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Real Time Efficiency Optimization: Beyond FET Silicon

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Agenda

- Efficiency trends
- Power trends
- Silicon has driven efficiency improvements
- Power management capability
- Managing phases on the fly
- Intelligent management of efficiency

Efficiency Trends

- Server farms and data centers are demanding higher efficiency for servers
- Utility costs can have significant savings by efficiency improvements
- Green power requirements are pushing the industry
- A server might cost $1,500 and the power costs currently $20 to $30 a month
  - Over the life of that server the utility cost will be 3 to 5 times the cost of the server

Trends in the Market

- Need to ensure instantaneous application responses to users

- There is uncertainty about whether turning components on/off frequently might add to or shorten their reliable service life

Today's Currents

- Typical currents today in servers
  - Intel processors
    - **90 amps to 130 amps** for servers
  - AMD processors
    - **90 amps** for servers
  - GPUs for servers
    - **90 amps to 150 amps**
  - Memory cards
    - **60 to 80 amps** for 8 cards of memory
- A lot of current is flowing on motherboards…or is there?

Efficiency

- Processor function
  - ***Idle state***: approximately 20% of full load
  - ***Running state***: can be typically 30 to 40% of full load
  - Full load current of processor is seldom seen
  - Peak currents vary on applications/software
- Memory
  - Approximately 40% of load current is leakage
  - Typically memory is running all the time
  - Difficult to power manage - turn off/on

Silicon Has Provided Key Efficiency Improvements

- Semiconductor companies keep developing better and better silicon
- FET solutions are being released at >40 amps/phase with high efficiency
- Discrete FETS from different vendors have allowed efficiency to exceed ***90%*** depending on output voltage and current
  - 5 years ago the number was in the low ***80%***

Power Management Capability?

- Most systems just do what they are designed to do
  - No intelligence
  - Enable and run the power
  - Fixed efficiency and phasing
  - Power systems are designed for maximum conditions
- Typical power systems are running at 30% - 40% of full load
- Overall, power systems are under-utilized for the power level consumed by the system

Power Management Options

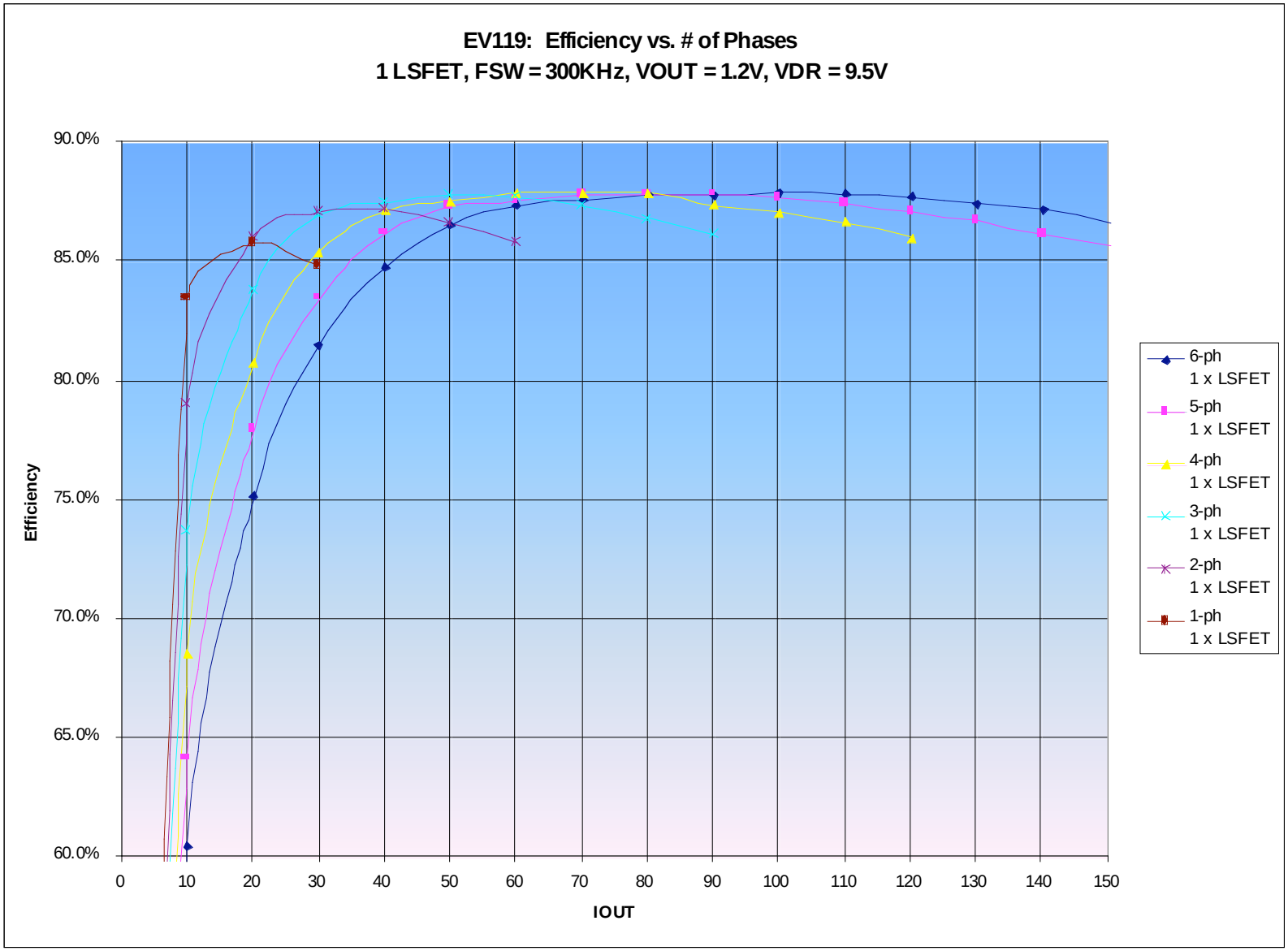
- Intelligent management of power can provide solutions to improve efficiency results
- Do not operate power with fixed solutions
- Make power management decisions at the local level
  - Current and voltage are monitored by control
  - Determine number of phases of operation
  - Number of FETS
  - View current draws and optimize power management choices for applications

Intelligent Power Decision

- **Decide on phasing at the beginning**
  - Communicate via I2C
  - Communicate via 2-pin logic
  - Change number of phases based on current on board
- **Change operation at light loads or idle states**
  - Lower frequency of operation
  - Reduce phases
- **Dynamic phasing decision by power management**
  - Configure the number of phases based on current draw
  - Optimize efficiency based on phase requirement
  - Local power management chooses optimization of phases vs. currents based on the application

Result: Overall Improvement of Efficiency

Efficiency Curves



Efficiency Examples

Load (Amps)	Vout (Volts)	Pout (Watts)	Phases	Efficiency (%)	Ploss (Watts)	Psaved (Watts)
120	1.2	144	6	87.0	21.5	3.0
			5	86.0	24.5	
50	1.2	84	4	87.0	12.0	2.0
			6	85.5	14.0	
30	1.2	36	3	87.0	5.4	2.5
			6	82.0	7.9	

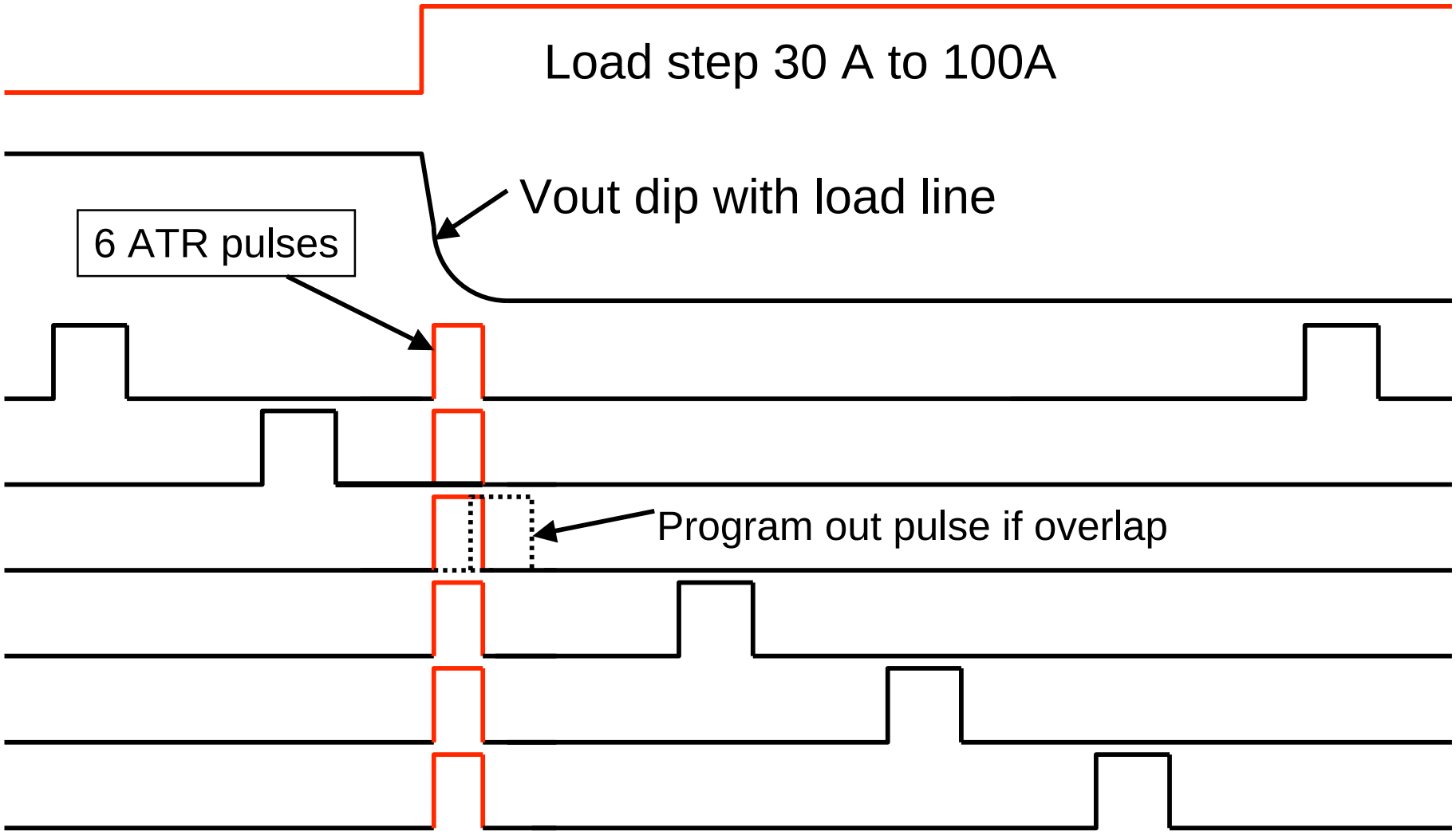
Intelligent Power Decision

- Dynamic phasing
  - Number of phases can be chosen to optimize efficiency and thermals
  - Maximum phases: 6
    - Vary phases from 1 - 6
  - Peak efficiency is approximately 87% from curves
    - Other solutions can have peaks above 90%
  - Operate phases vs. currents so that peak efficiency of FET solution is flat across the load

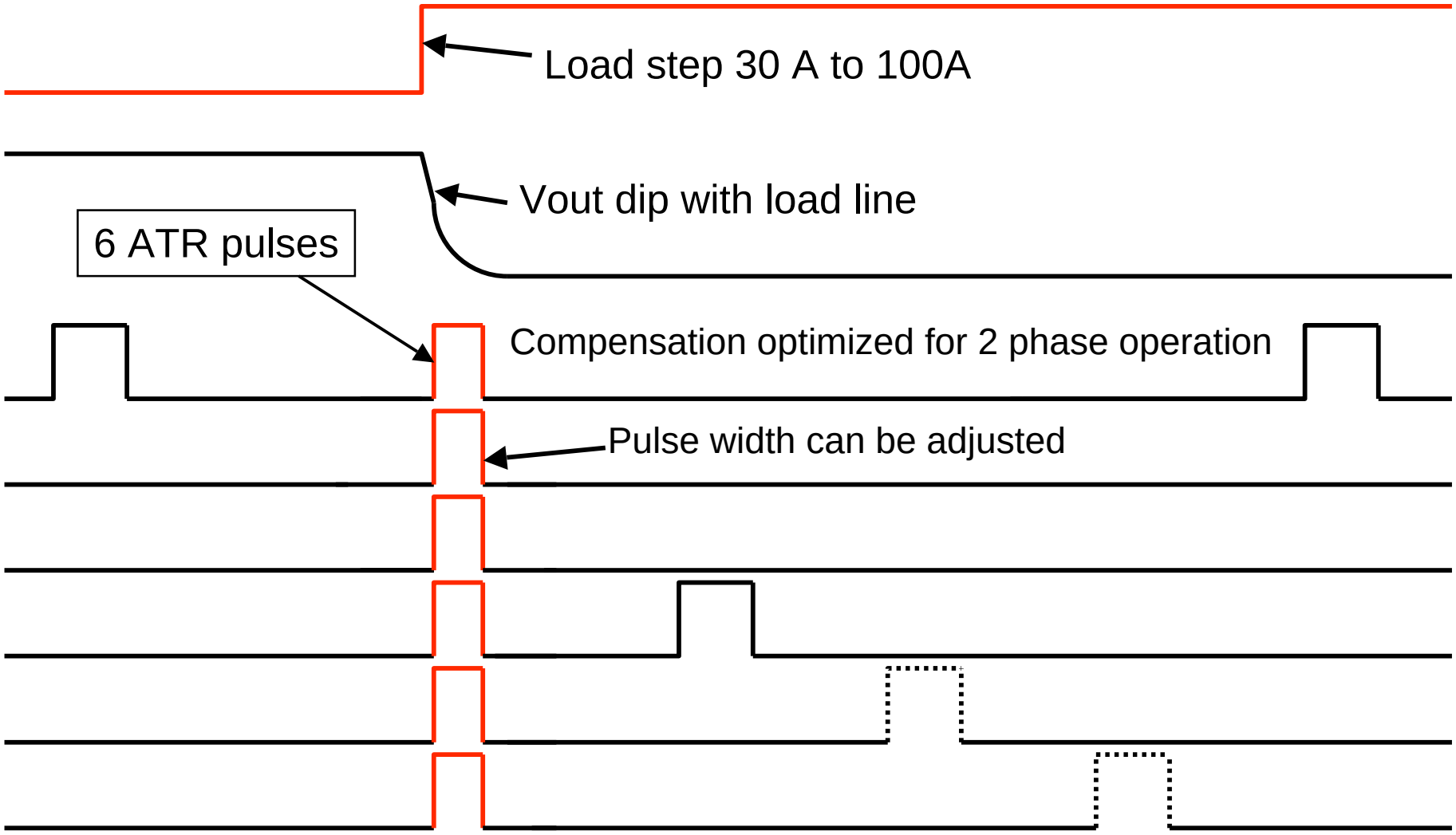
Dynamic Response

- Digital control systems can provide a dynamic response for the application
  - Change phasing by I2C
  - Program optimized compensation and control for each number of phases of operation in each state of operation
  - Monitor current and make decisions against a circuit algorithm for proper phase choice to optimize efficiency
- Transient response algorithm
  - Fast response to transients
    - Special control algorithms created digitally to optimize response for application
  - Fast change from low phase to high phase count
  - Optimized control response as you add or drop phases

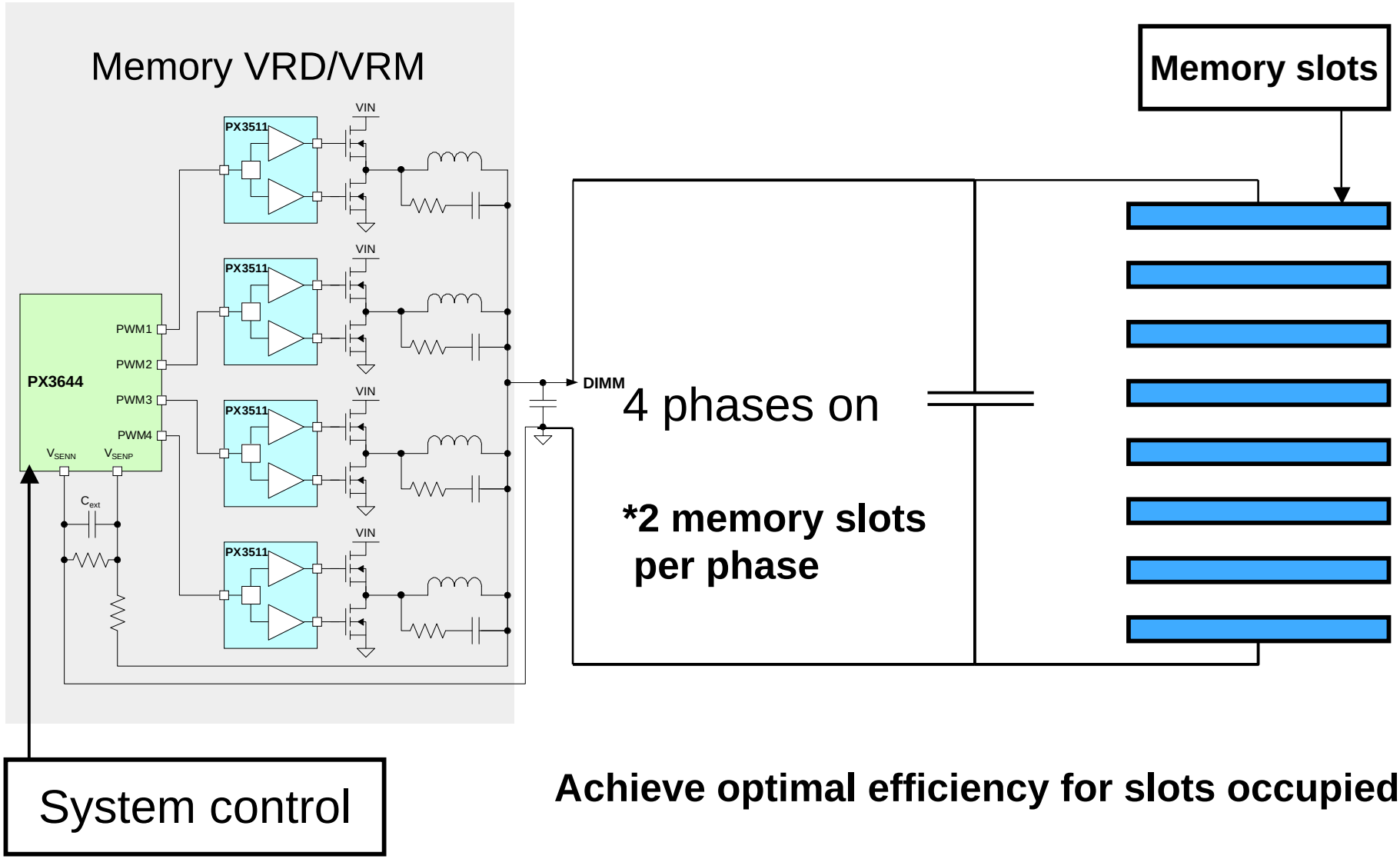
Typical 6-Phase VRD System



2-Phase to 6-Phase During Transition

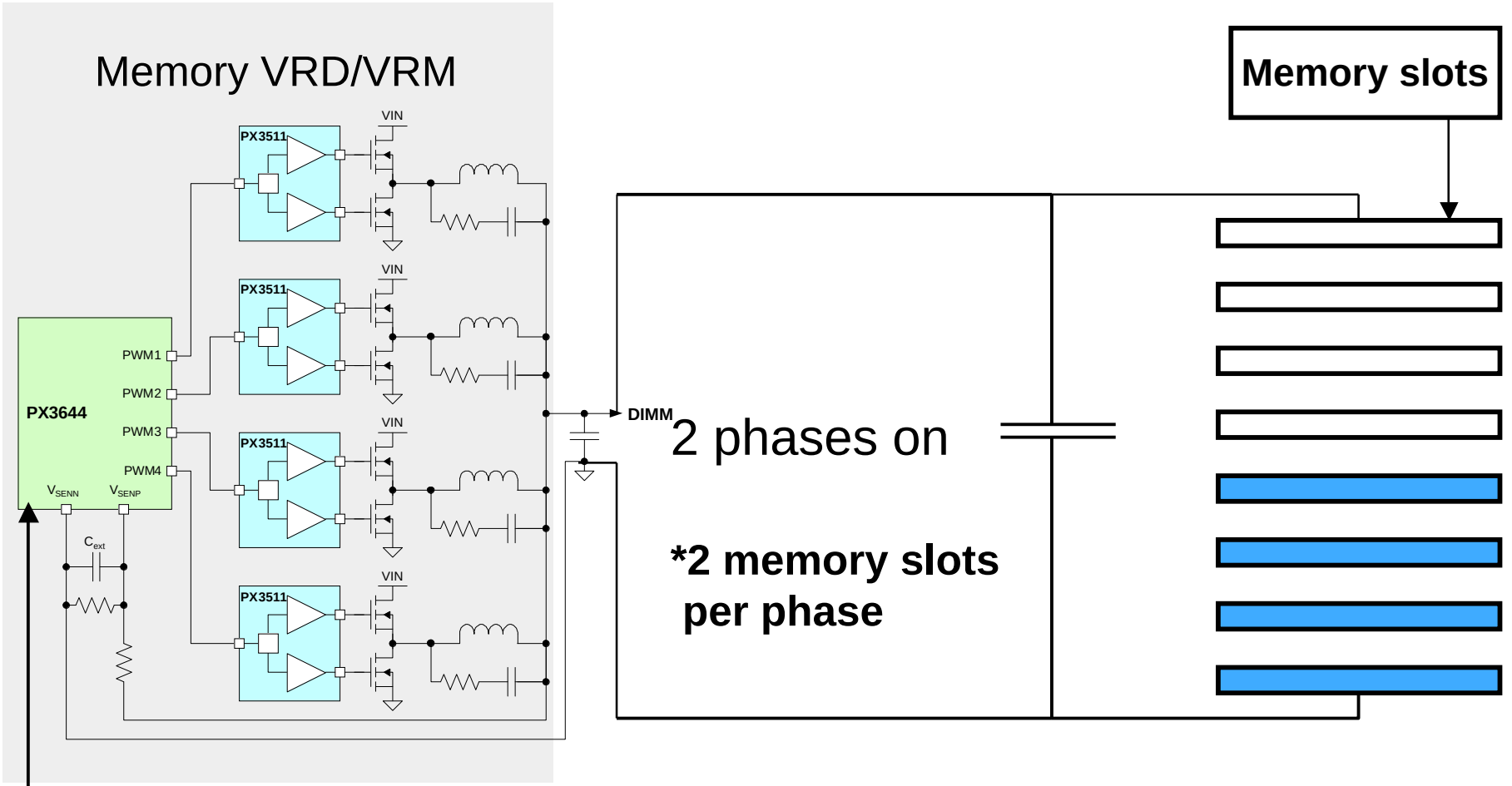


8 Memory Slots Populated



Achieve optimal efficiency for slots occupied

4 Memory Slots Populated



Achieve optimal efficiency for slots occupied

-Add/drop phases via I2C by system

-Add/drop phases dynamically by controller

Impact of Real Time Efficiency Improvement

No of racks	20	
No of servers per rack	40	
Total servers (20x40)	800	
Average power saved per processor	2.5	Watts
Power saved in a two-way server (2x2.5)	5	Watts
Power saved for memory	2.5	Watts
Total power saved per Server (%+2.5)	7.5	Watts
Total power saved per rack (7.5x800)	6000	Watts
Power saved from air conditioning	1780	Watts
Total power saved (5600+1780)	7780	Watts
Energy cost	$0.103	$ / KWH
Energy cost savings (0.103x24x365x7.78) per year	$7,020	
Energy cost savings (0.103x24x365x7.78) over 4 years	**$28,079**	
Energy cost savings per Server(28079/800) over 4 years	**$35.10**	
Energy cost savings per rail (35/3)	$11.70	

Summary

- Efficiency, heat dissipation, cooling and power management are all intertwined
- Power management can be accomplished at the local level by system digital communication
- Idle states can be identified by ASICS in order to optimize efficiency
- Dynamic management of power dissipation on high current systems provides efficiency, thermal and cooling improvements
- Local level intelligence is achievable