How to improve efficiency in solar power systems with wide bandgap devices

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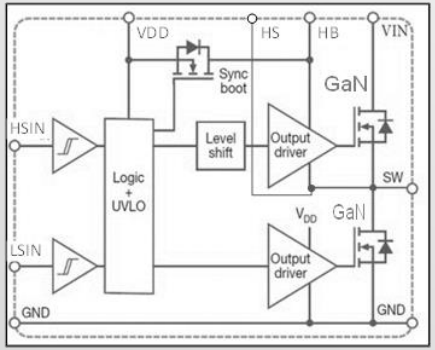
Bodo's Wide Bandgap Event 2024

Making WBG Designs Happen

The overall efficiency of a solar power system is measured in part by its ability to transfer the maximum available power from a solar panel into a string inverter or battery storage system.

GaN technology enables these systems to reduce solution size by operating at higher switching frequencies with improved efficiency.

LMG2100R044/026: Integrated 100V GaN half-bridge

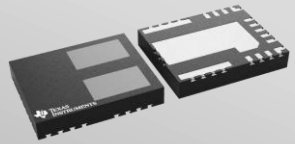


GaN half-bridge with integrated gate driver, level shifter and synchronous bootstrap diode

- 100V
- 30ns typical propagation delay, 2ns typical delay mismatch
- Only single V_{dd} supply 4.5V to 5.5V
- 3.3V or 5V logic inputs
- UVLO protection
- Double-sided cooling

LMG2100R026

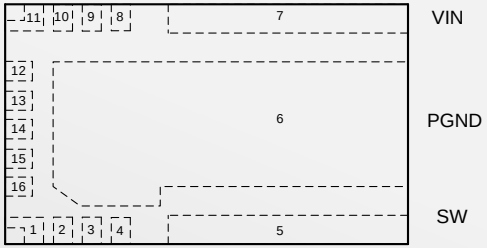
- **2.6 mΩ** typ **3.5 mΩ** max $R_{DS(on)}$ Drain to Source at 25°C
- **Package:** QFN with top-side cooling: 7.0 mm x 4.5 mm



LMG2100R044

- **4.4 mΩ** typ **5.7 mΩ** max $R_{DS(on)}$ Drain to Source at 25°C
- **Package:** QFN with top-side cooling: 5.5 mm x 4.5 mm

LMG2100R026



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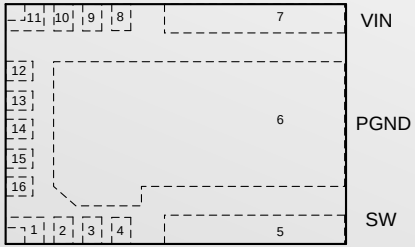
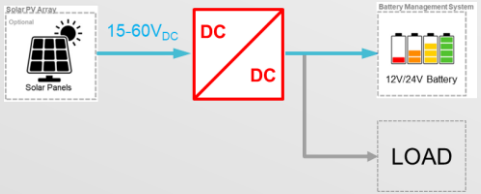
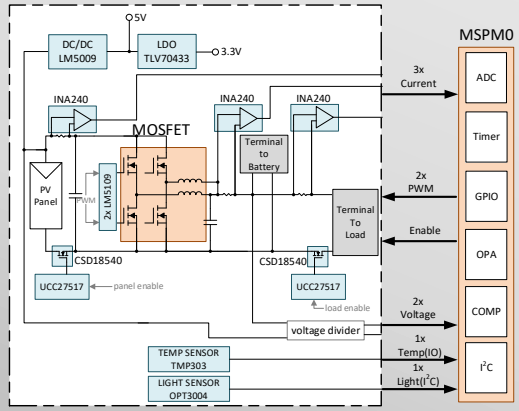


Case study: Solar charge controller

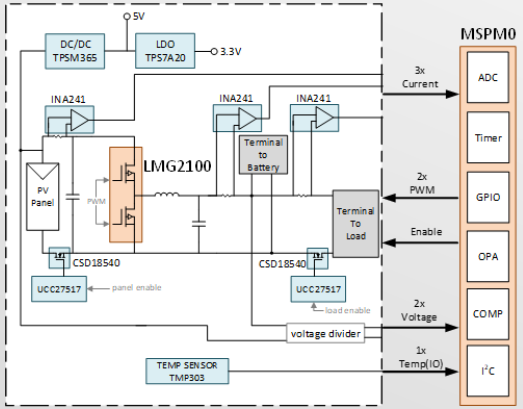


- Converts power from a solar panel to a DC-load or battery storage system
- 400W PV panels typically have V_{MPPT} ~ 33V_{DC}, I_{MPPT} <13A
- Battery voltages supported are typically in 12V/24V range

FET implementation: interleaved FETs (2 x 6.4mΩ Si-MOSFET)

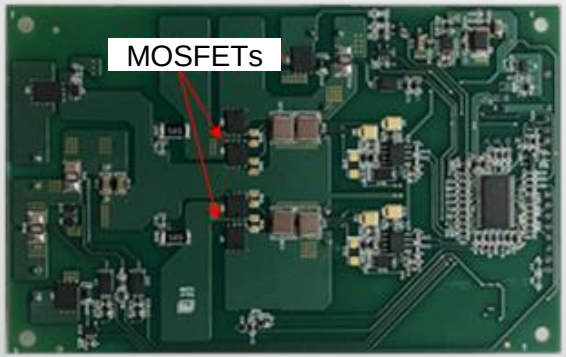


GaN implementation with LMG2100 (4.4mΩ half bridge)



Solar charge controller – Size improvements

MOSFET implementation: interleaved FETs



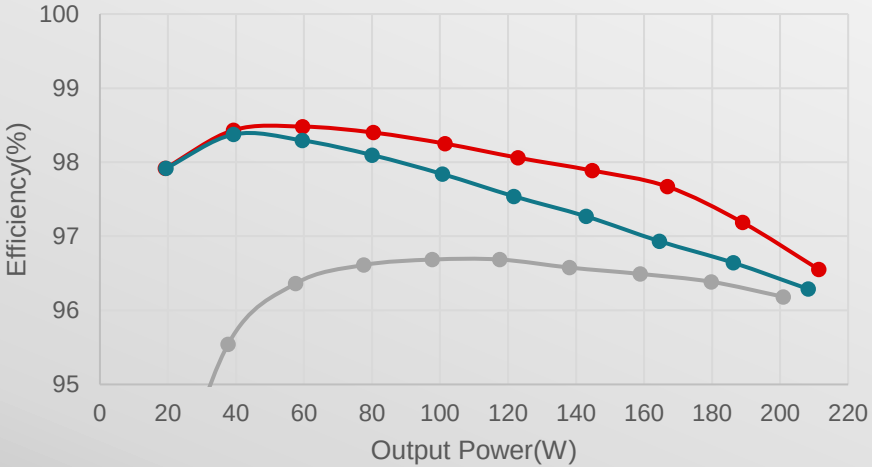
f_{PWM}: 180kHz (interleaved)
2 x boost inductor
Size: 130mm x 82mm

GaN implementation with LMG2100

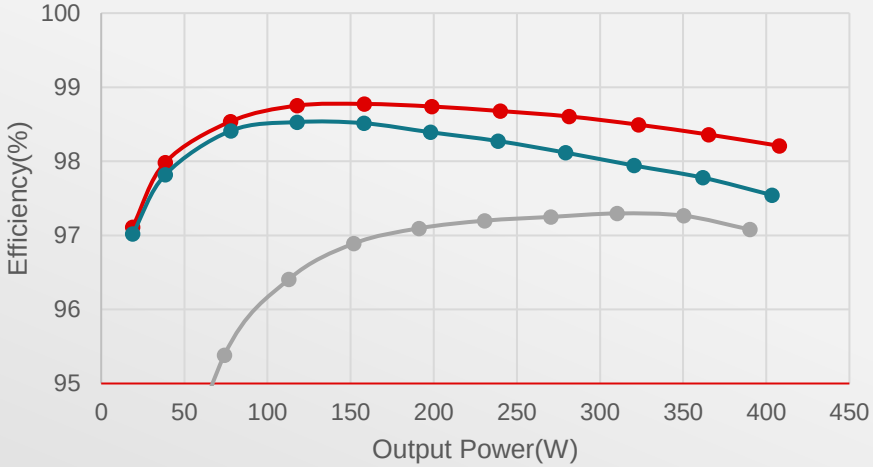
f_{PWM}: 250kHz
1 x boost inductor
Size:8.3 mm × 8.2 mm
37% PCB area saved

Solar charge controller – Efficiency improvements

12V battery system



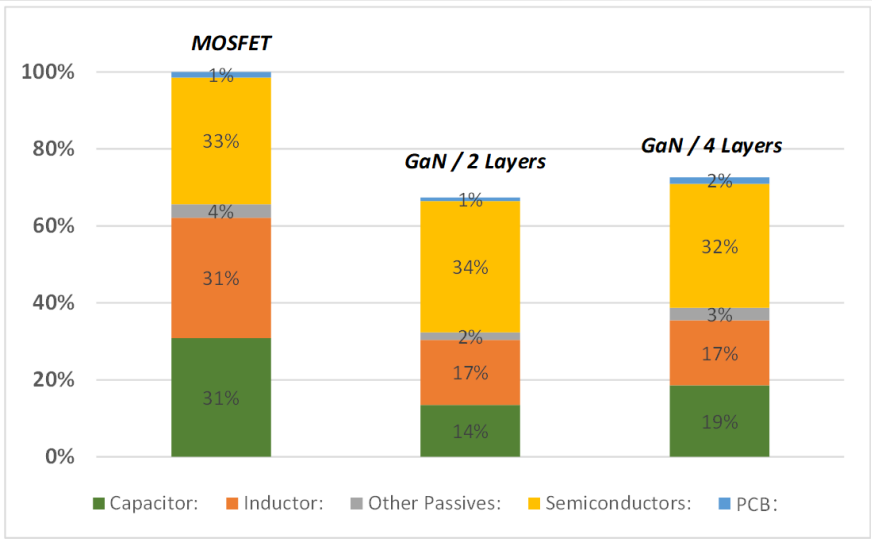
24V battery system



EU weighted efficiency: **97.9%**	4-layer Board with LMG2100	EU weighted efficiency: **98.5%**
EU weighted efficiency: **97.5%**	2-layer Board with LMG2100	EU weighted efficiency: **98.2%**
EU weighted efficiency: **96.3%**	2 layer Board with MOSFET	EU weighted efficiency: **96.4%**

GaN offers >2% weighted efficiency improvement compared to MOSFET

Solar charge controller – System cost improvement



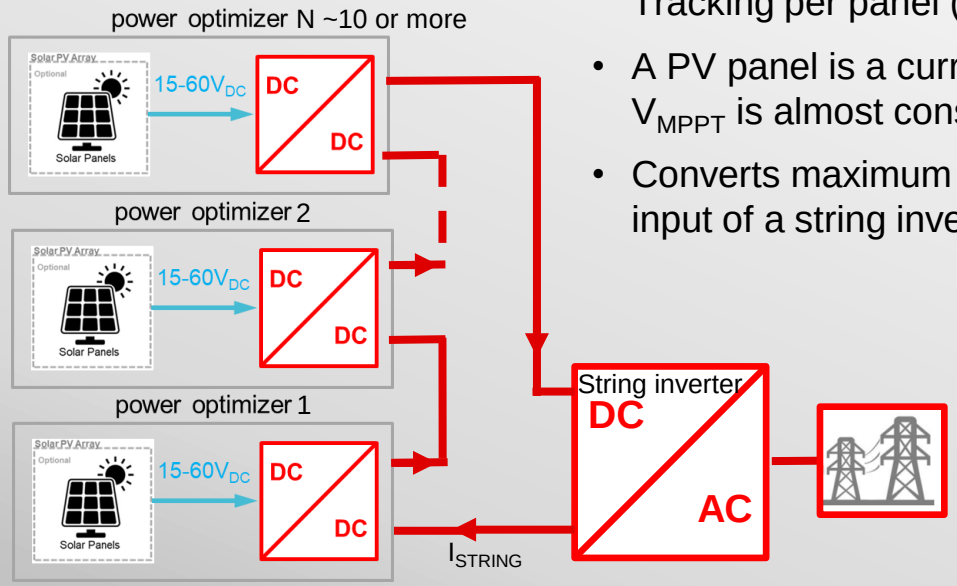
System cost comparison:

- Normalized pricing applied
- Baseline is MOSFET implementation with two-layer PCB
- Semiconductors, other passives and PCB are alike
- Inductors and capacitors greatly reduce cost

More information available:

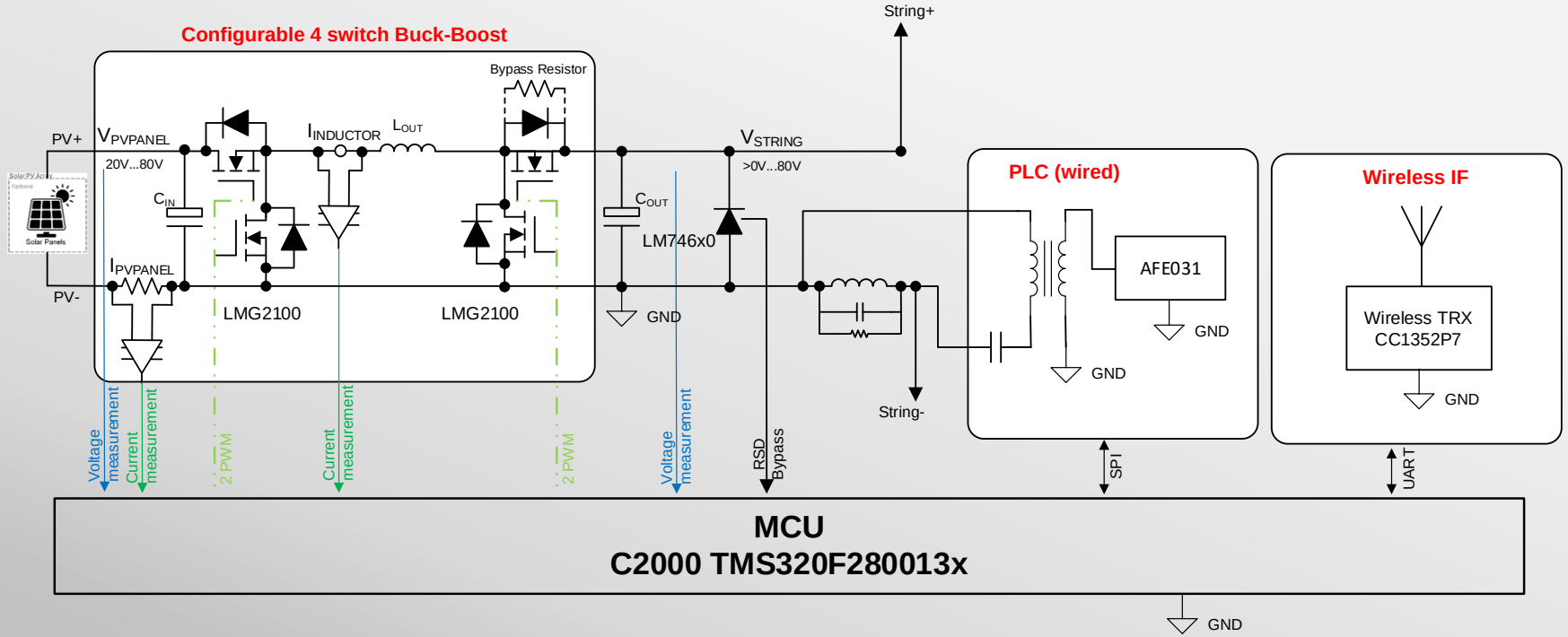
- Reference design: TIDA-010042
- App brief: How GaN Improves Solar Charge Controllers

Case study: Solar power optimizer

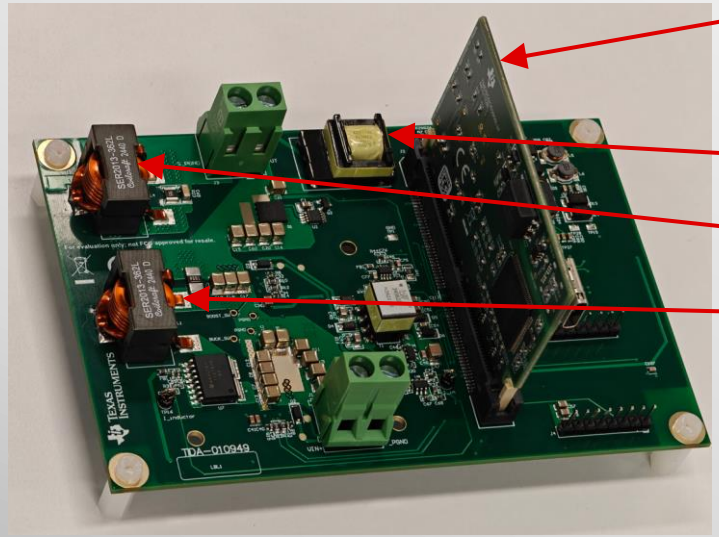


- Optimize the power delivered by a PV panel by Maximum Power Point Tracking per panel (MPPT)
- A PV panel is a current source; Current changes with sun-exposure and V_{MPPT} is almost constant
- Converts maximum available power from each solar panel to DC/DC boost input of a string inverter by adjusting to I_{STRING}

Solar power optimizer – Buck/boost topologies



Solar power optimizer – Board and functions



F2800137 control card

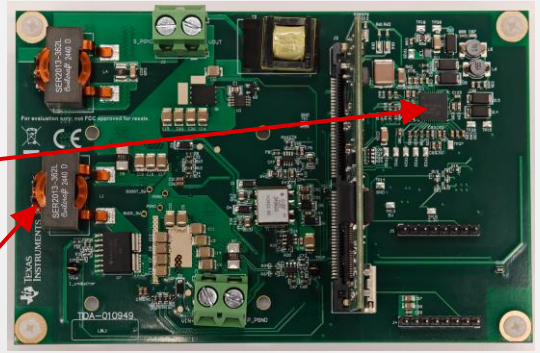
AFE031 for PLC

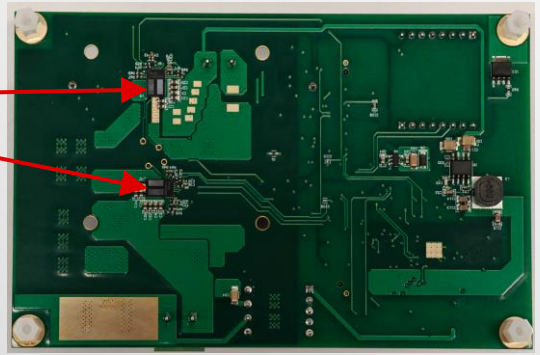
Coupling transformer for PLC

Coupling inductor for PLC

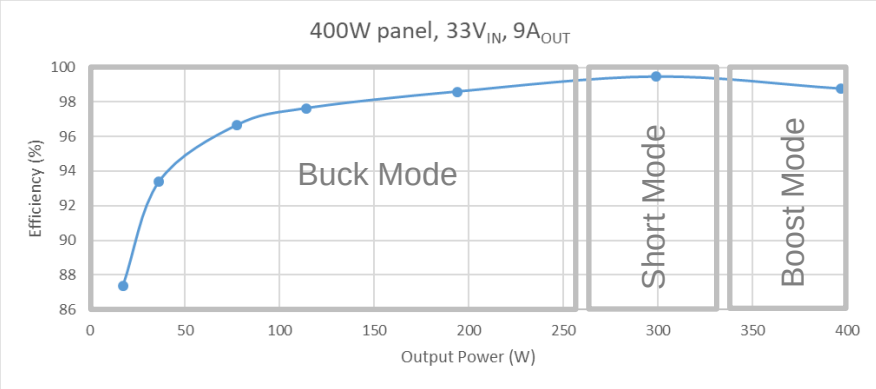
Boost inductor (optimizer)

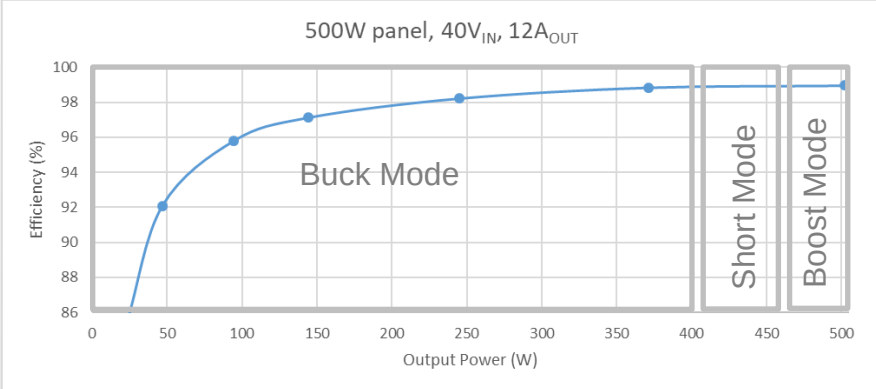
LMG2100R026

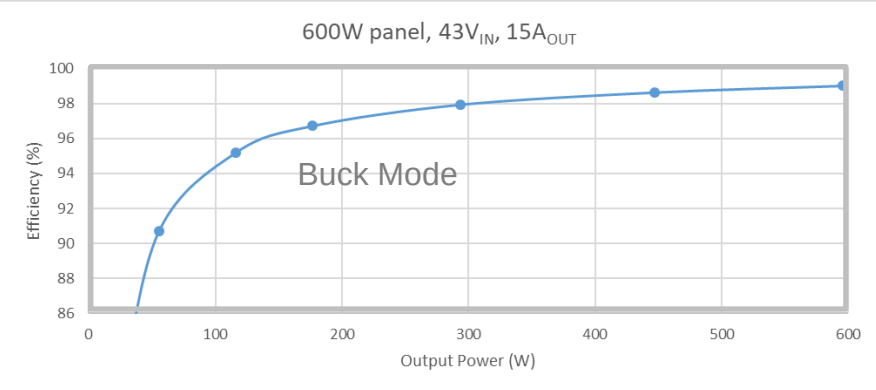




Solar power optimizer – Efficiency







Panel Power	Peak Efficiency	Euro Efficiency	CEC Efficiency	I_{string} (I_{out})	T_{j_rise}(w/o heatsink)
400W	98.7%	97.7%	98.2%	9A	35°C
500W	98.8%	96.9%	97.9%	12A	47°C
600W	99.0%	96.7%	97.7%	15A	70°C

Exceptionally high efficiency compared to MOSFET solutions

In summary, GaN technology…

… enables a reduction in solution size and improved efficiency in solar charge controller and solar power optimizer systems by operating at higher switching frequencies.

… can increase power density and efficiency in end equipment, increasing overall performance of a solar power system.

… can lower total solution cost.

Integration of a gate-driver into a half-bridge device simplifies design and can shorten time to market.

Thank you!