

UCD92xx Digital Controller Solutions – You Don't Have To Write Code

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Manager, Power Management



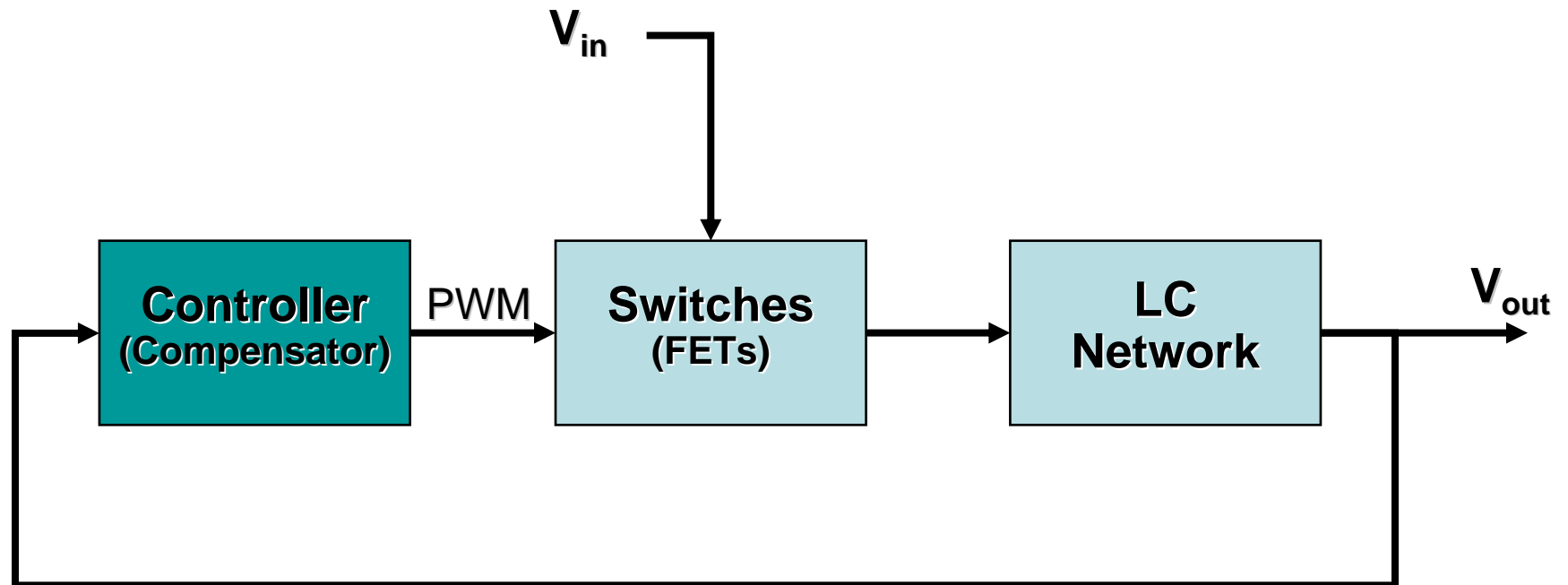
Overview

- What is Digital Power?
- Key Digital Power Controllers
- Designing a POL using digital controllers
- Application Examples
- Summary



What is Digital Power?

Generic Power System Block Diagram

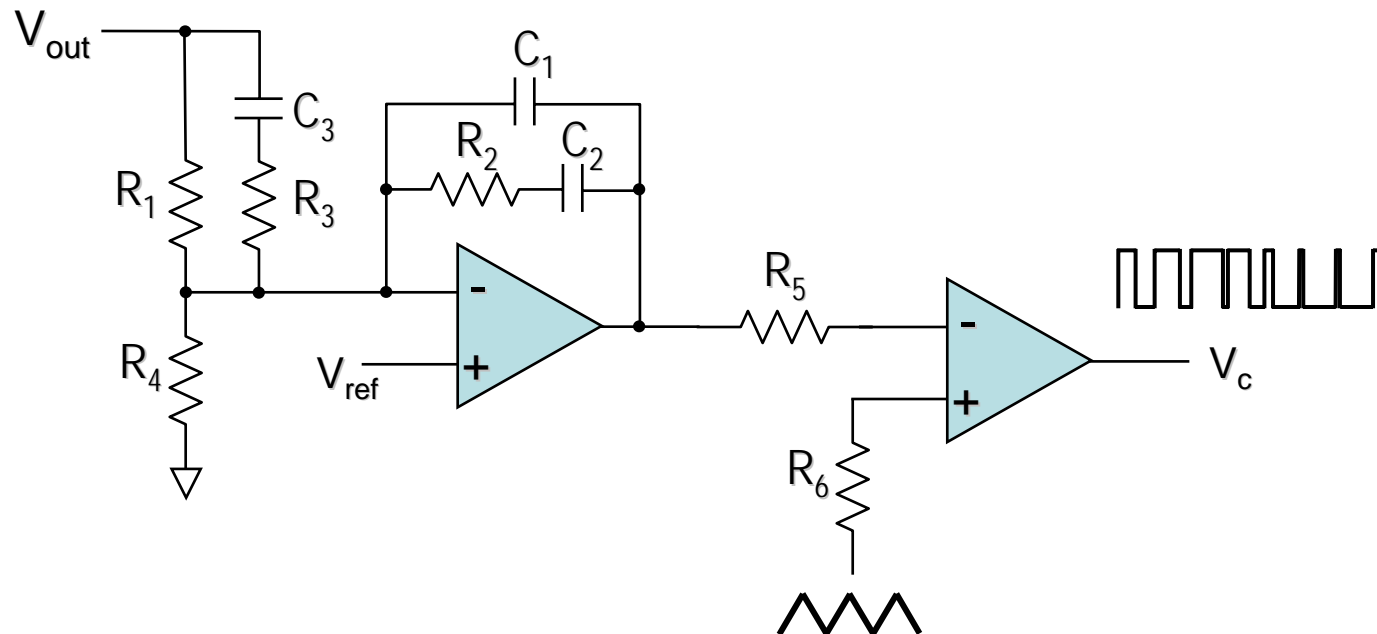
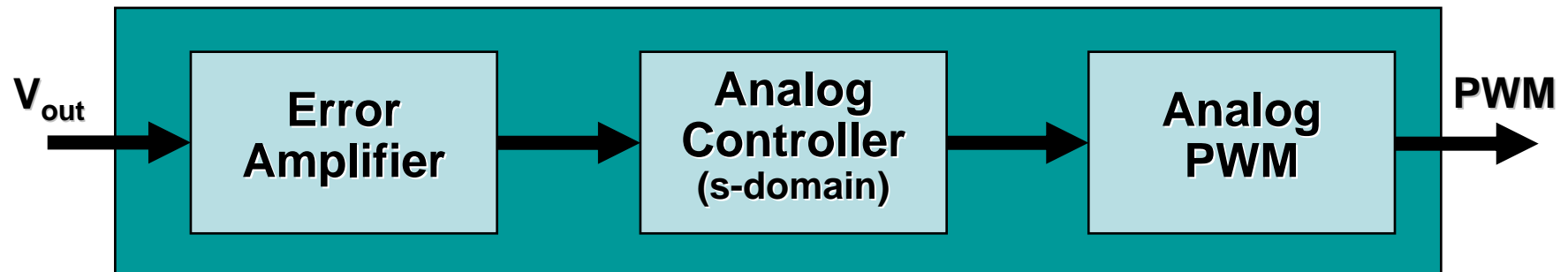


The controller block is what differentiates between a digital power system and a conventional analog power system



What is Digital Power?

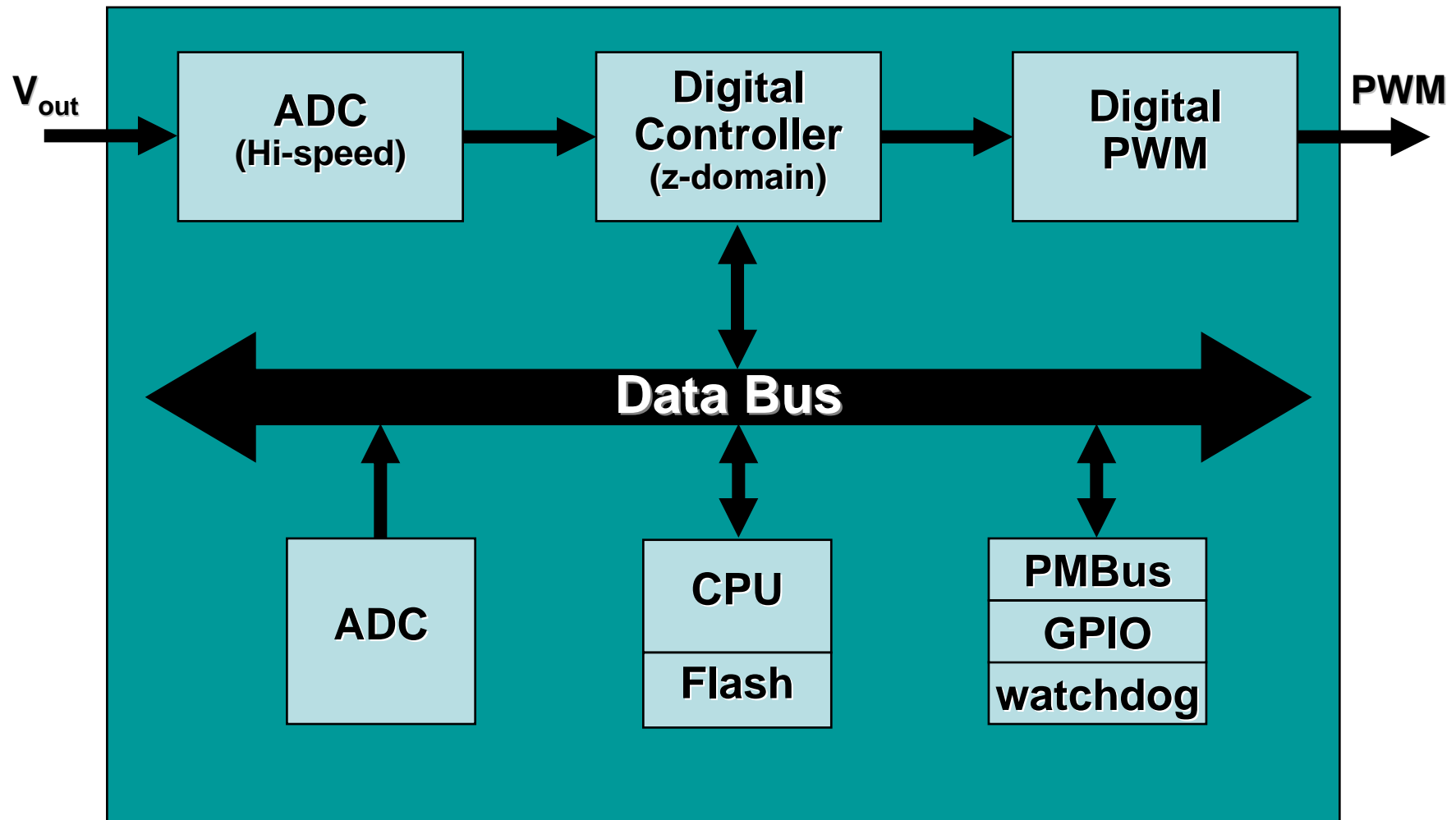
Analog Controller (s-domain)





What is Digital Power?

Digital Controller (z-domain)





Analog vs. Digital Solution Tradeoffs

	Strengths	Weaknesses
ANALOG	<ul style="list-style-type: none">• Continuous operation (infinite sample rate)• Low power consumption• Single chip solutions available (integrated driver)	<ul style="list-style-type: none">• Hardwired design• Separate “signal” lines for every converter• No communication with controllers• Need separate system manager
DIGITAL	<ul style="list-style-type: none">• GUI, programmable parameters• Adaptive and nonlinear compensation• Flexibility, easier board development• Features integration• Multiphase reliability<ul style="list-style-type: none">– Phase shedding– N+1 redundancy• Easier PWM synchronization• Fault logging• Up to 32 devices on single PMBus	<ul style="list-style-type: none">• Discrete PWM operation• Higher quiescent current• Dual chip solution (controller + driver)



What does a digital solution provide?

- ***High levels of integration***
 - Multiple outputs and phases with one controller
 - Integrated sequencing, margining, management
- ***Advanced functionality***
 - Real time power system diagnostics – data logging and failure prediction
 - Adaptive control for varying operation modes and load characteristics
 - Calibration in manufacturing
- ***System optimization***
 - Dead band control for improved efficiency
 - Enhanced phase management



Digital Power Ready End Equipment

- ***Computer***
 - Servers
 - Storage
 - UPS
- ***Communications***
 - Rectifiers
 - Base stations
 - Routers
- ***Industrial, Test and Measurement***
 - Semiconductor Test Equipment
 - Lighting
 - Medical equipment



Digital Power Conversion

UCD92K

Family Products



UCD92xx Digital Controllers

- Digital Multi-Phase Architecture
 - UCD9220: 2 rails, up to 4 phases
 - UCD9240: 4 rails, up to 8 phases
 - Internal phase distribution
 - Current and temperature balancing
 - Phase adding/shedding
 - Compensation changes at light load
 - Non-linear control
- Optimized for 12Vin to low voltage conversion
- High Frequency Operation to 2MHz
 - 250ps PWM resolution to support wide Vin to Vout ratio's
 - 3mV @ 1MHz and 12V input

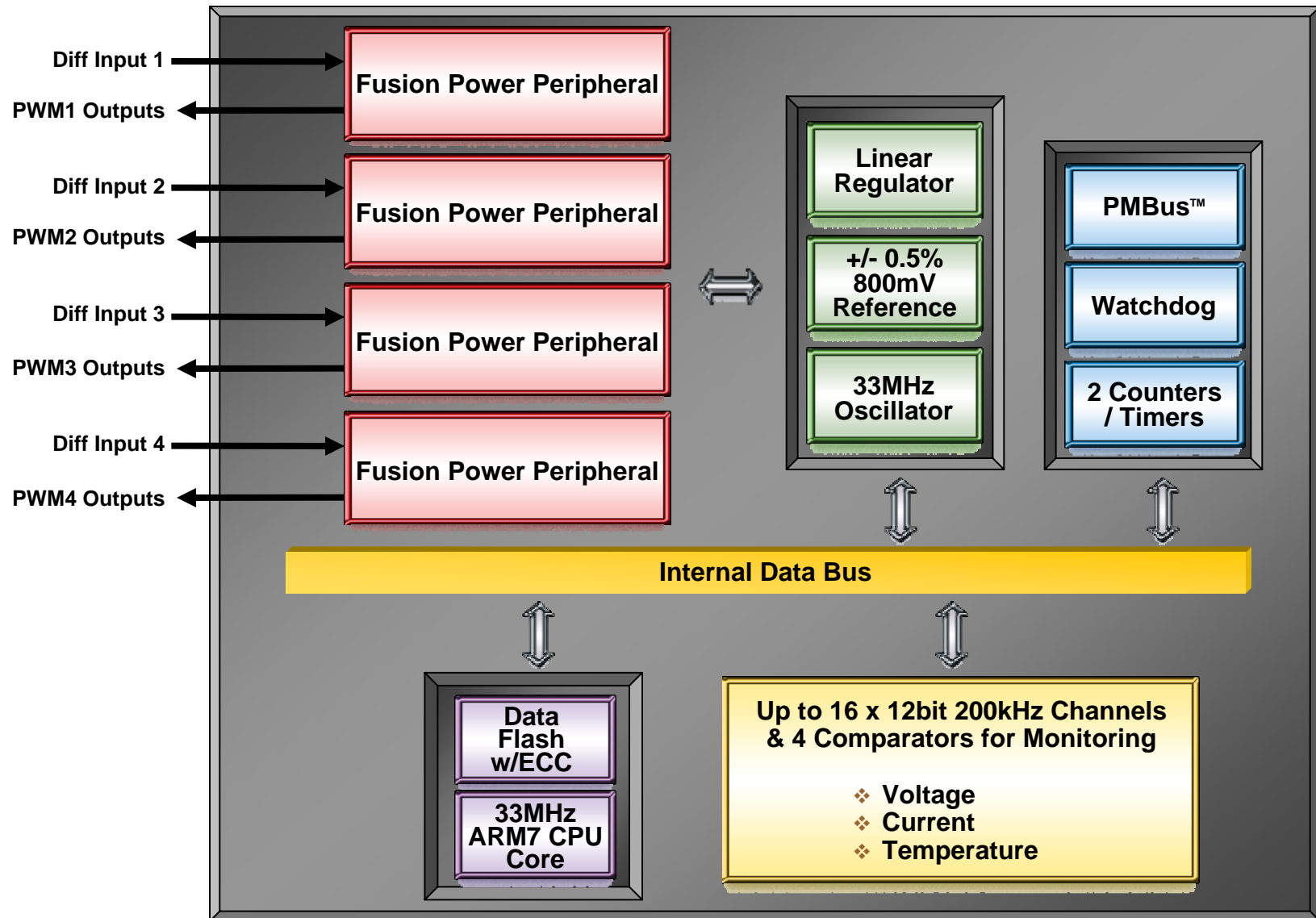


UCD92xx Digital Controllers

- Integrated interface for monitoring & control
 - Output voltage set-point and margining
 - Load current monitoring
 - Temperature monitoring
 - OC, OV, and OT protection threshold programming
 - Margining, Sequencing, Synchronization
- Power Good, Critical Fault Indicators
- Load ID analyzer function optimizes power supply design
- Error logging to flash
- Capable of start up into pre-biased loads
- QFN Packages
 - UCD9220: 48-pin
 - UCD9240: 64-pin and 80-pin



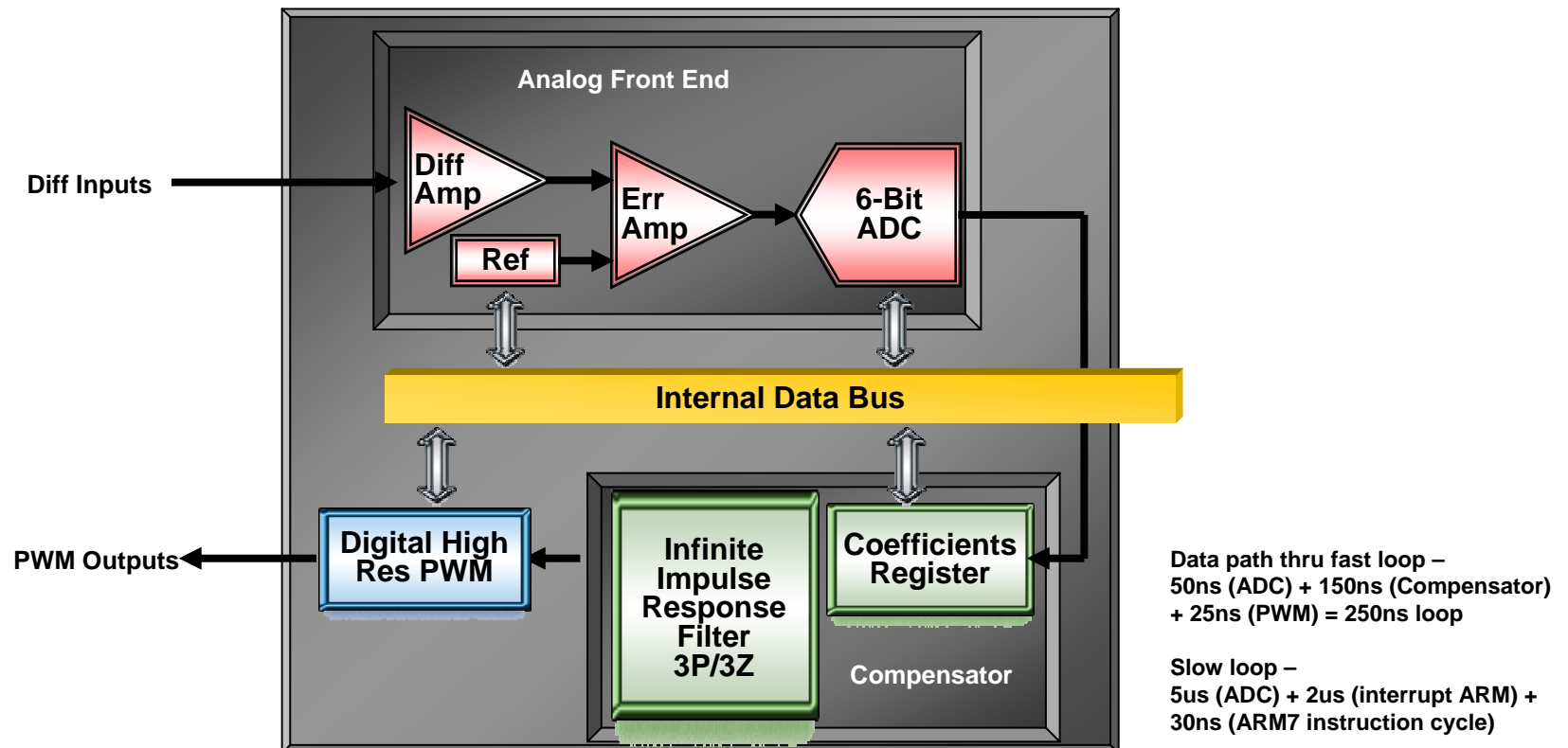
UCD9240 Controller Overview





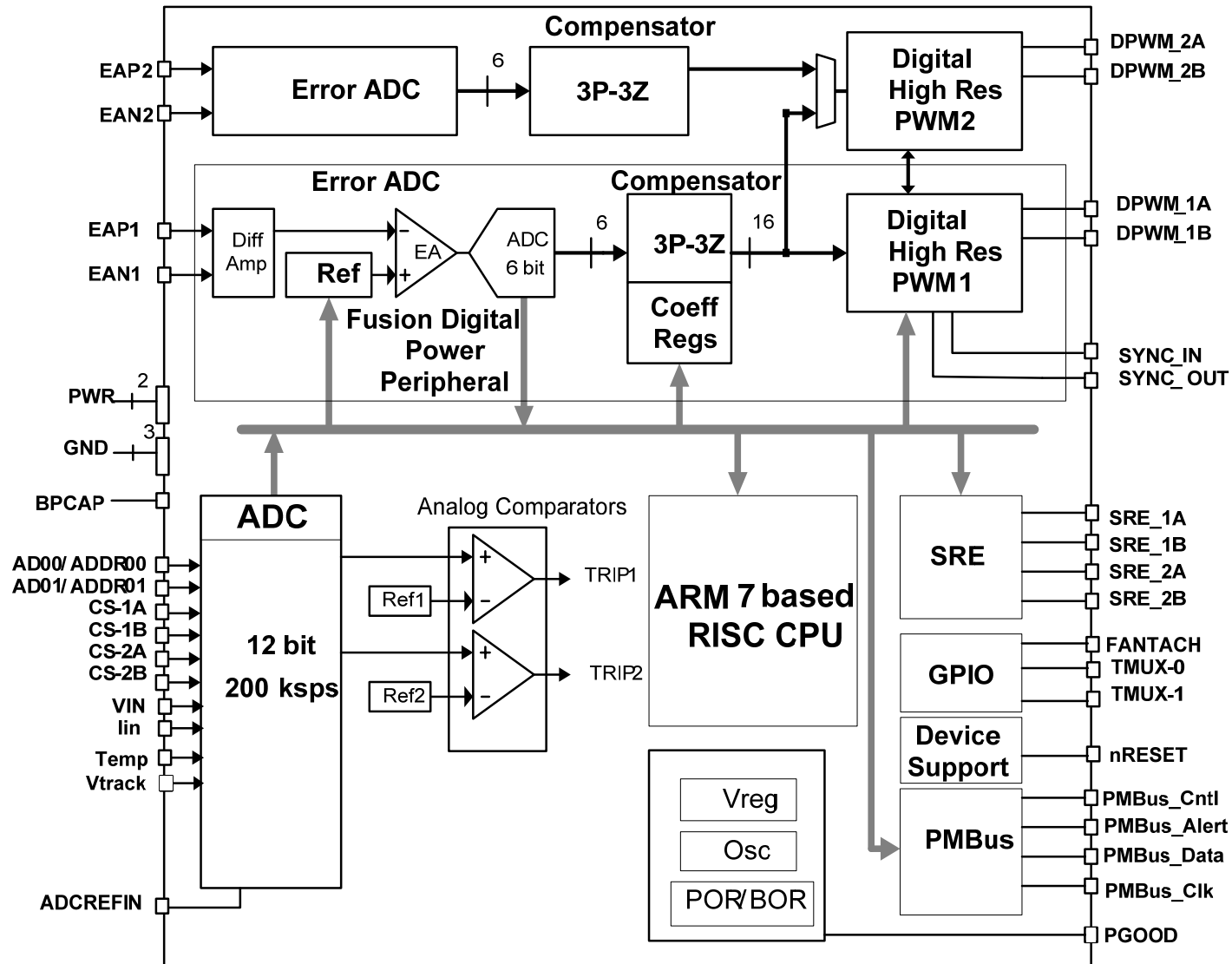
UCD9240 Controller Overview

- Fusion Power Peripheral
 - Analog front end (AFE)
 - Compensator (Control Law Algorithm, CLA)
 - Digital pulse width modulator (DPWM)





UCD9220 Digital Controller



Digital Power Conversion

Designing POL Using Digital
Controllers

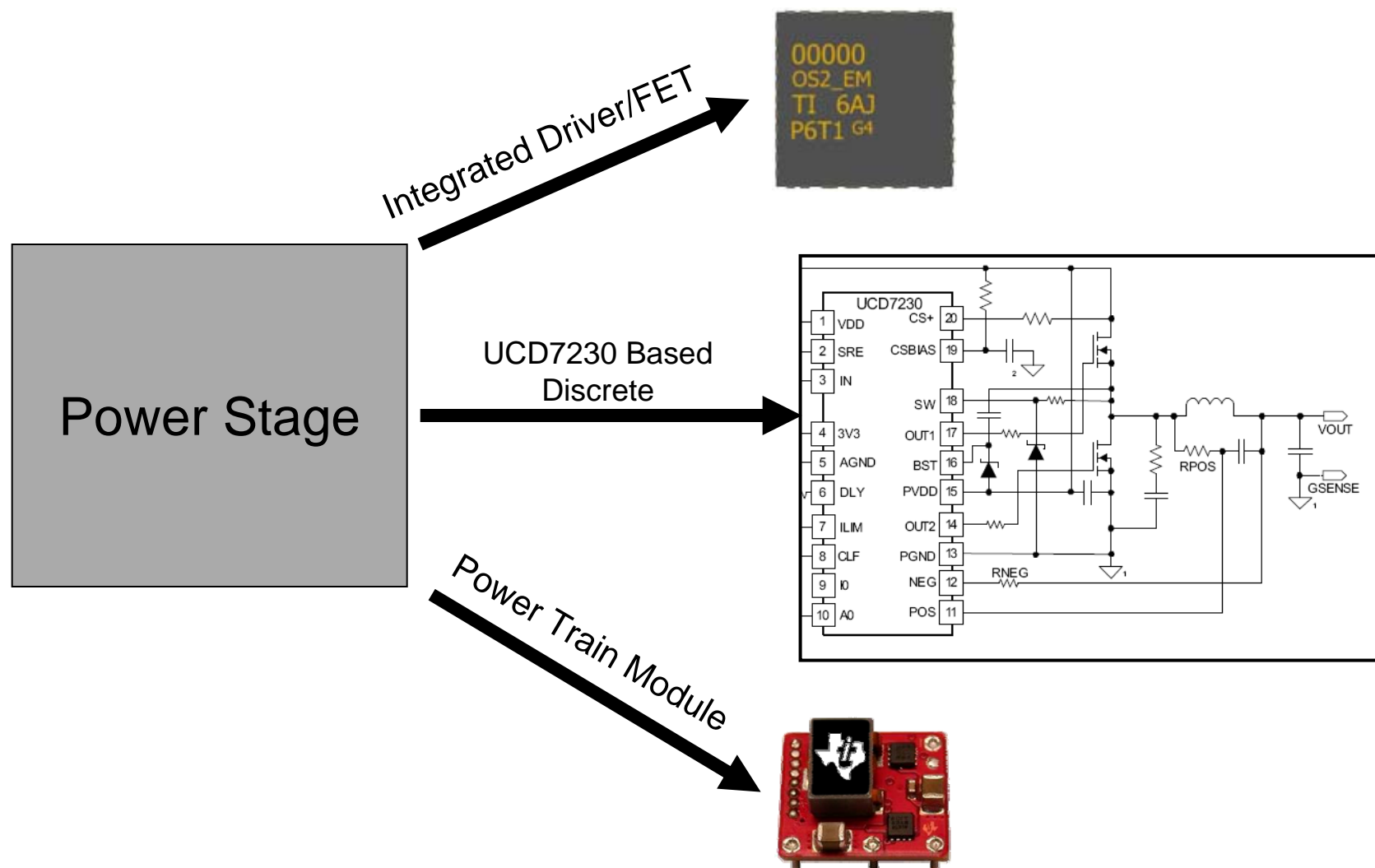


Using Digital Controllers

- Power stage
 - Standard analog plus digital “features”
- Controller
 - Terminating the pins
- Programming
 - Fusion GUI

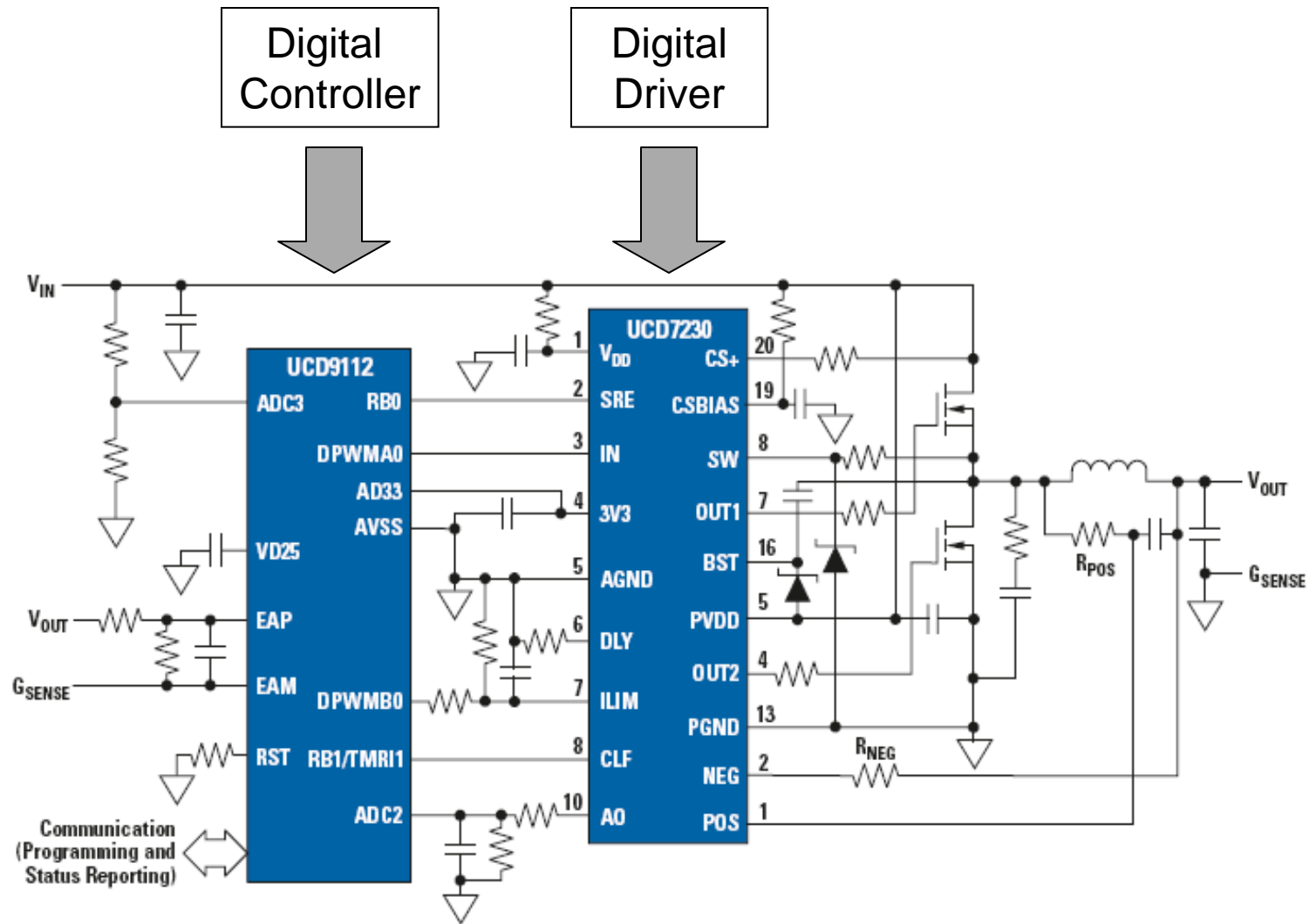


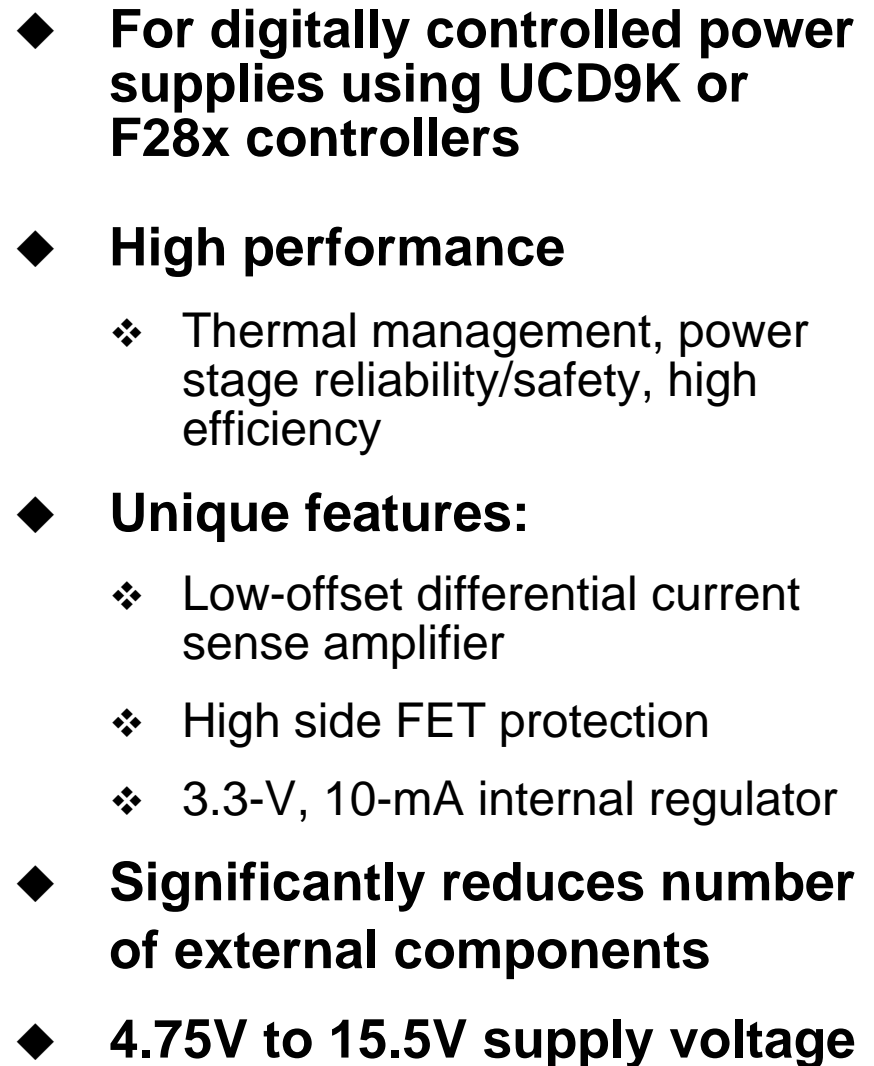
Power Stage Options





UCD7230 Implementation







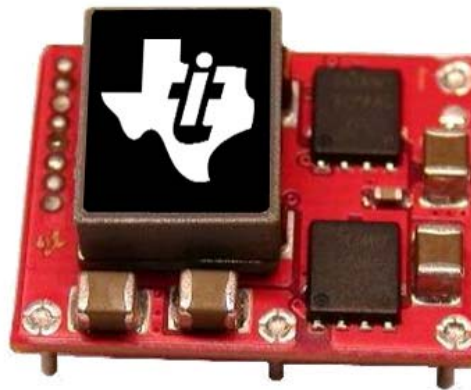
Digital PowerTrain Modules

Driver

◆ Digital Configurability

- Output Voltage
- Current limit
- Frequency
- UVLO
- Over-temp
- Monitoring of V_{in} , V_{out} , I_{out} , Temperature

Inductor



FET

FET

◆ Convenience of Modules

- Designed and tested 6A, 10A and 20A PowerTrains

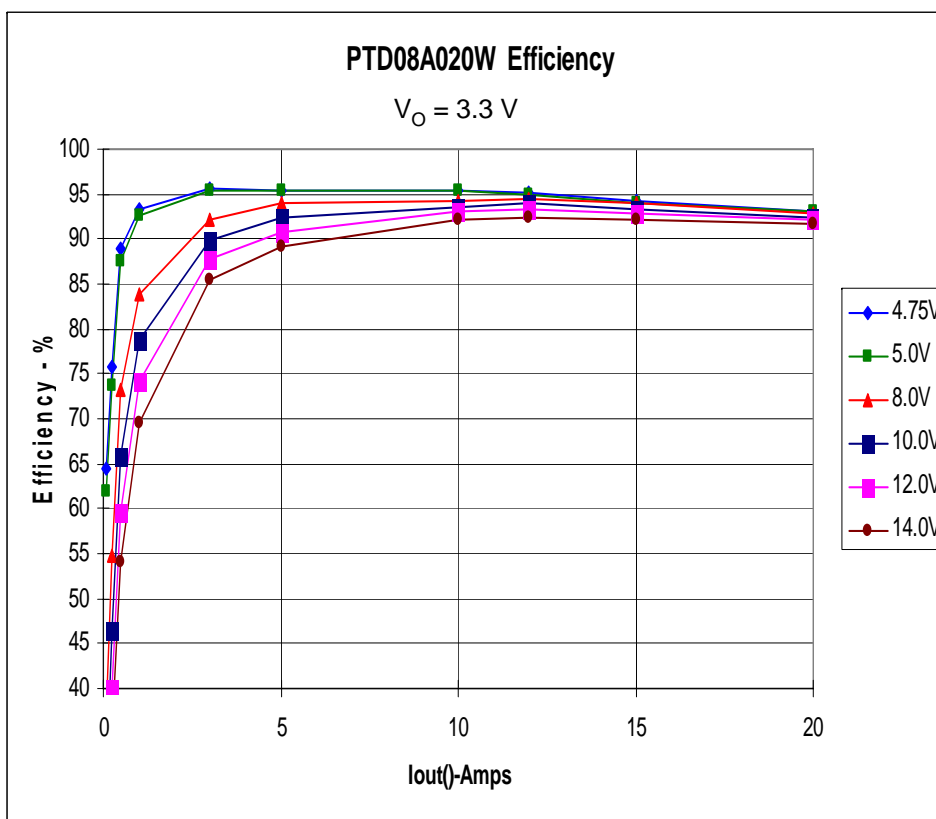
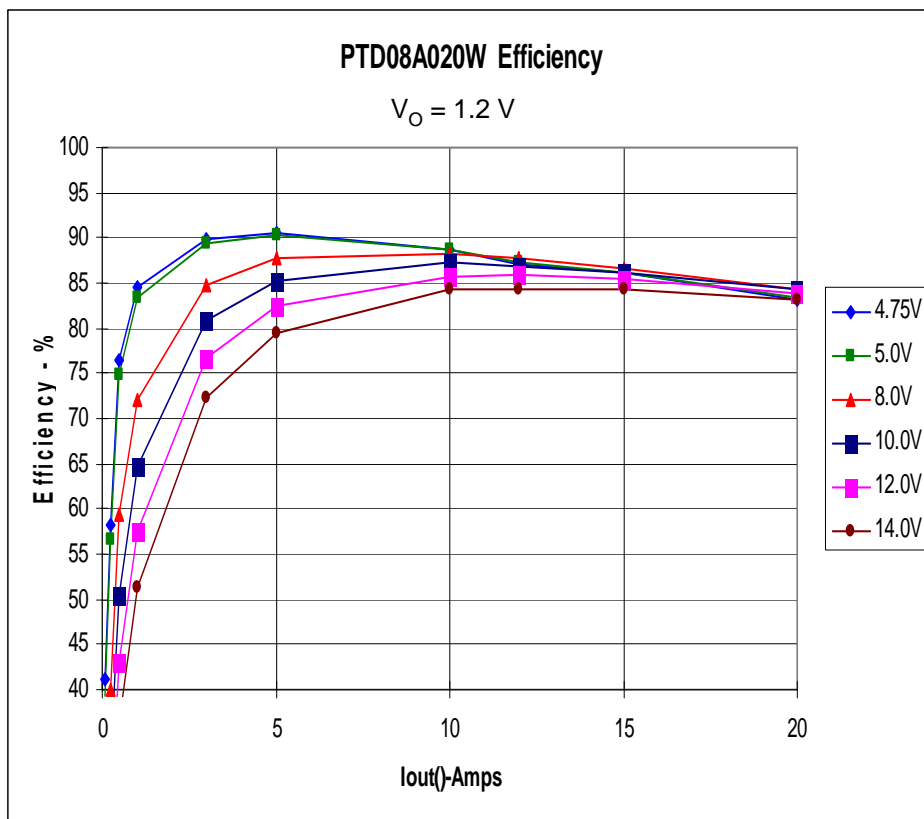
◆ PTD08A0xxW, xx =, 06, 10, 20

Current
Sense

Temp
Sense

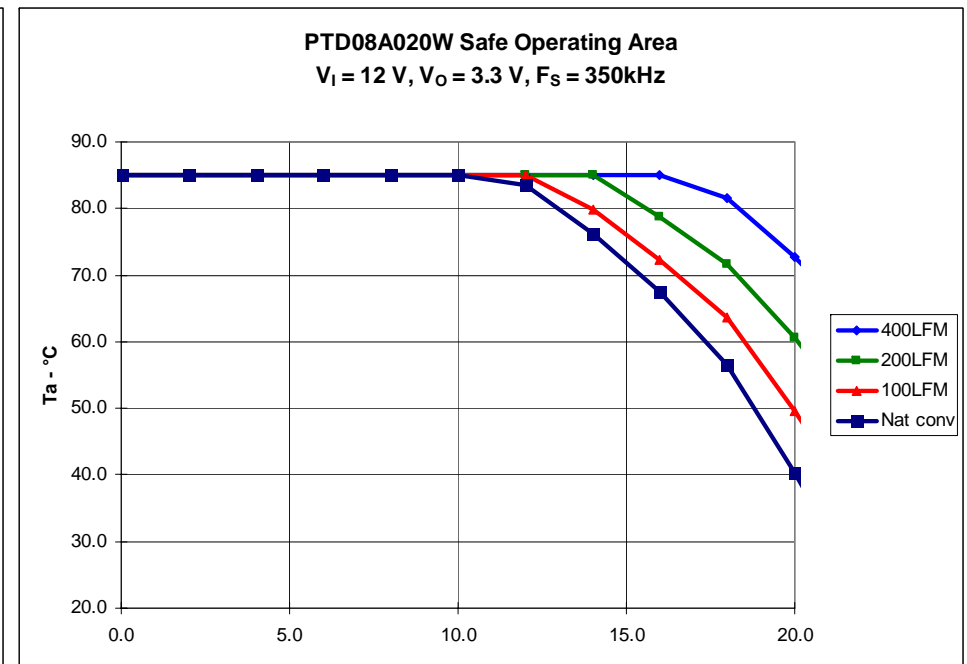
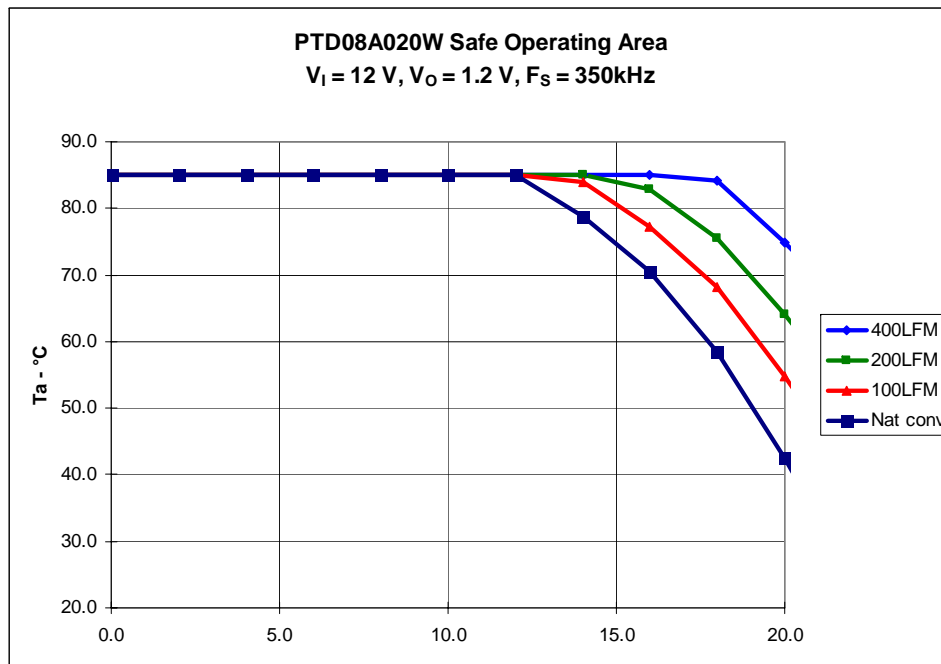


Power Train Efficiency



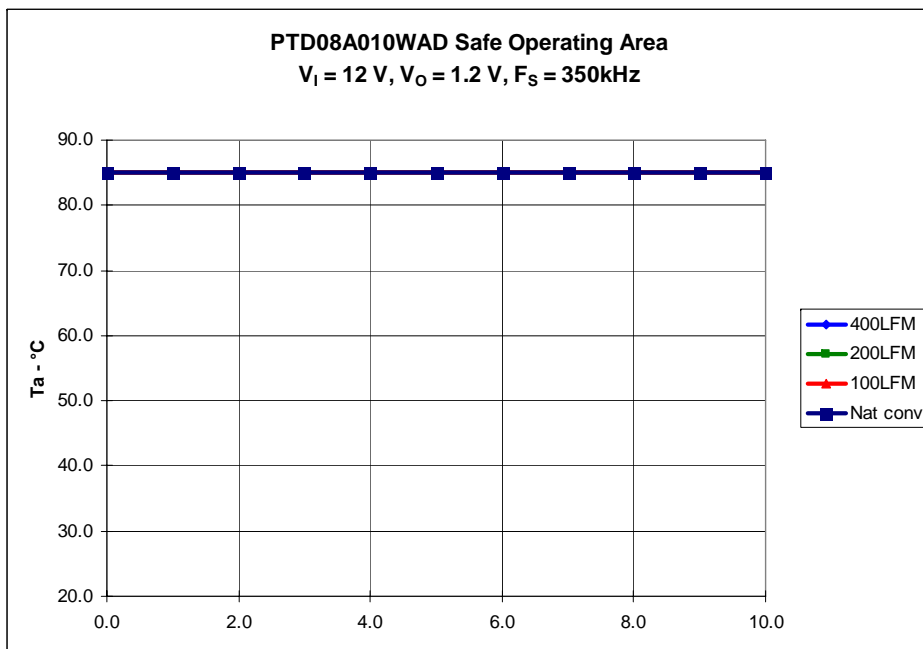
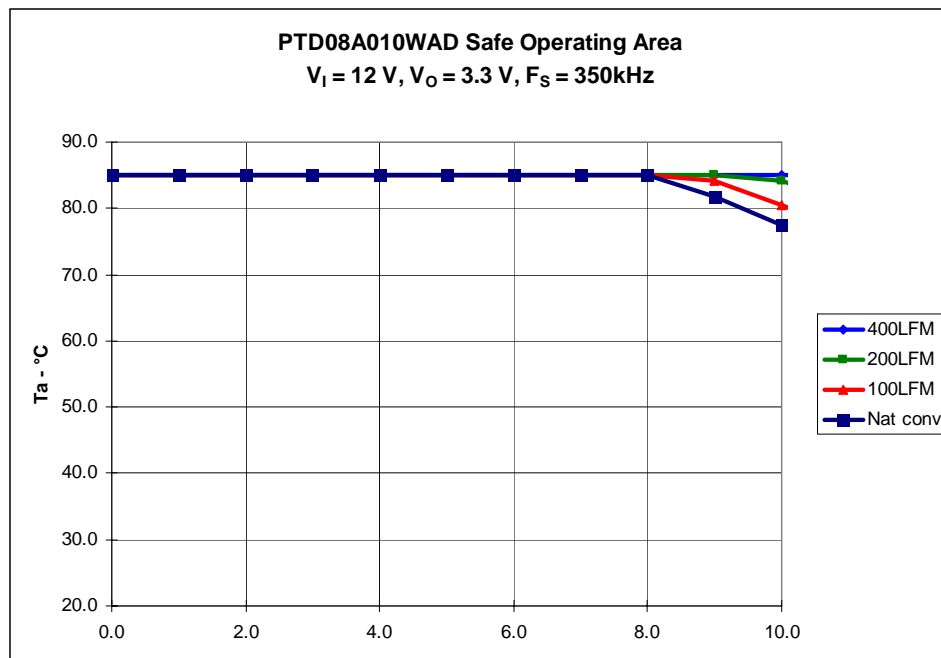


Power Train – Thermal Performance



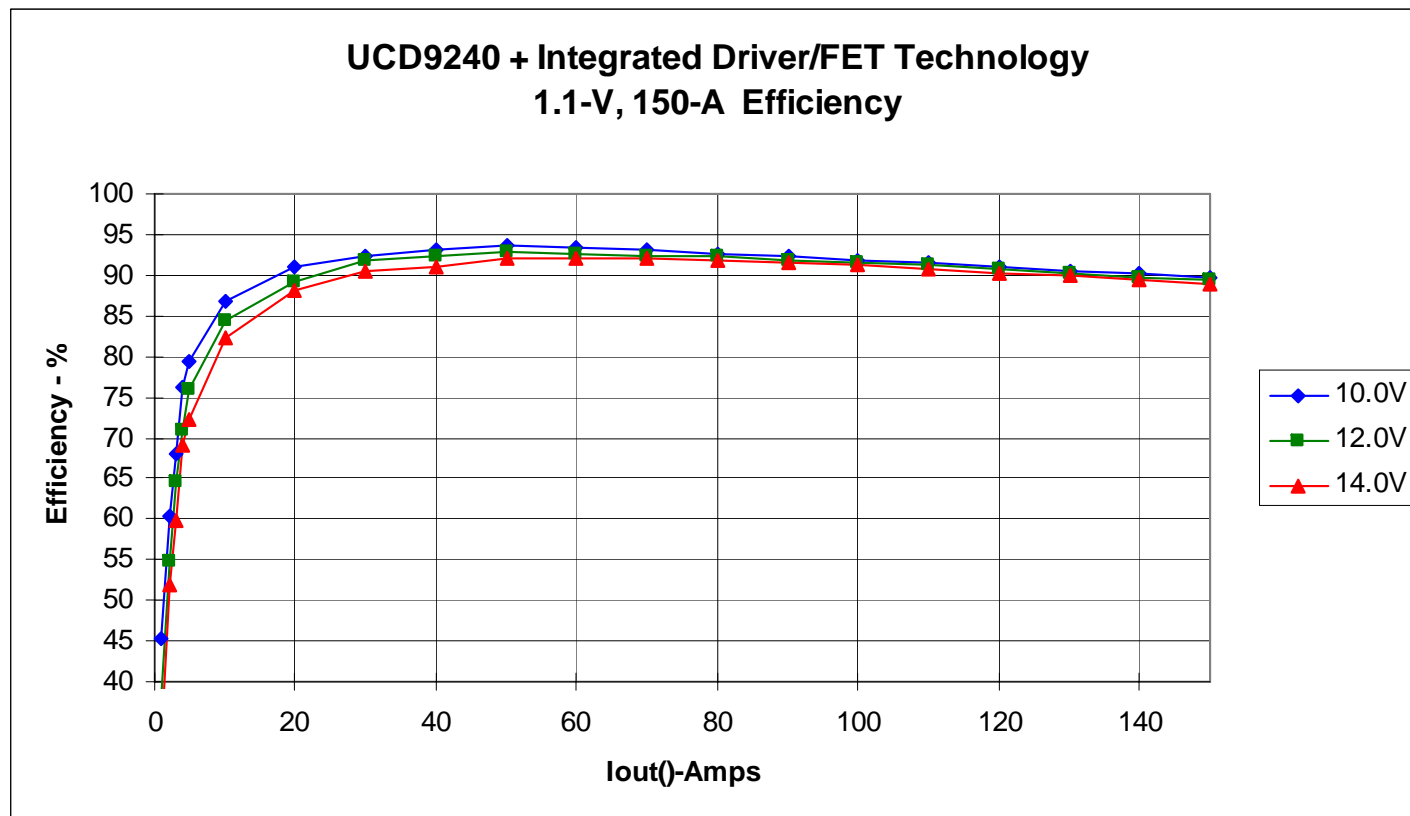


Power Train – Thermal Performance





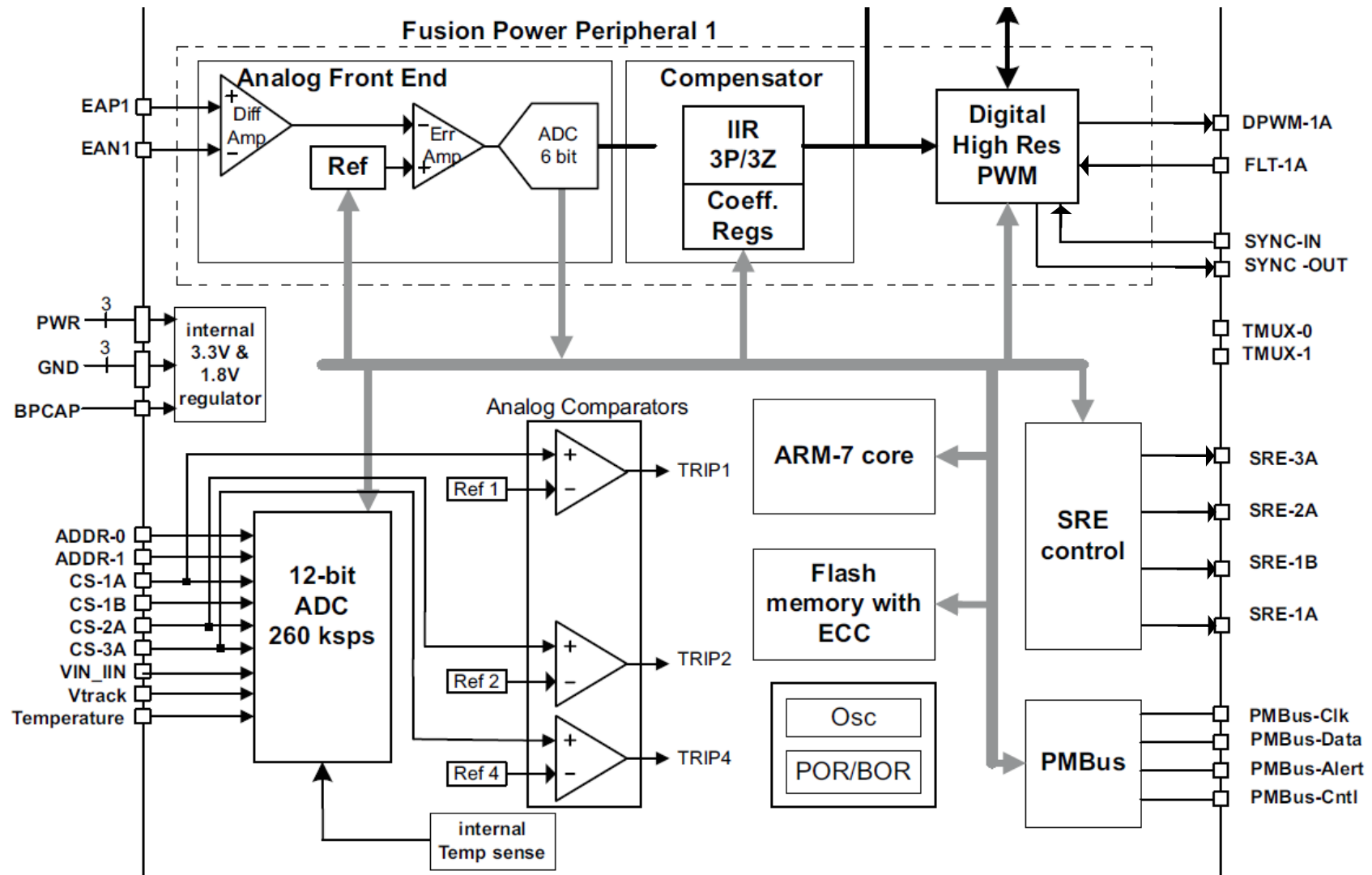
Maximize Efficiency with Integrated Driver/FET



*Plots of various input voltages with output voltage set to 1.1V
Switching frequency at 300kHz, UCD9240 six phase with Renesas DrMos (8V gate drive)*



UCD92xx Controller Overview





Digital Power External Circuits

- Diff amp analog inputs
 - EApn, EAnn: Connect to output voltage
- Analog ADC inputs
 - AddrSens0, AddrSens1: PMBus address select
 - CS-*nA*, CS-*nB*: Current sense, 1.4V typical input. *nA* have analog comparator
 - Vin/lin: Input voltage and current monitoring, TMUX-0 selects
 - VTRACK: Analog tracking voltage
 - Temp: Temperature measurements, TMUX-0, TMUX-1 and TMUX-2 allow 8 temperatures to be measured.



Digital Power External Circuits

- Digital PWM outputs
 - dPWM nA , dPWM nB : PWM signals, nA and nB must drive the same rail,
- External fault Inputs
 - FAULT- nA , FAULT- nB
- Synchronous rectifier enable
 - SRE- nA , SRE- nB : Used to turn off sync rectifiers, e.g. during pre-bias start up.



Digital Power External Circuits

- Miscellaneous digital I/O
 - TMUX-0, -1, -2: Used to select Vin/lin and monitoring temperature
 - RESET: Active low reset input
 - FAN-PWM: Fan control output
 - PowerGood
 - FAN-Tach: Fan speed input
 - Sync_Out, Sync_In: Sync interface to and from dPWM

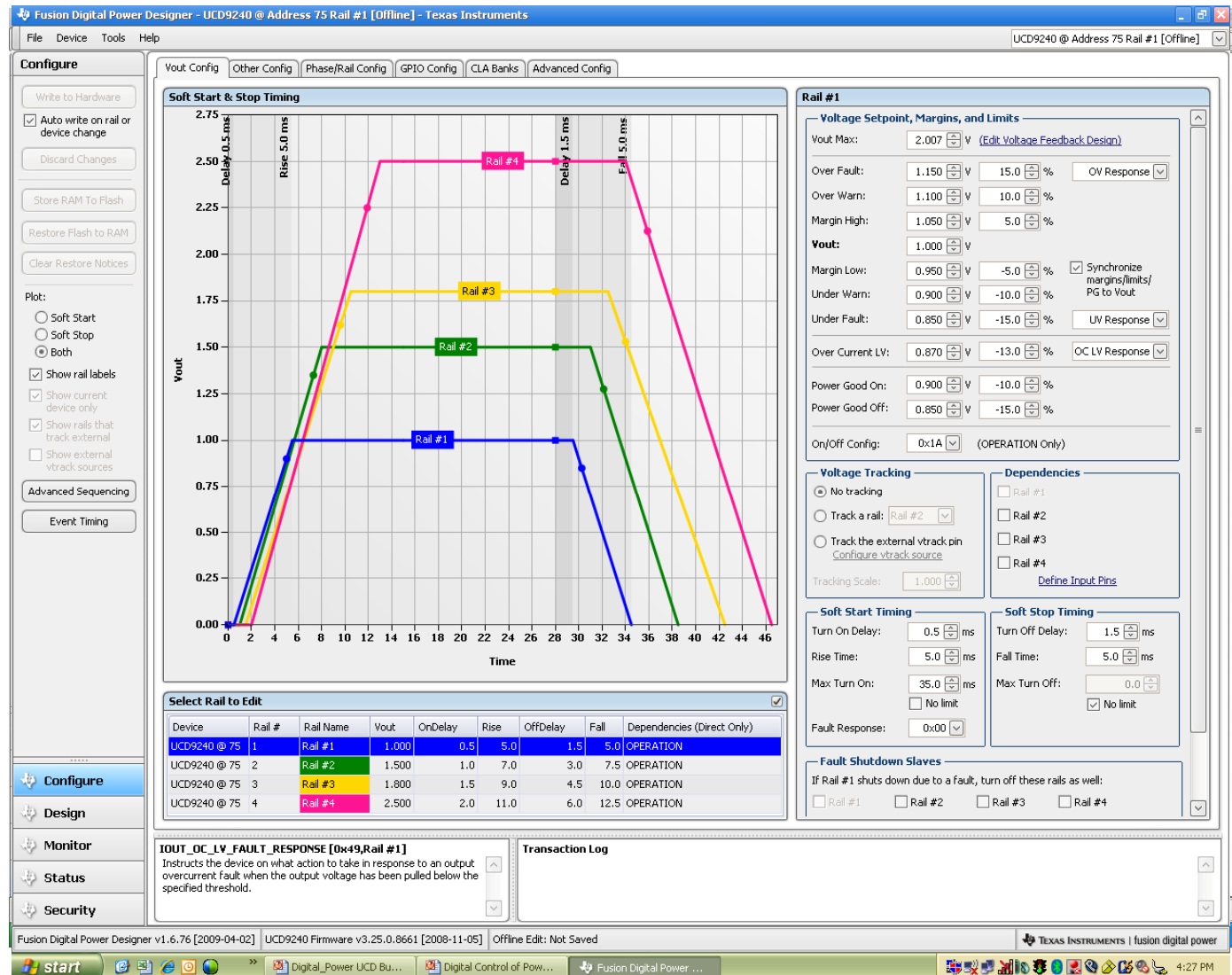
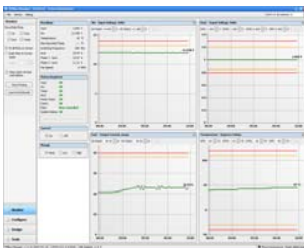
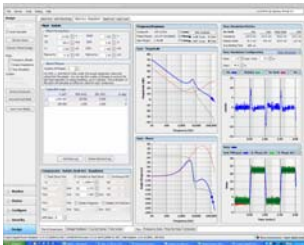
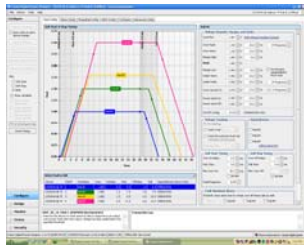


Digital Power External Circuits

- PMBus I/O
 - PMBus_Clk, PMBus_Data, PMBus_Alert, PMBus_Cntrl
- JTAG I/O
 - TRCK, TCK, TDO, TDI, TMS, TRST
- Power I/O
 - V33FB: 3.3V linear control pin
 - V33A, V33D, V33DIO : 3.3V input, Analog, Core and I/O
 - BPCap: 1.8V decoupling
 - AVss, DVss: Ground, Analog and Digital



Power + Designer Graphical User Interface





UCD9240EVM - Four-Output POL Evaluation Board



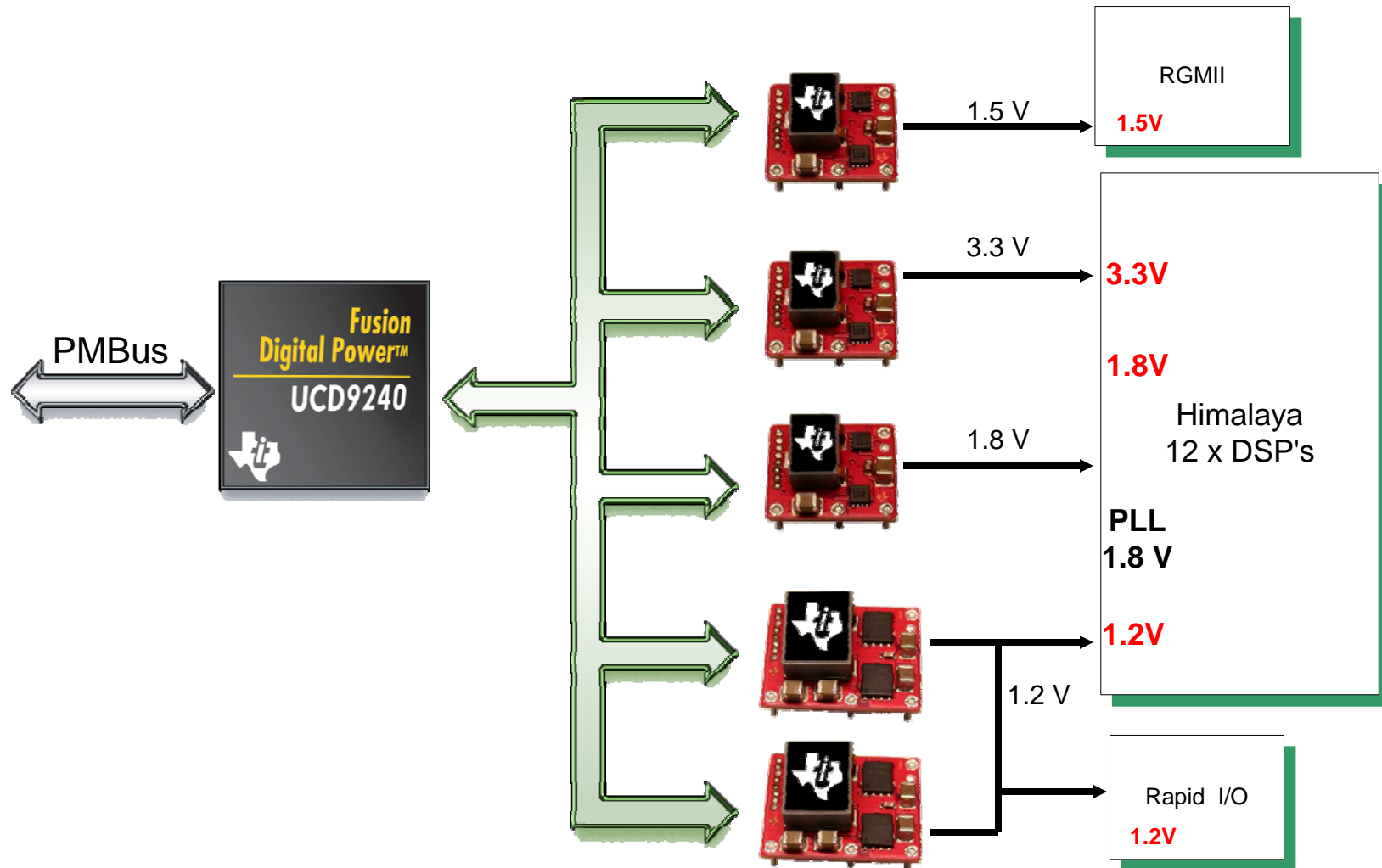
- Digital Control
- Dynamic configuration
- Full feature
 - Margining
 - Soft start/stop
 - Tracking
 - Sequencing
 - Selectable fault response
- GUI Configurable

Digital Power Conversion

UCD9xx Applications



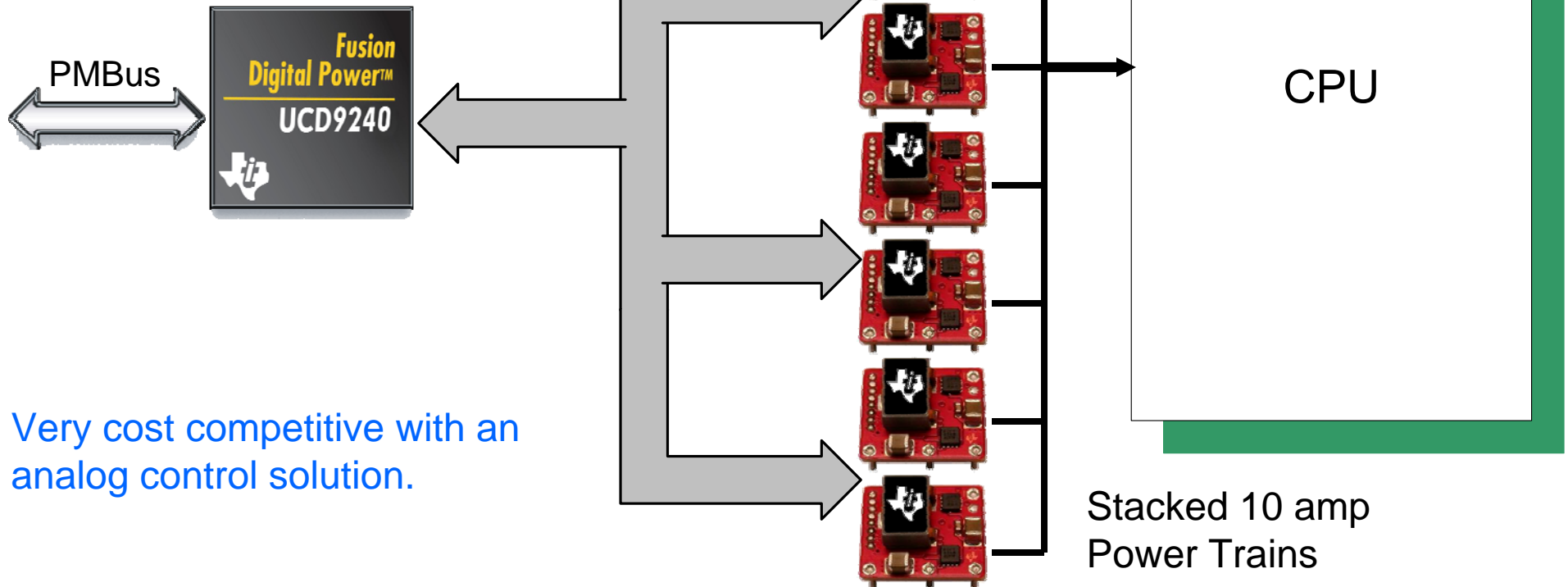
Multi-Processor, Multi-Supply Rail Systems





High Current Application

- A digital control “stacking” alternative to analog solutions TPS40140 and PTH08T250W



Very cost competitive with an analog control solution.



What is “digital” Power Management?

It's all about **monitoring** voltage or current to determine the health of the power system!

PTH or TPS
Analog Based
Control

+

UCD908x
Sequencing &
Monitoring
(+ INAxxx for current)

or

UCD9240
Digital Controller

The UCD9240 solution supports monitoring of both voltage and current. Sequencing capability is also built into the solution. The complementary GUI simplifies the design process and helps improve TTM!



Cost Analysis – Does “Digital” Cost More? UCD9240 Controller -vs- Analog

Got 4 rails? Need to sequence and monitor those rails? Need multi-phase or load sharing operation?

	UCD9240 RGC Digital Controller		Analog Based Controller	
	# of Devices	Estimated Cost	# of Devices	Estimated Cost
Controller	1	\$4.50	4	\$6.40
MOSFET Driver	4	\$2.20	0	\$0.00
Sequencer	0	\$0.00	1	\$2.00
Bias Supply	1	\$0.40	1	\$0.25
Total	6	\$7.10	6	\$8.65

- Estimated cost figures are based on “typical” 1k unit pricing.
- The output current requirement is estimated to be at least 6-A/rail.
- The analog based controller is assumed to have a MOSFET driver built-in.
- Analysis is based on TPS40180 analog solution.
- Power stage cost estimates are not included and are assumed to be identical for both analog and digital.



Fusion Digital Power™ – UCD92xx

Bringing Intelligence to the Point-of-Load

