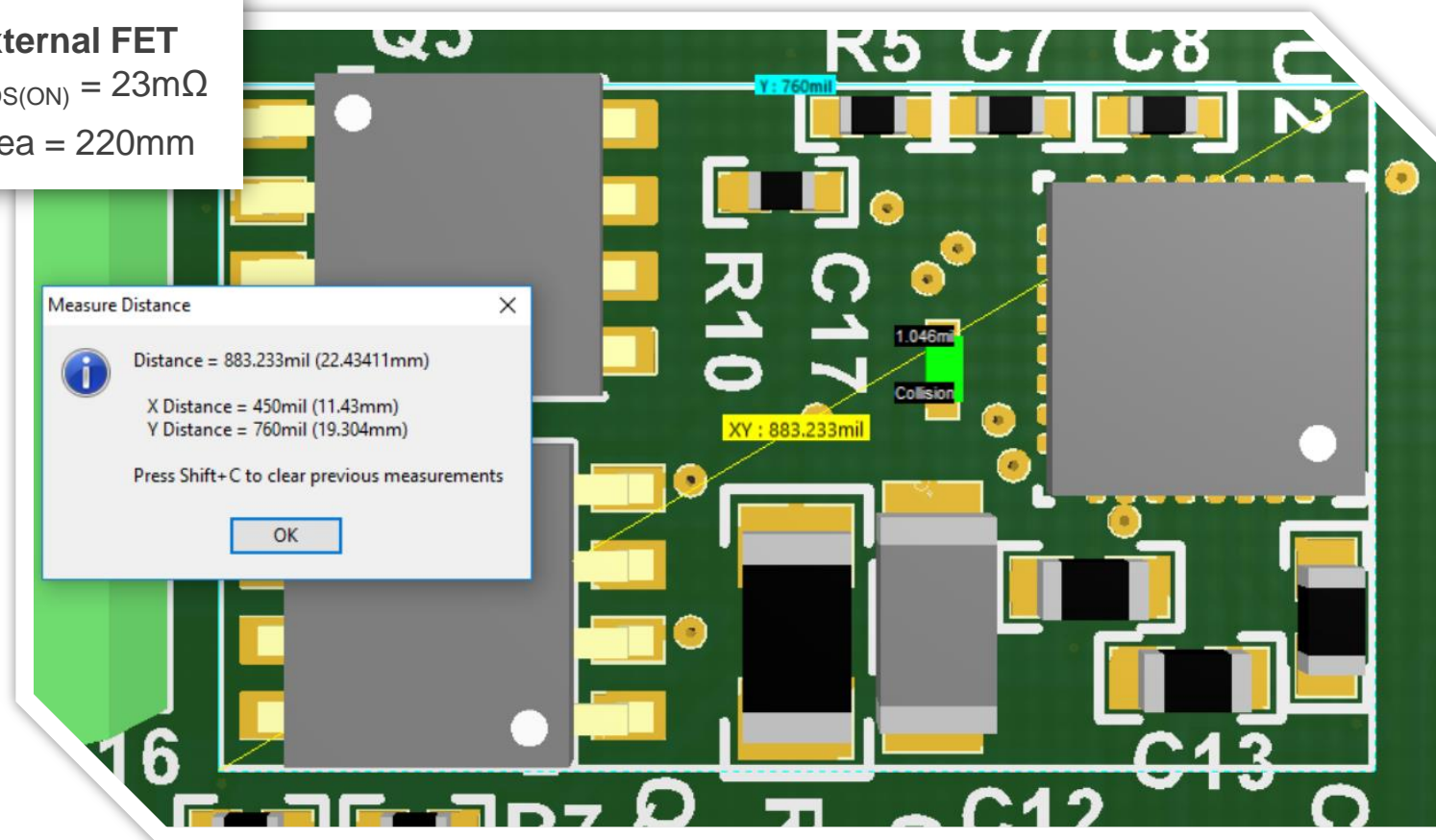


Integrated FET Topology

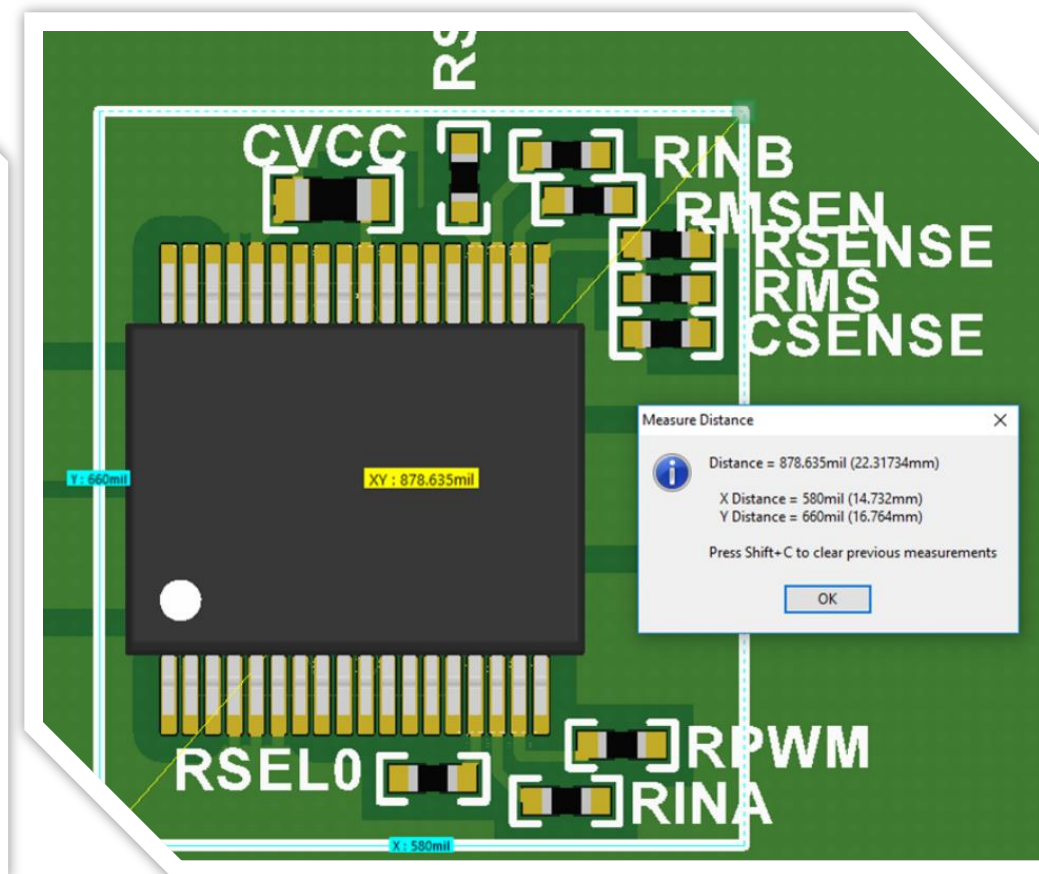
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External FET
 $R_{DS(ON)} = 23m\Omega$
Area = 220mm



External FET Topology

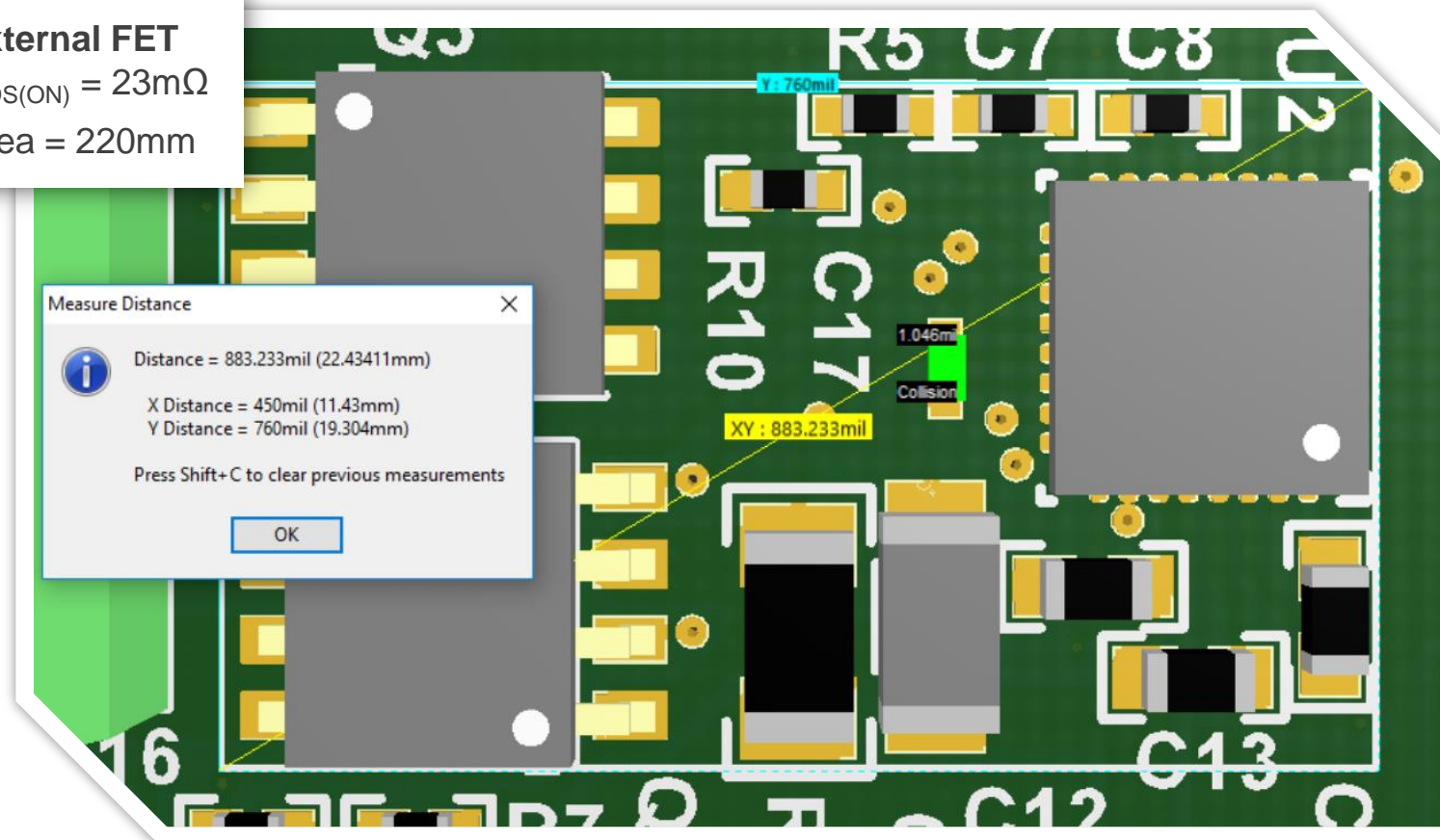


Integrated FET Topology

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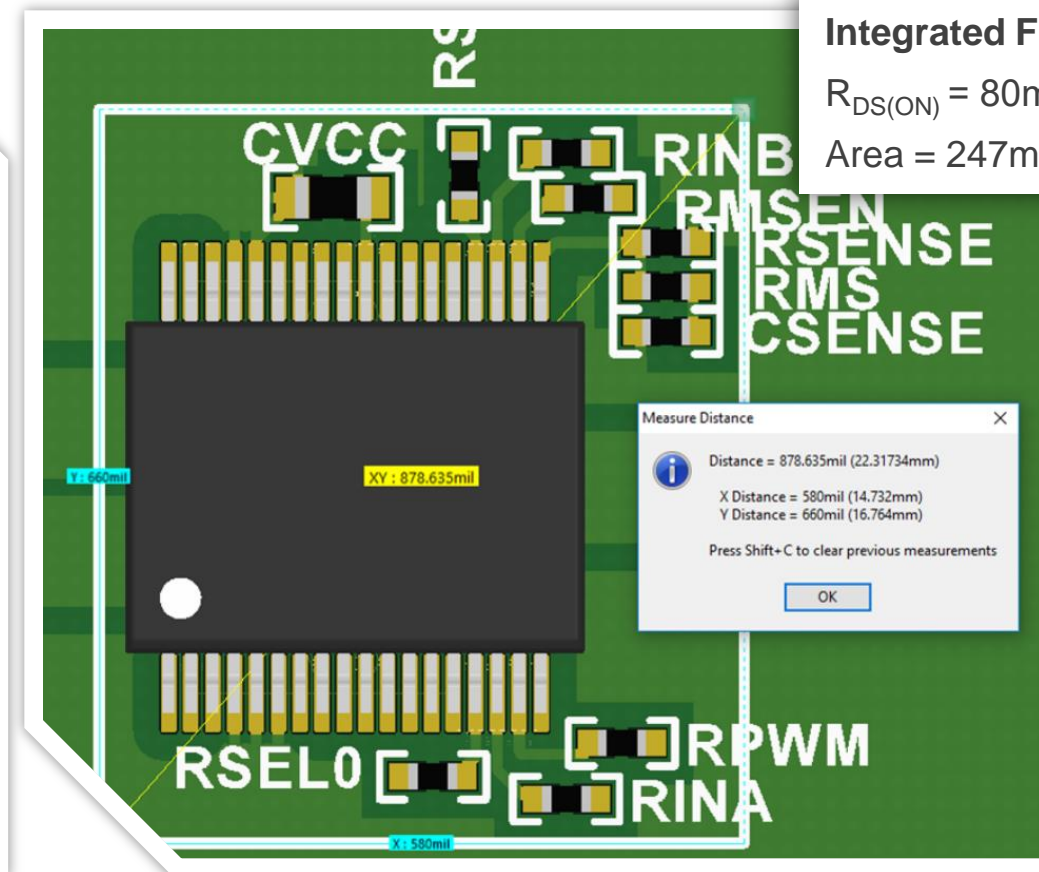
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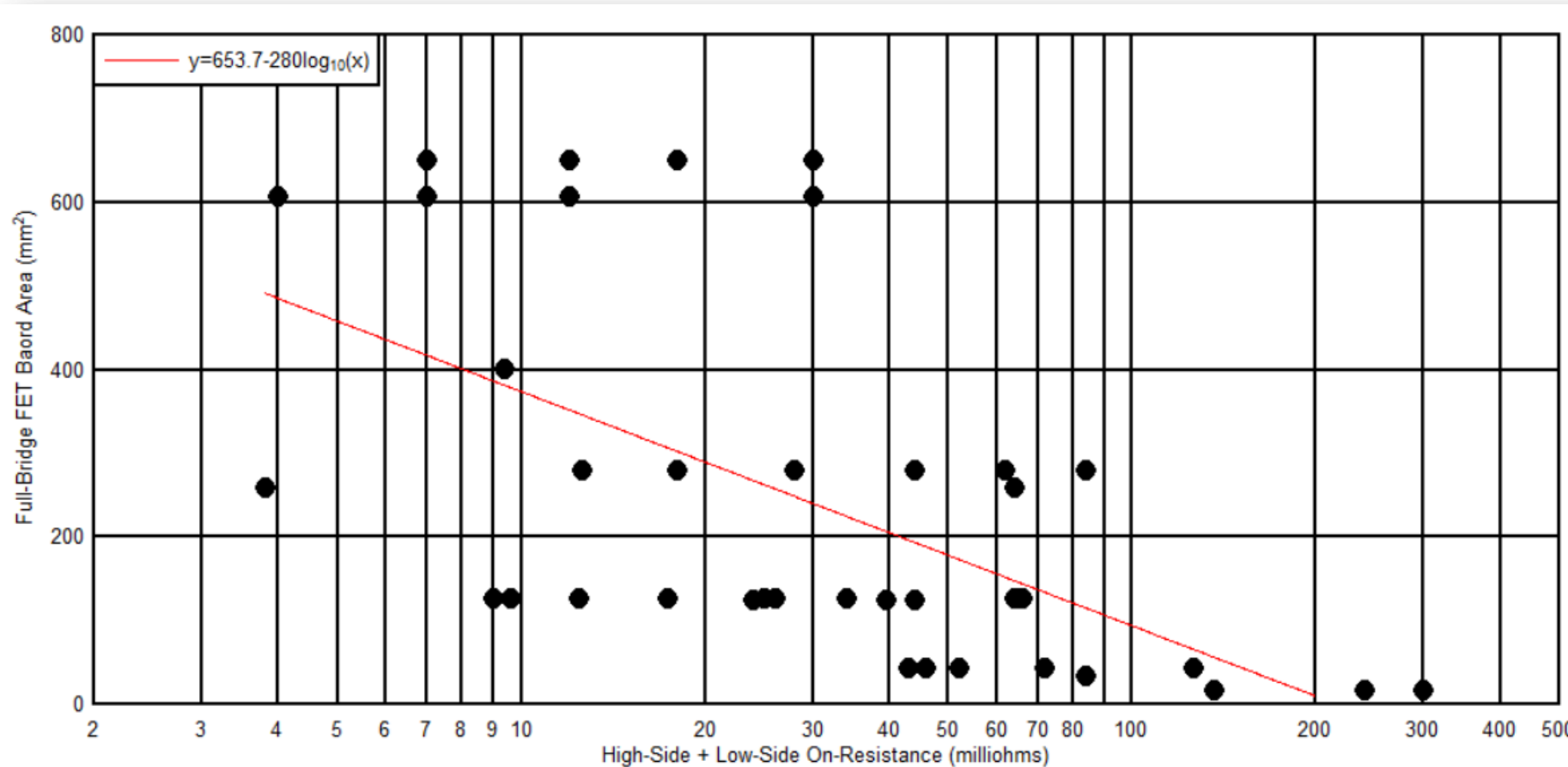
Integrated FET
 $R_{DS(ON)} = 80m\Omega$
Area = 247mm²



Integrated FET Topology

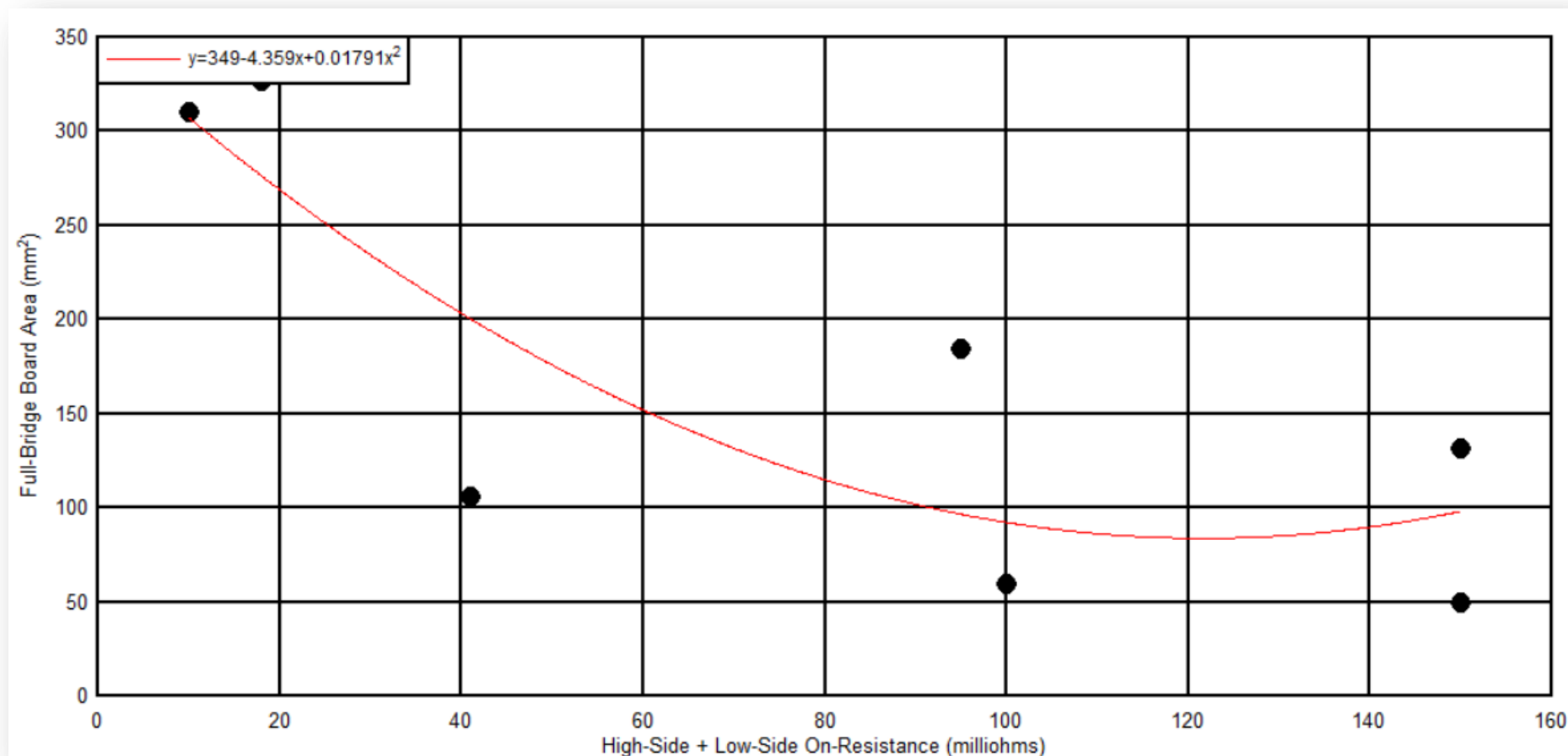
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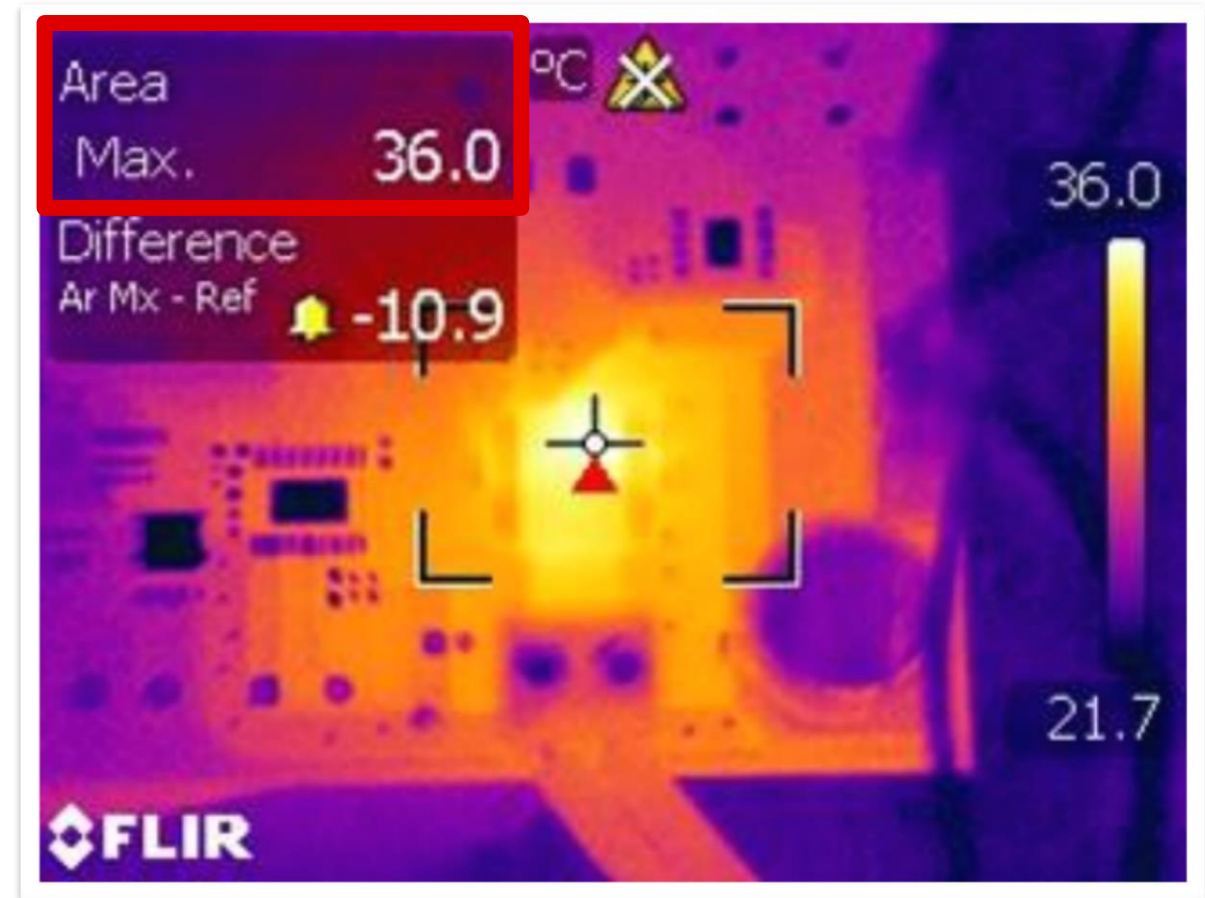


Thermal considerations

When using FETs comparable to the integrated topology driver, the gate driver has similar thermal characteristics. Thermal performance in gate drivers may be improved by choosing lower $R_{DS(ON)}$ FETs while integrated drivers may do so by spreading heat across multiple packages.



External FET Topology



Integrated FET topology

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