



OPEN
Compute Project



OCP U.S. SUMMIT 2017

Santa Clara, CA



Flexible & Scalable 48V Solutions Powering Tomorrow's Data Centers

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Maxim Integrated
3/9/2017

OPEN HARDWARE.



OPEN SOFTWARE.



OPEN FUTURE.



Rack Architectures are Changing from 12V to 48V

Why a New Rack Power Architecture is Needed

Data Centers are Focused on Reducing Energy Consumption

- 2% of Global Electricity use
 > Equivalent Electricity Usage of Italy
- US data centers forecasted to consume 140B KWhrs by 2020
- Rack Power is One of the Largest OpEx Consumers in Data Centers

1

CPU & Memory Consume Most Power in Rack

- CPU & Memory Represent ~80% of Total Server Power
- CPU Power & Dynamic Requirements Continue to Increase

2

New 48V Rack Power Architecture

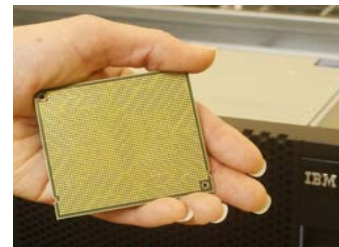
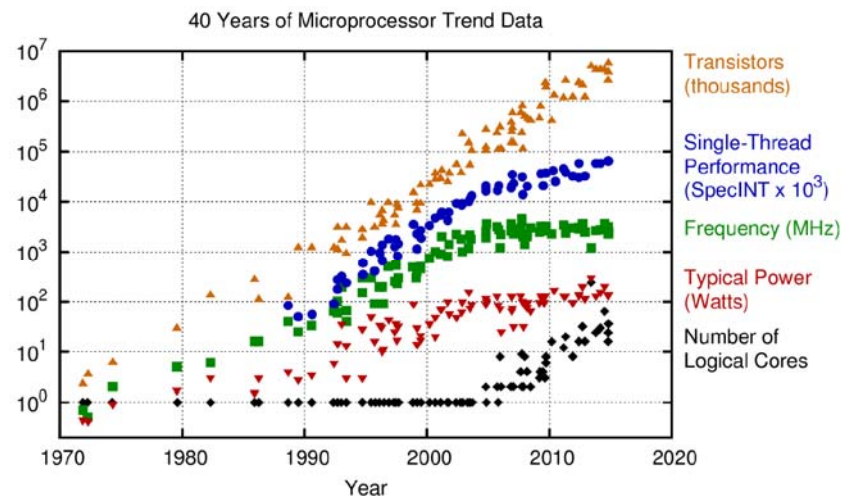
- Google Introduced a 48V Rack Power Architecture at 2016 OCP Summit to Replace 12V Racks
- Requires New High Efficiency 48V to PoL Regulator for CPU & Memory

3

Racks are Moving from Typically 8kW Today to 20kW by 2020 Timeframe

High Performance Silicon Trends

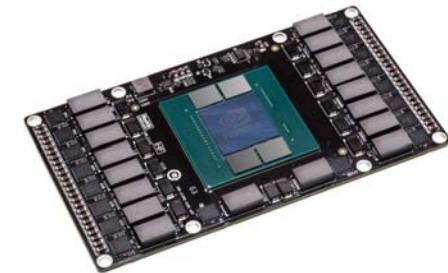
CPUs, GPUs & FPGAs



Open Power P8 with NV Link



FPGA Accelerators add 100W +



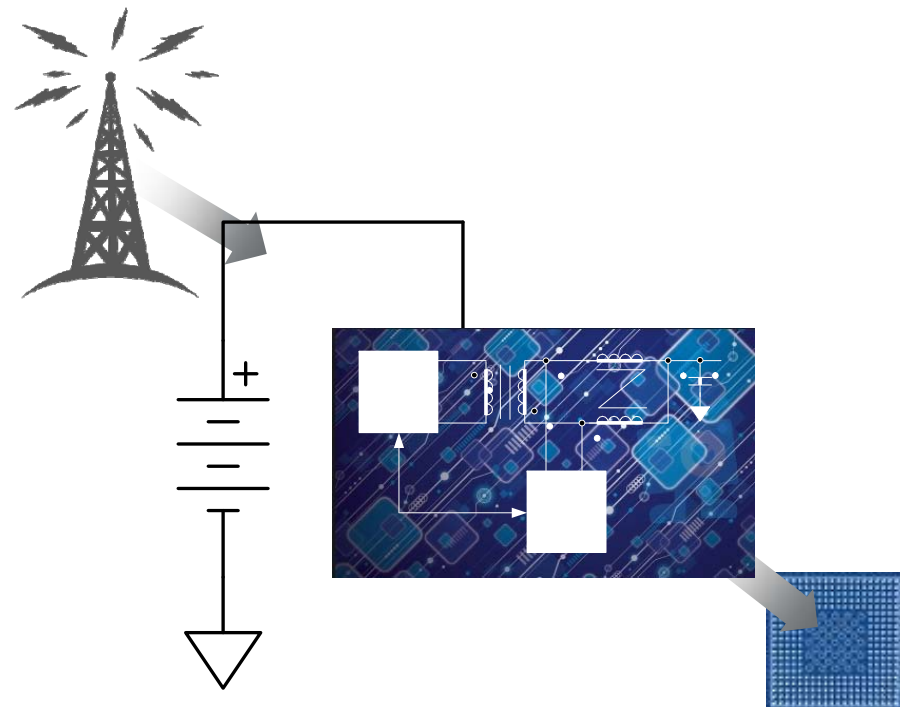
GPUs 300W+

Artificial Intelligence, Machine Learning, Big Data, Autonomous Cars & Cloud Computing
Driving Rack Power to 20kW+

48V to PoL DC/DC Regulator

Challenges & Requirements

- Eliminate a Conversion Step
 - > Direct 48V to PoL DC/DC
- Scalable Output Voltage & Current
 - > CPUs, Memory, GPUs, FPGAs and ASICs
- High Efficiency 48V to 1V
- Cost-Effective



48V OCP Rack

Performance & Features

- Energy Savings Achieved
 - > Greater than 20% Less Conversion Losses
 - > 16x Less Power Distribution Losses
 - Connectors, Cables, Board
 - > Upstream Conversion & Distribution Savings
- Characteristics of Ideal 48V Solution
 - > Fast Dynamic Response
 - > High Efficiency
 - > Scalable & Flexible

48V OCP Rack



AC/DC

UPS

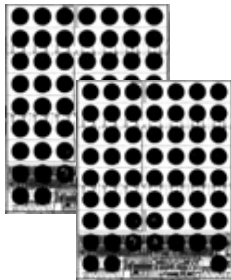
Conversion to 48V is Economical for Racks Greater than 12kW

Maxim Technology & Architecture Advantage

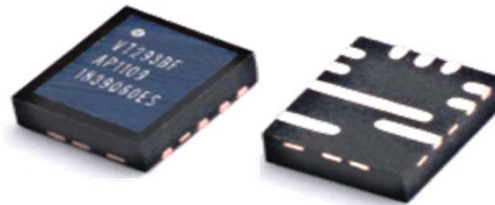
Scalable Single Stage Quick PWM Converter
with Proprietary Magnetics & Power Stages

Maxim's Unique Solutions Solve Customer Challenges

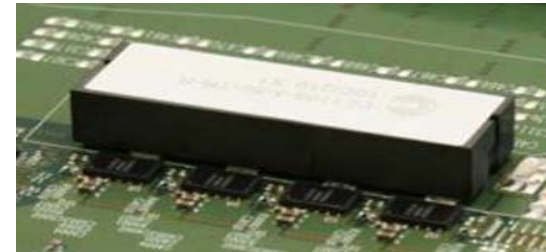
Monolithic
Integration



Optimized
Power Packaging



Integrated
Magnetics



Leveraging Maxim Expertize for 48V Solutions

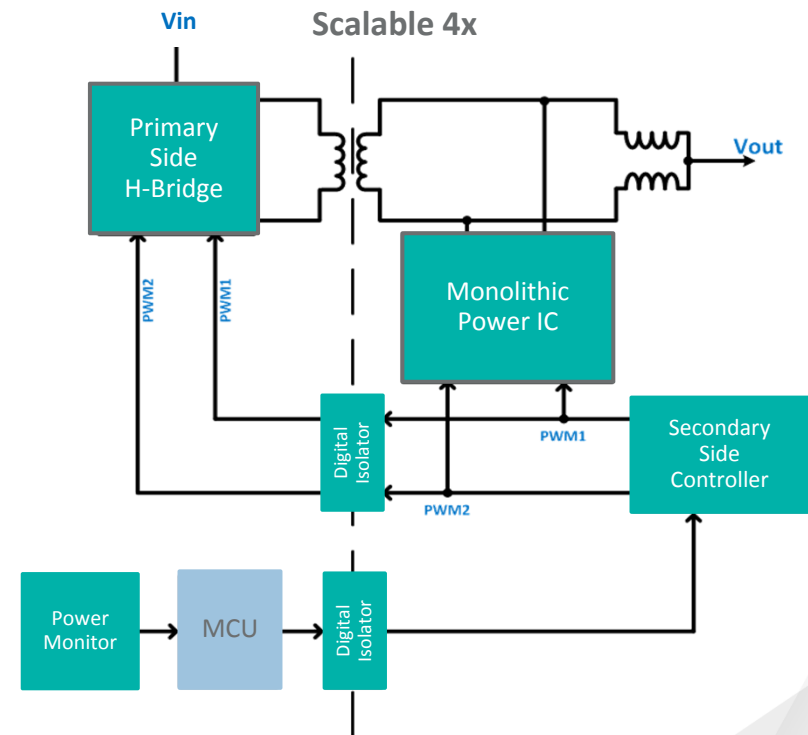


- 15+ years of Server Power Experience
 - > Significant Market Share over Multiple Generations of Server CPU/Memory Power Products at 12V
 - > Intimate Understanding of Server Systems & CPU Requirements
- Leveraging Same Core Technology to Implement 48V Solutions
 - > Existing 12V Products Leverage Process, Package & Magnetics Expertize
 - > Reduce Risk with Maxim's System & Technology Experience
 - > Combination of Unique Technologies Provides Best TCO @ 48V

Scalable Single Stage Quick PWM Converter with Integrated Magnetics & Power

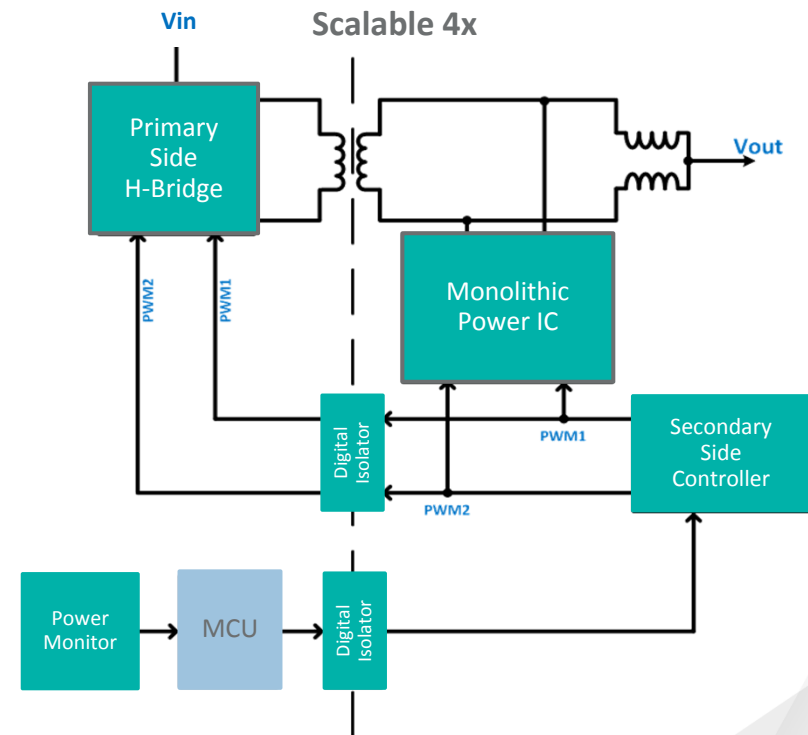
Technology Building Blocks

- Optimized for Efficiency
 - > Monolithic Power Stage with 2 Phases per IC
 - > Integrated Loss-less Current Sensing
 - > Energy Recovery
- Best-in-class transient response
 - > Advanced ISO-Quick PWM Control Architecture
 - > Proprietary Coupled Inductor Technology
- Supports Isolated or Non-Isolated Options



Scalable Single Stage Quick PWM Converter with Integrated Magnetics & Power

- Primary Side HV: $60V \geq V_{in} \geq 40V$
- Transformer Ratio 6:1, 10V Secondary
 - > Multiphase System up to 8 Phases
 - > High Load Current per Transformer Stage
- Secondary Side Controller
 - > Drive Up to 4 Scalable Transformer Stages
- Secondary Side Power Stage
 - > Synchronous Rectifier
- Optional Isolator
 - > Primary to Secondary Isolation: 600V – Noise Relief
 - > Fast Response – Sub 15ns Transit Delay



Scalability & Flexibility of Maxim Solution

- Scalability & Flexibility:
 - > Simply Add More Stages to Increase Power Level
 - > No Tuning Required – Change Output Voltage and Current with No Design Changes
 - > Multiple Magnetics Options Available
 - > Meets all Intel Specifications

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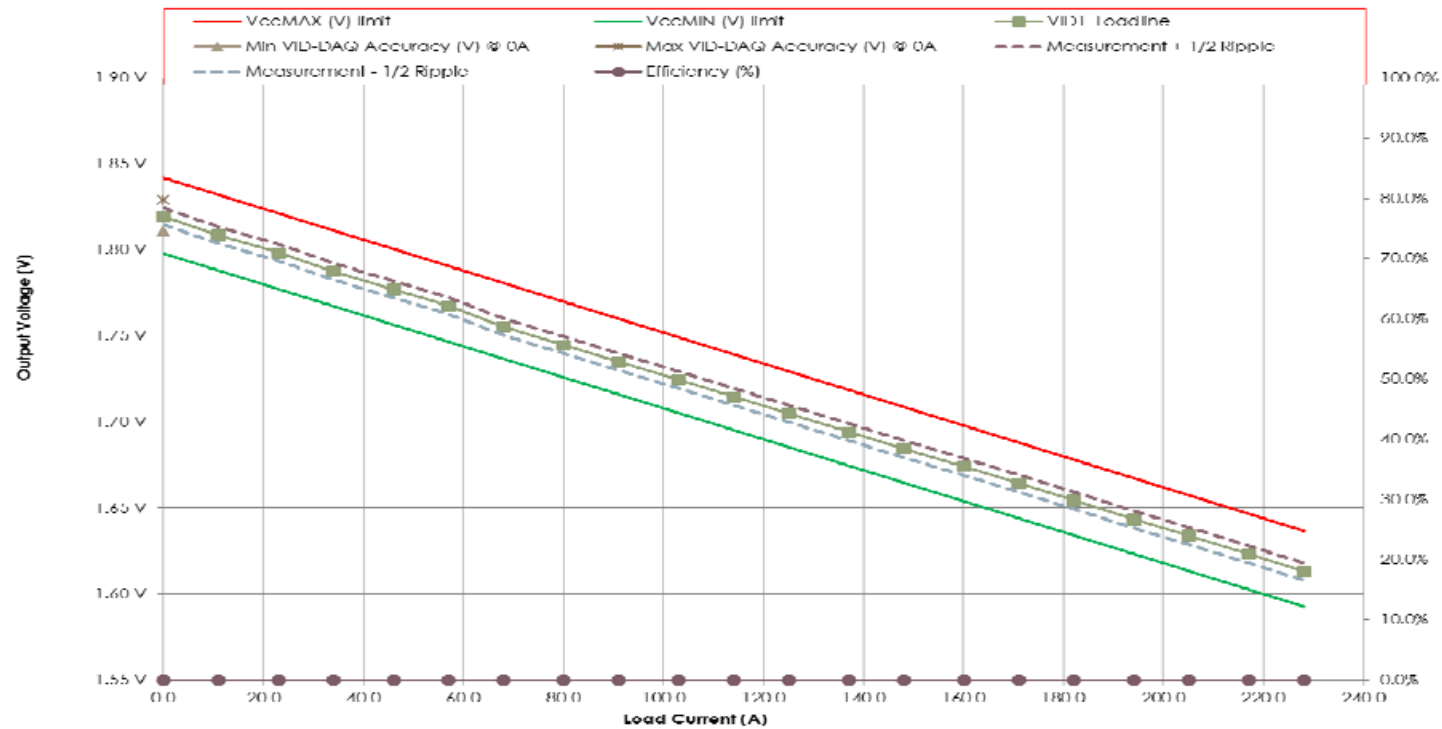
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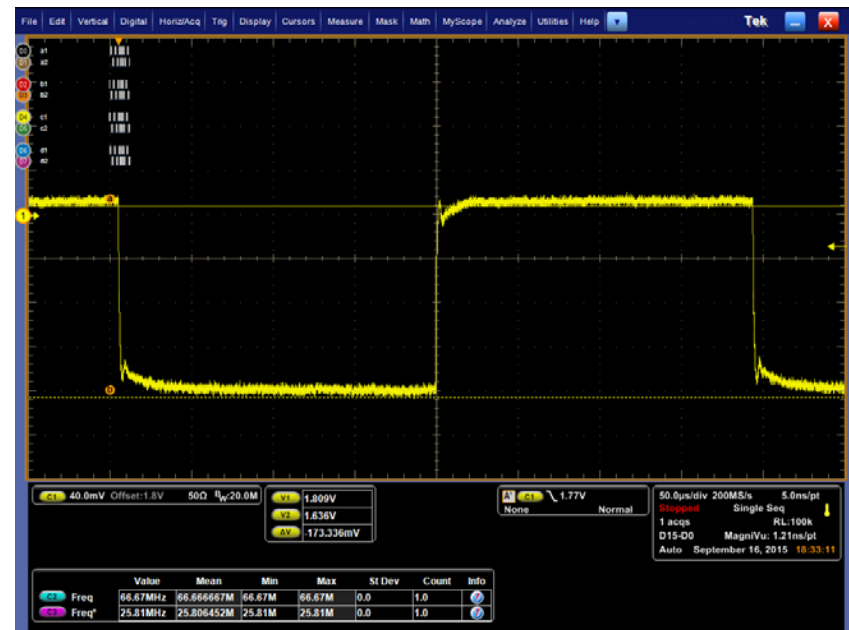
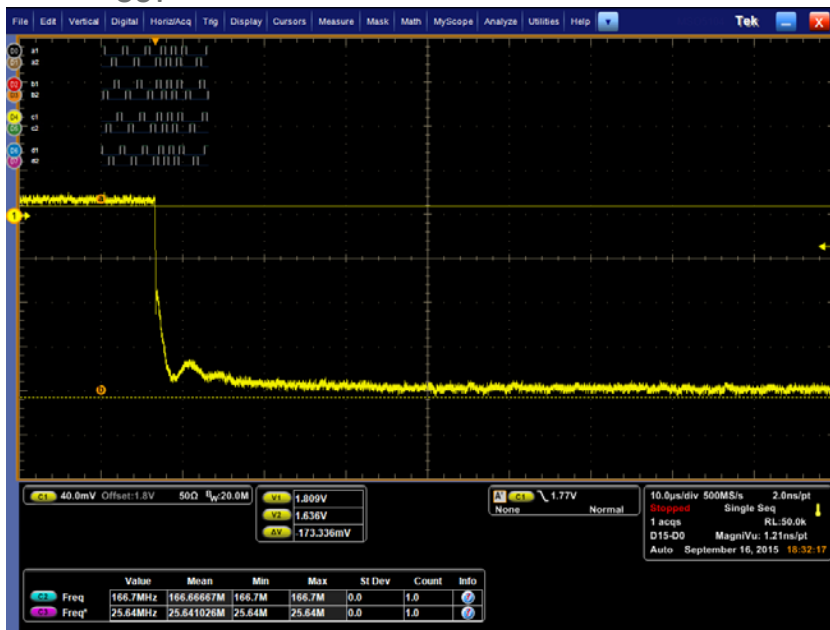
Regulator Performance

Transformer Load Line: $V_{OUT} = 1.80V$



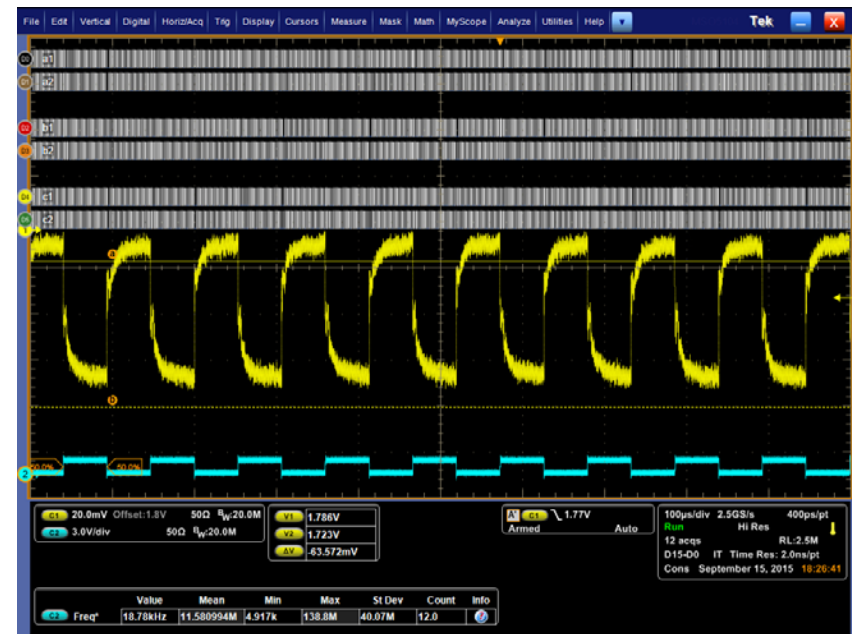
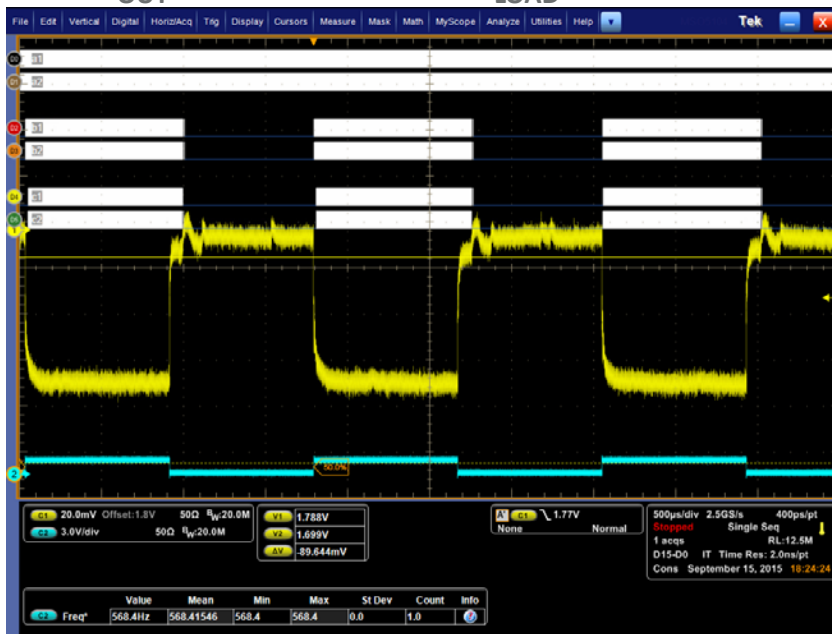
Transient Response: 10A – 197A – 10A

CH1: V_{OUT} 40mV/DIV



Auto Phase Shedding: 6A to 63A @ Variable Load Repetition Rate

CH1: V_{OUT} 20mV/DIV; CH2: I_{LOAD}



Dynamic VID Transition: 1.5V to 1.8V, $I_{LOAD} = 10A$

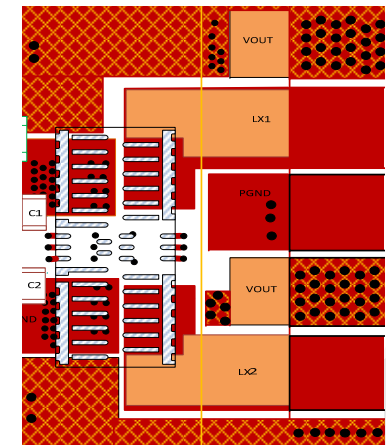
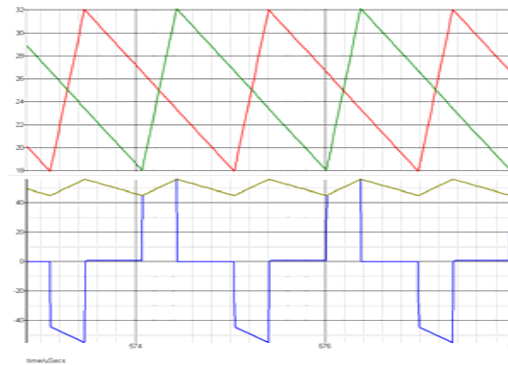
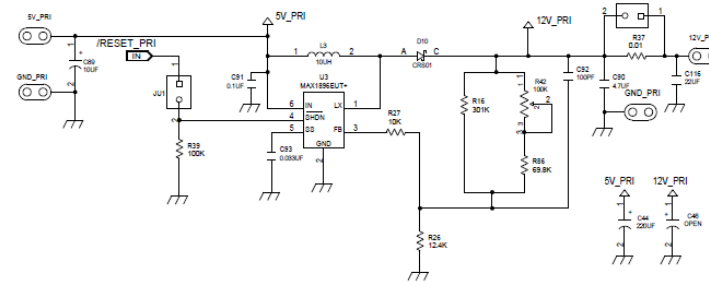
CH1: V_{OUT} 60mV/DIV; CH2: ALERT 90mV/DIV, CH3: SKIPB 2V/DIV, CH4 SKIPDC 2V/DIV



Design Support

Full Design & Verification Support

- Complete Reference Designs
- SIMPLIS Models
- PCB Layout Support
 - > From Concept to Gerber Out



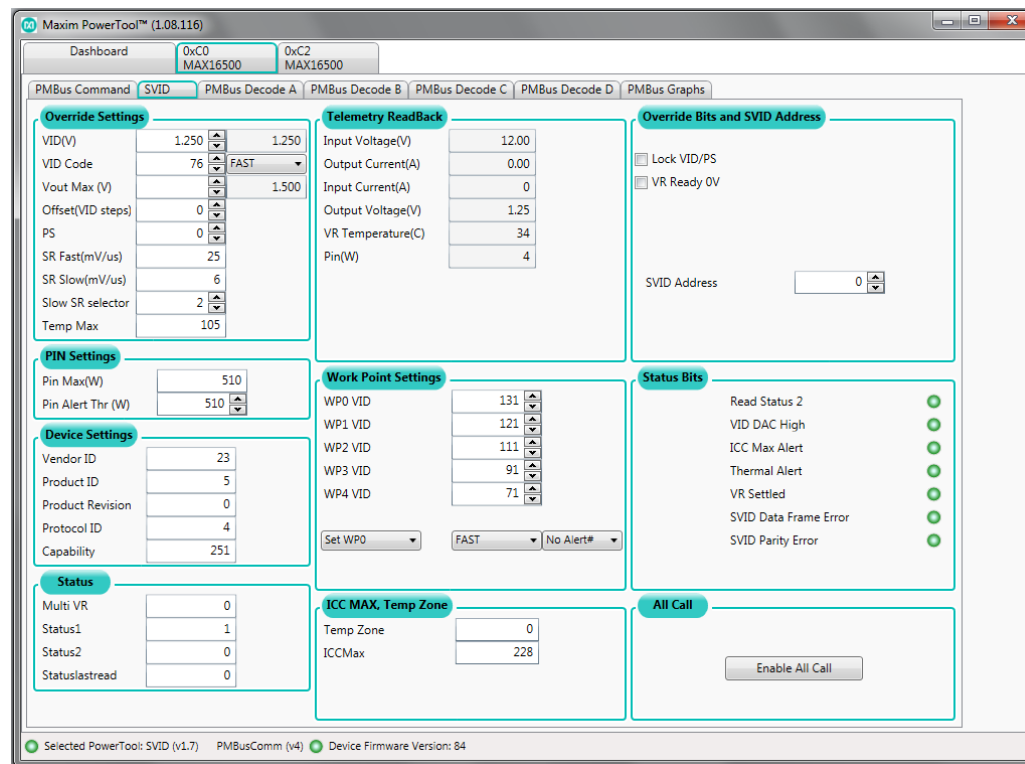
Full Design & Verification Support

- Verification
- Characterization
- Thermal Evaluation



Easy-to-Use GUI

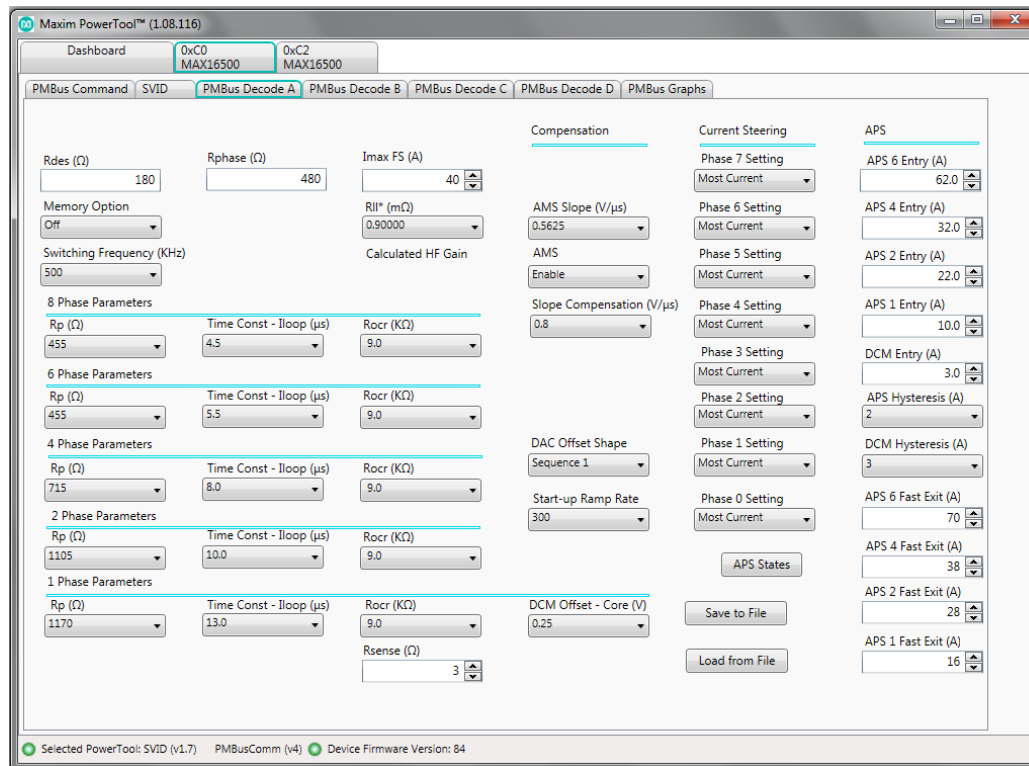
GUI makes it easy for the user to monitor, control, and measure the parameters of interest.



SVID
Parameters

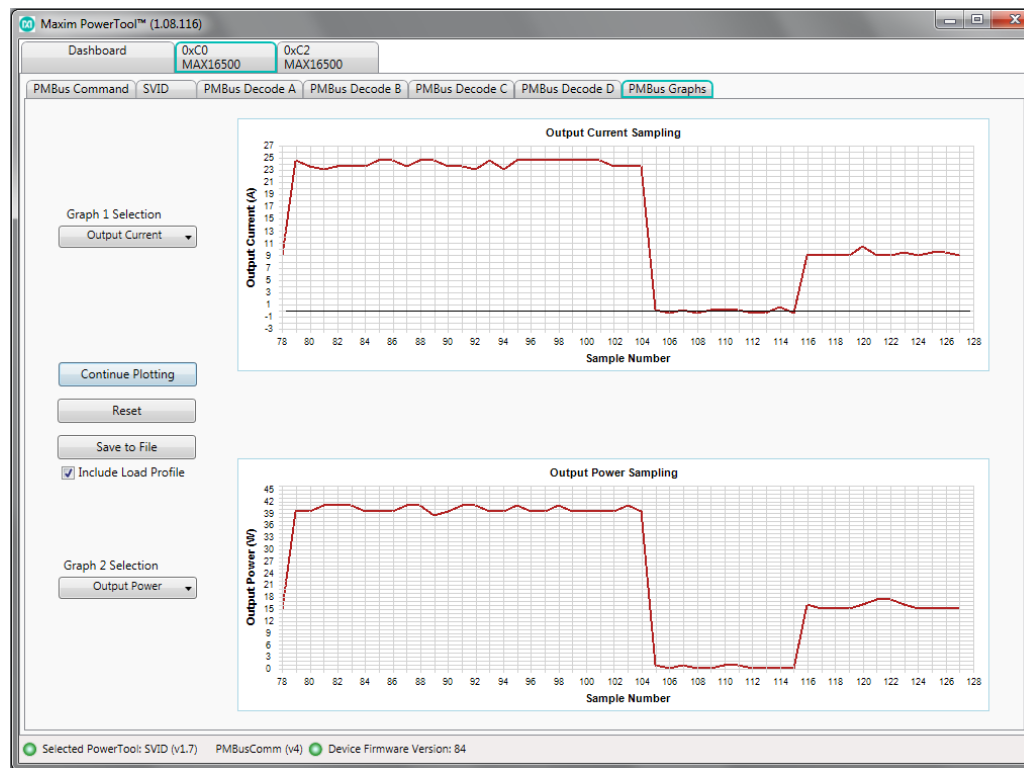
Easy-to-Use GUI

GUI makes it easy for the user to monitor, control, and measure the parameters of interest.



PM Bus
Parameters

Easy-to-Use GUI



Plotting feature allows monitoring telemetry parameters in real time or record the data for analysis.

48V TCO Advantage

12V to 48V Rack TCO Assumptions

Open Compute Rack			
Server Lifetime (Years)		4	
Hours Per Day		24	
Days per Year		365	
Cost of Energy (\$/kWhr)		\$0.10	
	Year	2017	2019
Efficiency & Distribution Delta		2%	3%
CPU Power (W)		100 x 2	160 x 2
Memory Power (W)		30 x 4	80 x 4
Total Server Power (W)		400	800
# of Servers per Rack		20	25
Rack Power (kW)		8	20
Data Center PUE		1.1	1.05

48V TCO Savings Summary

48V TCO Cost Savings Summary (4 years)			
Rack Architecture		Open Compute	
	Year	2017	2019
Rack Power (kW)		8	20
Lifetime Savings per Server		\$15	\$128
Payback Period (Years)		4.7	1.1
100K Server Savings		\$0.7M	\$12M

Full Payback in 1.1 Years

Hyper-Scale Data Centers

48V Rack Architecture Driving Compute Density

Data Center Trends

- New Applications Driving need for Higher Power Compute Nodes
 - > 200W+ CPUs with 100W+ Accelerators and 300W GPUs
 - > 10kW Racks Today, 25kW Tomorrow

Our Solutions

- Two Decades of 12V Server Power Technology Leadership
- 48V to PoL Technology for High Power Rack Density
 - > Passes all Intel's Skylake Tests
 - > Supports all CPUs, Memory, GPUs, FPGAs & ASICs
 - > Best in Class Efficiency



OPEN
Compute Project

