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8-Oct-04

New Cost Effective Approach to Digital Power Management

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Power Systems World Conference

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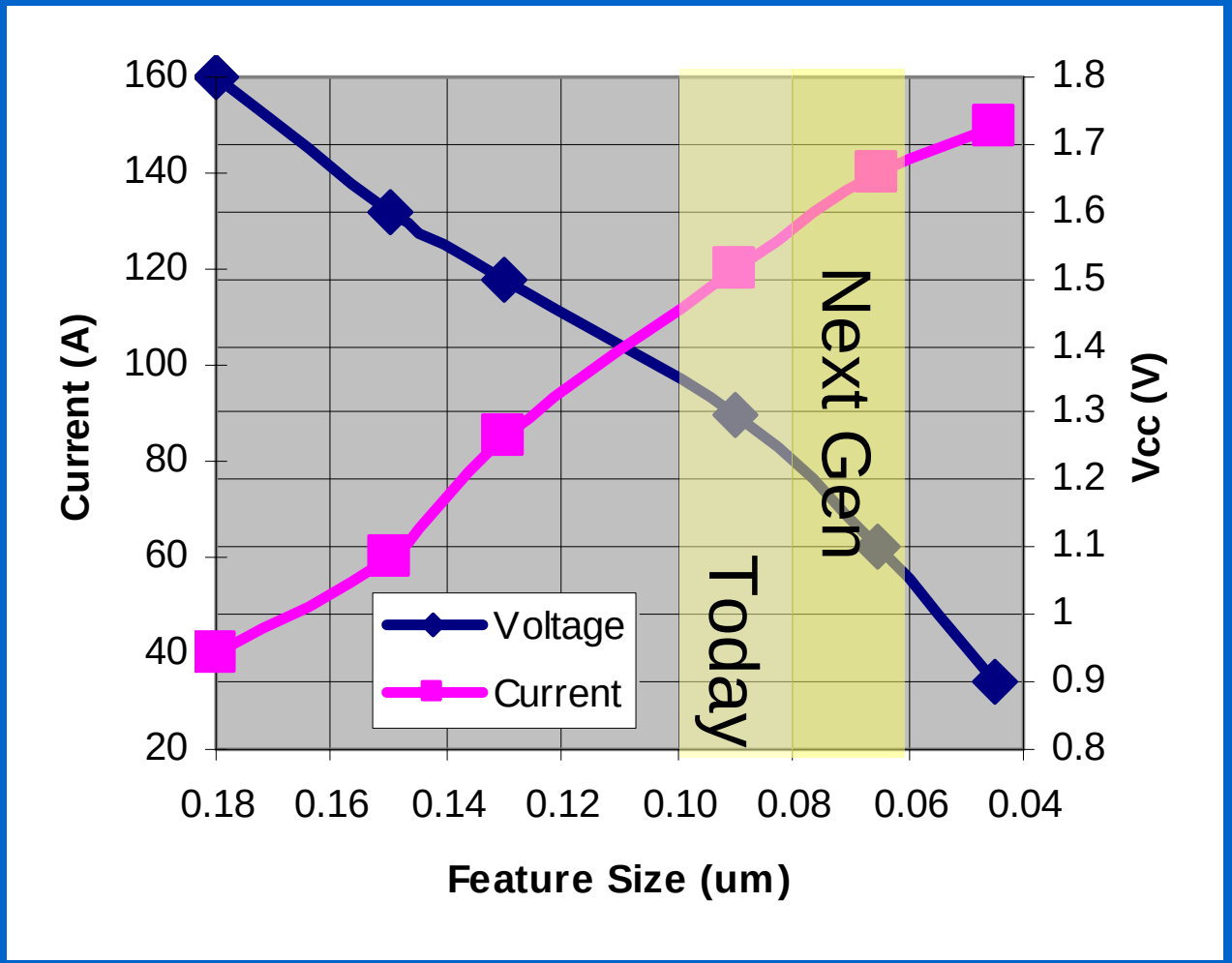
Outline

- System and Power Delivery Trends
- Cost Effective Digital Control
- New Primarion Solutions

Processor Current and Voltage Trends

- Today's Processors
  - 100 to 130A
  - 1.2 to 1.4V
  - 120A Current steps
  - 1200A/us
- Next Generation
  - 130 to 150A
  - 1.0 to 1.2V
  - 140A Current Steps
  - 1400A/us



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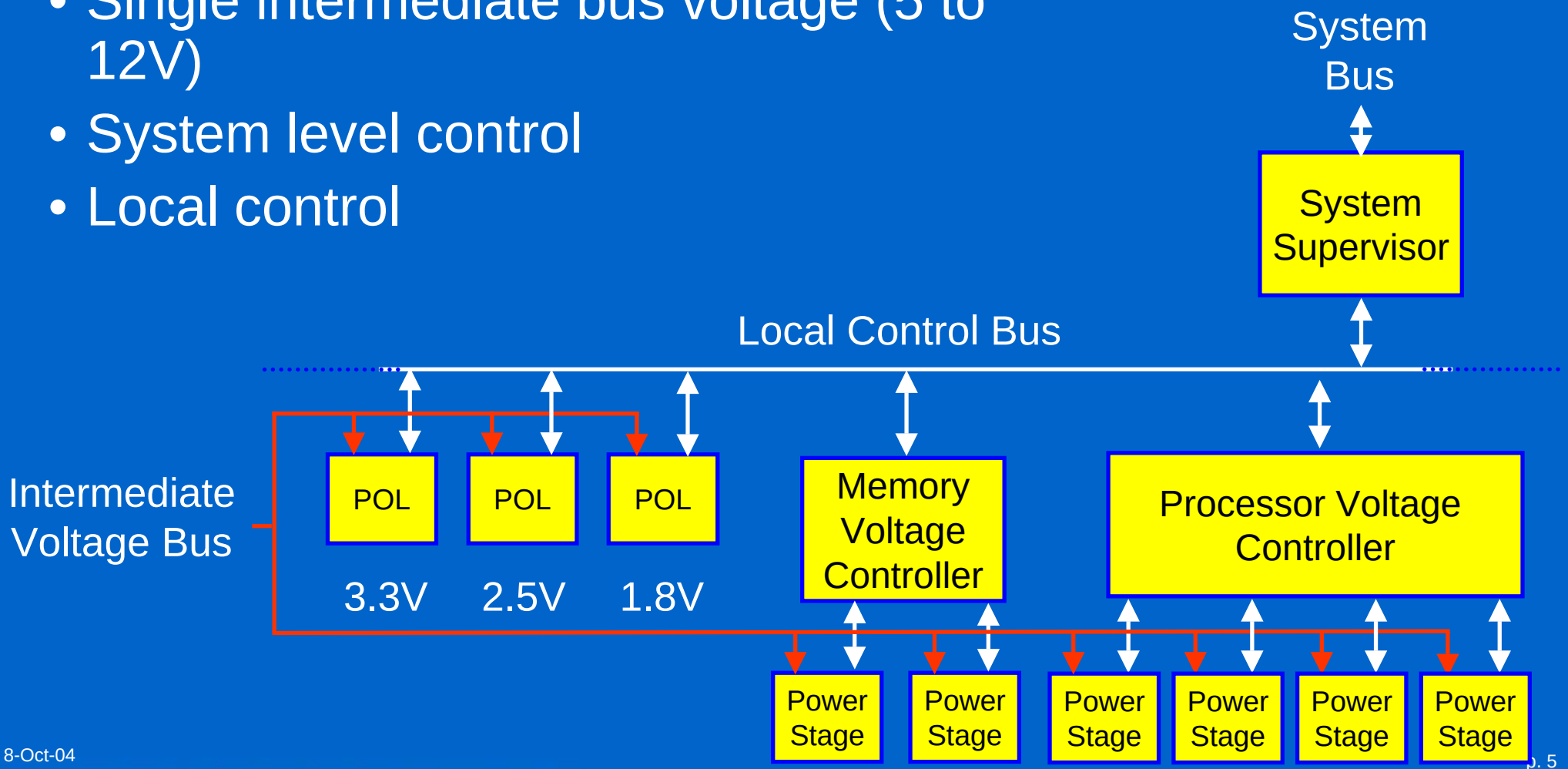
System Power Delivery Trends

- Power delivered at the “point of load”
- Single intermediate bus voltage (5 to 12V)
- System level control
- Local control



Power Delivery Challenges and Solutions

Challenge	Digital Power Solution
Accuracy: 3% regulation	• Digital Calibration • Digital temp compensation
Area: Same or less board area with each new processor gen.	• Integration • Faster switching speeds, less cap, smaller components
Cost: Decreasing with each Gen	• Digital control to reduce parts count • Implement solutions in std. CMOS
Efficiency: 85% at less than 10% duty factor	• Integration chosen to maximize efficiency
Intelligence: • More local and system control	• Programmable digital loop control • I2C bus

Primarion Patented Active Transient Response and Digital Calibration features address key challenges

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Disruptive Technology?

For widespread adaptation, digital power needs to be

- Cheaper to use
- Exhibit at least as good performance as current solutions
- Be easier to use

When will this happen?

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Primarion Digital Power Advantages

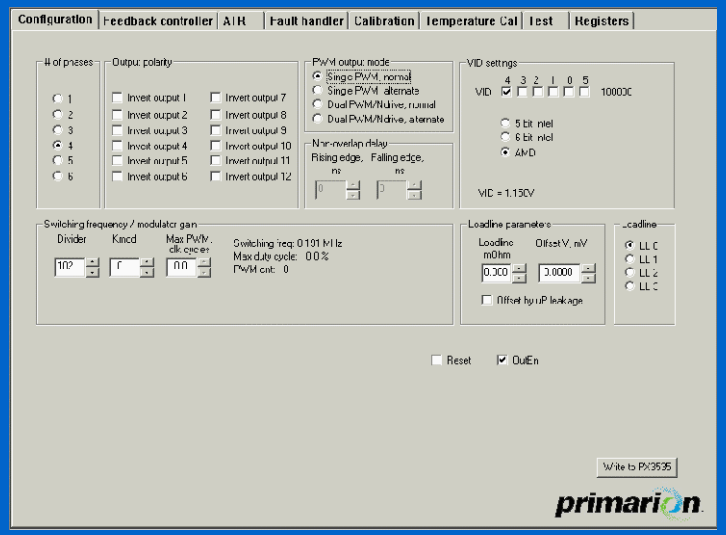
- **Lower Costs – 20-30% savings**

Lower cost Inductors

Fewer output capacitors

Fewer misc components

- **New Way of Designing**
  - Easy to use GUI
  - Design optimization by GUI programming on-board NVM instead of soldering components



- **Higher Performance – for broad applications**
  - Better transients, higher accuracy, highest power density
  - Immunity to noise, temperature, tolerances, aging

Primarion IP results in lower costs, higher performance, new design methods

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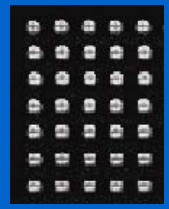
New Primarion® PX3535 and PX3520 Chipset



PX3535 Digital Controller

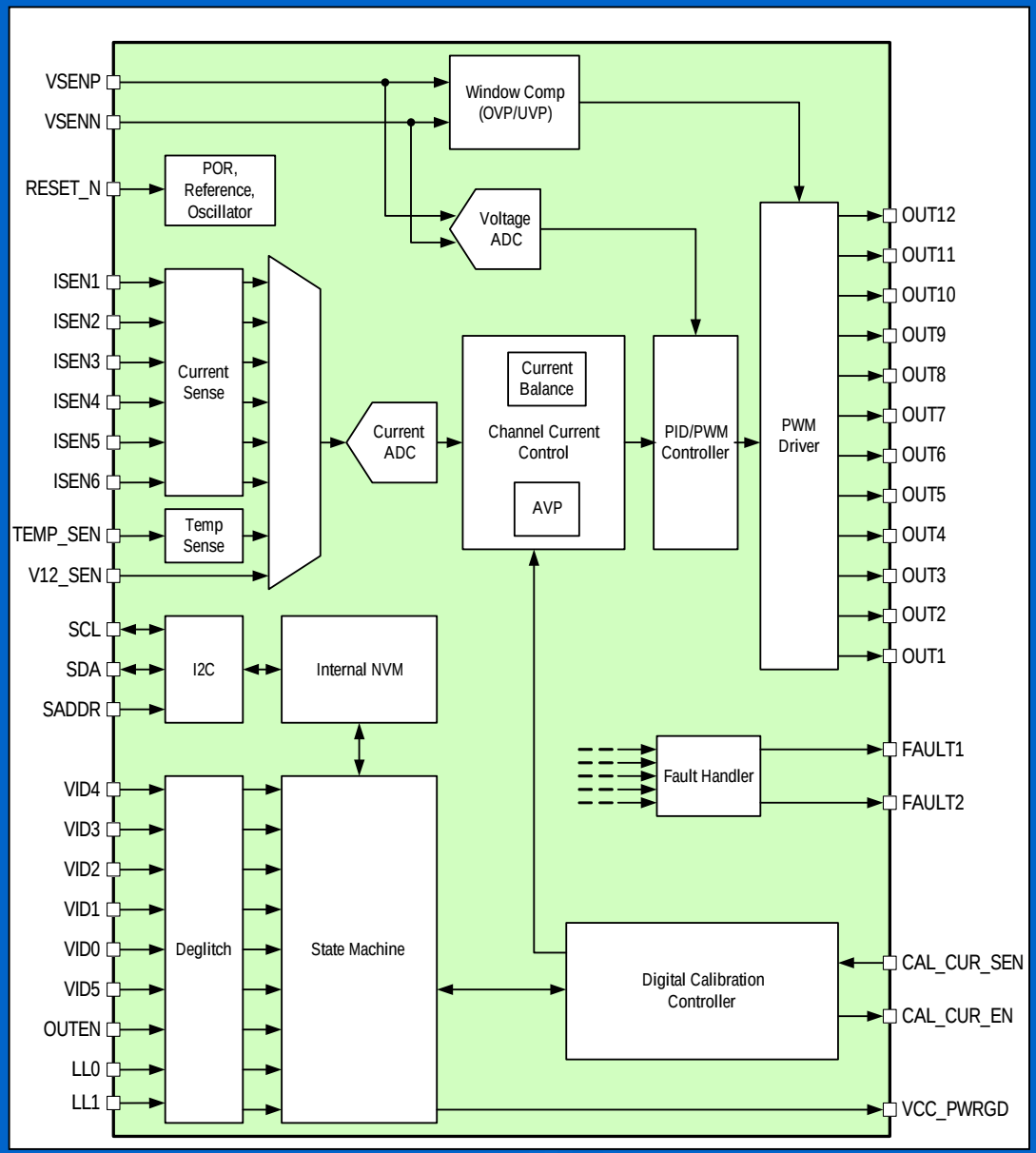
- 6 Phases
- Range of power stage choices
- Self-calibrating current sense
  - VRTOB of +/- 14 mV
- Digital temperature compensation
  - Piecewise linear function
- Active Transient Response
  - Reduced output capacitance
- I2C Bus
  - Monitor I, V, T, Faults
  - Programmable digital control
- 3.3v Supply, 48-Pin TQFP

PX3520 Integrated Power Stage

- 30A Power Stage
- Integrated control FET, drivers and current Sense
  - Fast switching
  - Process and temp independent current sensor
- Discrete sync FET
  - Customize for each application
- CSP package
  - Area efficient

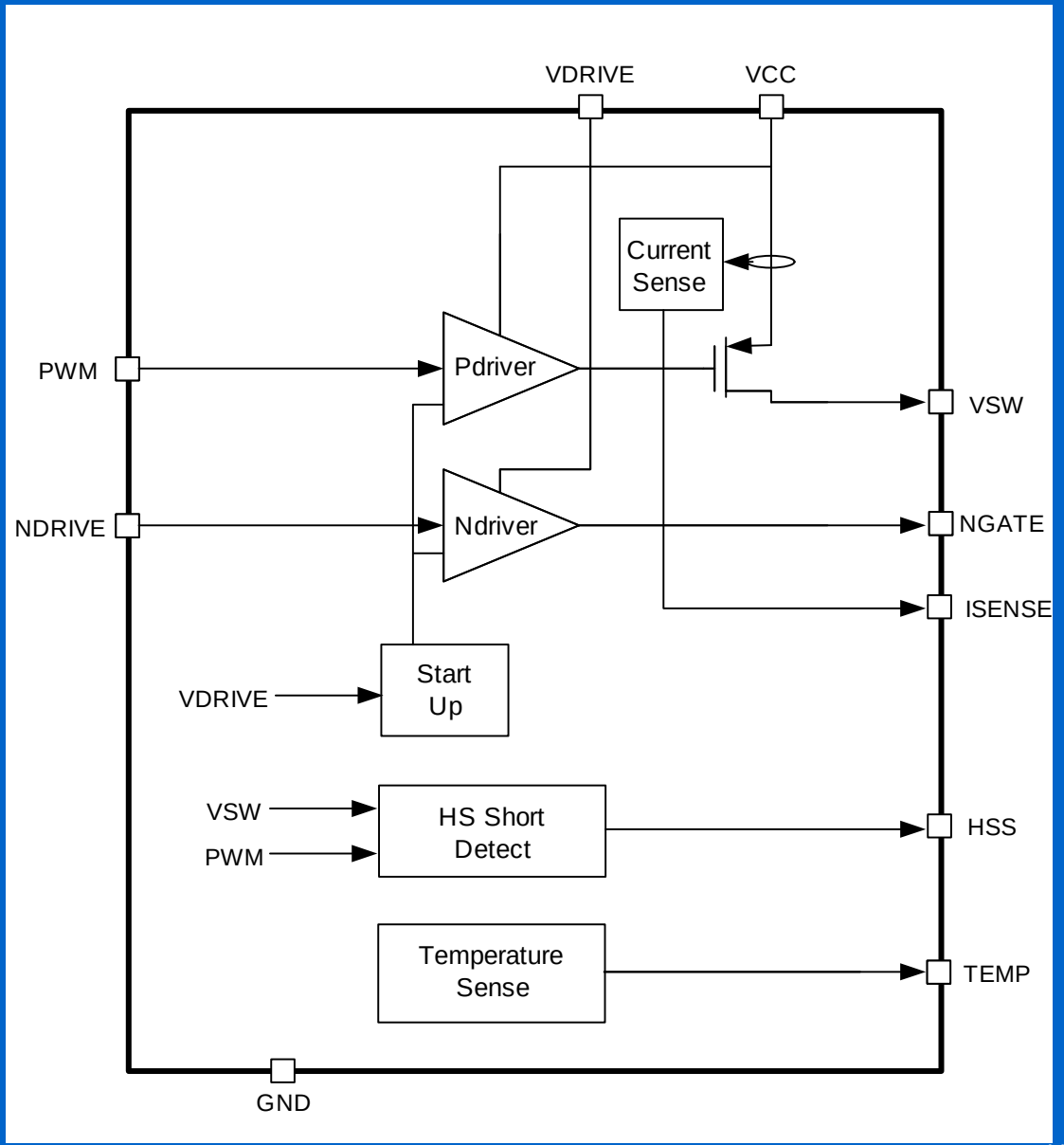
Primarion® PX3535 Digital Controller

- Integrated voltage and current digitizers
- Programmable digital control loop
- Programmable fault settings
- I2C Serial interface
- Intel VR 10.X and AMD compliant
- Integrated Non-Volatile Memory

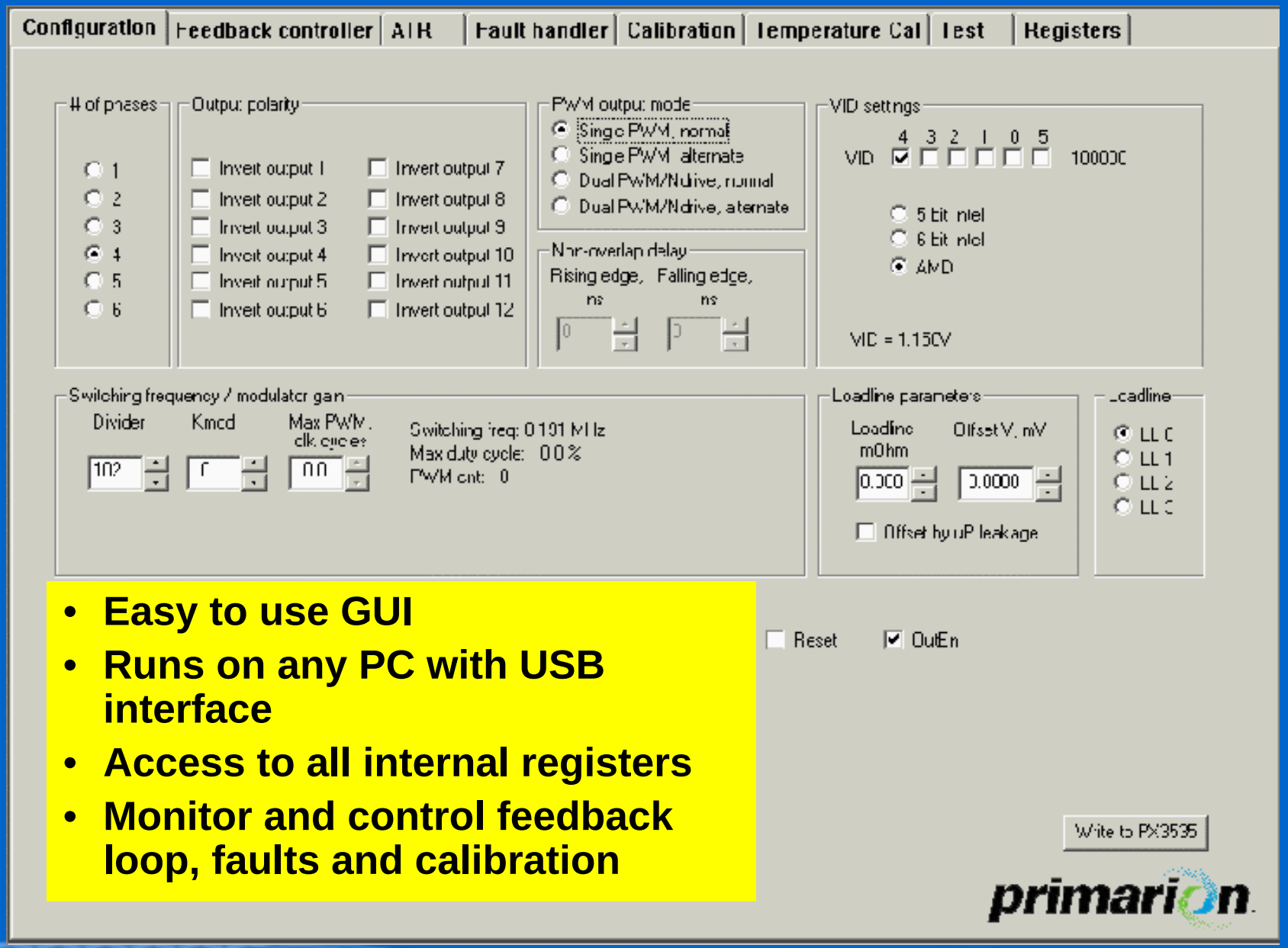


Primarion® PX3520 Integrated Power Stage

- Patented integrated current sensor
  - Process and temp insensitive
- Integrated temp sensor
- Fast switching (4ns) Low RDSon (12 mΩ) FET
- 30A per channel
- CSP package
  - Smallest footprint
  - 1°C/W θjc
  - 0.65mm ball spacing for easy assembly



PowerCode User Interface



- **Easy to use GUI**
- **Runs on any PC with USB interface**
- **Access to all internal registers**
- **Monitor and control feedback loop, faults and calibration**

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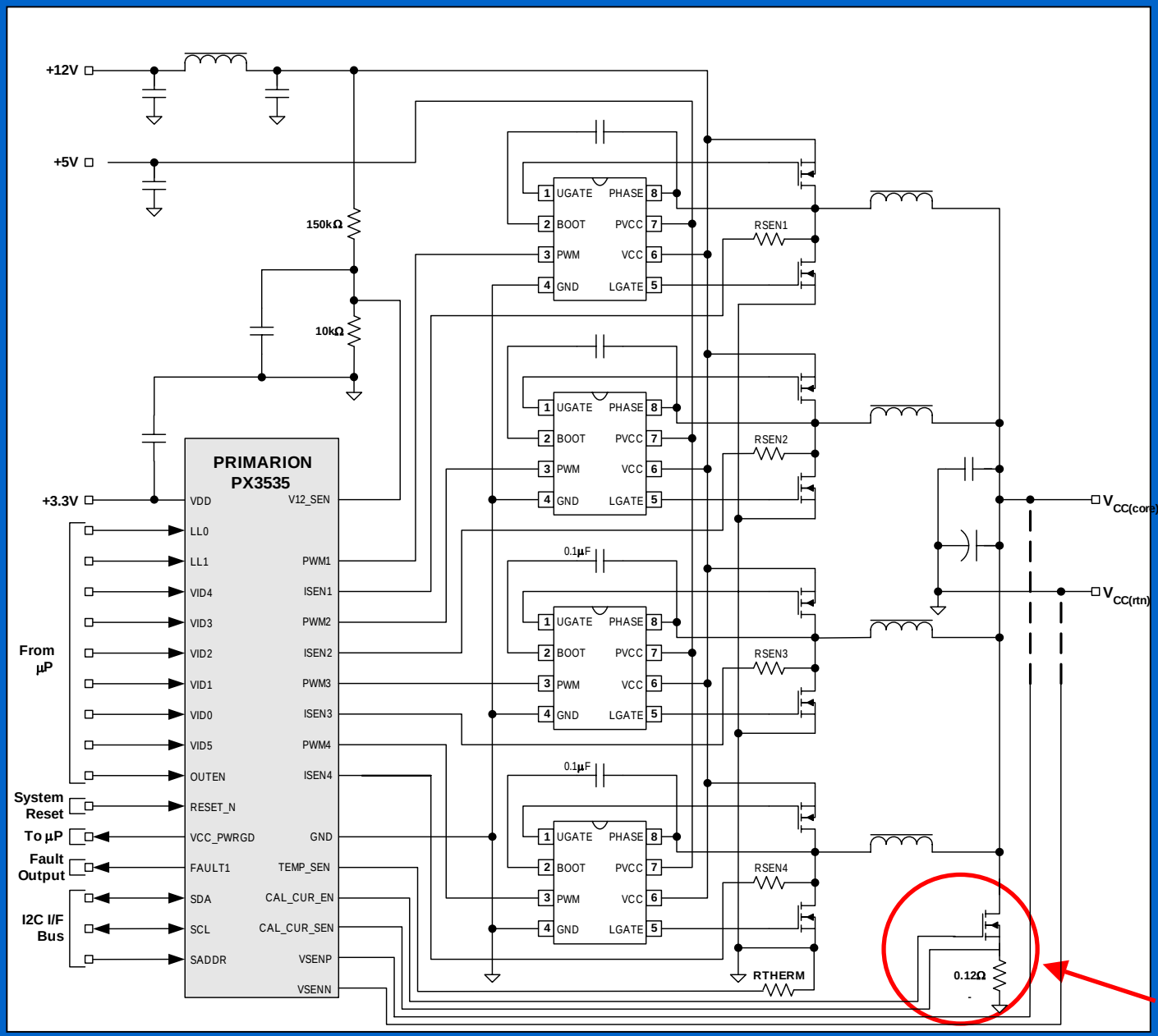
Current Sense Calibration*



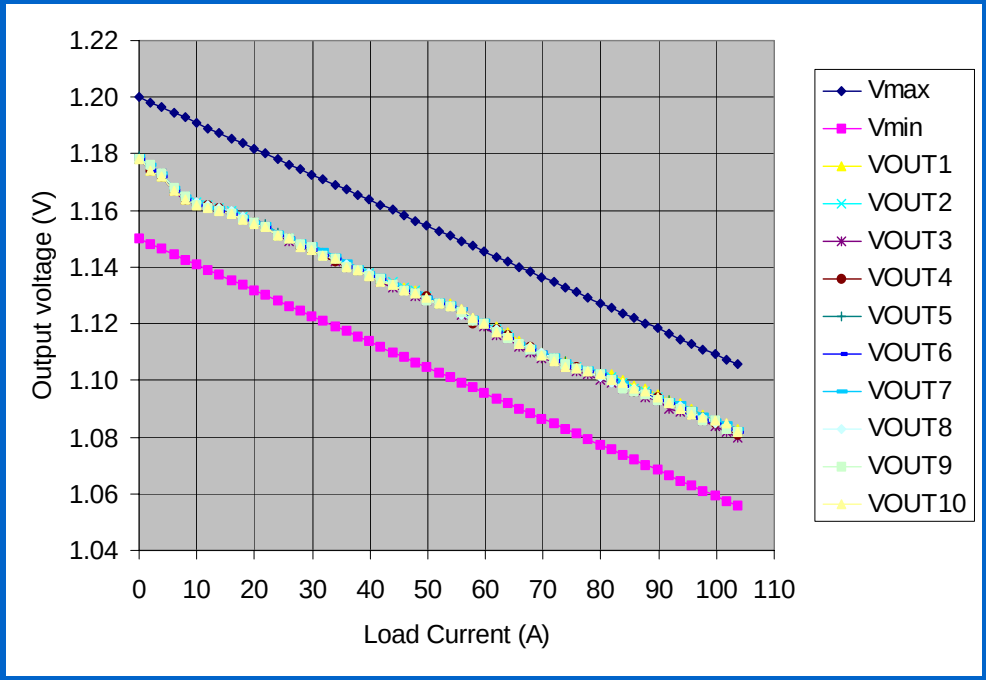
- Constant current source engaged during startup
- RDSon of each sync FET measured
- Calibration values stored in controller
- Uses one low-cost FET and one precision resistor

Calibration current source

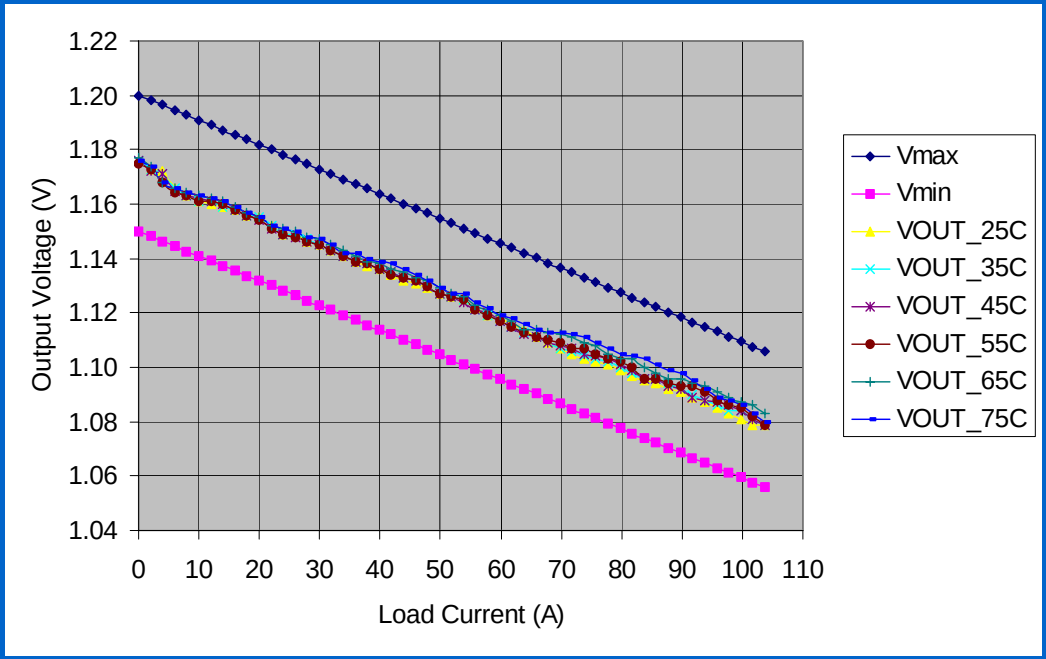
8-Oct-04 *Patent Pending

VRD with Calibrated RDSon Isense
VR10.1, 4 Phase VRD, DPAK FETs, 105A

Calibration Repeatability



Digital Temperature Compensation

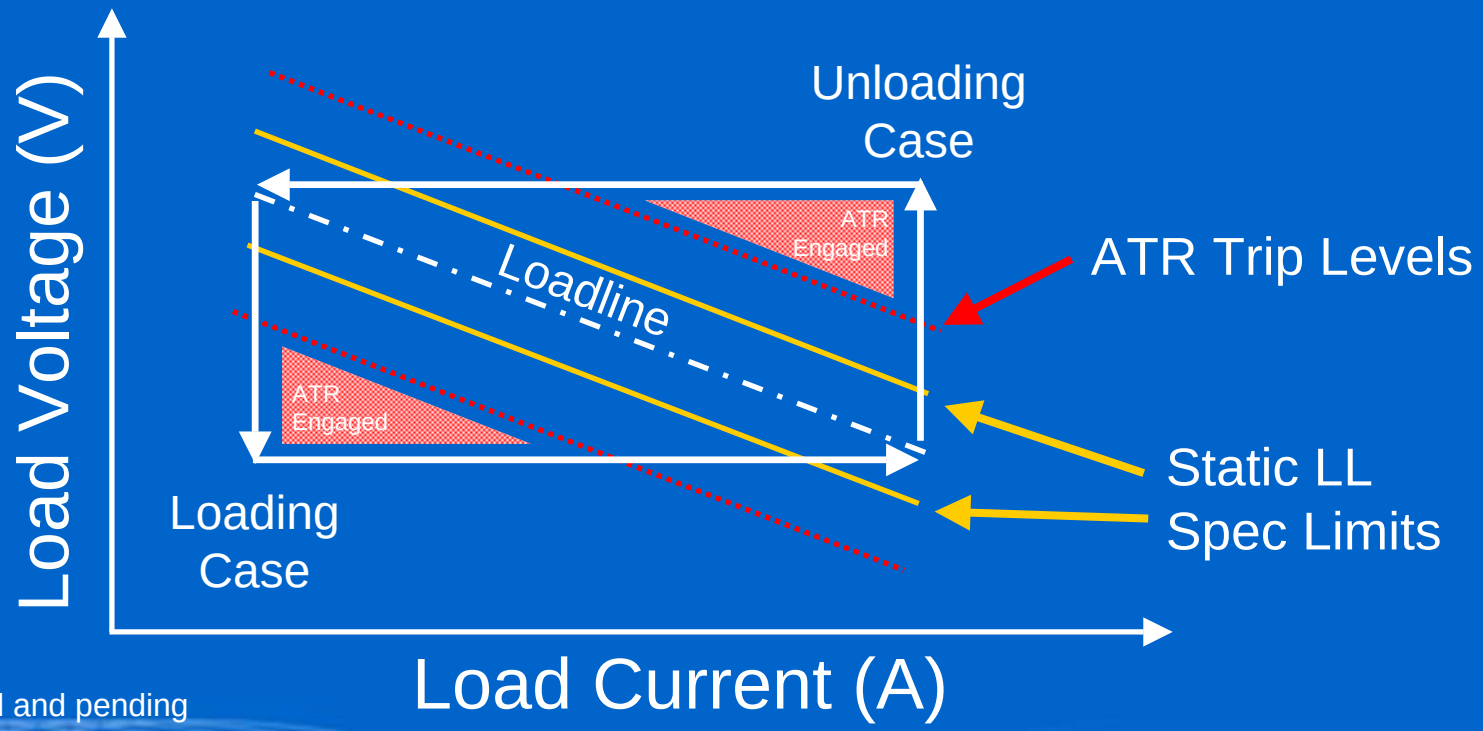


10 Calibrations Result In Nearly Identical Loadlines

Good Loadline Stability

Active Transient Response*

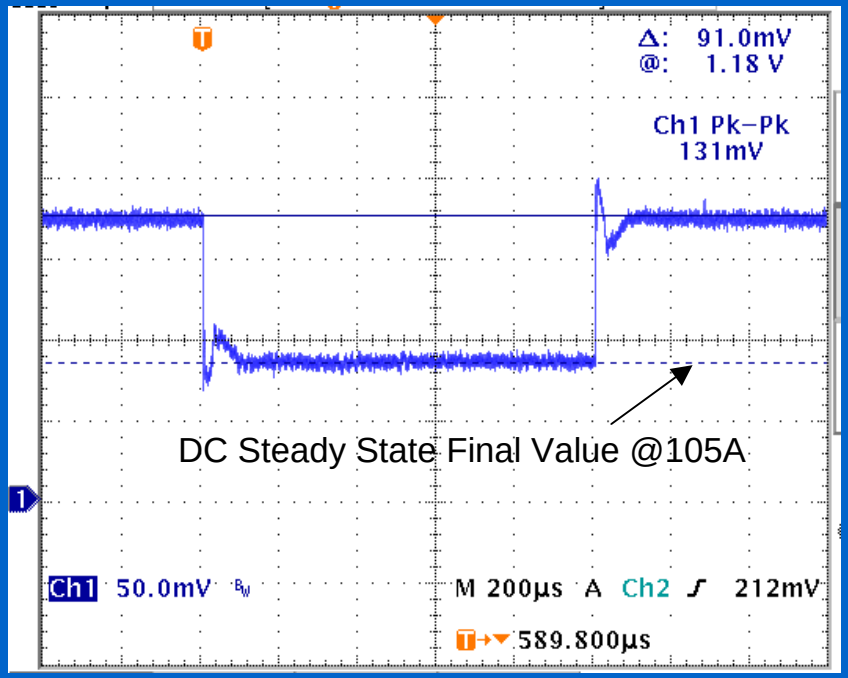
- Loadline tracking hysteretic control mode
  - Adjustable hysteretic window tracks loadline voltage
- Provides wide bandwidth response to transients
- Meets transient requirements with ½ the bulk output capacitance



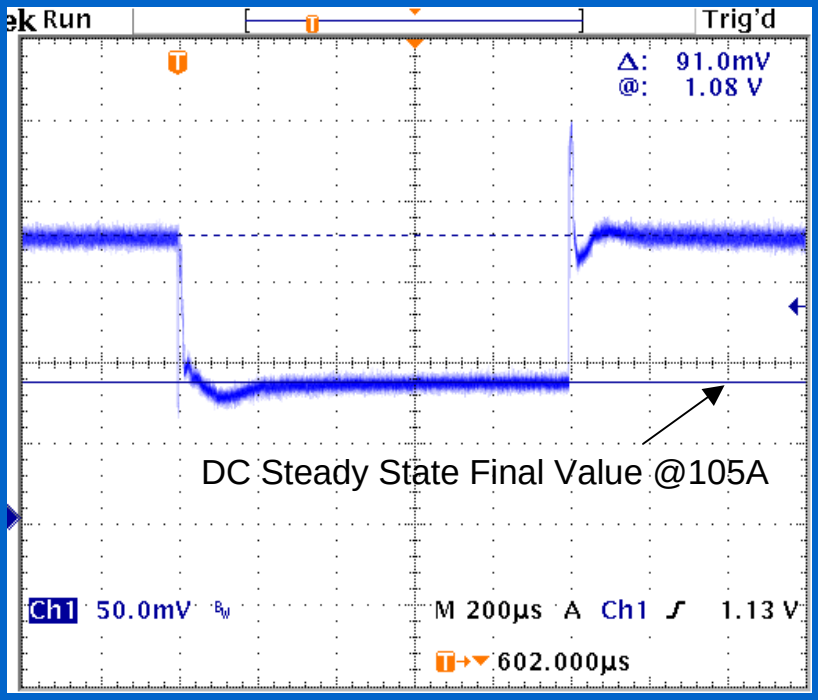
*Patents granted and pending

VRD Transient Response
5.0 A to 105.0 A (1,000 A/us)

With 5600 uF Bulk No ATR



With 2800 uF Bulk and ATR



Bulk Cap: 5600 uF
Ceramic Cap: 396uF
Oscilloscope BW: 20MHz

½ Bulk Cap

Bulk Cap: 2800 uF
Ceramic Cap: 396uF
Oscilloscope BW: 20MHz

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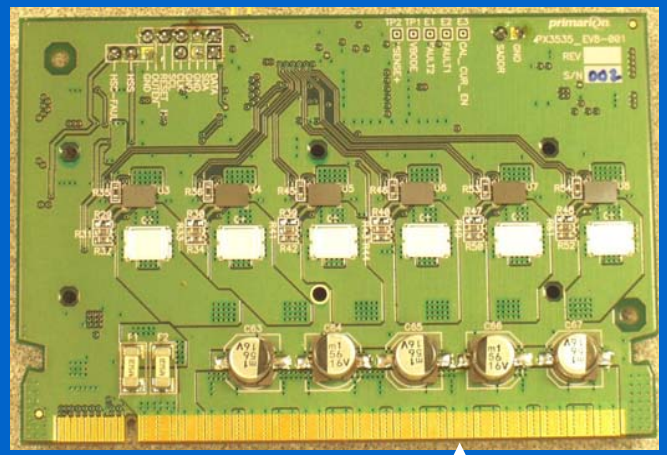
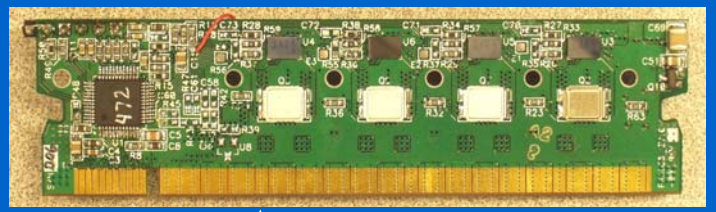
Primarion EasyPower™ Solutions

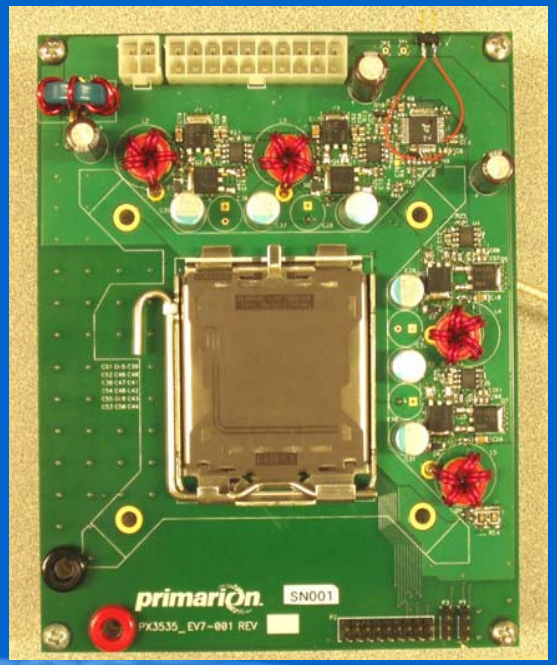


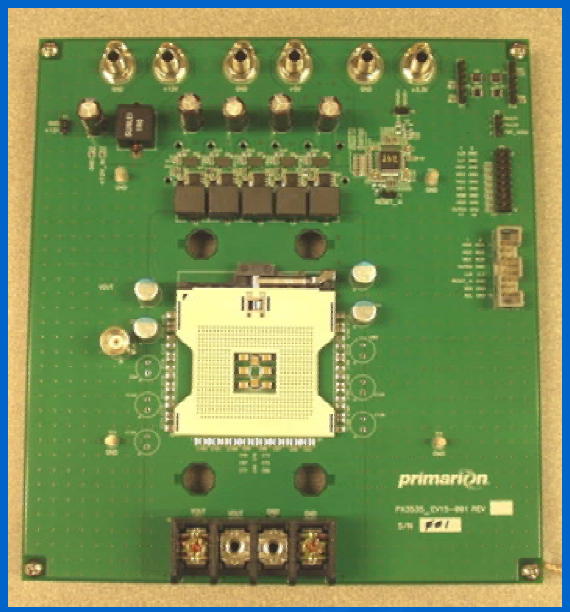
2U 120A 6-phase VRM



1U 105A 4-phase VRM

105A 4-phase
VRD Discrete



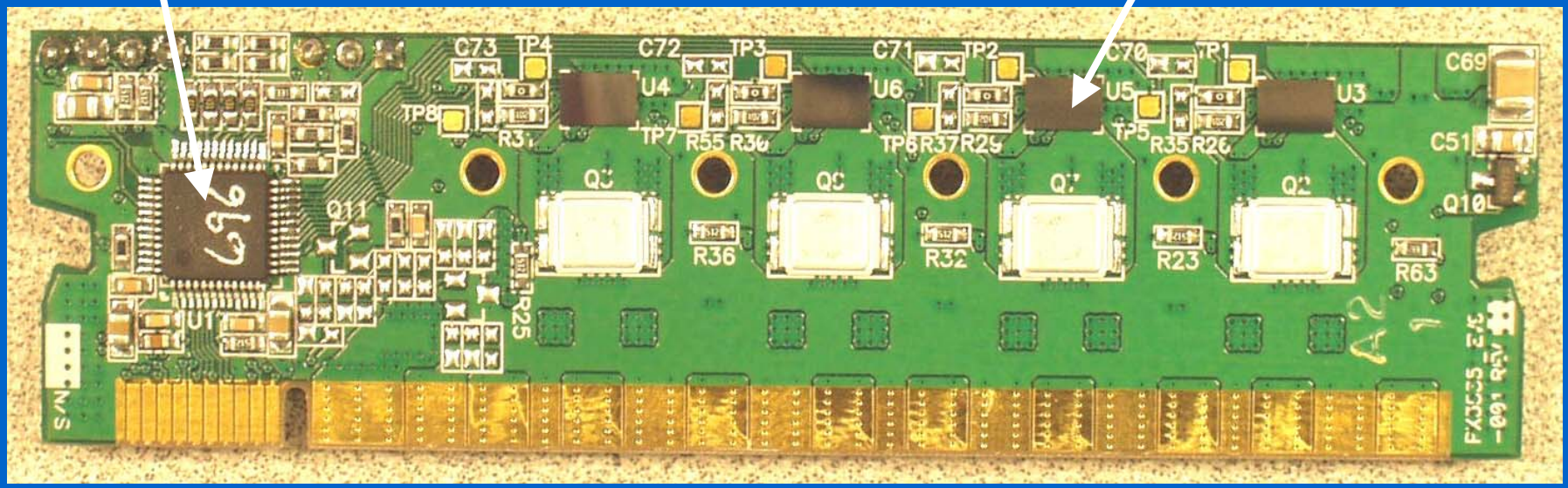


Nacona Server
4-5 phase VRD
Integrated Chipset

4-Phase 120A 1U VRM

PX3535 Digital Controller

PX3520 Power Stage



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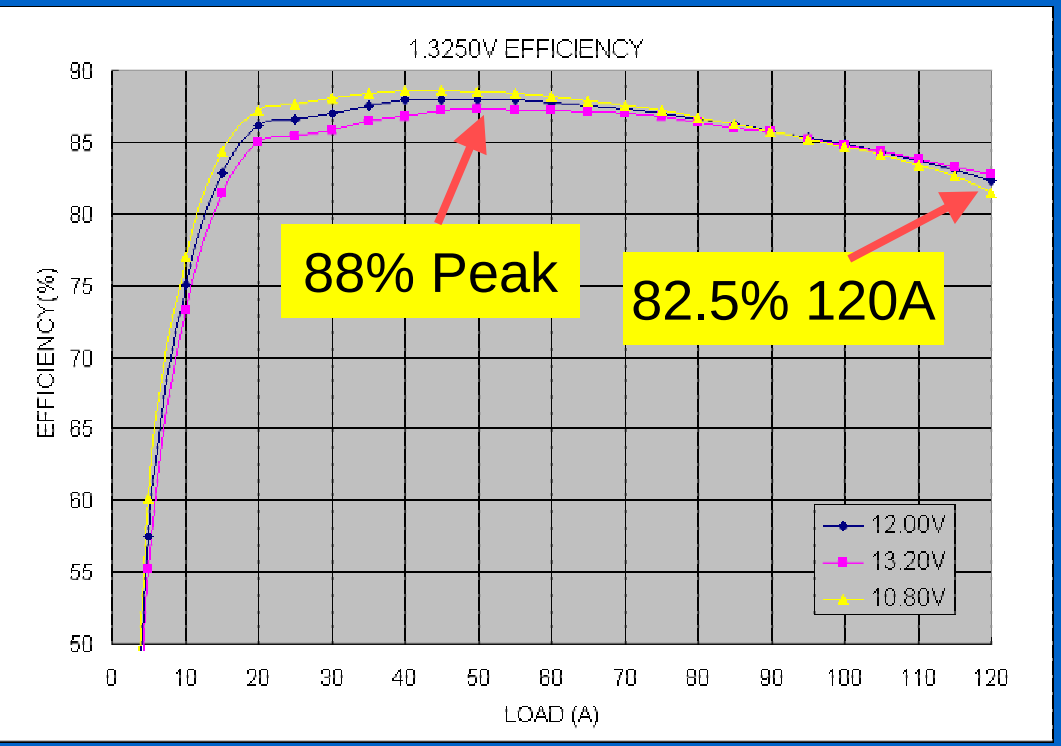
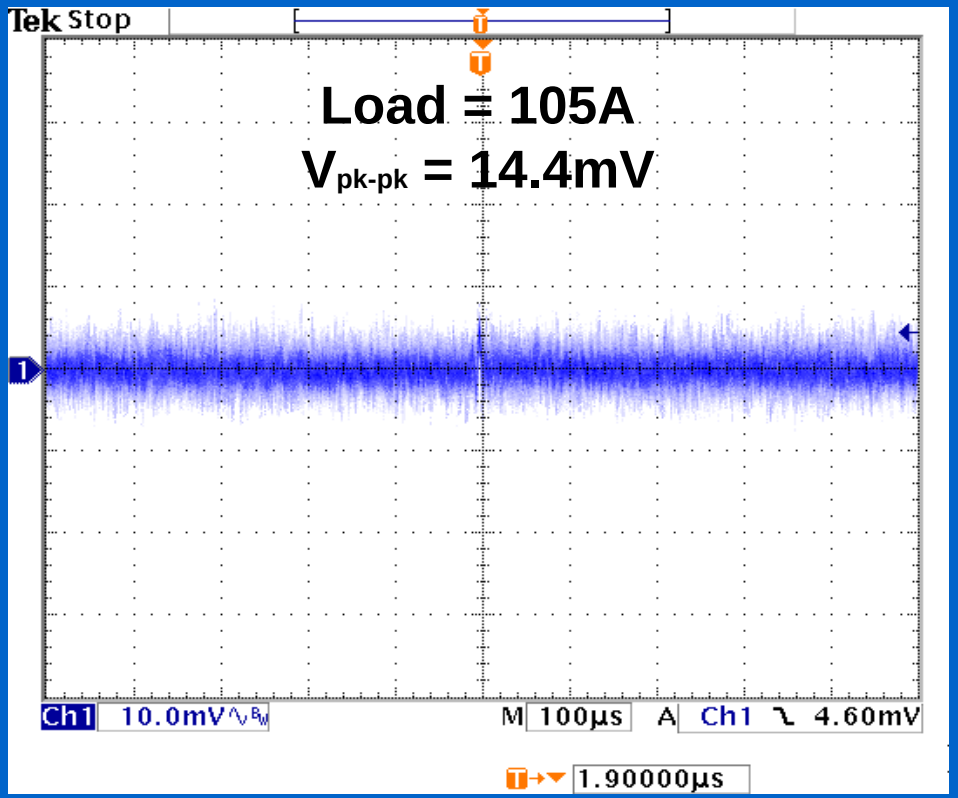
4-Phase VRM Performance

VID = 1.325V; Vcc = 12.0V; LL=0.91mohm
Fswitch = 600KHz, Cbulk = 2000uF





Includes Connector and Test Board Losses (2% at full load)

Low Ripple with no Digital Artifacts

Primarion Digital Power Summary

- Highest Performance
  - High efficiency and power density and accuracy
- Lower System Costs
  - Active Transient Response (ATR) reduces output capacitance requirements
  - Use for high density and low cost applications
- Easy, flexible VR design
  - I2C enables new level of intelligence and flexibility for monitoring and adjustment
  - Design VR with GUI

True Disruptive Technology with Lower Costs, Higher Performance, New Way of Designing

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Thank You!