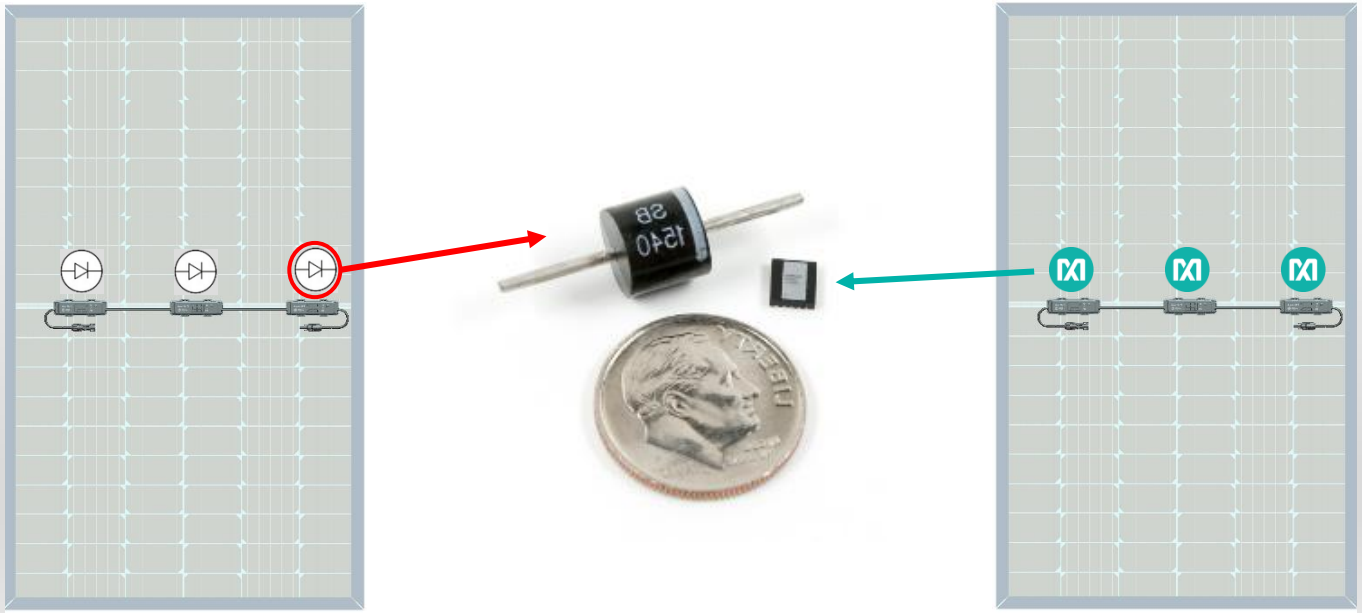
Maxim Submodule Optimizers

PV Optimization for Utility Scale Solar

Maxim Submodule Optimization

Conventional
Bypass diode per 24 cells

Bypass underperforming cells and modules to prevent fire risk



Maxim
Optimizer per 24 cells

Harvest all available energy and provide value-add functionality

Factory Installed	Traditional bypass diodes are replaced with Maxim's submodule optimizer
Distributed MPPT	3x MPPT per module provides mismatch loss recovery and improved performance
Value	Reduce Capex and LCOE with up to 50% longer strings
Reliability	Technology proven with over 20 years in mission critical applications

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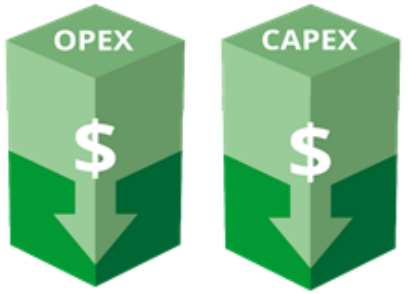
Capex Savings



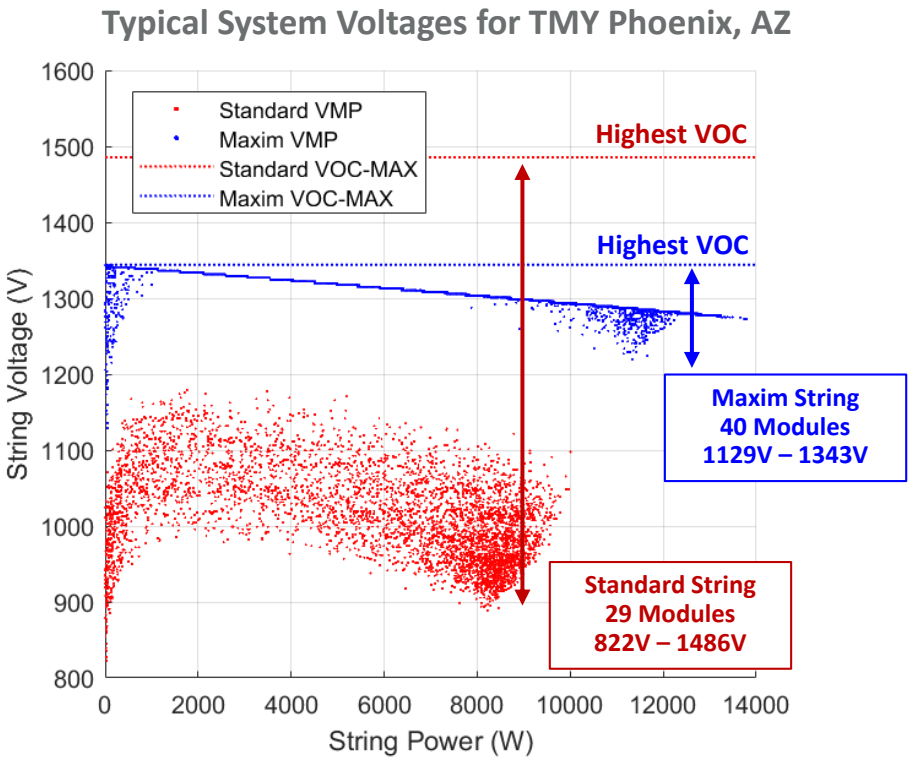
- Voltage limiting feature enables up to 1.5x more modules per string
  - > 33% fewer DC strings, combiners, cabling, and labor
  - > Utilize more cost-effective (higher power) central inverters
  - > 15% fewer medium voltage AC runs, combiners, and labor

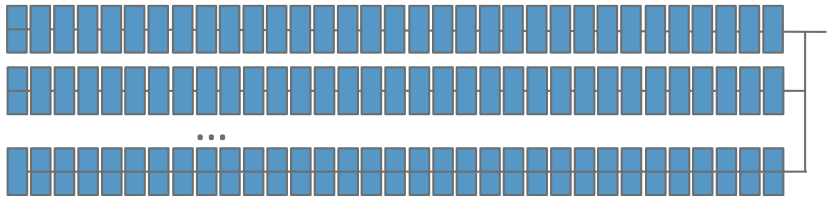
Increased Energy

- Submodule optimization boosts production output by up to 5%
  - > Recover DC system mismatch losses
  - > Eliminate backside mismatch losses in bifacial modules
  - > Reduce long-term system degradation rates

Capex Savings + Increased Energy → Reduce LCOE by over 5%

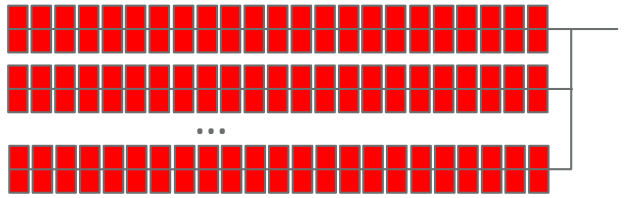
Longer Strings





1500V Maxim System

- 40 modules per string
- 75 strings per MW
- 29 inverters per 100MW



1500V Standard System

- 26 - 30 modules per string
- 100 - 115 strings per MW
- 33 - 35 inverters per 100MW

- **Voltage limiting** allows 50% more modules per string while remaining under 1500V
  - > Longer strings results in fewer home runs, combiners, fuses, and installation labor
  - > Higher and narrower voltage window allows use of 15-20% fewer more cost-effective inverters

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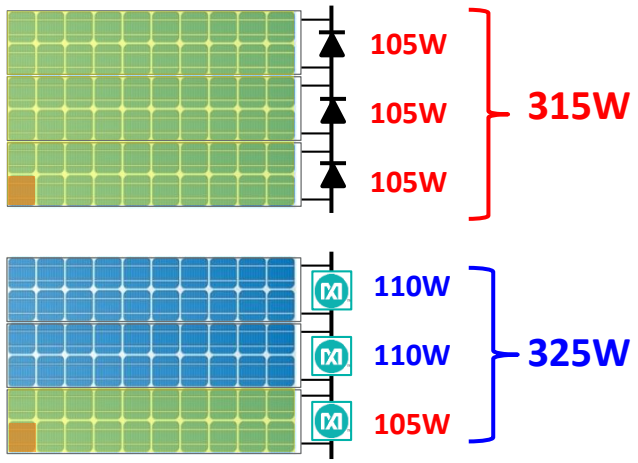
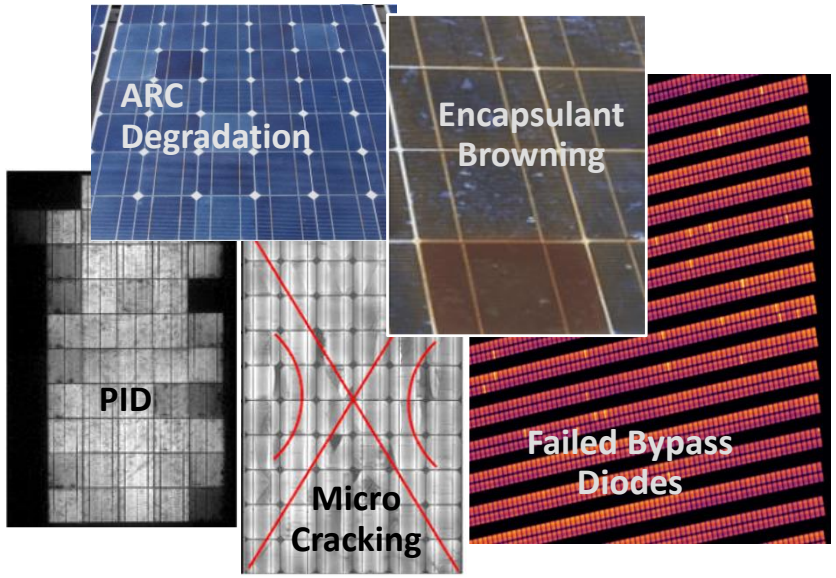
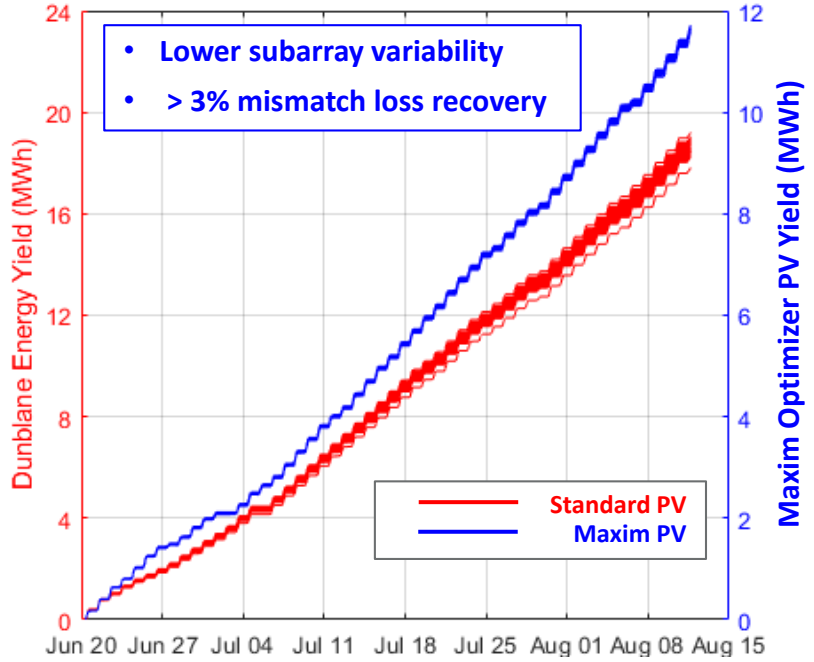
Eliminate Mismatch Losses



Maxim Optimizers Eliminate Mismatch



Many Sources of Mismatch



DC Subarray Variability

- Prevent submodule or module variation from leading to mismatch system losses
  - > Minimize electrical losses from all forms of variation (cracked cells, PID, LID, thermals, shading, etc.)
- Increase output over 3% in 'good' systems, protect from unforeseen more severe loss mechanisms

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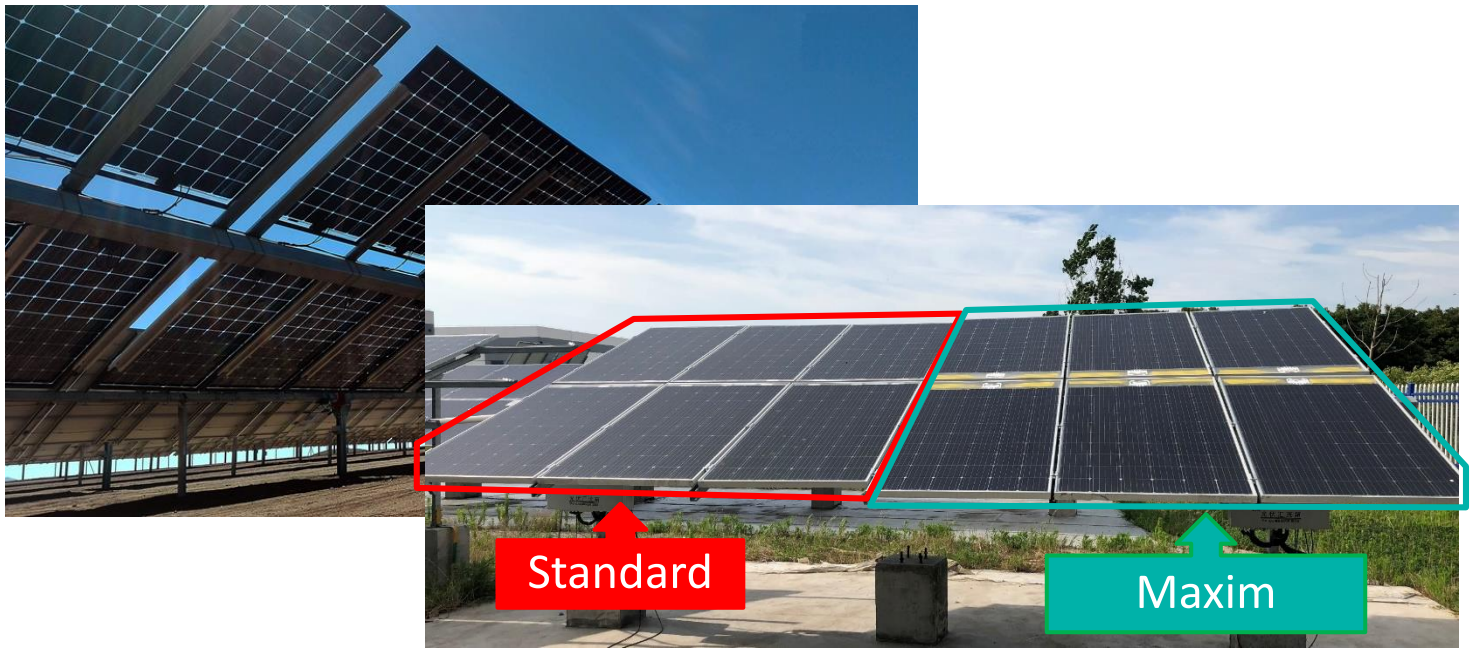
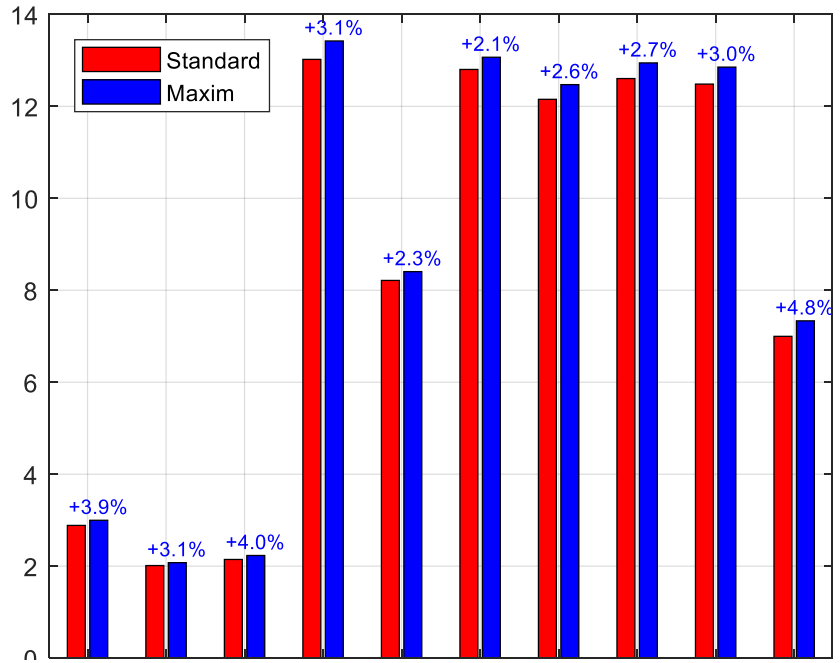
Bifacial Irradiance Mismatch

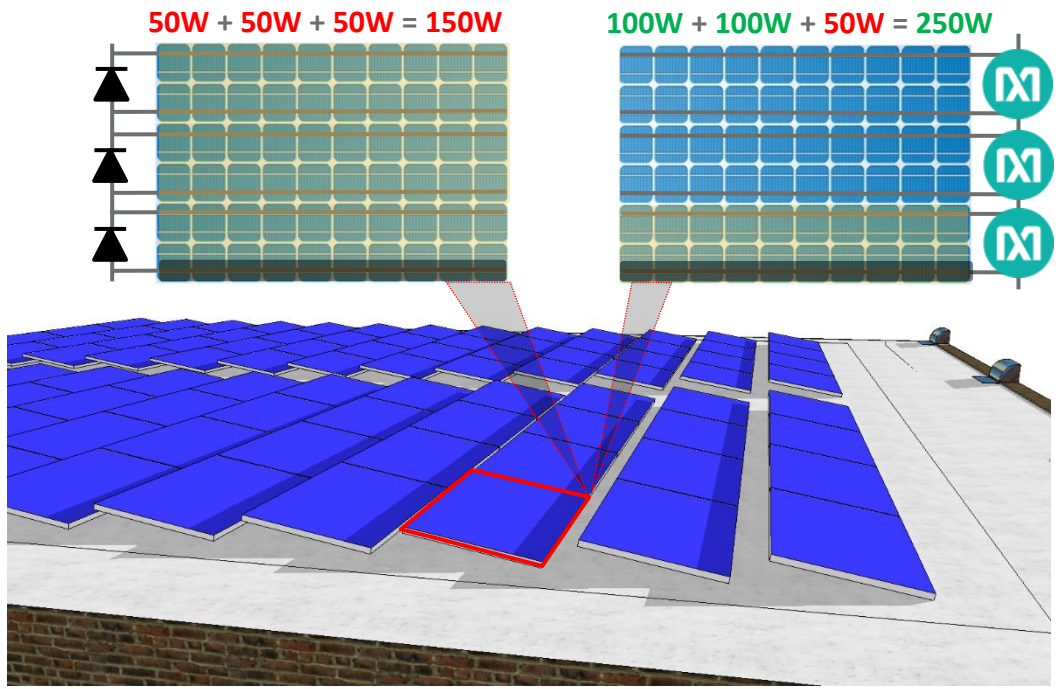


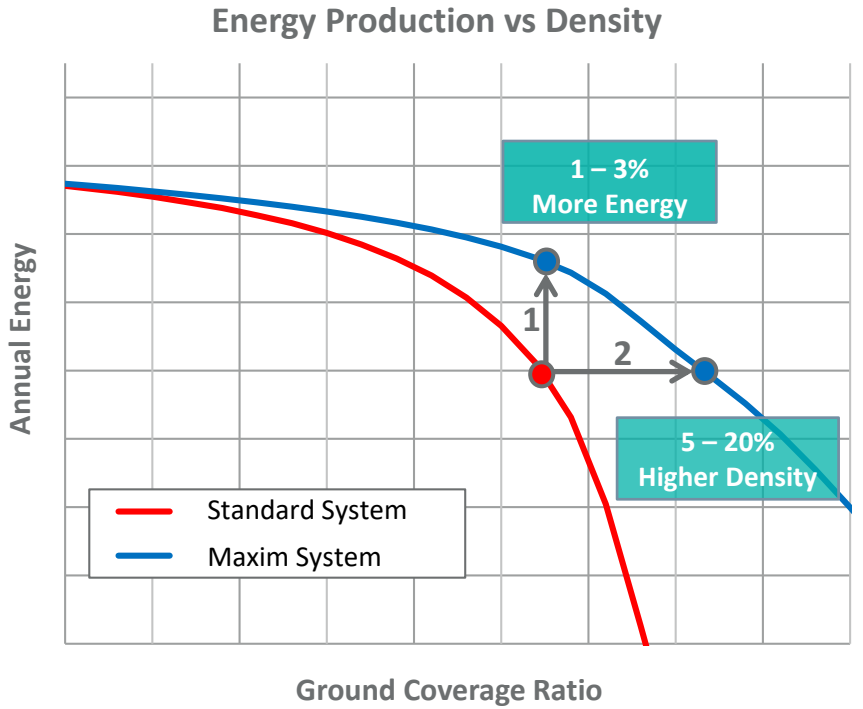


Bifacial Field Trial Results

- Bifacial production boost is hampered by backside irradiance mismatch
- Initial small-scale trial with Maxim optimizers had an average gain of 2.9% over a 10 day period
- Maxim is commissioning several Independent Engineer trials to fully characterize the benefit

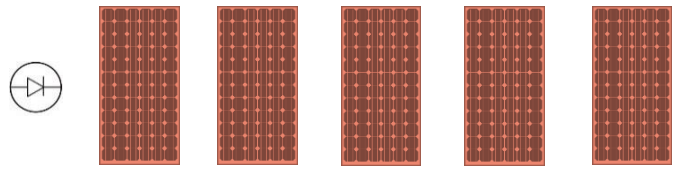
High Density Systems



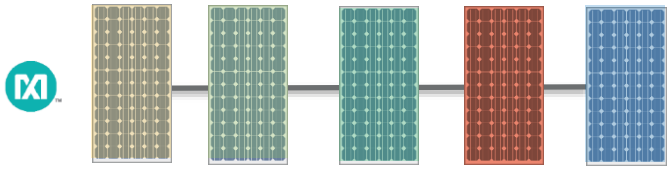


- Space constrained systems must balance absolute [kWh] and relative [kWh/kW] performance
- Maxim optimizers can provide 1-3% more energy or 5-20% higher capacity

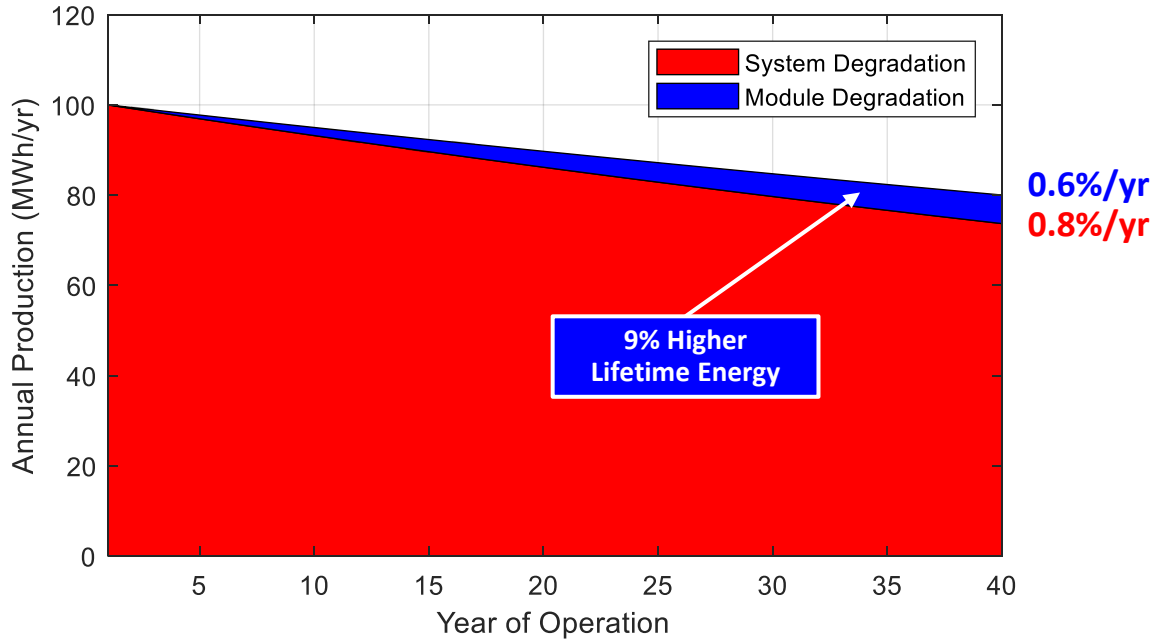
Reduced Aging and Degradation



Standard System: Power Dictated By Weakest Modules



Maxim System: Each Module Contributes Maximally



- DNV data substantiates a mean module degradation of 0.6%/yr and mean system degradation of 0.8%/yr
- Maxim optimizers limit degradation to the module's rate without the additional system loss

Installation Friendly

Factory Installed

Inverter Compatibility

- No external boxes to install or communication networks to setup and debug
- Broad compatibility with string and central inverters
- Simpler plant design with temp independent string lengths, fewer cables, combiners, inverters, etc.

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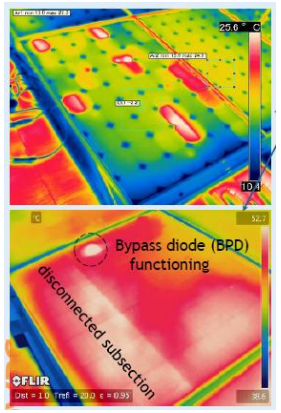
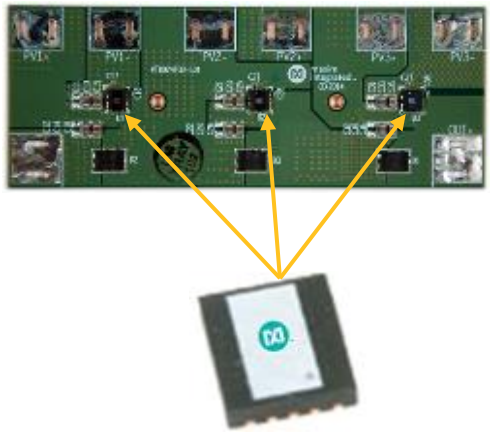
Field Reliability



Better Application Level Reliability



Better Component Level Reliability

Failure Prone | **Reliable By Design** | **Overly Complex**

- Independent engineering validated to surpass 35 year operating life
- Maxim power ICs are proven from 2B+ units shipped over 20 years into server and telco markets
- Removeable junction box for field serviceability
- Standard 25 year module manufacturer's warranty

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Utility Scale Value Stack

Benefit	Diode	Maxim Optimizer	Value
Triple MPPT Per Module	✗	✓	
Reduce Electrical BOS	✗	✓	2 c/W
More Cost-Effective Inverters	✗	✓	1 c/W
Mismatch Recovery	✗	✓	3 c/W
Bifacial Production Increase	✗	✓	2 c/W
Reduced Aging & Degradation	✗	✓	1 c/W
Total Value			**9 c/W**

Reduce Installation Costs, Improve Performance, Minimize Investment Risk

The Only Utility Scale Optimization Solution

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