

# Learn the Different System Design Considerations When Selecting a Low-Voltage PMIC

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SECURE CONNECTIONS  
FOR A SMARTER WORLD

EXTERNAL

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# Agenda

- Introduction to Processors
- Power Management for Micro & Crossover Processors ( $\mu$ PMIC)
- Power Management for i.MX Application Processors
- Power Management Solutions for Complex Processors & Systems
- Summary
- Contacts

# Introduction to Processors

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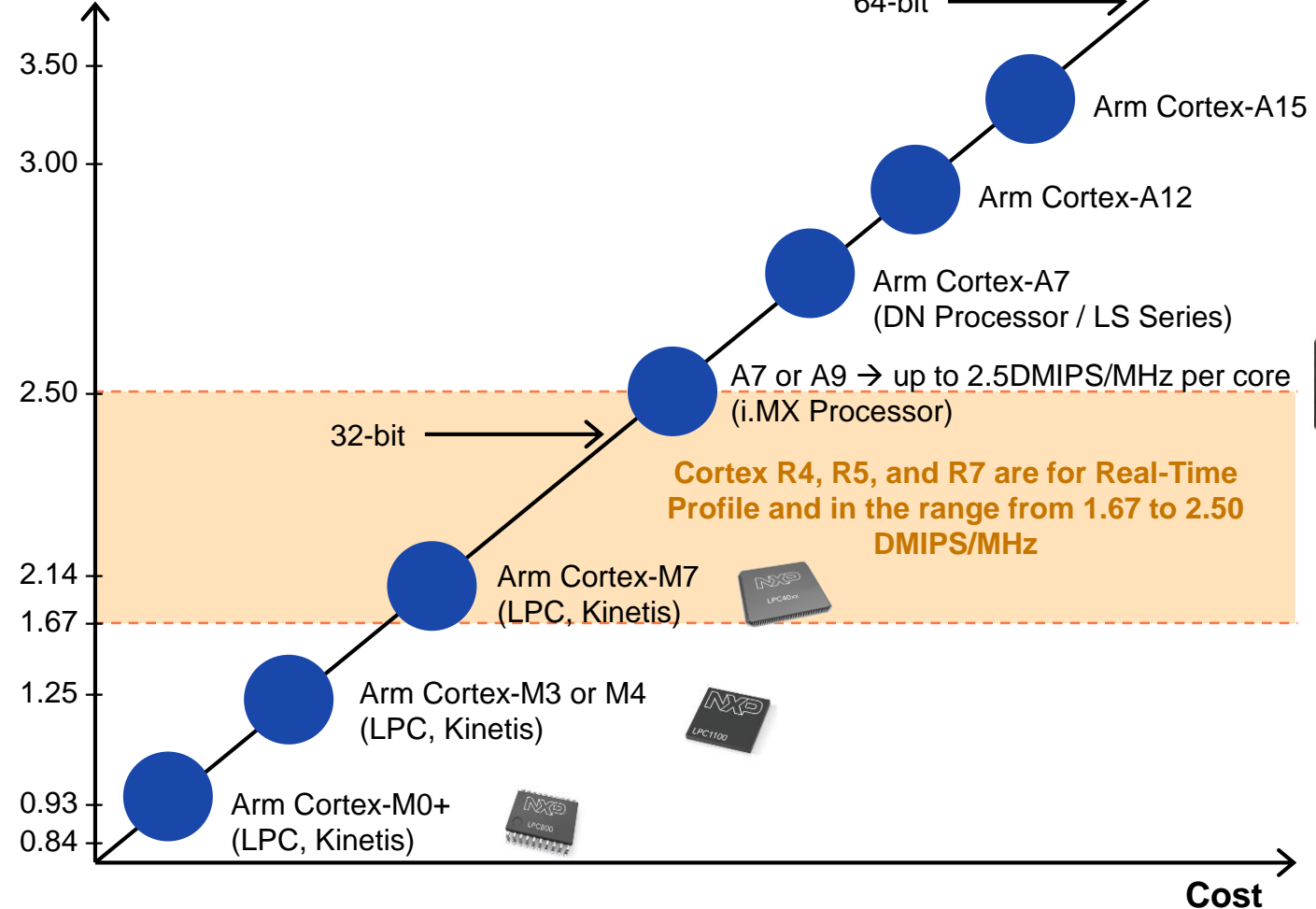
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# OVERVIEW OF DIFFERENT CONTROLLERS & PROCESSORS

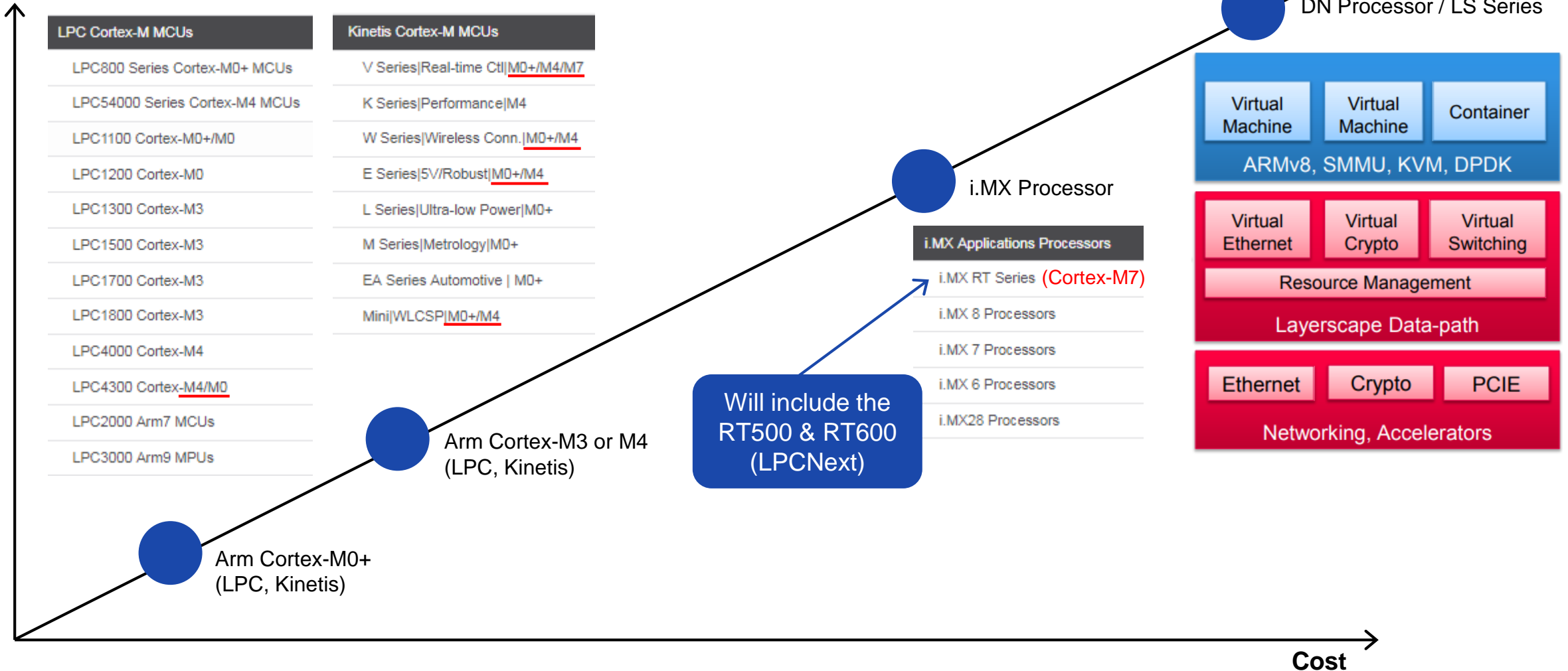
	Microcontroller MCU	Microprocessor MPU	System on Chip (SoC)
Chip count	Single	Supporting chips required	Single
Cost	Low	High	High
Operating System	No	Yes	SoCs can be MCU or MPU-based. A compact OS is more likely if there is an OS
Rapid Boot Up	Yes	No	No
Data/Computing Width	4-, 8-, 16-, 32-bit	16-, 32-, 64-bit	16-, 32-, 64-bit
CPU clock speed	≤ MHz	GHz	MHz - GHz
Memory (RAM, in range of capacity)	Most often in KB or less, sometimes low MB	Usually 512 MB – several GB	MB – GB
External Storage (Typical)	KB to MB (e.g., Flash, EEPROM)	MB up to TB (e.g., SSD, Flash, HDD)	MB up to TB (e.g., SSD, Flash, HDD)
USB	Sometimes	Yes	Depends on Application
Complex Interfaces: Gigabit Ethernet, Multiple simultaneous Ethernet, High-Speed USB 2.0 and higher	No	Yes	Yes
Time-critical/deterministic applications	Yes	No	Depends on Application
Power Consumption	Low – needs only one voltage lower rail	High – needs several voltage power rails	Depends on Application
Applications	Controls a specialized, often pre-defined task	Intensive computing	Application-specific; can include intensive computing
Image Processing	No	No	Depends
Display-ready	Rarely	Often	Depends
Rich user interface	No	Capable	Application-specific
Physical size of the board/system	Small	Large	Small
Application Examples	Programmable thermostat, household appliances	Desktop or Laptop	Smartphones, tablets, specific applications
Product Examples	Microchip Technology PIC, Atmel MCUs, 8051	x86, Raspberry Pi board, Beaglebone Black board	Cypress PSoC, Qualcomm Snapdragon

Performance (DMIPS/MHz)



# OVERVIEW OF DIFFERENT NXP CONTROLLERS & PROCESSORS

Performance



# Power Management for Micro & Crossover Processors ( $\mu$ PMIC)

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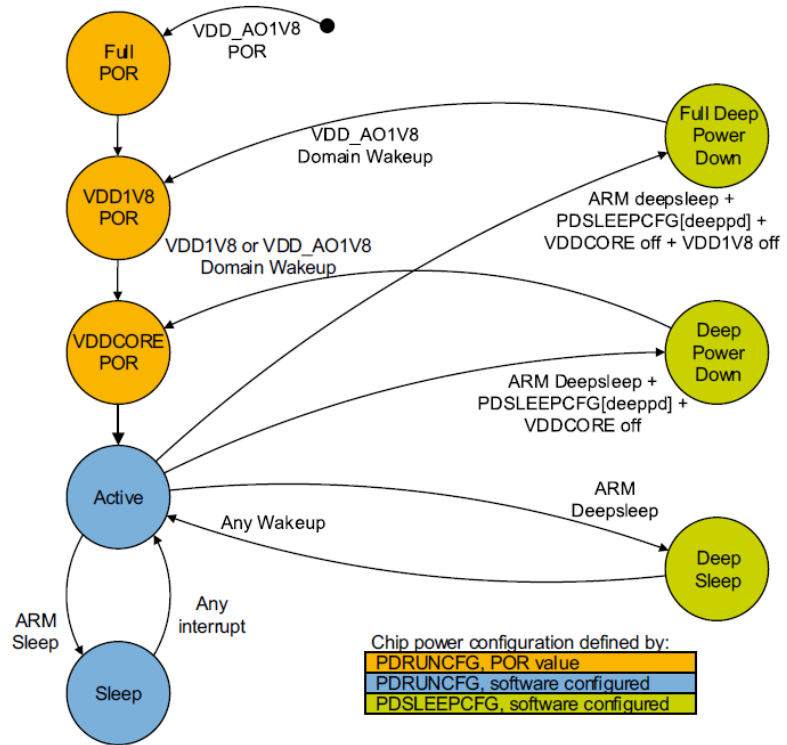
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# POWER MANAGEMENT REQUIREMENTS FOR i.MX RT600/500 FAMILY



## Power Interface

- Always-on supply
- VDDIO (1.8 V or 3.3 V)
- VDDCORE (0.7 V – 1.1 V)
- VDD1V8 (1.8 V)

## Power Mode Control

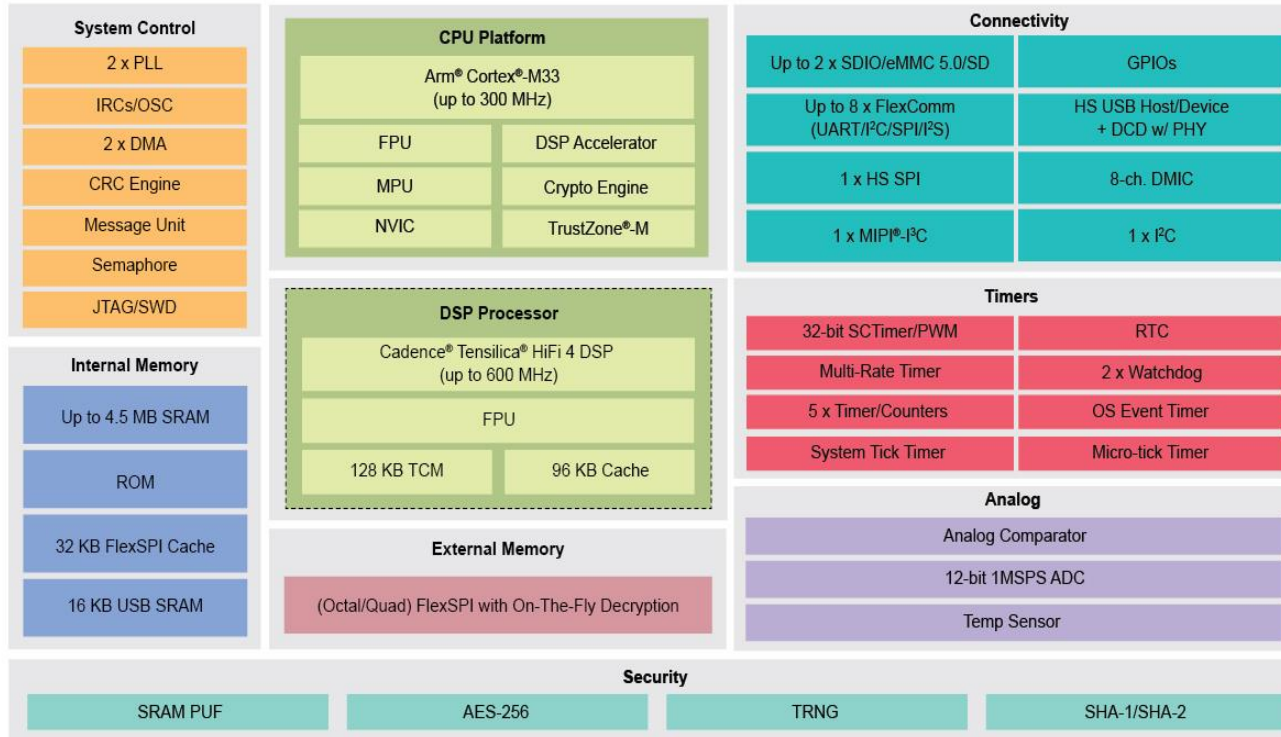
- Active Mode
- Sleep Mode
- Deep Sleep Mode
- Deep Power Down
- Full Power Down

## PMIC Control

- LDO Enable
- PMIC\_MODE0 / PMIC\_MODE1
- RESETN
- PMIC\_IRQN
- PMIC\_SCL / PMIC\_SDA

# POWER MANAGEMENT REQUIREMENTS FOR i.MX RT600/500 FAMILY

## i.MX RT600 Family | Block Diagram



Available on certain product families

## Target Applications

- Audio Equipment
- Voice Assisted Products
- Headphones
- Smart Speakers
- Game Controllers

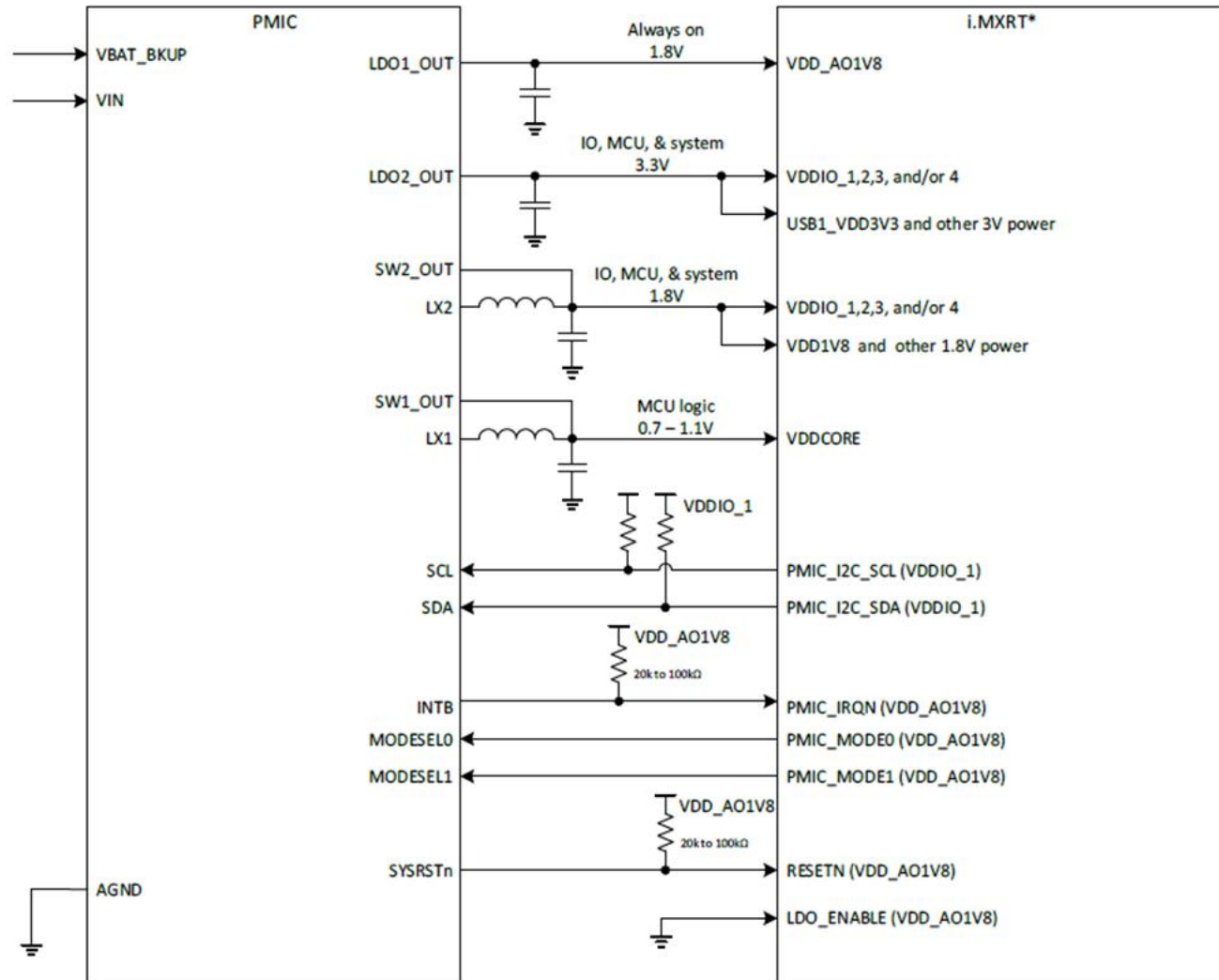


# POWER MANAGEMENT IC (PMIC) SUITABLE FOR RT600/500 FAMILY

## Power-Up Sequence

### Mode Setting

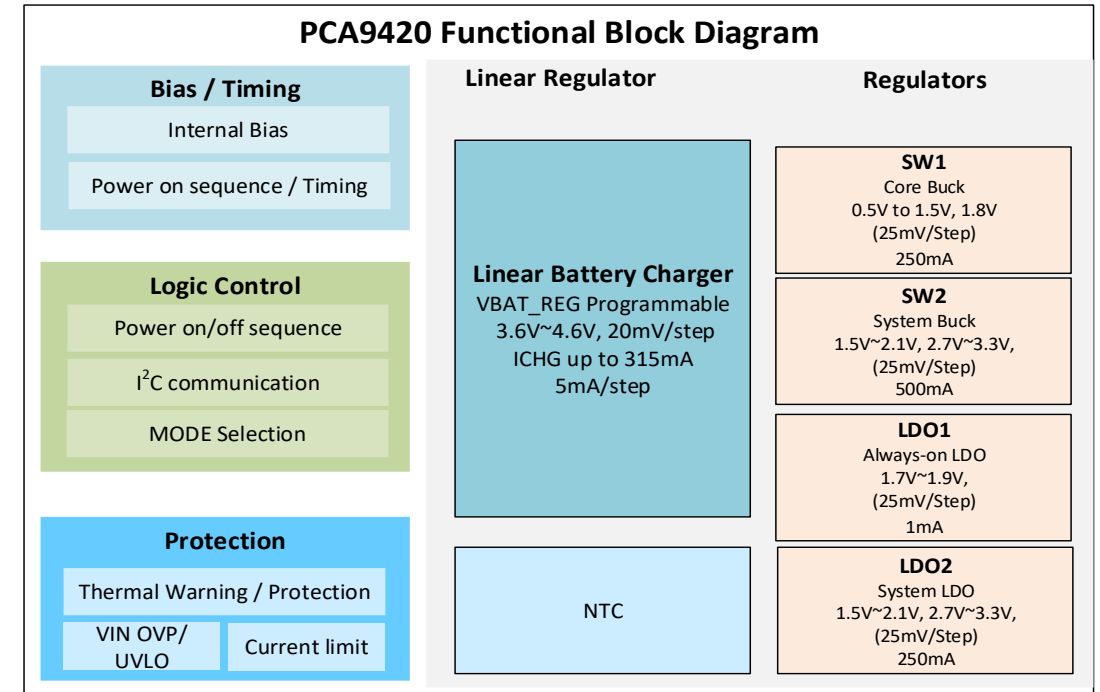
- Mode 0 – Run Mode
- Mode 1 – Deep Sleep Mode
- Mode 2 – Deep Power Down
- Mode 3 – Full Power Down



# PCA9420: PMIC FOR LOW POWER APPLICATIONS

## Ultra-Compact Low $I_Q$ PMIC for Low Power Application

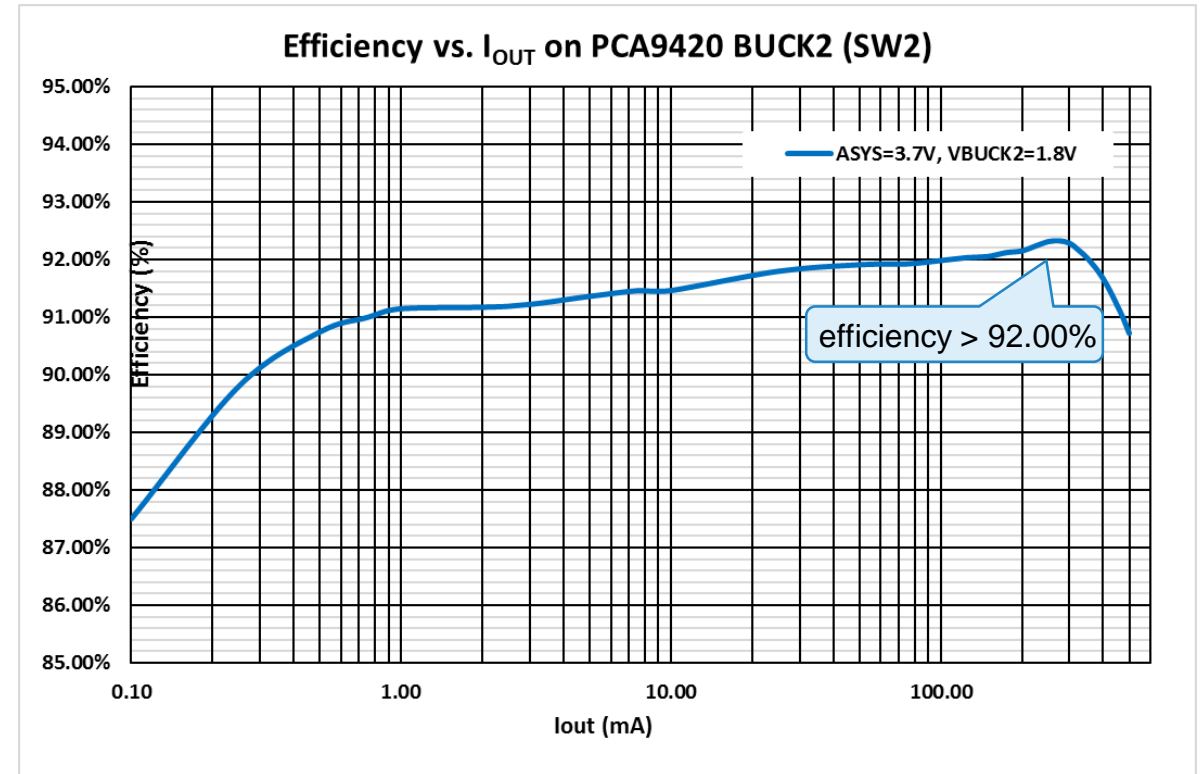
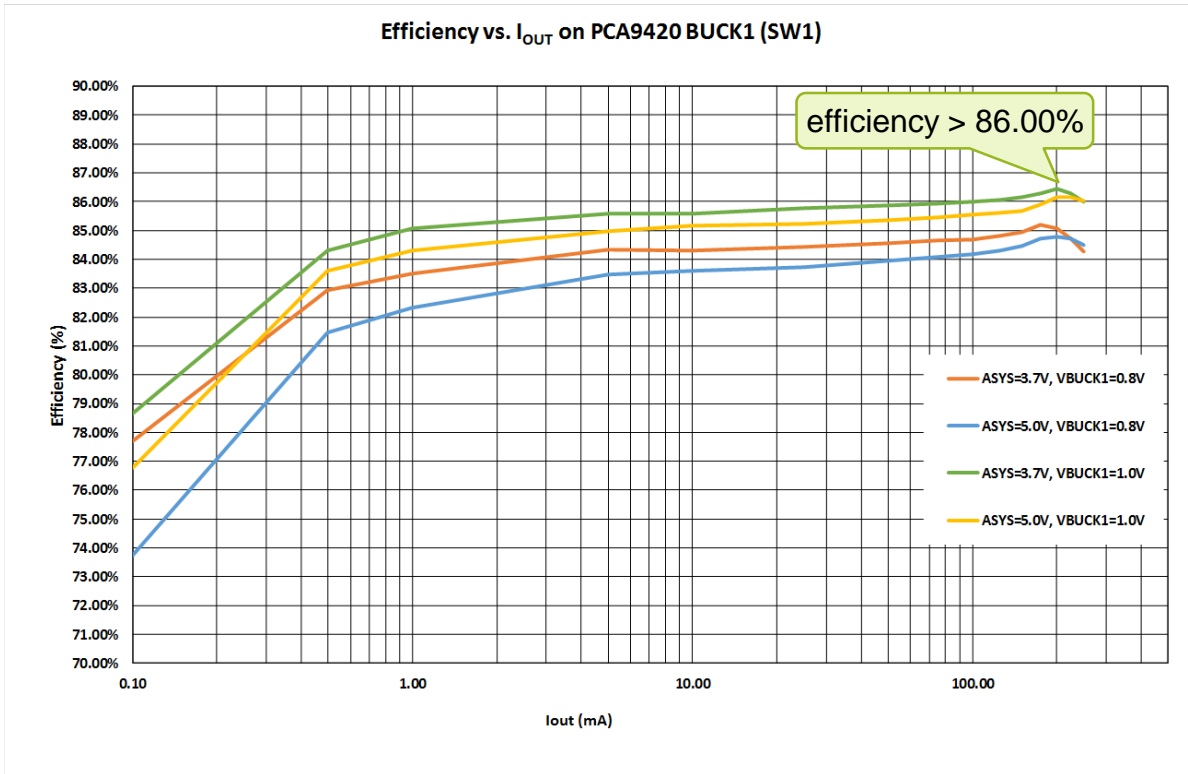
- Very low  $I_Q$ , high light load efficiency, longer system standby time
  - Very Low Quiescent Current in Ship mode (< 150 nA)
- Highly integrated solution, flexible programmability, small solution size
  - 1x Linear Battery Charger (up to 315 mA)
  - 2x Buck Regulators (500 mA, 250 mA)
  - 2x LDO (250 mA, 1 mA)
  - Built-in “Mode” Configuration to Accommodate Fast Mode Switch Supporting Different MCU Operation Modes
  - 20 V DC Tolerance on Vin Pin with Programmable OVP
  - Fm+ 1MHz I<sup>2</sup>C Interface
  - Package:
    - WLCSP 25-bump, 2.09 mm x 2.09 mm, 0.4 mm pitch
    - QFN 24-pin 3 mm x 3 mm



## Target Applications

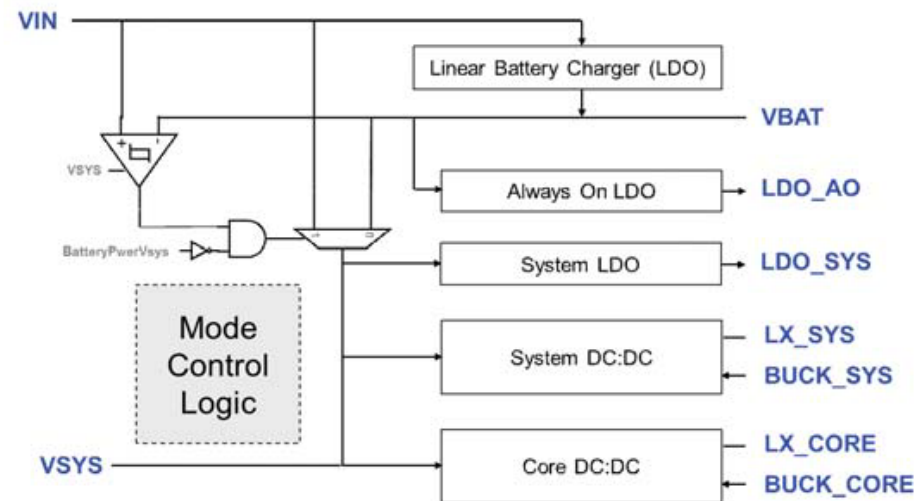
- Wearable devices – Watches, bands, accessories, etc.
- Hearable devices – earbuds, headsets, etc.
- Other low-power applications powered by Li-ion battery

# BUCK1 (CORE BUCK) & BUCK2 (SYS BUCK) EFFICIENCY VERSUS LOAD CURRENT



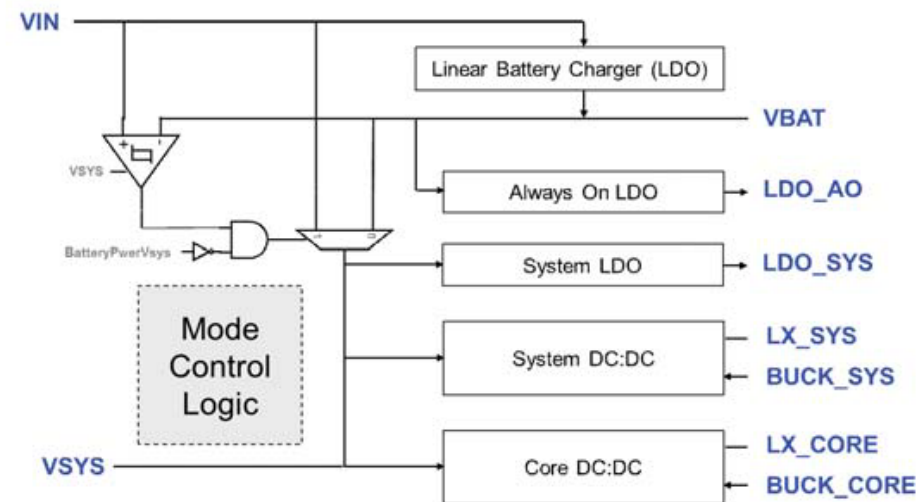
## PCA9420: FUNCTIONAL BLOCK SUMMARY

	Linear Battery Charger	SW1	SW2	LDO1	LDO2
$V_{OUT}$ Range	3.6 V ~ 4.6 V (CV regulation range) 0.5 % Accuracy @ 25 °C	0.5 V ~ 1.5 V, and 1.8 V	1.5 V~2.1 V 2.7 V-3.3 V	1.7 V~1.9 V	1.5 V~2.1 V 2.7 V-3.3 V
$V_{OUT}$ Adjustable Resolution	20 mV/step	25 mV/step (DVFS)	25 mV/step	25 mV/step	25 mV/step
Output Current Range	Up to 315 mA	Up to 250 mA	Up to 500 mA	Up to 1 mA	Up to 250 mA
Input Voltage DC Rating	Up to 20 V	Built-in	Built-in	Built-in	Built-in



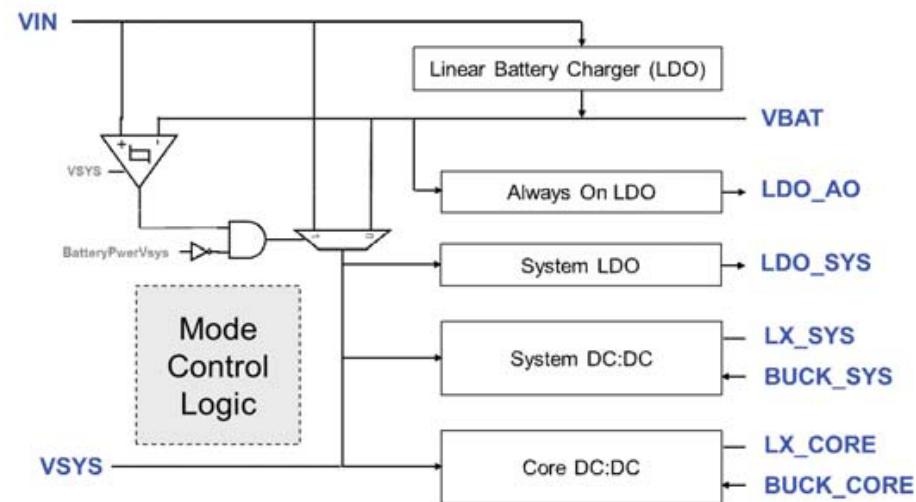
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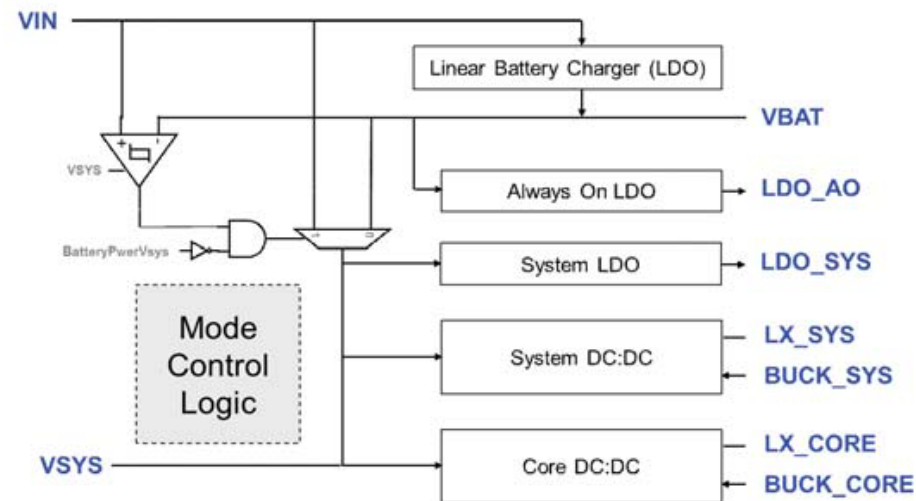
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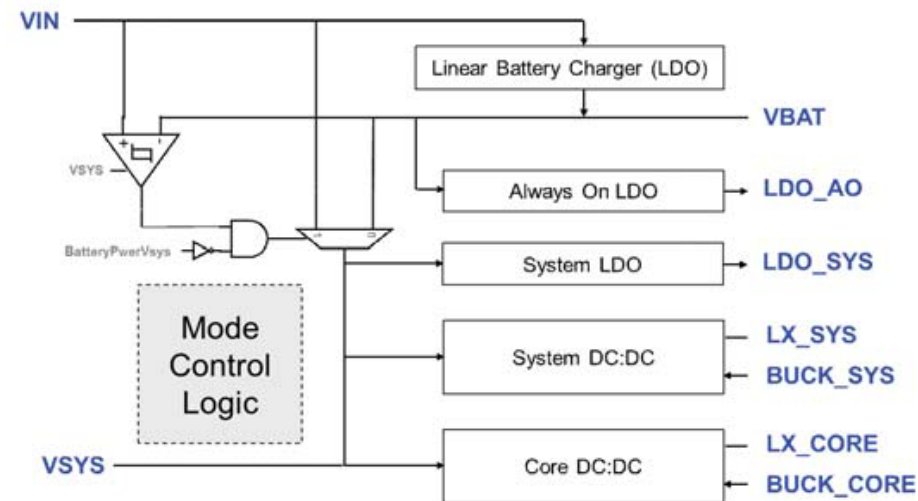
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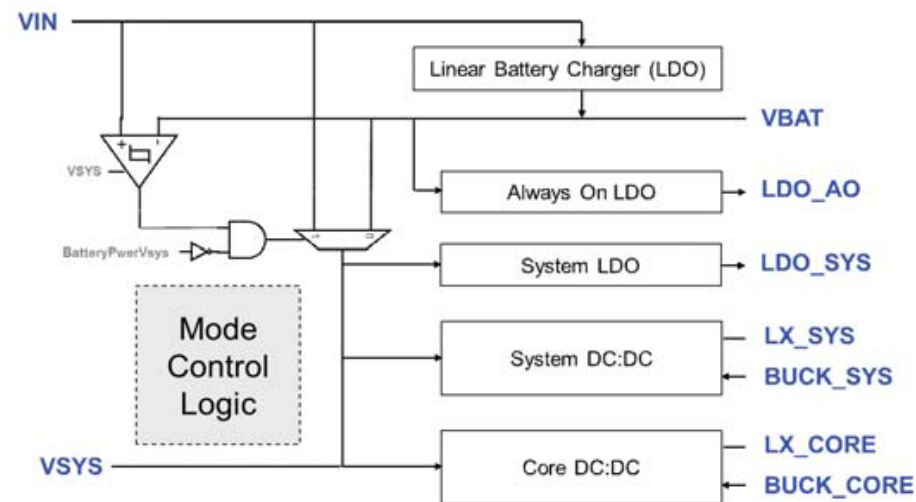
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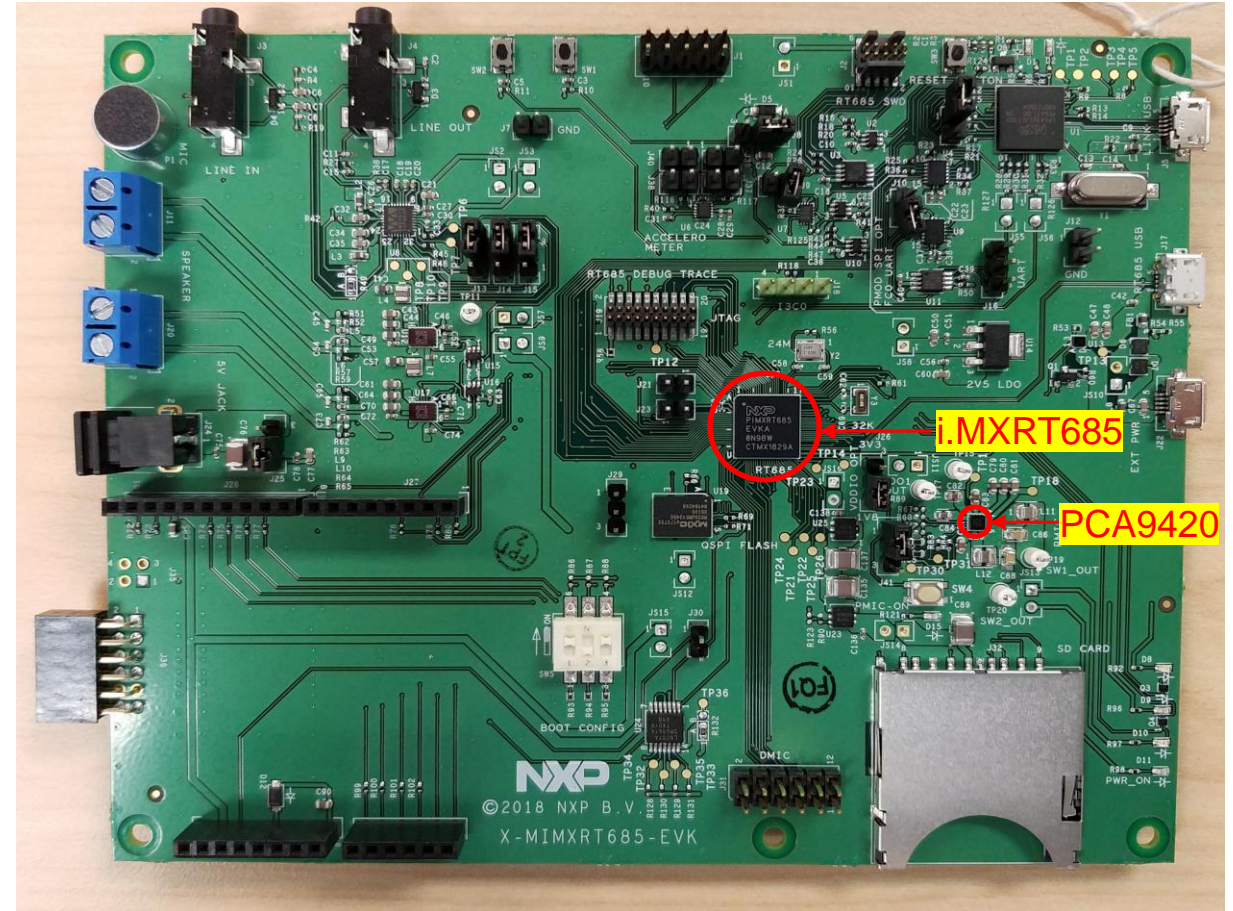
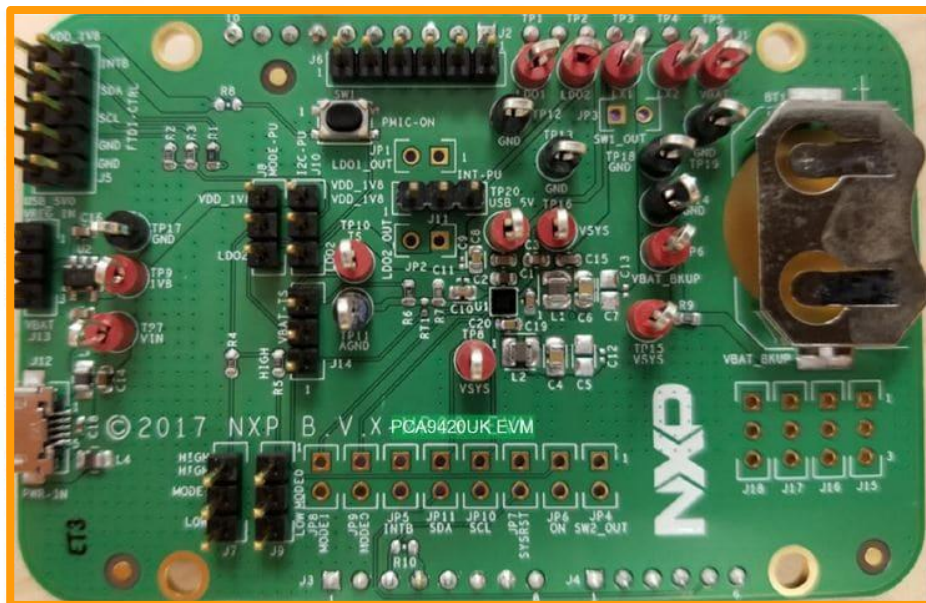
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# TOOLS: i.MXRT685 EVALUATION KIT & EVALUATION BOARD

## Resources

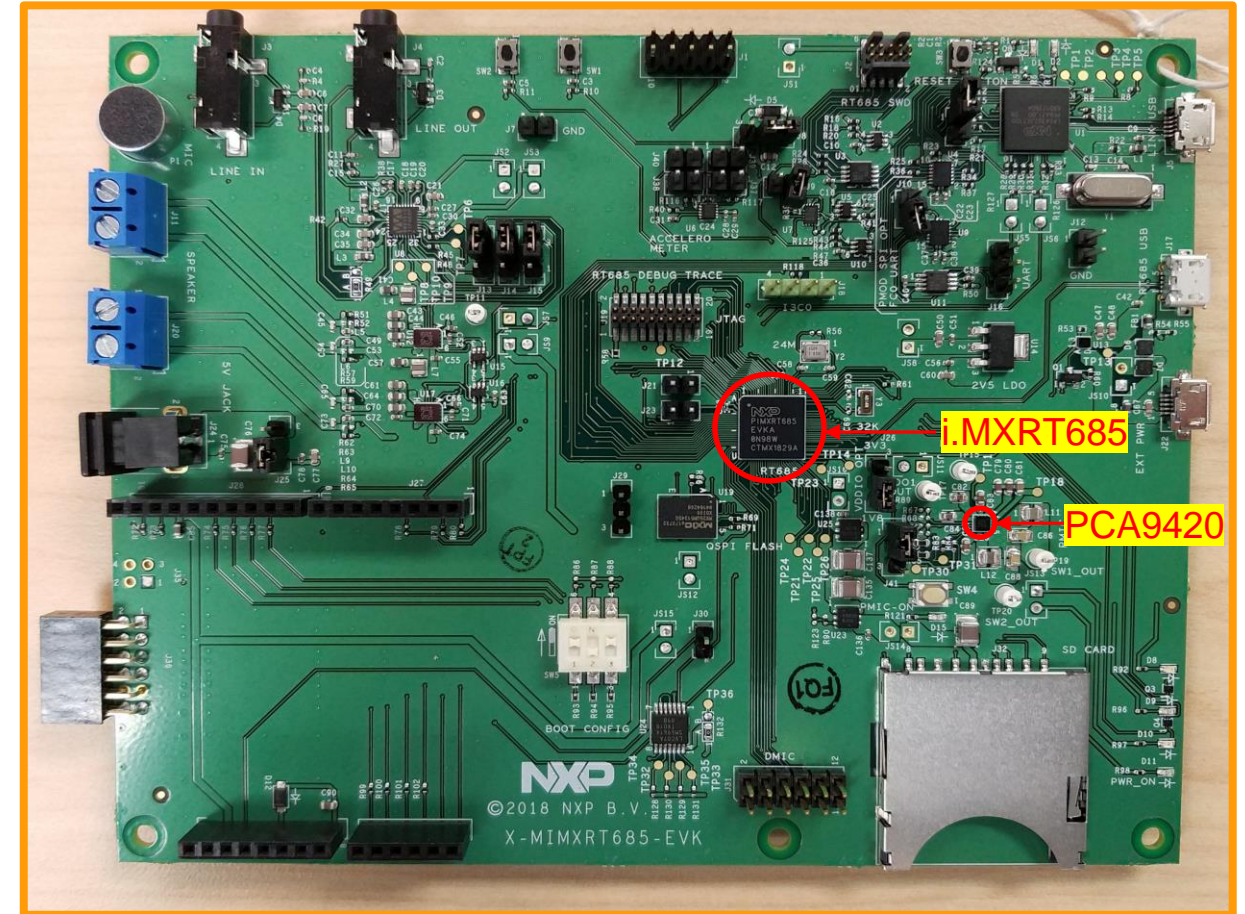
- [UM11216](#): PCA9420UK-EVM Evaluation Board User Manual
- PCA9420 GUI → Click [Here](#) to Download
- PCA9420UK-EVM Getting Started → Click [Here](#) for Information



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# Power Management for i.MX Application Processors

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# i.MX 8M FAMILY – EXTENDS ACROSS MULTIPLE APPLICATIONS

## i.MX 8M Family

A53

M4/  
M7

General Purpose Edge Processing

- High Performance Computing with up to 4x Cortex-A53 Cores
- Up to 2+ TOPS ML Acceleration
- Cortex-M Co-Processor for HMP
- Video Encode/Decode
- 3D GPU
- Display/Camera
- High Speed Interfaces
- High-End Audio Support
- Hardware Scalability
- Software Scalability
- Industrial and Consumer

Similar 'look and feel' to the popular i.MX 6 series, but with upgraded performance and features



**i.MX 8M Plus**  
8M Plus Quad  
8M Plus QuadLite  
8M Plus Dual  
(...)

First  
Samples

### i.MX 8M

8M Quad  
8M QuadLite  
8M Dual

Now

### i.MX 8M Mini

8M Mini Quad  
8M Mini QuadLite  
8M Mini Dual  
8M Mini DualLite  
8M Mini Solo  
8M Mini SoloLite

Now

### i.MX 8M Nano

8M Nano Quad  
8M Nano QuadLite  
8M Nano Dual  
8M Nano DualLite  
8M Nano Solo  
8M Nano SoloLite  
8M Nano QuadUltraLite\*  
8M Nano DualUltraLite\*  
8M Nano SoloUltraLite\*  
(\*11x11 package, sampling 4Q2020)

Now

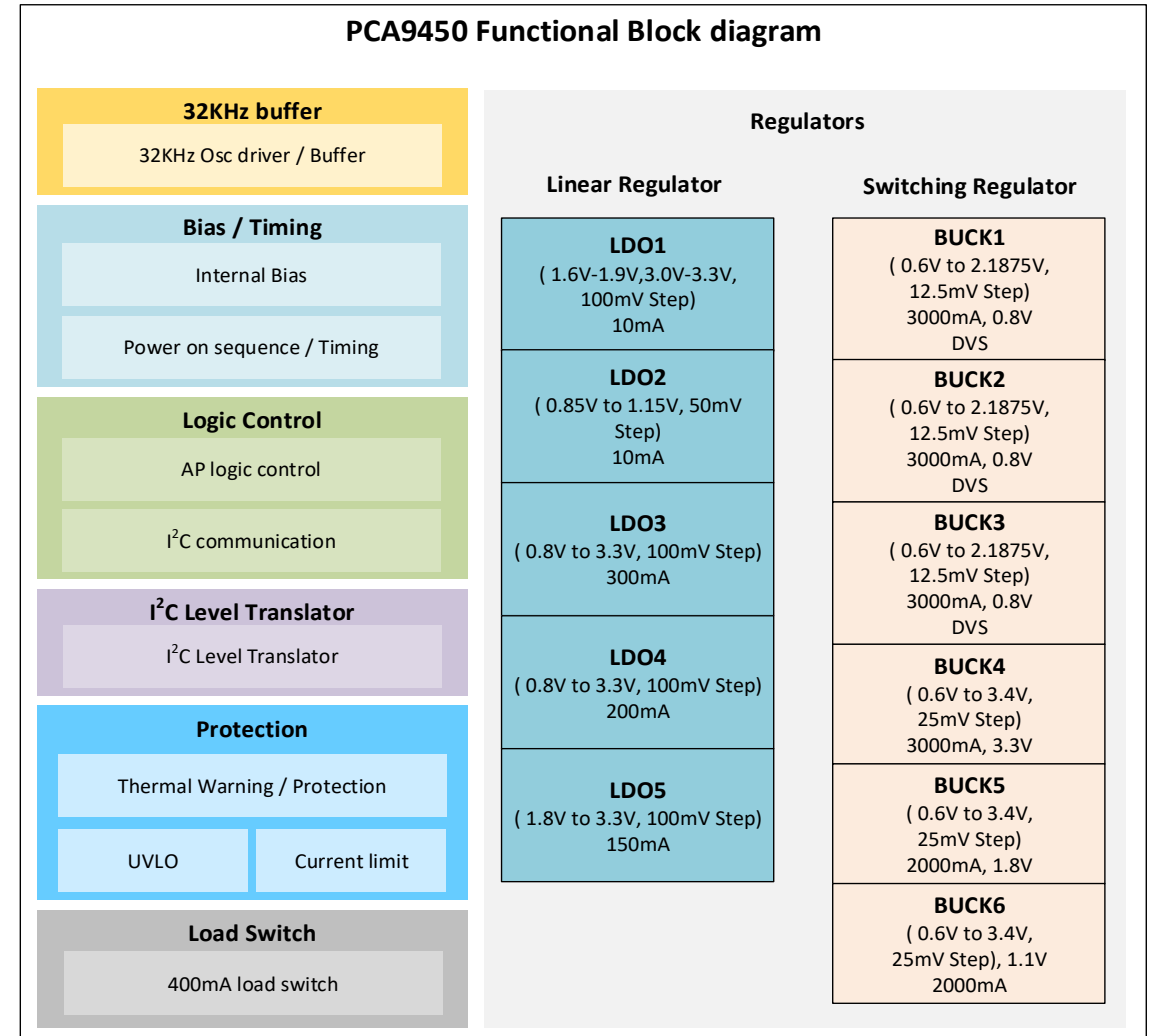
Pin-to-pin Compatible

Software Compatible



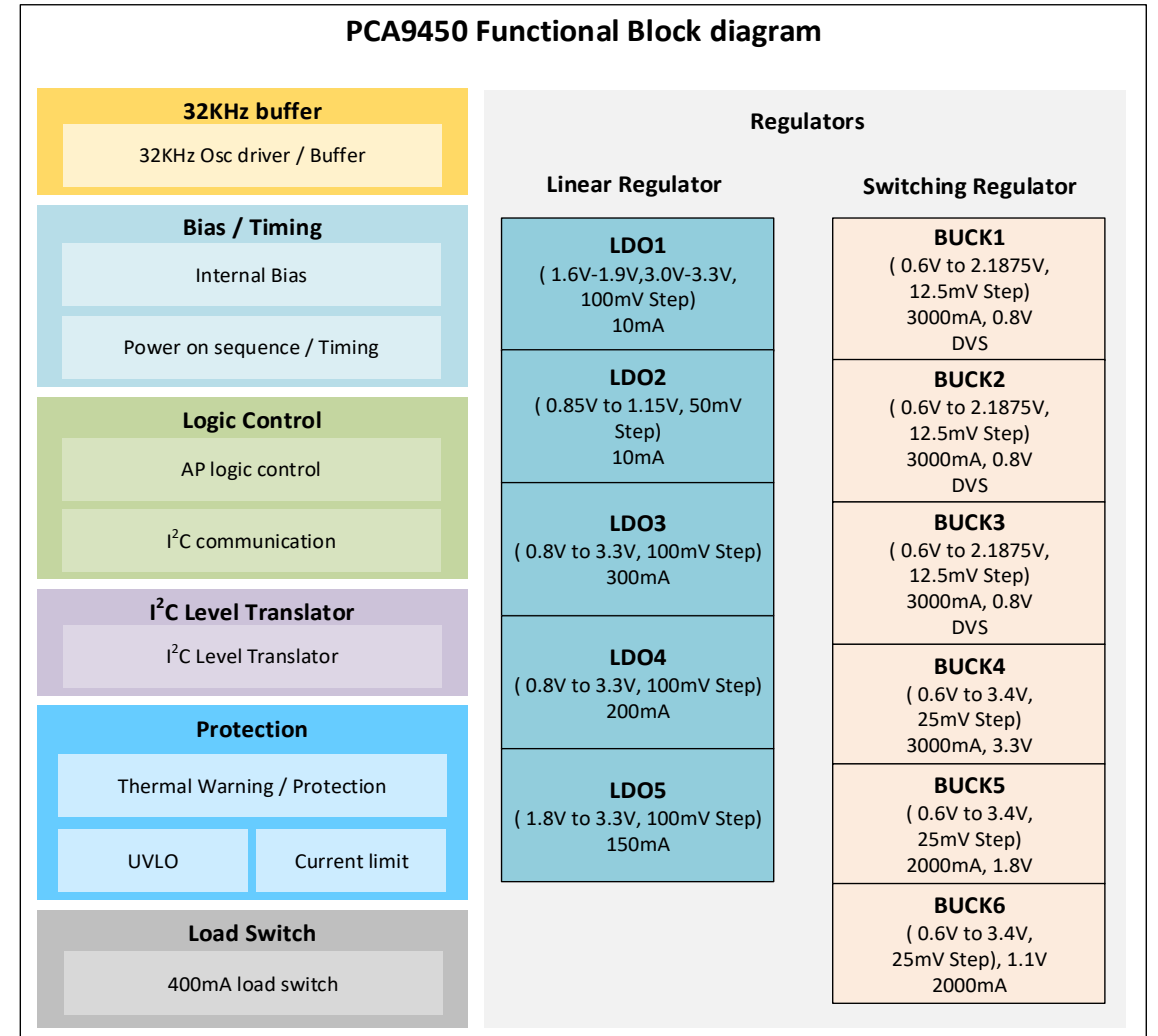
# PCA9450: PMIC FOR i.MX 8M MINI, NANO, & PLUS

- Optimized PMIC for i.MX 8M Mini/Nano/Plus
  - PCA9450A for i.MX 8M Mini
  - PCA9450B for i.MX 8M Nano
  - PCA9450C for i.MX 8M Plus
  - All three options are pin-to-pin compatible
- Support various memory types: DDR4/LPDDR4/DDR3L via System UBOOT configuration, no hardware change required
- 6x High-efficiency buck regulators
  - Three 3 A buck regulators with DVS and remote sense capability (Buck1/Buck3 can be configured as a dual-phase buck)
  - One 3 A buck regulator
  - Two 2 A buck regulators
- 5x LDOs
  - Two 10 mA LDO for SNVS power rails
  - One 150 mA LDO with voltage select pin
  - One 300 mA LDO, one 200 mA LDO



## PCA9450: PMIC FOR i.MX 8M MINI, NANO, & PLUS

- One 400 mA load switch for SD Card
- 32.768 kHz crystal oscillator buffer
- Integrated I<sup>2</sup>C level translator
- Power control I/O's
  - Power On/Off control
  - Standby/Run mode control
- Fm+ 1 MHz I<sup>2</sup>C interface
- Offered in HVQFN package 7 mm x 7 mm, 0.4 mm, 56-pins



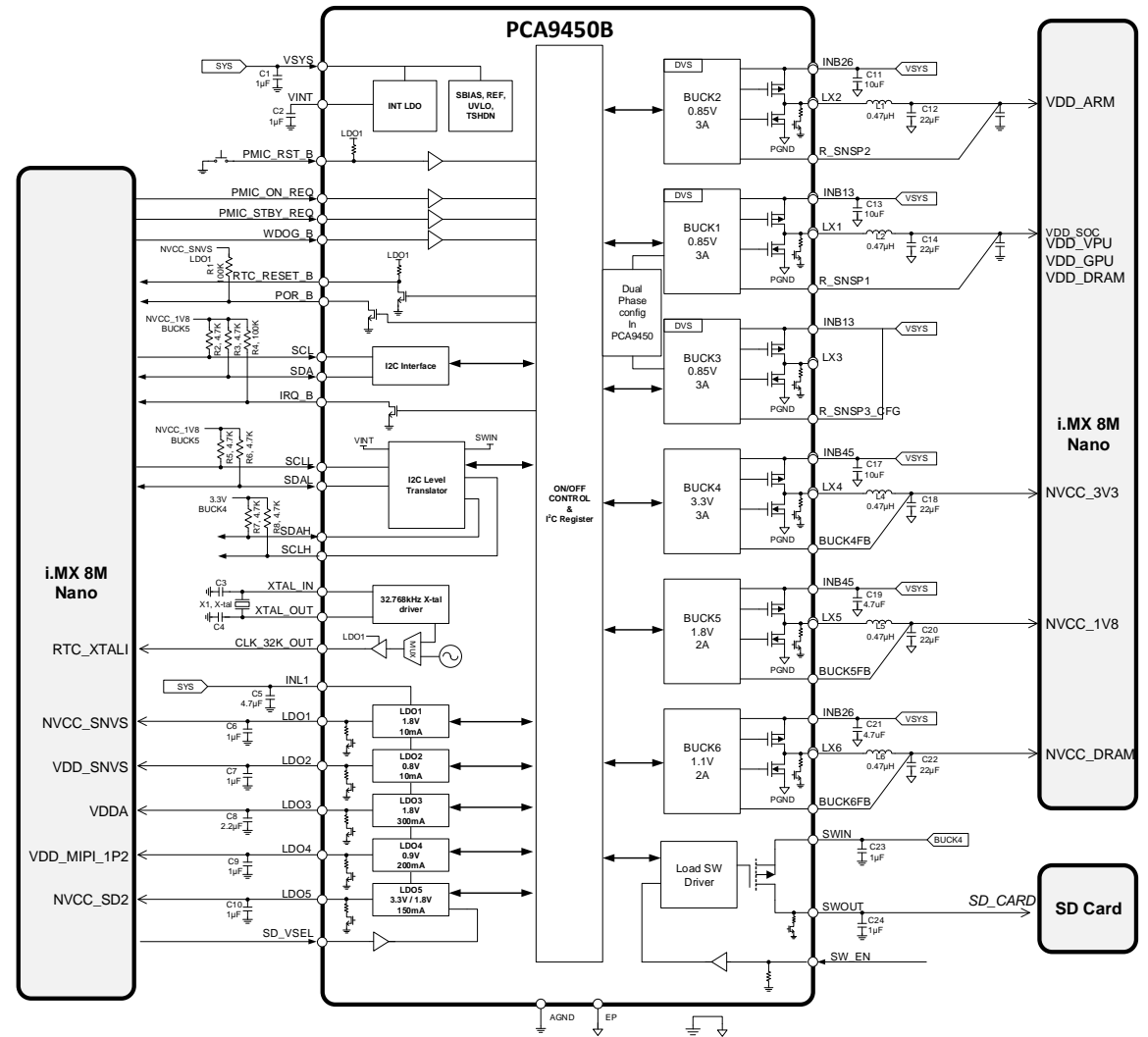
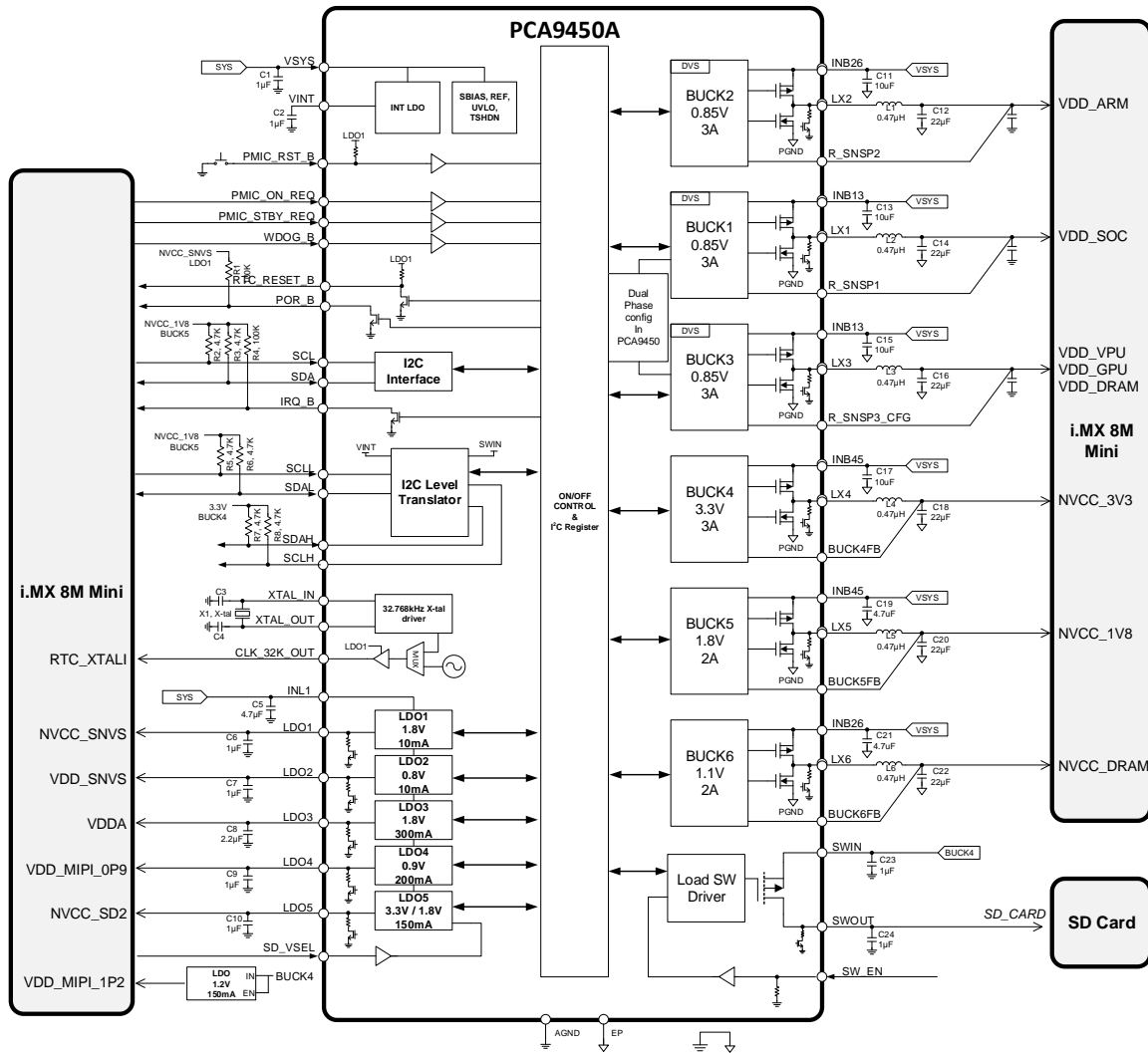
## PCA9450: PRODUCT FAMILY SUMMARY

→ PCA9450 supports i.MX 8M Mini, Nano, and Plus by pin configuration and factory setting.

PMIC Part Number	Application Processor	Buck1	Buck3	LDO4	MTP Option (LDO4_seq_off)	Dual-Phase Buck Option
PCA9450A	i.MX 8M Mini	3 A for SOC (Default ON)	3 A for VPU/GPU/DRAM (Default ON)	0.9 V for VDDA (Default ON)	"0"	R_SNSP3 is feedback of BUCK3
PCA9450B	i.MX 8M Nano	3 A for SOC/VPU/GPU/DRAM (Default ON)	- (OFF)	1.2 V (Default OFF)	"1"	R_SNSP3 = VSYS ( Single Phase )
PCA9450C	i.MX 8M Plus	6 A for SOC/VPU/GPU/DRAM (Dual Phase) (Default ON)	6 A for SOC/VPU/GPU/DRAM (Dual Phase) (Default ON)	1.2 V (Default OFF)	"1"	R_SNSP3 = GND (Dual Phase)



# CONFIGURATION EXAMPLE: i.MX 8M MINI + PCA9450A AND i.MX 8M NANO + PCA9450B



# i.MX 8M MINI & NANO + PMIC – REFERENCE DESIGN SUMMARY

## NXP Platform

## Status

<p>i.MX 8M Mini &amp; PCA9450A</p>	<ul style="list-style-type: none"> <li>• i.MX 8M Mini + PCA9450A Reference Design Schematic, PCB, Layout, SW Patch Available:</li> <li>• Developed by Embedded Power Team following compliance from MICR Team</li> </ul>
<p>i.MX 8M Nano LPDDR4 &amp; PCA9450B With Cypress CYW43455 (Wi-Fi)</p>	<ul style="list-style-type: none"> <li>• Reference Design Schematic available from NXP website (Developed by MICR Team)</li> <li>• Software enablement in post-GA release (Linux post-GA now, Android Feb-2020)</li> <li>• Availability: Not for sale</li> </ul>
<p>i.MX 8M Nano LPDDR4 &amp; PCA9450B With Azurewave 88W8987 (Marvell/NXP Wi-Fi)</p>	<ul style="list-style-type: none"> <li>• Developed by MICR Team</li> <li>• Availability: \$399</li> </ul>
<p>i.MX 8M Plus LPDDR4 &amp; PCA9450C</p>	<ul style="list-style-type: none"> <li>• To be developed by MICR Team Schedule:             <ul style="list-style-type: none"> <li>– Board Design – 1Q-2020</li> <li>– Linux SDK – Early Q4-2020</li> <li>– Android SDK – Late Q4-2020</li> </ul> </li> </ul>



# Power Management Solutions for Complex Processors & Systems

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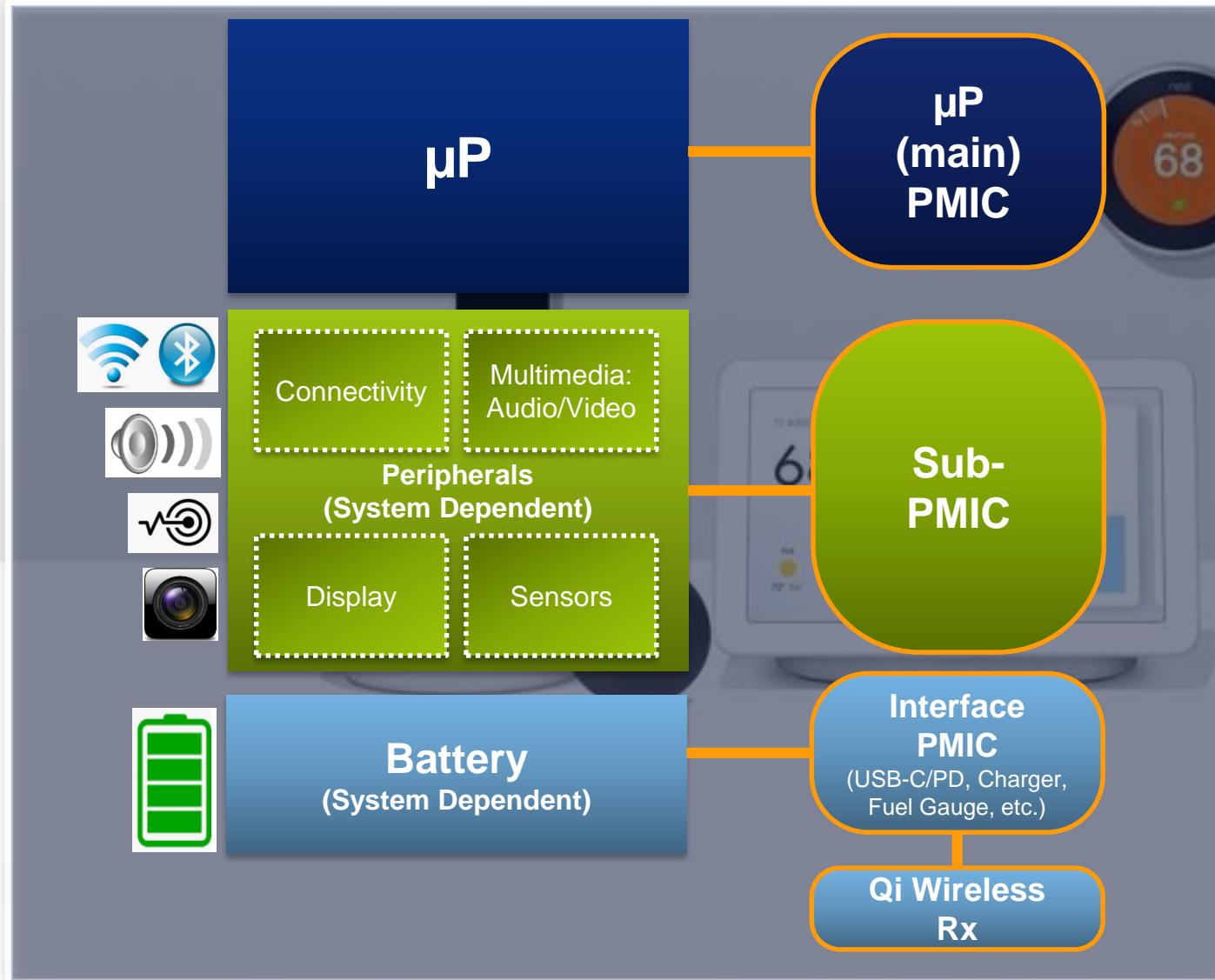
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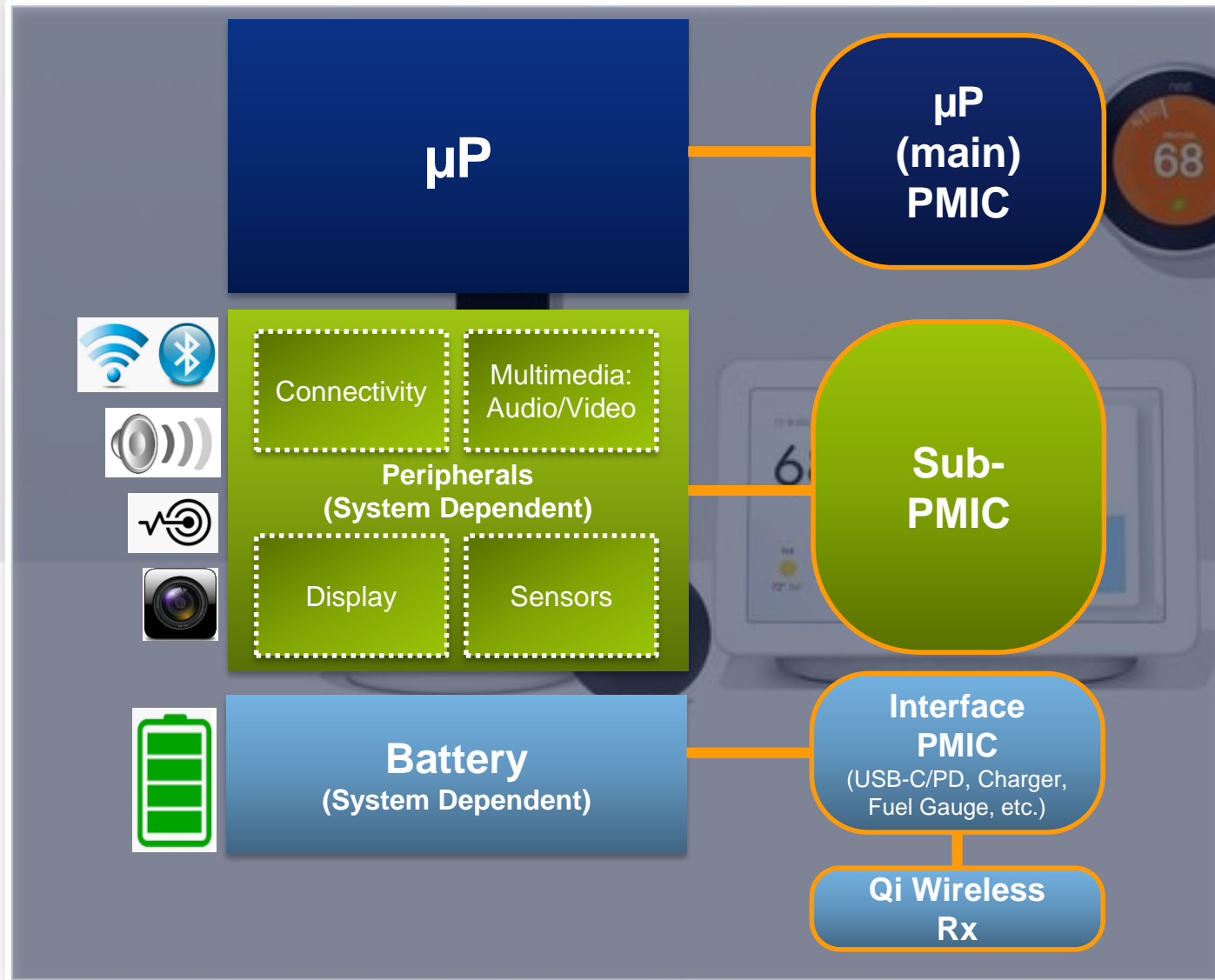
**POWER MANAGEMENT IS A SYSTEM-LEVEL ISSUE  
FOCUS ON  $\mu$ P POWER REQUIREMENTS, THEN OFFER COMPANION PMICS FOR SCALABILITY**



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Attach #1 100% Coverage of NXP  $\mu$ P platforms for mass market

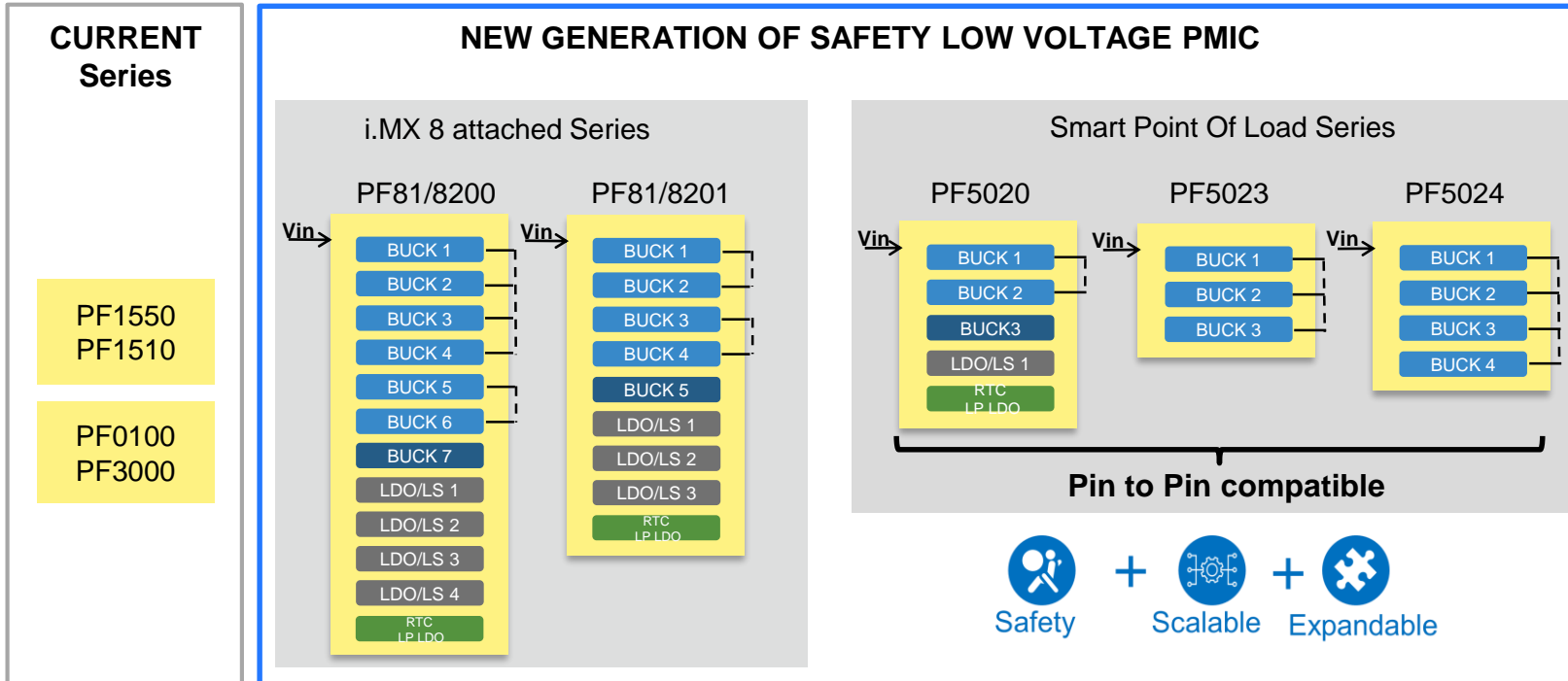


System Power Solutions #2 Application Specific Companion PMIC - System Scalability



System Power Solutions #3 Selected Application Specific Integrated PMIC

# LOW-VOLTAGE EXPANSION PMIC FAMILY



# PF502X: MULTI-PHASE BUCK COMPANION PMIC

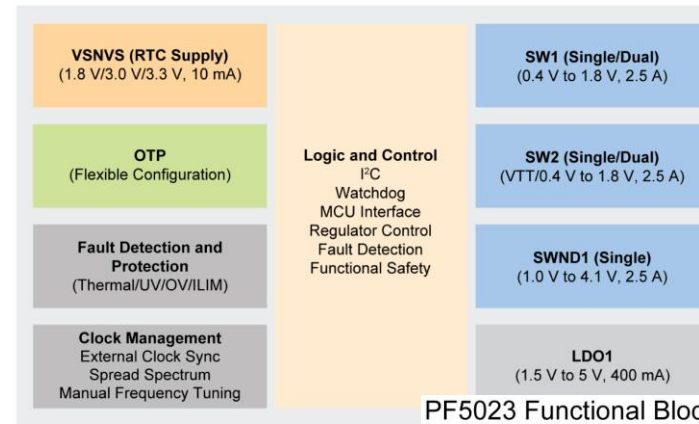
## Differentiating Points

- Multi-Phase Configurable Buck Regulator with ASIL-B
  - PF5020: Up to Dual-Phase with ASIL-B
  - PF5023: Up to Three-Phase with ASIL-B
  - PF5024: Up to Four-Phase with ASIL-B
- Hardware Control and I<sup>2</sup>C control
- Supports DVS Operation
- Supports independent/dual-phase operation
- Use as Standalone Regulator, or Companion for an Optimized System Solution

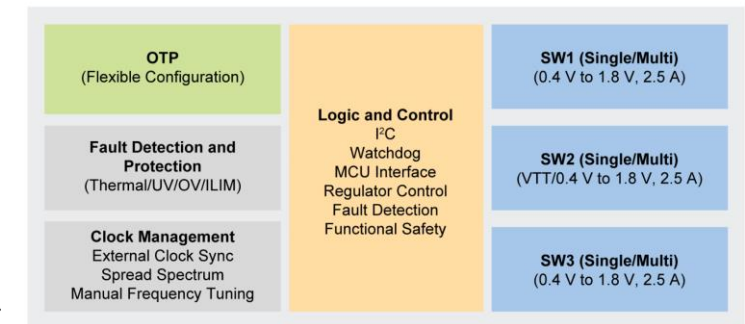
## Product Features

- Advanced thermal management
  - PF5020: Up to 5 A Core/GPU Supply
  - PF5023: Up to 7.5 A Core/GPU Supply
  - PF5024: Up to 10 A Core/GPU Supply
- Reduced noise: Spread spectrum, manual frequency tuning, frequency synchronization and dual-phase operation
- Reduced solution size through internal compensation,
- PMIC to PMIC Synchronization and Fault Management Pin (XFAIL)
- OTP configurability for scalable/flexible solutions
- 40 °C to 125 °C Operating Ambient Temperature
- 6 mm x 6 mm 40-LD QFN-EP
- Automotive and Industrial grades available

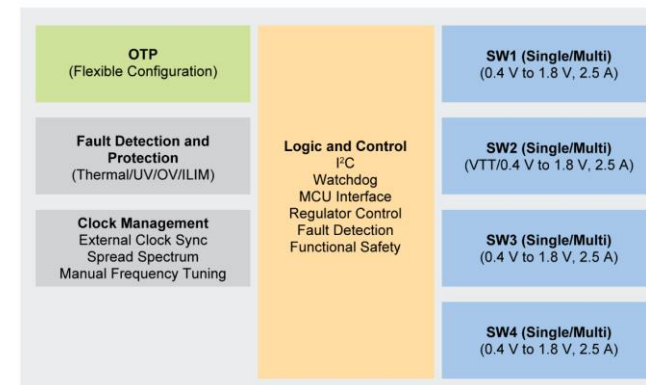
PF5020 Functional Block Diagram



PF5023 Functional Block Diagram

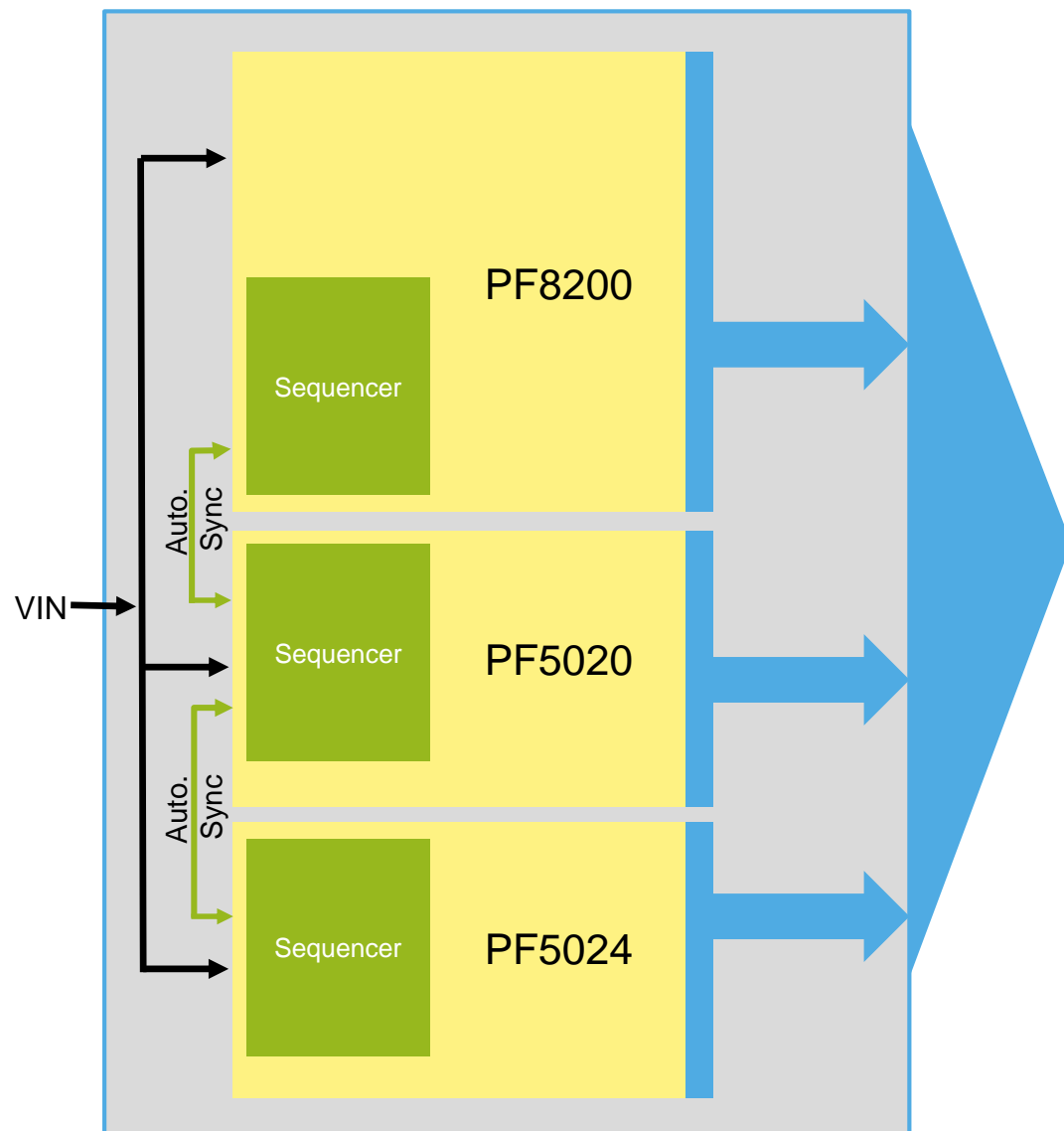


PF5024 Functional Block Diagram

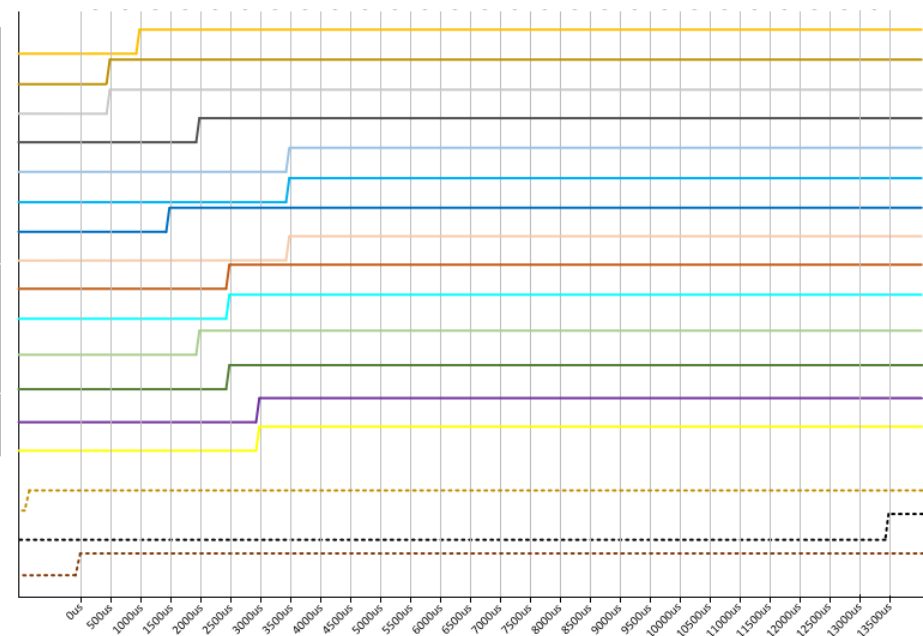
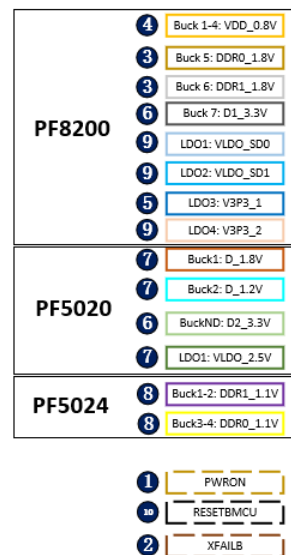




# PF502X: LOW-VOLTAGE EXPANSION PMIC FAMILY

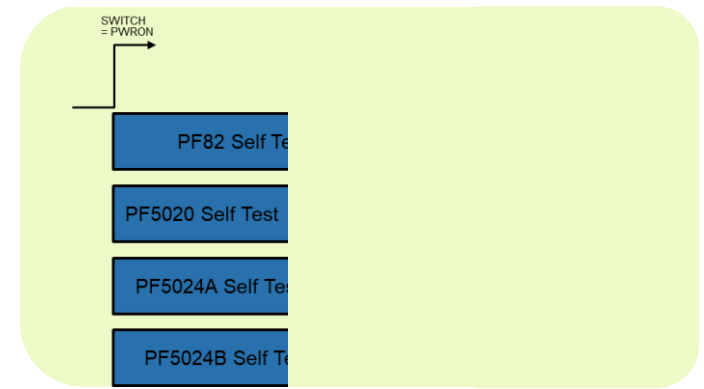
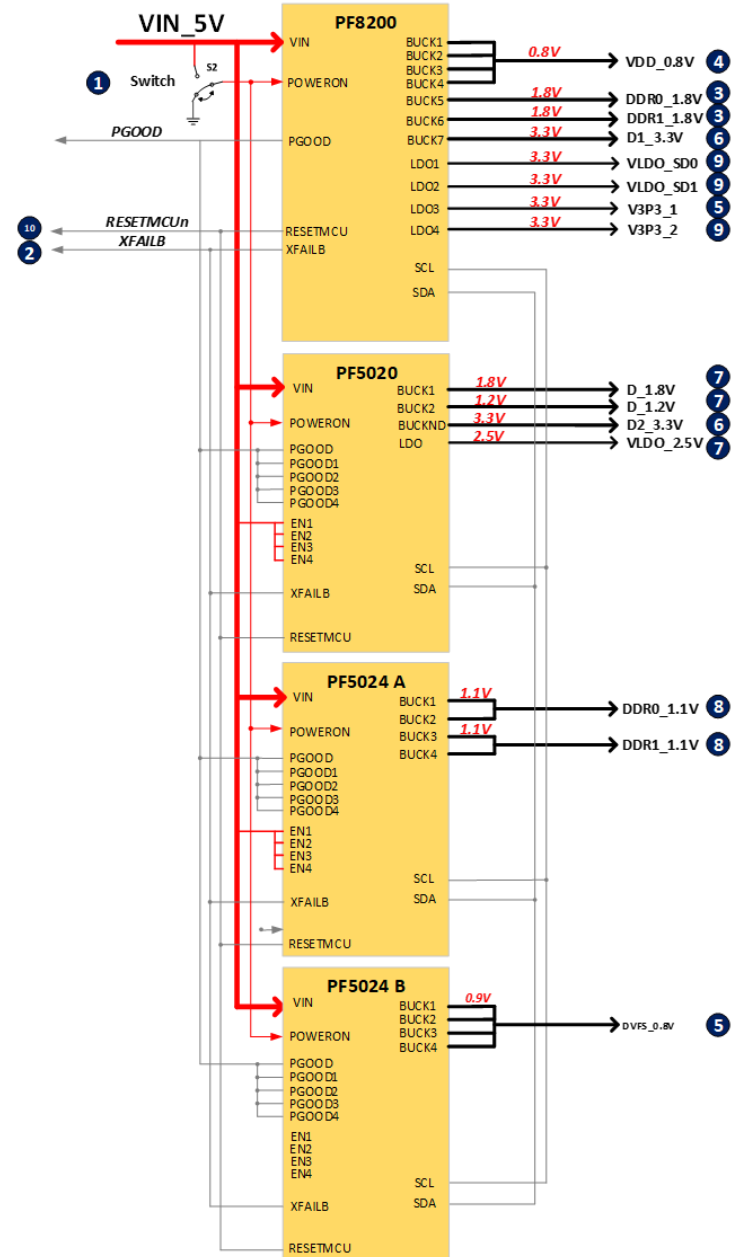
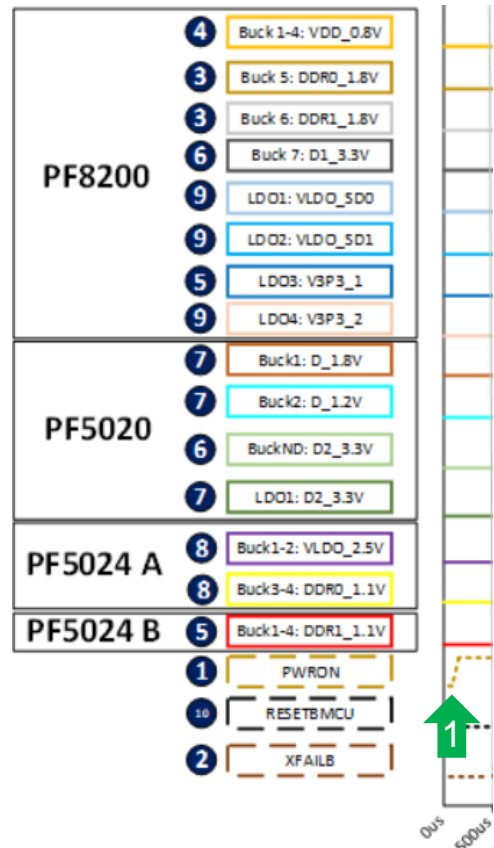


## Ensuring Complex Power Up and Down Sequence ACT AS ONE PMIC, WITHOUT EXTERNAL CONTROLLER

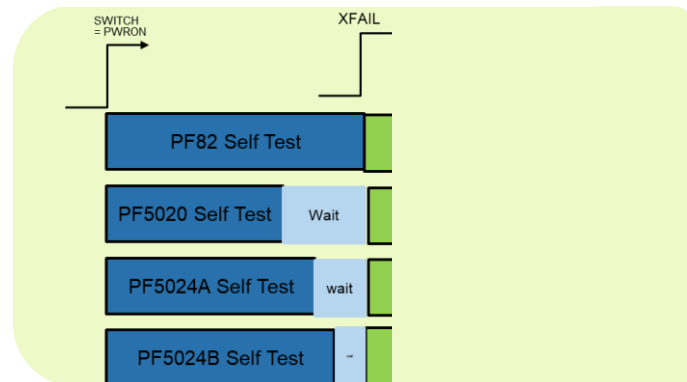
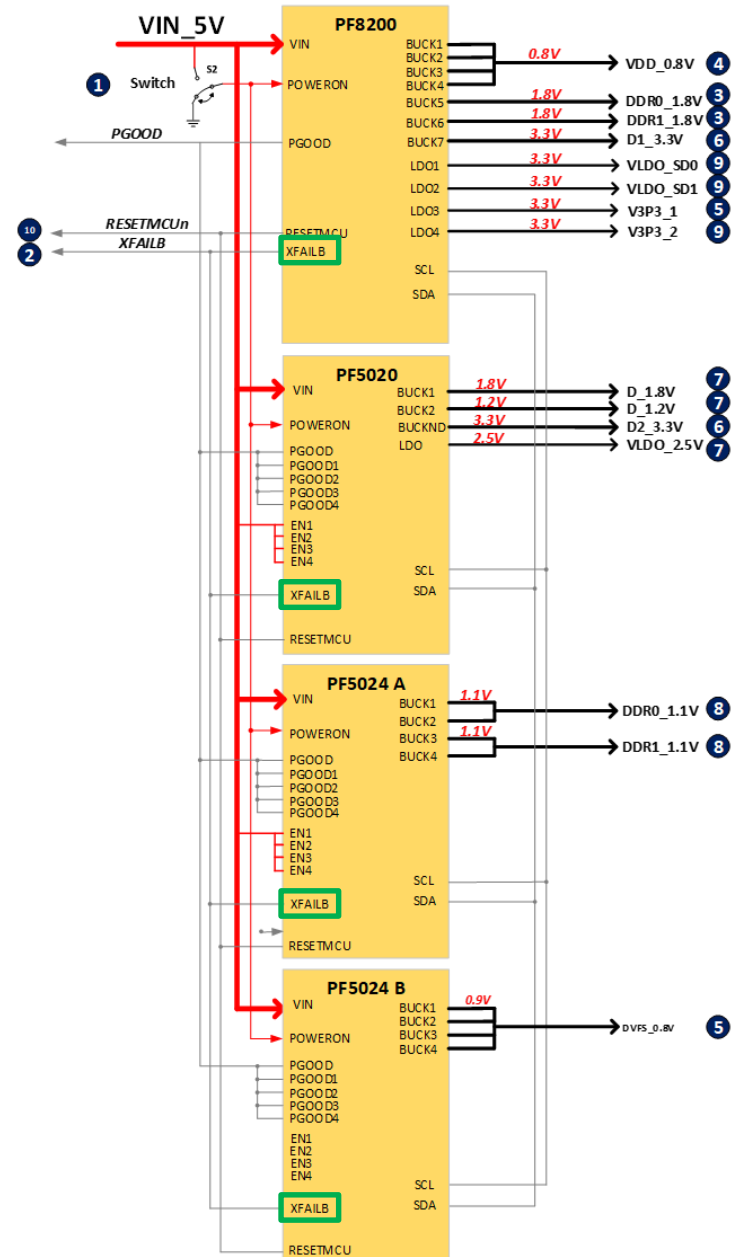
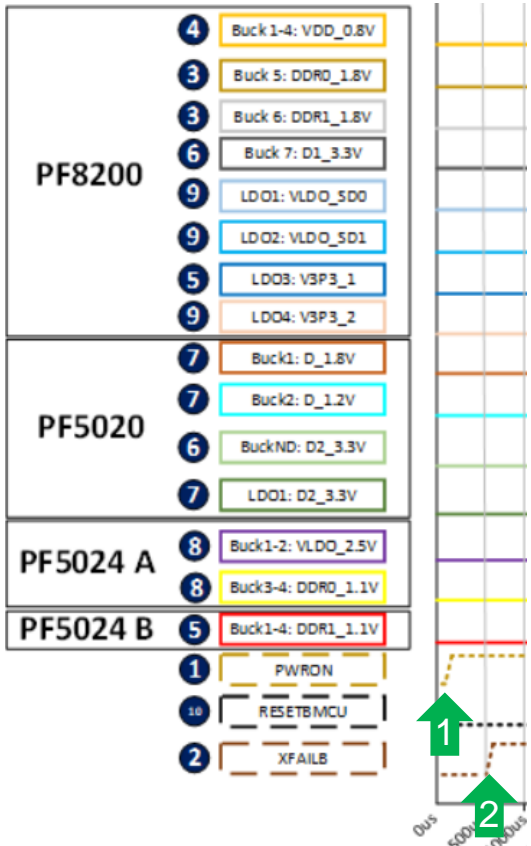


- Complex power up /Down sequencer synchronization
- Global OV/UV monitoring insured
- NXP PMIC solution attached to non-NXP processors

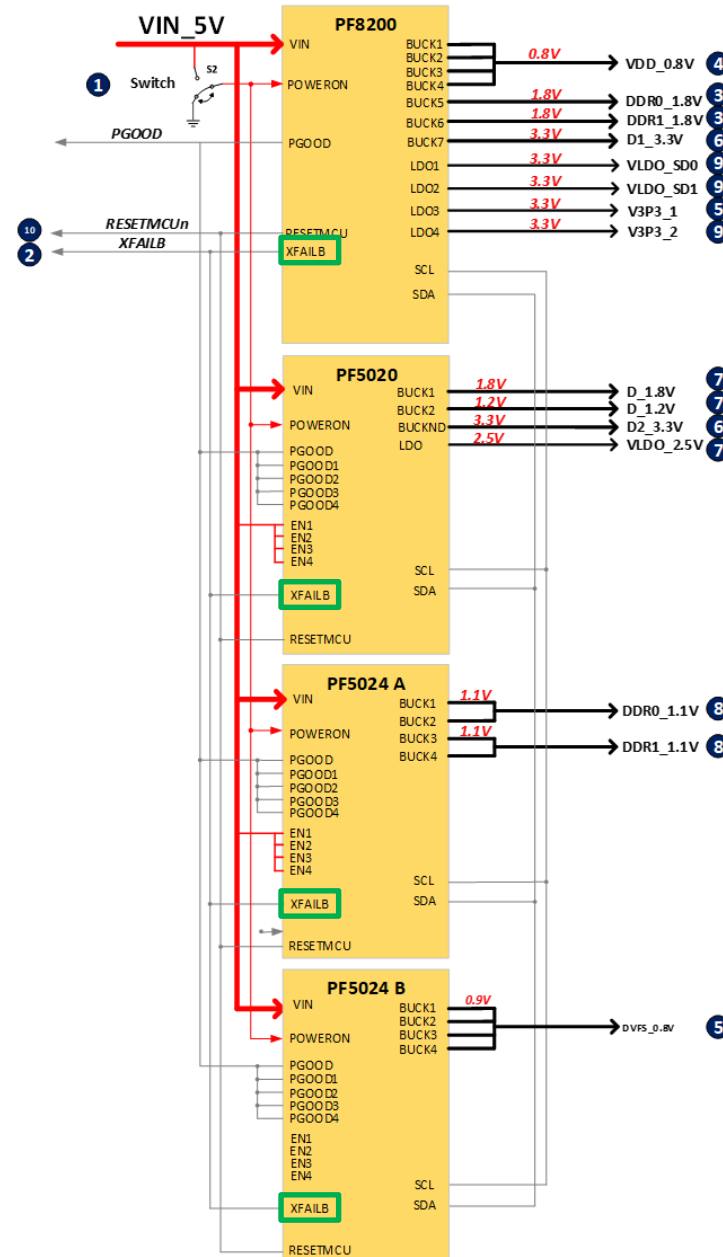
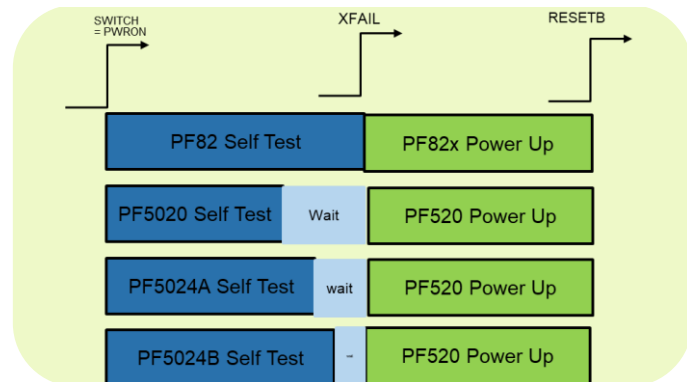
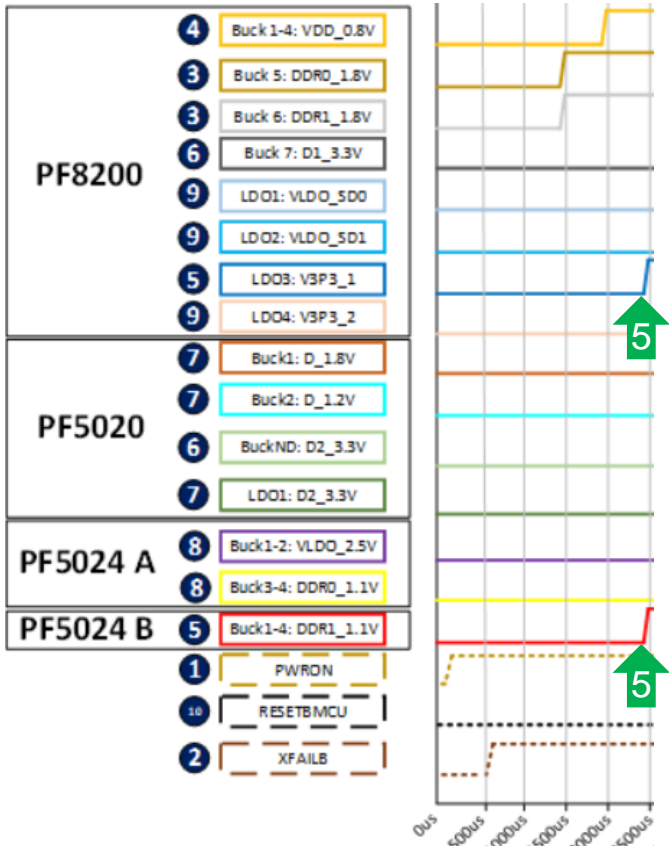
# EXAMPLE MULTIPLE PF DEVICES CONNECTED FOR "SMART COMPANION" CONFIGURATION



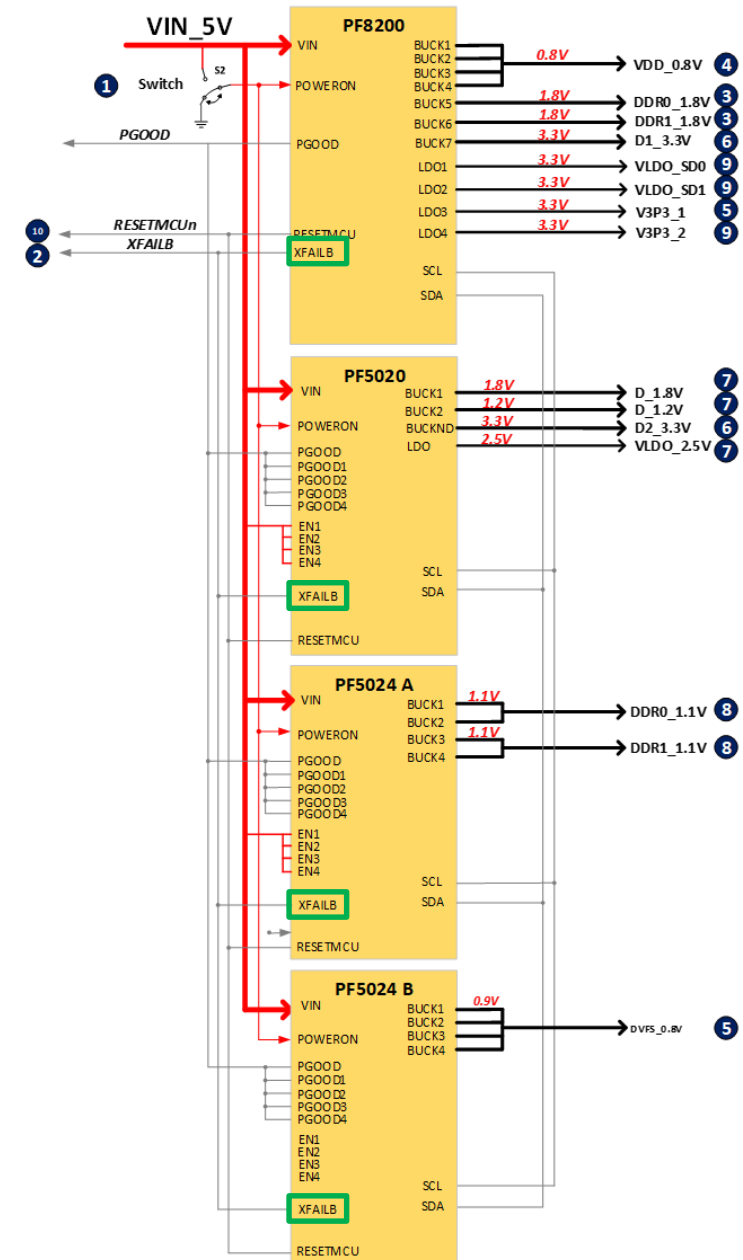
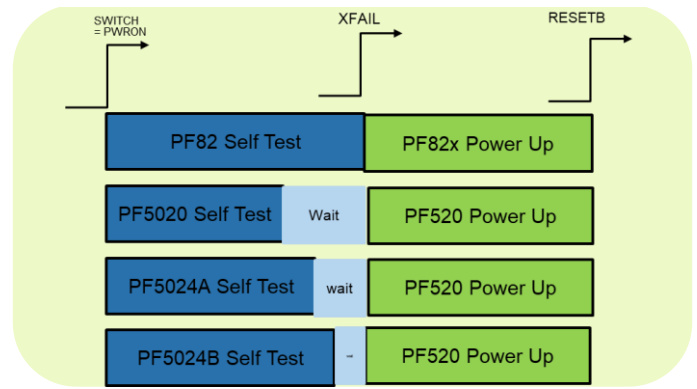
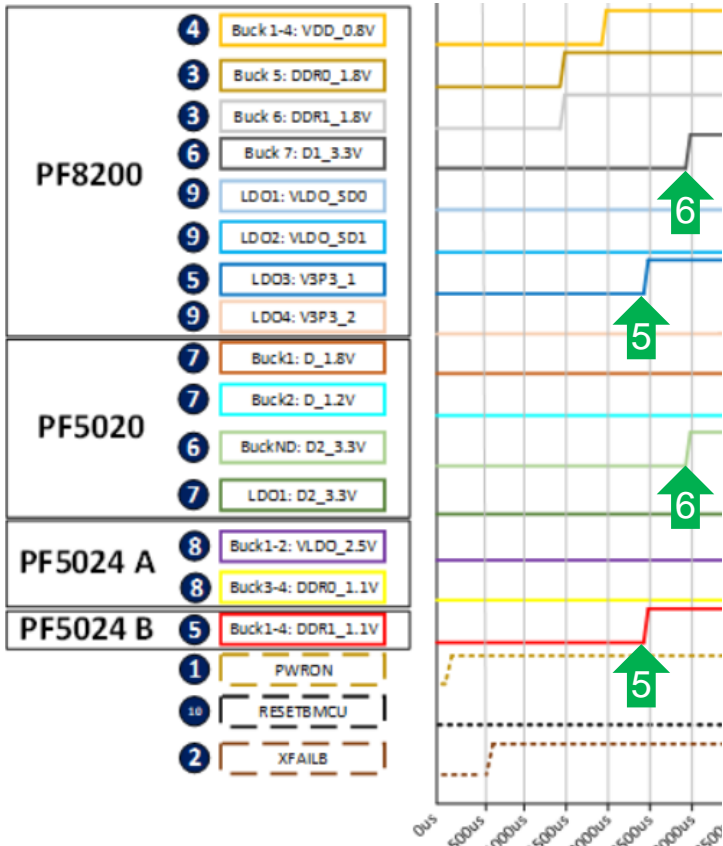
# EXAMPLE MULTIPLE PF DEVICES CONNECTED FOR "SMART COMPANION" CONFIGURATION



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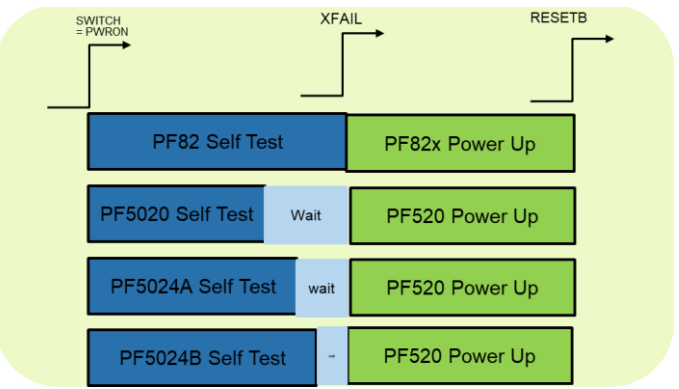
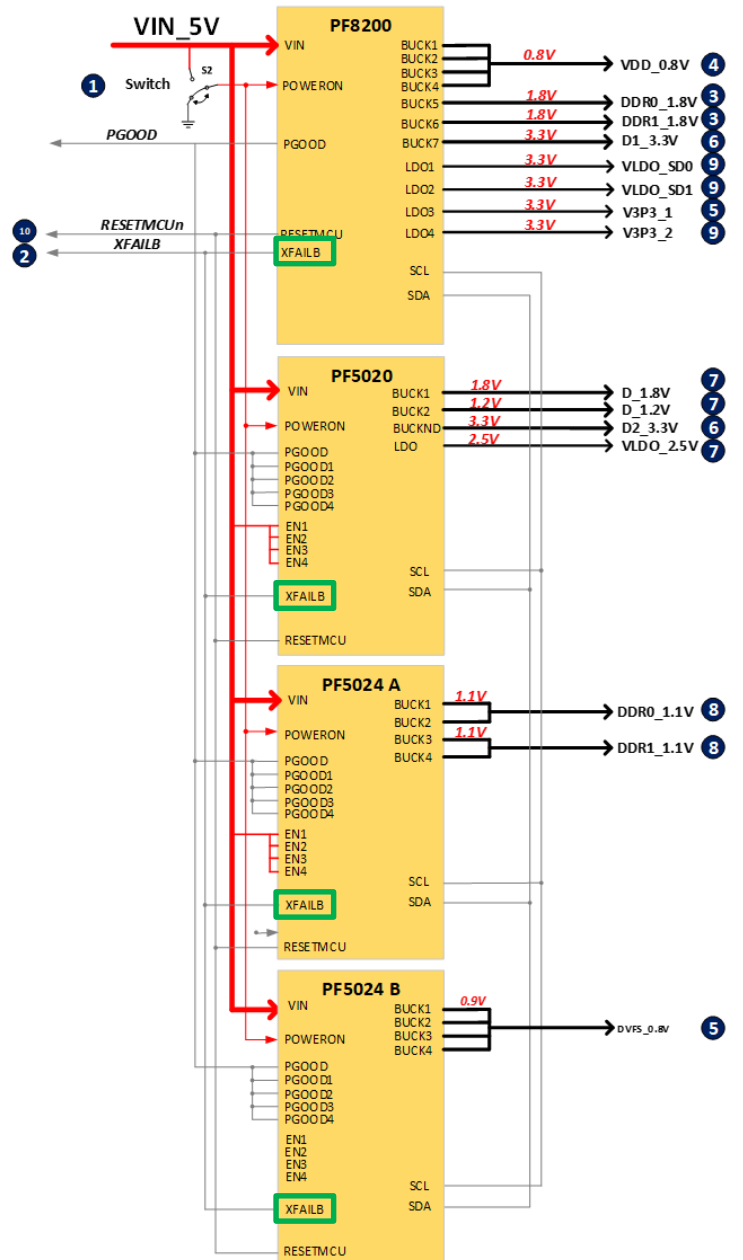
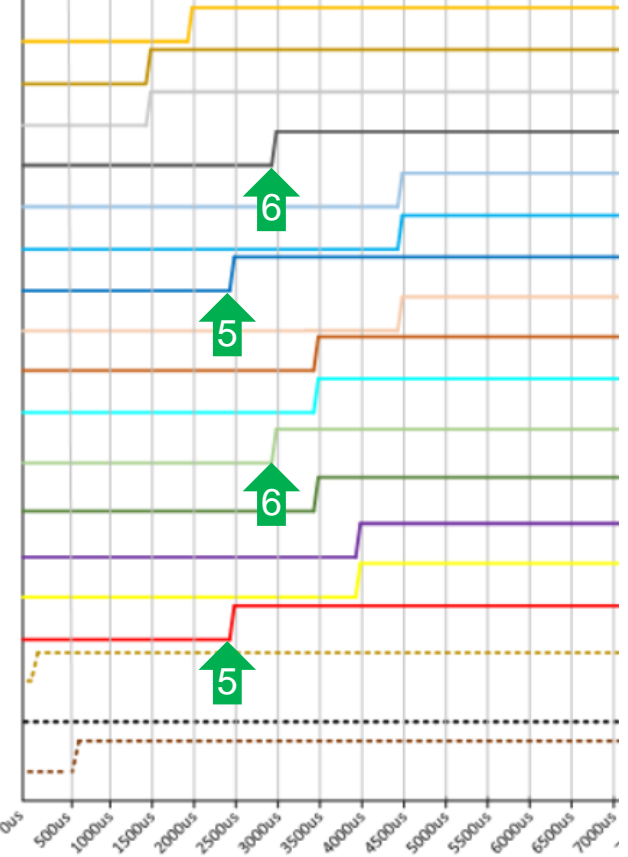


# EXAMPLE MULTIPLE PF DEVICES CONNECTED FOR "SMART COMPANION" CONFIGURATION



# EXAMPLE MULTIPLE PF DEVICES CONNECTED FOR "SMART COMPANION" CONFIGURATION

<b>PF8200</b>	4	Buck 1-4: VDD_0.8V
	3	Buck 5: DDR0_1.8V
	3	Buck 6: DDR1_1.8V
	6	Buck 7: D1_3.3V
	9	LDO1: VLDO_5D0
	9	LDO2: VLDO_5D1
	5	LDO3: V3P3_1
	9	LDO4: V3P3_2
<b>PF5020</b>	7	Buck1: D_1.8V
	7	Buck2: D_1.2V
	6	BuckND: D2_3.3V
	7	LDO1: D2_3.3V
<b>PF5024 A</b>	8	Buck1-2: VLDO_2.5V
	8	Buck3-4: DDR0_1.1V
<b>PF5024 B</b>	5	Buck1-4: DDR1_1.1V
	1	PWRON
	10	RESETBMCU
	2	XFAILB



- One Box System through Sync.
- Better Thermal Approach
- Ensure Signal integrity

# Summary

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# MCU / MPU SEGMENTATION MATCH TO PMICs

## i.MX RT & Kinetis

RT600	PCA9420
RT500/300	PCA9420

## i.MX ULP

7ULP	PF15xx
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## i.MX mScale Consumer & Industrial MPU

i.MX8M Quad	PF42
i.MX8M Mini	PCA9450
i.MX8M Nano	
i.MX8M Plus	

## i.MX Auto & Industrial MPU

i.MX6	PF0100
i.MX7	PF3000
i.MX8	PF8200

## AMP VDS, CNS, GPIS, ADAS

MPC56/57	FS65xx
S32K1	UJA11
S32K3	FS26 / UJA124x
S32S2	FS6600
S32G	VR5510
S32V	FS85+PF82/50

## IDA V2X / Radio / Radar MMIC

SAF51/2	PF3000
SAF53/4	VR55xx
SXF1800	PF3000
Mercury	VR5500
DiRaNA	VR5500
Titan	VR5500
Merlin	FS5501
Lithio	FS5501
Dolphin SIP/ED	FS85
Dolphin+	FS85/PF50

## LS / LX

LS1012	VR5100
LS1024	VR500 FS56 + PF82
LS102x	VR500 FS56 + PF82
LS1043	VR500 FS56 + PF82
T1013/23	VR500



# Contacts

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