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Primarion Confidential

True digital solutions simplify full featured cost effective buck converters

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Agenda

- Changing the power management ecosystem
- Misconceptions about Digital Power
- System power management requirements
- Advantages of Digital Power
- Di-POL™ PX7510 & PX7520 Integrated Power ICs
- System implementation approaches
- Summary

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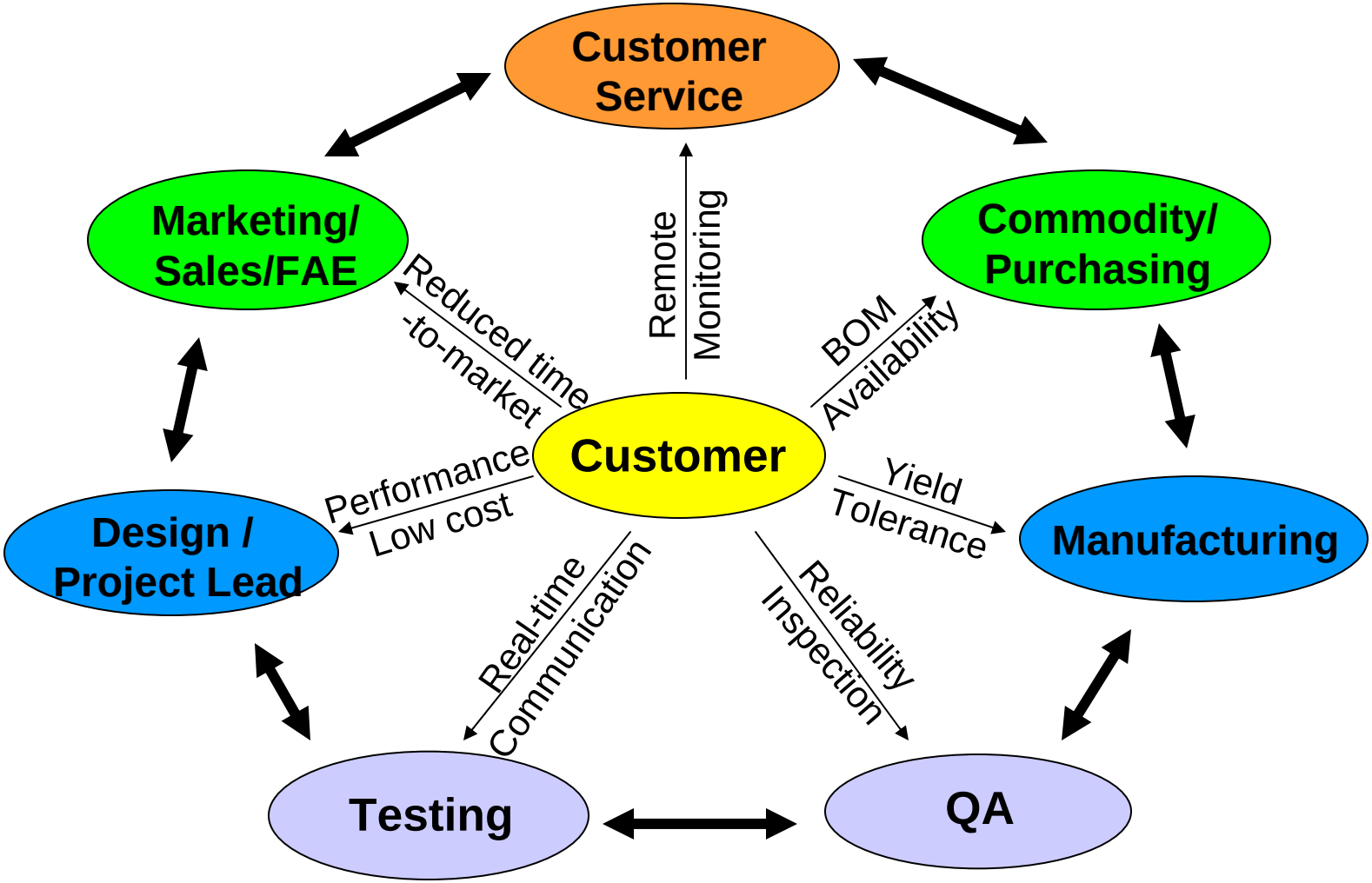
Changing the Power Management Ecosystem

- ***Going Digital***
  - We would not do justice just comparing technical differences between Digital & Analog Solutions
  - Question is not only " can Digital do it better than analog" but "what are the possibilities beyond power conversion and management"?

Digital Power Management Ecosystem



Misconceptions about Digital Power

- ***Digital Introduces too much complexity***
  - **Not true**
  - Analog solutions involve multiple layers to deal with power conversion, communications interface and management. Digital solutions compress all layers into single chip to simplify the design.
  - Programming doesn't mean coding but simply dealing with a wizard driver GUI to get all system-level benefits.
- ***Digital is Cost-Prohibitive***
  - **Not true**
  - Delivers lower BOM cost compared to existing analog solutions where system communications and multi-rails required.
  - Eliminates expensive additional sequencer/Power Manager ICs.
- ***Not field proven***
  - **Not true**
  - Primarion® alone has millions of digital controllers in the field via major OEM systems with zero field failures.

What is DPM?

- Digital implementation of traditional analog functions into a dense mixed signal CMOS digital control device
- DPM takes advantage of high volume, low cost standard CMOS process technology to deliver a cost effective VR solution
- DPM extends monitoring and control capabilities through a serial link to the power supply, processor, and other system components
- DPM design is made simple and flexible through a suite of "user friendly" software tools

Digital Trends for Power Management

- I2C communication bus definition - ex. PMBus™
- Each CMOS process improvement step can give 2x real-estate reduction
- Functionality doubles at approximately same cost
- Future digital power management will take advantage of low cost high volume CMOS process
- System costs with digital power management will continue downward

System Power Management Requirements

- System power management complexity continues to increase
  - Up to 16 POL modules on system board required in various applications.
  - Timing, delays, sequencing, tracking, hot swap functionality
- Optimized power consumption at system level
  - Idle modes- Management of power to meet Green Power requirements
- Need for seamless interaction with the system CPU
  - Communication of faults to system
  - Fault reporting of each power device
  - Communication with other power devices and load IC
  - Reporting of voltage, power, current, temperature parameters to system
- Diagnostics- Anticipation of faults, monitoring and correcting parameter drifts
- High Transient load environments- smaller windows of deviation

Analog and Digital Difference?

- Today's PWM controllers:
  - First process signals in the analog domain and then process PWM logic in the digital domain.
  - Process internal information externally by digitizing signals with another device or add on digital wrappers
  - Increased solution cost
- True digital controllers:
  - Convert signals immediately into the digital domain
  - The digitized signals are placed into registers
  - All subsequent signal processing is done digitally
  - Information can be directly communicated to the system
  - Lower solution cost

Digital Power Management

Since all information is digitized:

- One can multiply, divide, filter, compensate, compare, calibrate, store and communicate each piece of information
- I2C flexibility built in- PMBus™, SST, Future Bus choices easily adapted
- Specific algorithms define total functionality for power device
- Asynchronous and non-linear control loop algorithms can be easily implemented for optimal fast transient response or advance functions
- Digital power management can enable system communication and control of power delivery to the load IC

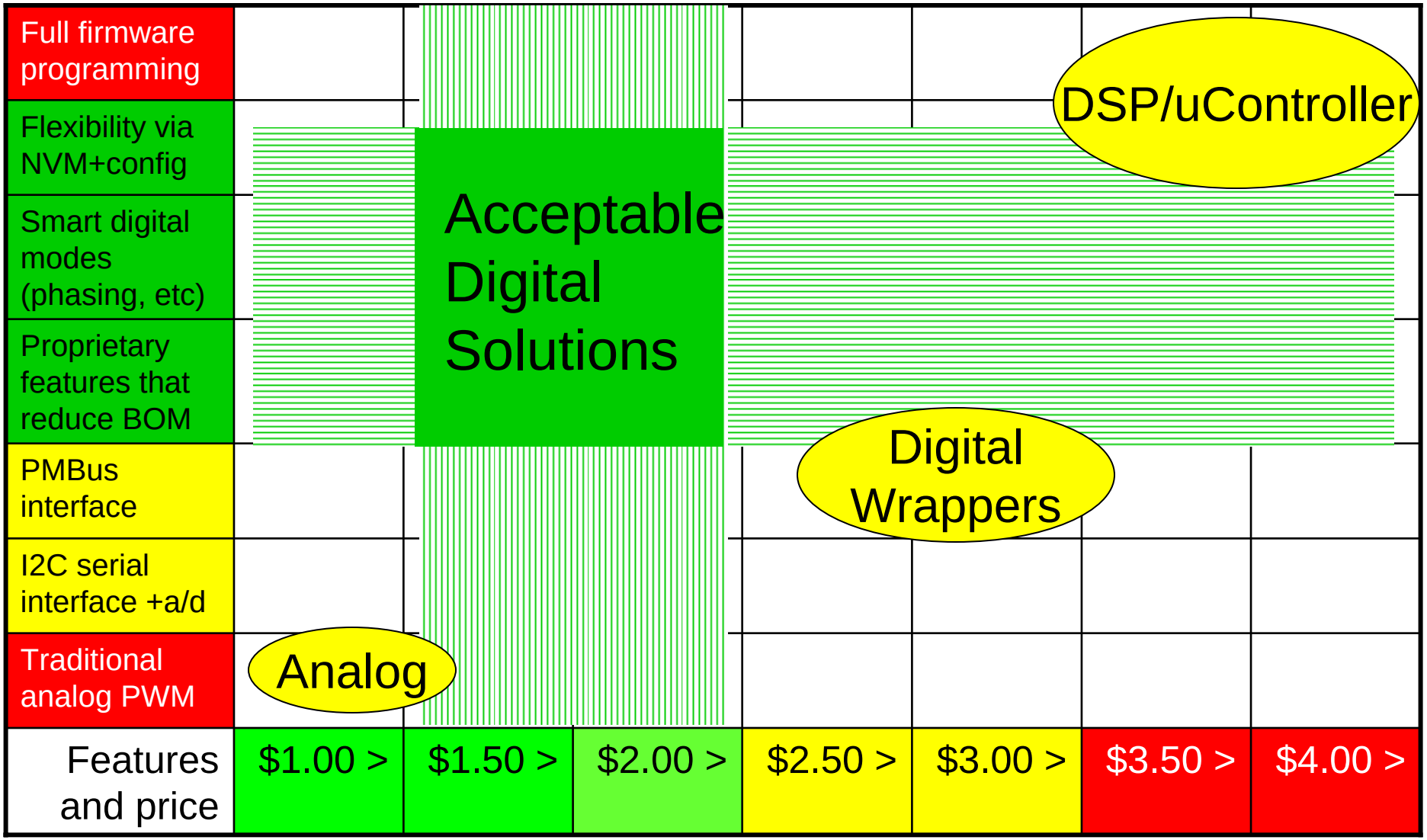
True Digital implementation

- Provides design ***Flexibility***
  - Compensation can be optimized for each rail's capacitance and inductance
  - All design parameters are programmable
  - No discrete components for design implementation
  - Component calibration and drift monitoring
- Provides ***Personalization*** for each power stage
  - Each rail can be uniquely defined for its requirements
  - One chip can provide multi-faceted design options
  - Full telemetry of power stage is available to system
  - Full custom programmability with one standard part

Value Positioning :

vs uC+DSP : All needed features at much lower cost

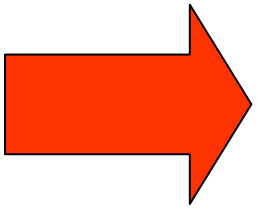
vs analog+add ons (“digital wrapper”) : Major system gains with no extra cost



Driving the Conversion to Digital Control

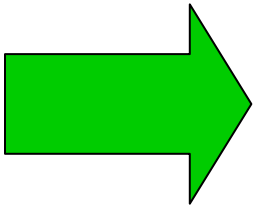
- Change the adoption question for customers . . .

From :
- What premium will you pay for the system advantages of Digital ?



Slow, Selective Conversion

To :
- For the same solution cost as Analog, why not realize the system benefits of Digital ?



Rapid, Mainstream Conversion

Di-POL™ Product Family

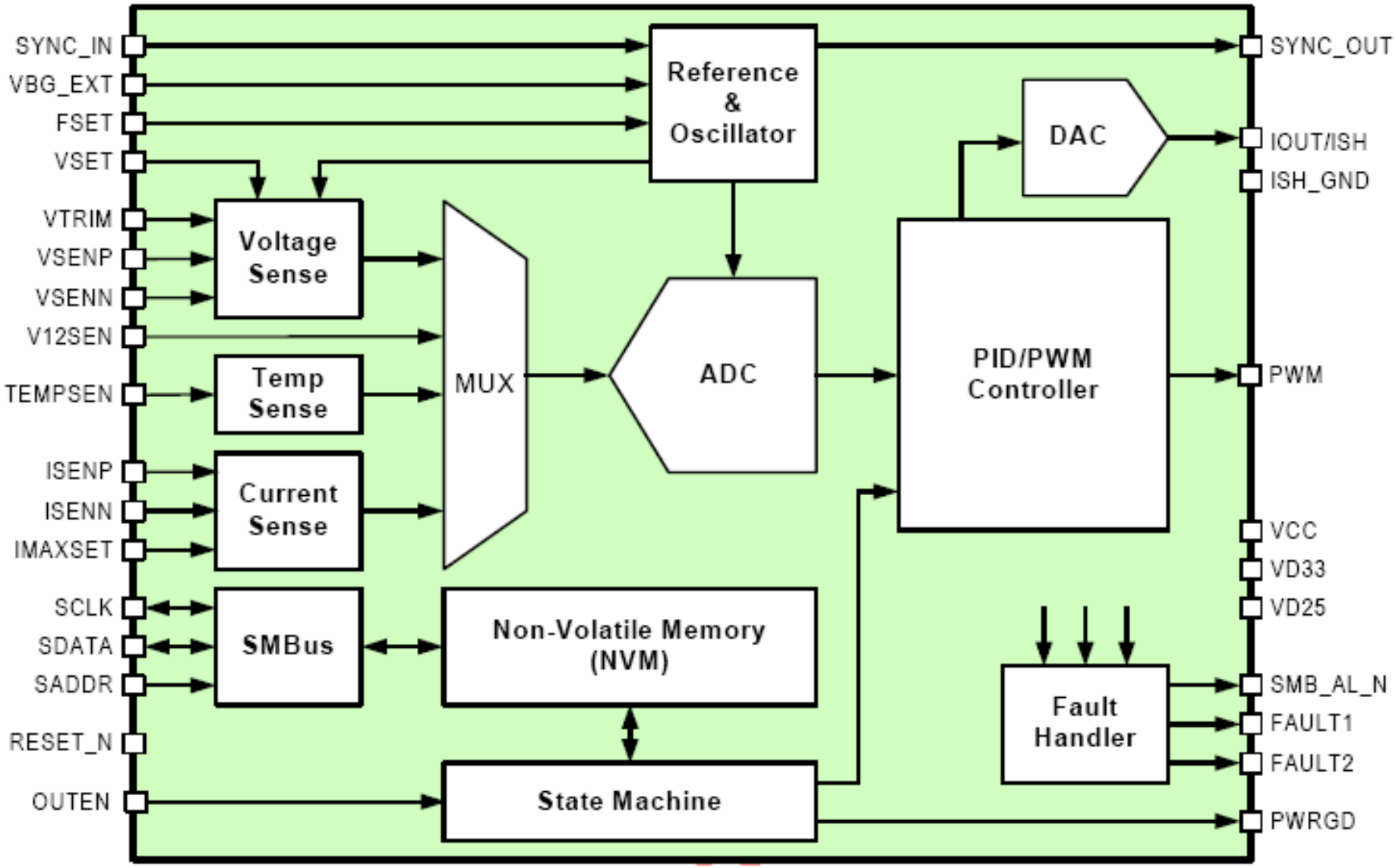
Di-POL = Digital integrated Point of Load

- All-digital, low-cost POL power IC with On-Chip NVM:
  - Single chip delivering power conversion + power management
  - Programmability for total flexibility - configure key power supply parameters
  - PMBus™ compliance and broad support
  - Competitive pricing compared with analog solutions

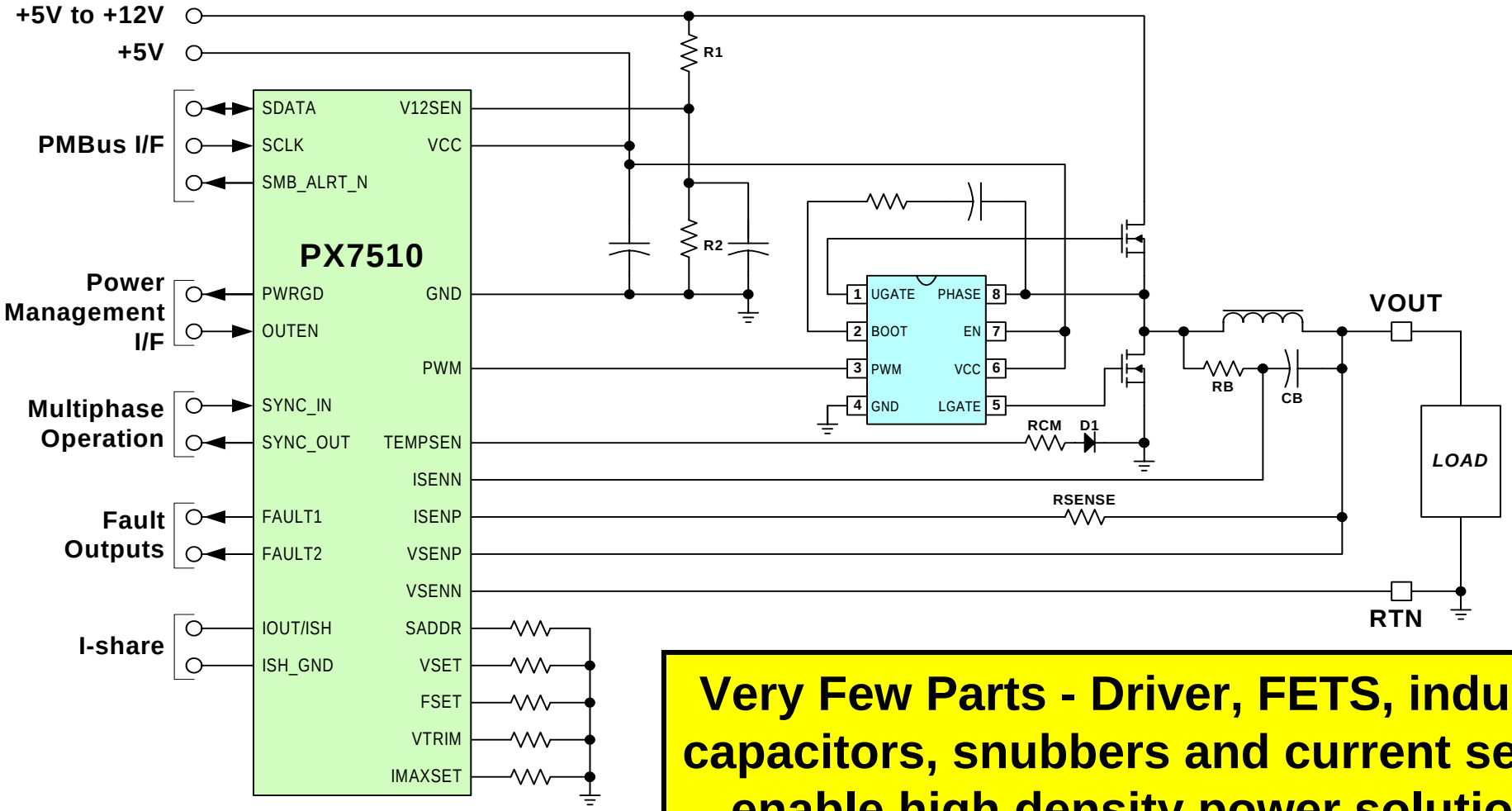
- **PX7510 single-phase controller**
- **PX7520 dual-phase controller – increased power, multi-phase support**

Di-POL™ PX7510

Functional Block Diagram



Basic Buck Circuit Block

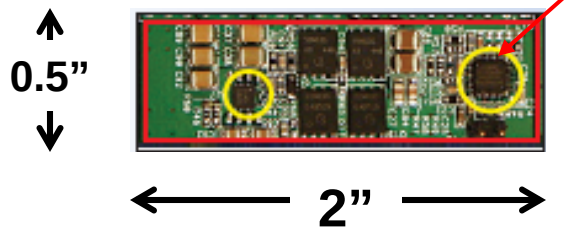


Very Few Parts - Driver, FETS, inductor capacitors, snubbers and current sense: enable high density power solutions

PMBus™ Compliant 30A POL Solution

- **PMBus™ serial interface**
  - Query V, I, T telemetry & faults
  - Tracking, sequencing and margining
  - Override hardwired settings
  - Fault levels and responses

- **Di-POL PX7510**
  - Single 5V supply
  - 150 KHz to 2Mhz switching
  - On-chip NVM
  - Digital Control Loop
  - Auto calibration upon startup
  - Frequency Synchronization
  - Current Sharing

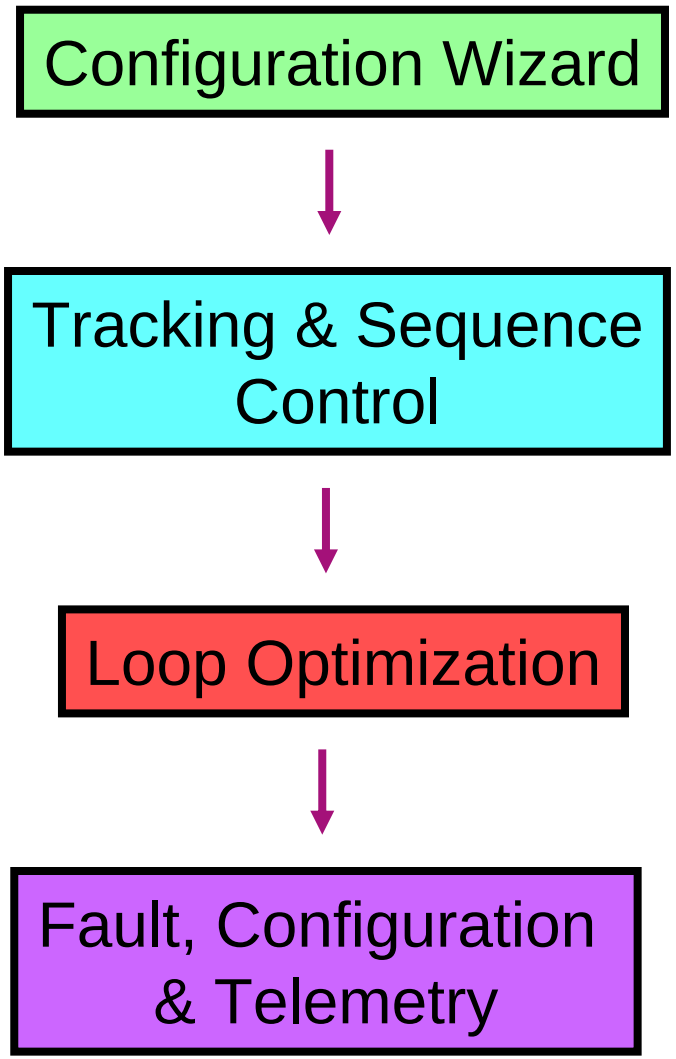


- **Programmable Fault Management**
  - Output under/over-voltage
  - Output over-current
  - Input under/over-voltage
  - Temperature fault & warning
  - Communication

- **Telemetry (Reads)**
  - Voltage, Current, Temperature
  - Duty Cycle, Frequency
  - PMBus revision
  - MFR ID, Model, Rev, Location

Di-POL™ PX75xx Software GUI

Focus on "Ease of Use" & Flexibility



Input system parameters: Vout, Scale Factor, # phases, bus address etc by rail

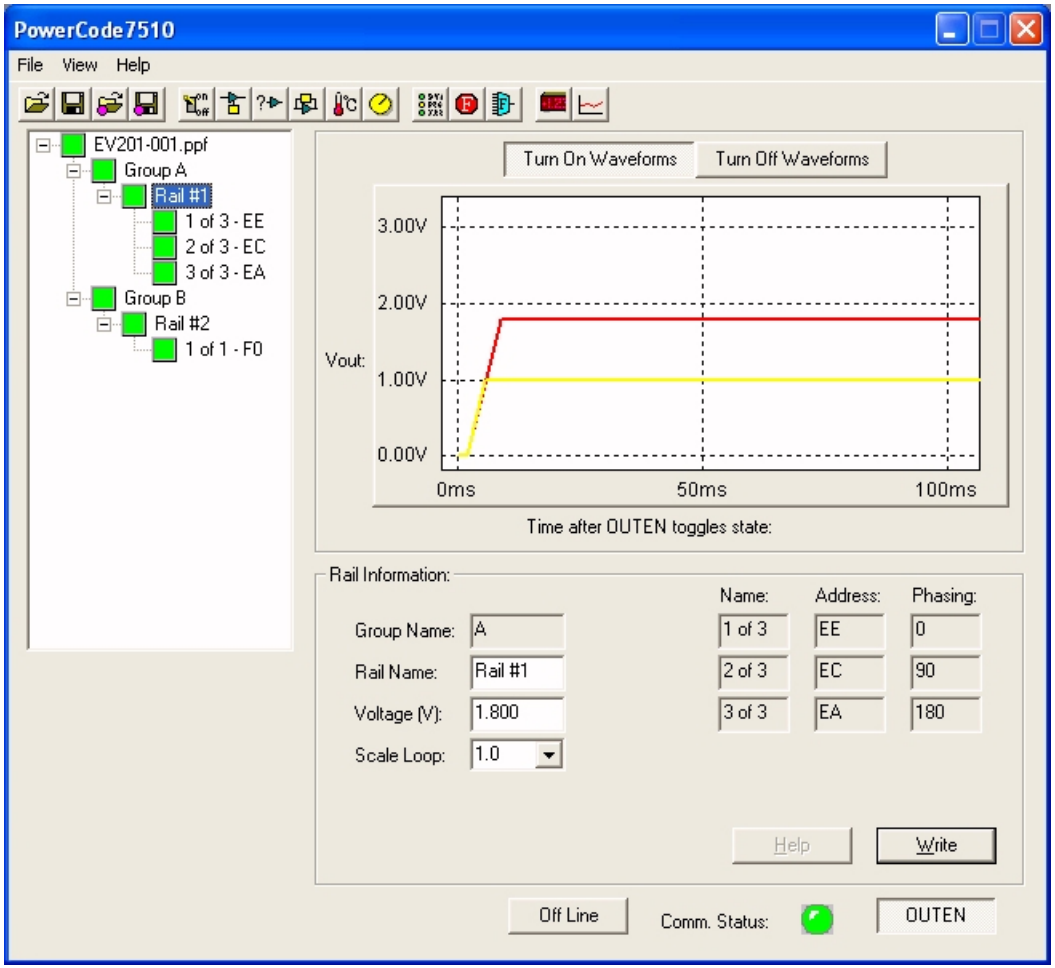
Input ton delay & rise, toff mode, delay & fall time. Graph V vs. time by POL

Input Fswitch, L & C, load model
BW, Gain & Phase Margin optimizer
Graph Gain & Phase vs. Freq

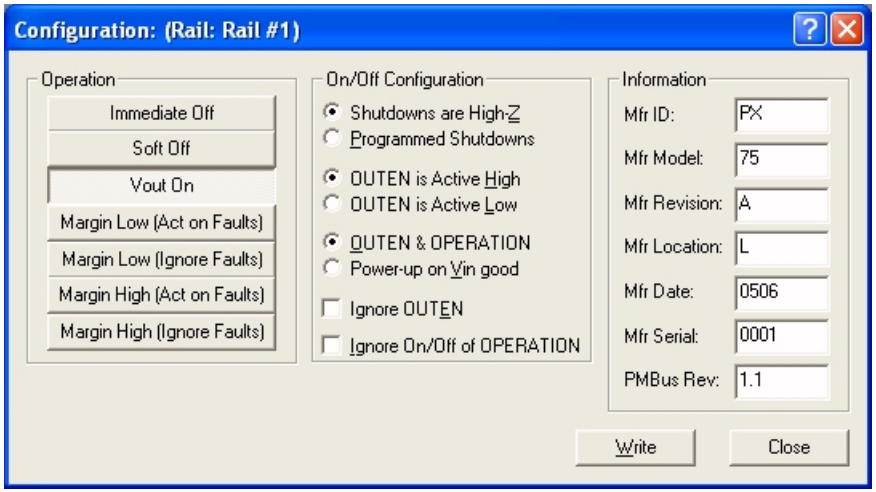
Set System Faults & Behavior
Temp, Current sense etc settings
Readout V, I, Fault status

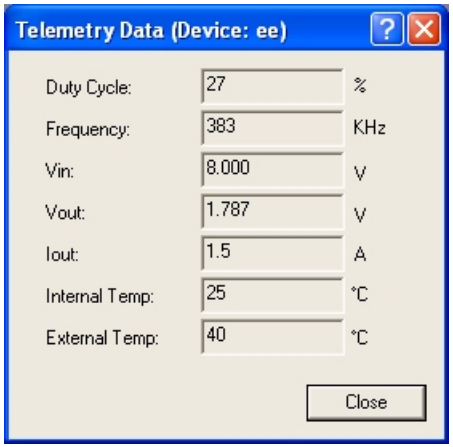
PowerCode GUI

Main Page

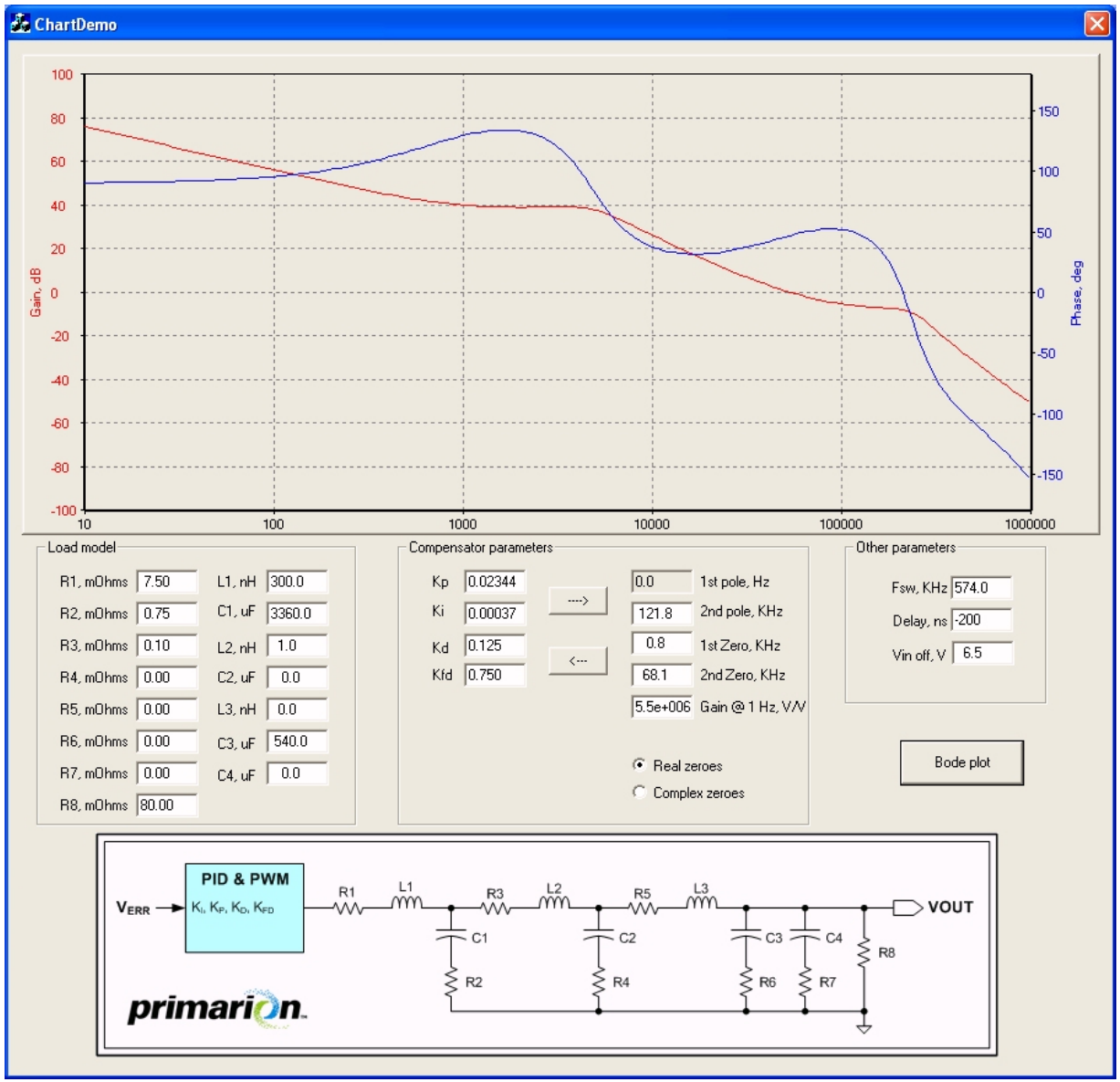


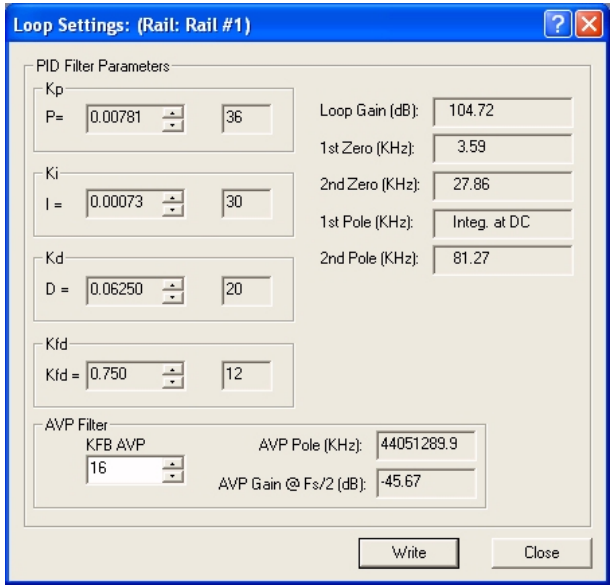
Real-time Telemetry and Easy-to-Use Pop-Up Windows



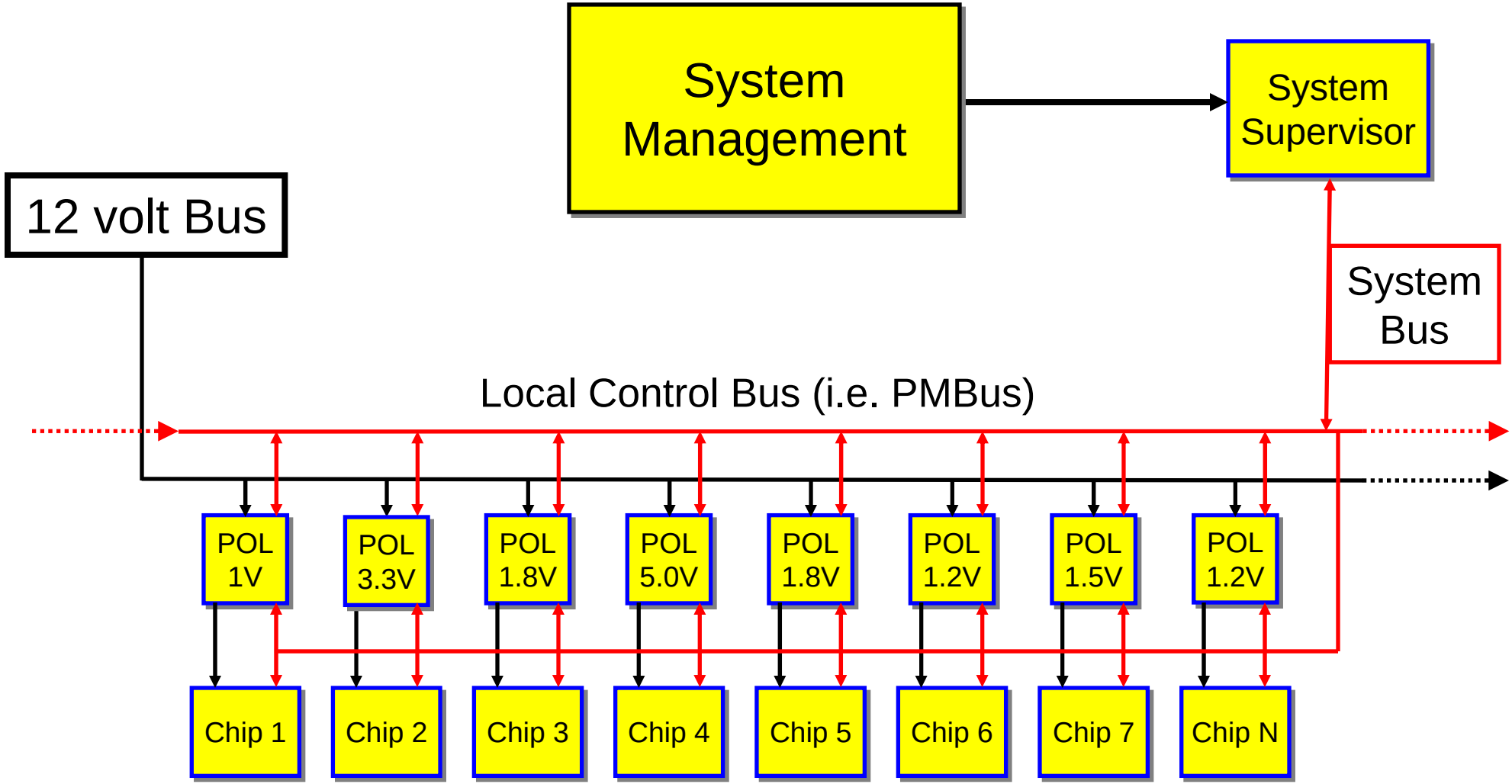


Loop Simulation Tool and Stability Optimization





System Implementation



Digital Systems Tomorrow

Summary

- True Digital Solutions for today's Computing & Communications Systems offer many advantages not available economically with traditional analog solutions
- There are Digital solutions which are simple, easier to implement and already field proven
- Digital power management has the scalability and flexibility to innovate future system solutions