qorvo
all around you

Multi-rail Power Management (PMIC) for Compact-size System

Sep 2021

Is Now

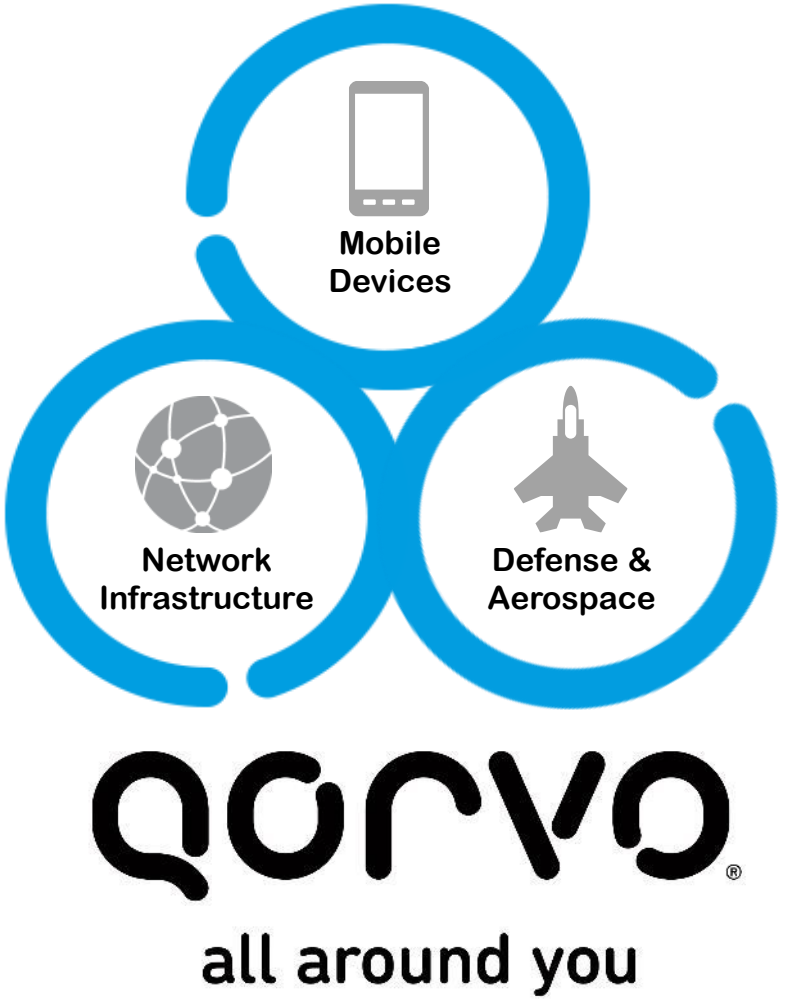
qorvo®

We Are Qorvo®

Innovative RF solutions for everything that connects our world

- We provide innovative RF solutions at the center of connectivity
- 8,000+ global employees
- Calendar 2020 revenue: $4 billion
- An S&P 500 company – Nasdaq: QRVO

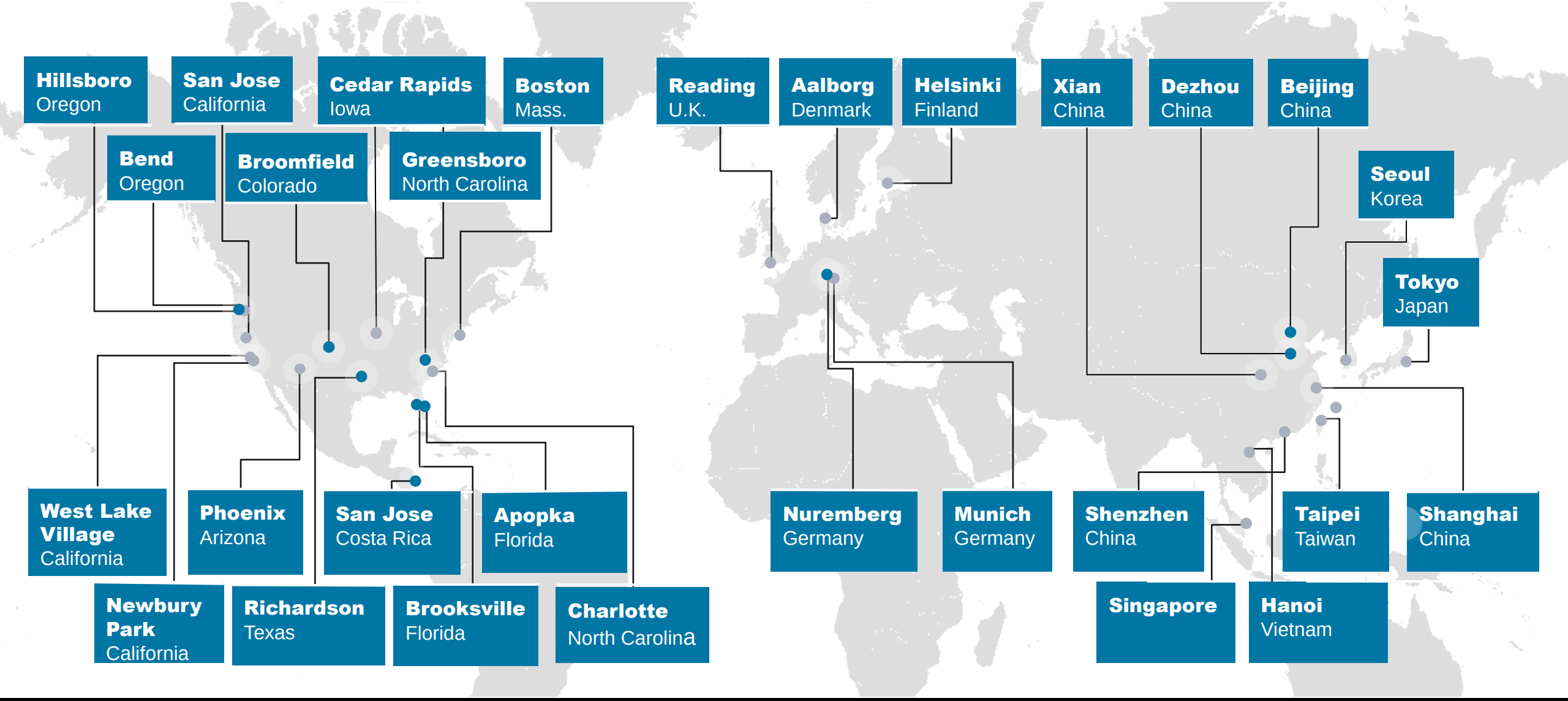
- Active-Semi is now PPM (Programmable Power Management) at Qorvo.



Our Global Footprint

Blue dots indicate Manufacturing/ Test Operations

Gray dots indicate R&D and Sales Centers



PPM Product lines

Intelligent
Motor control

Power
Management

Power Loss
Protection

Battery
Management

DC-DC
Converter

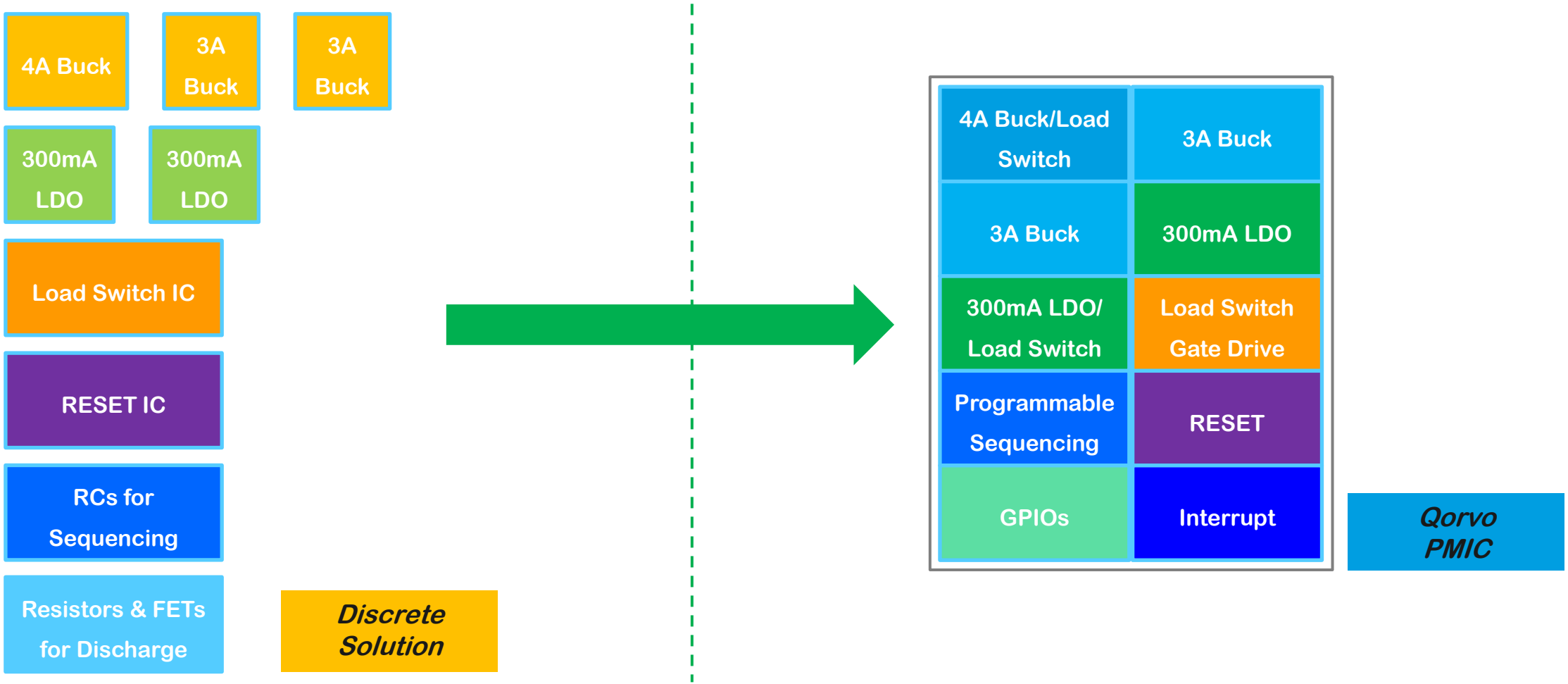
DC-DC For RF

One PMIC Fits Many Applications and Platforms

Integration & Configurability

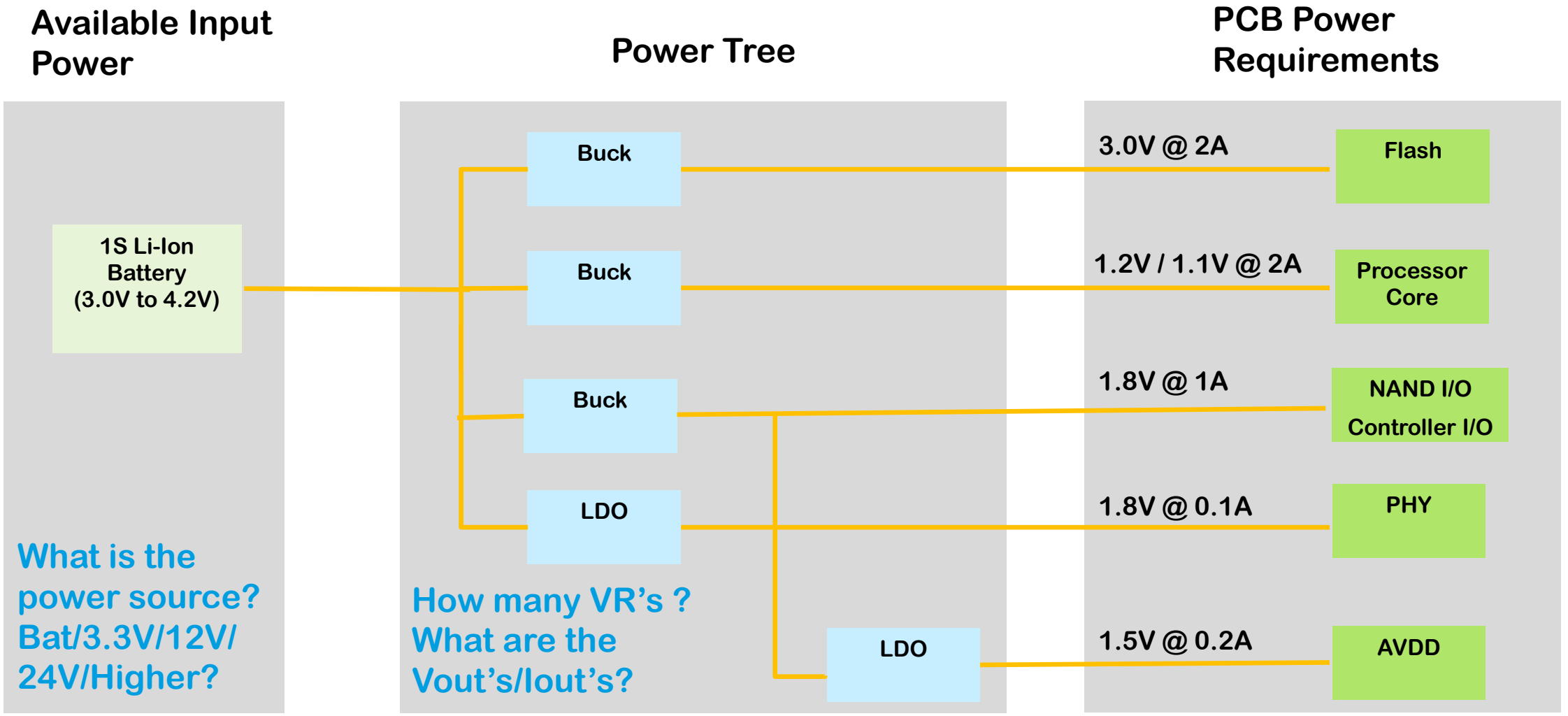
Integration

Discrete vs PMIC



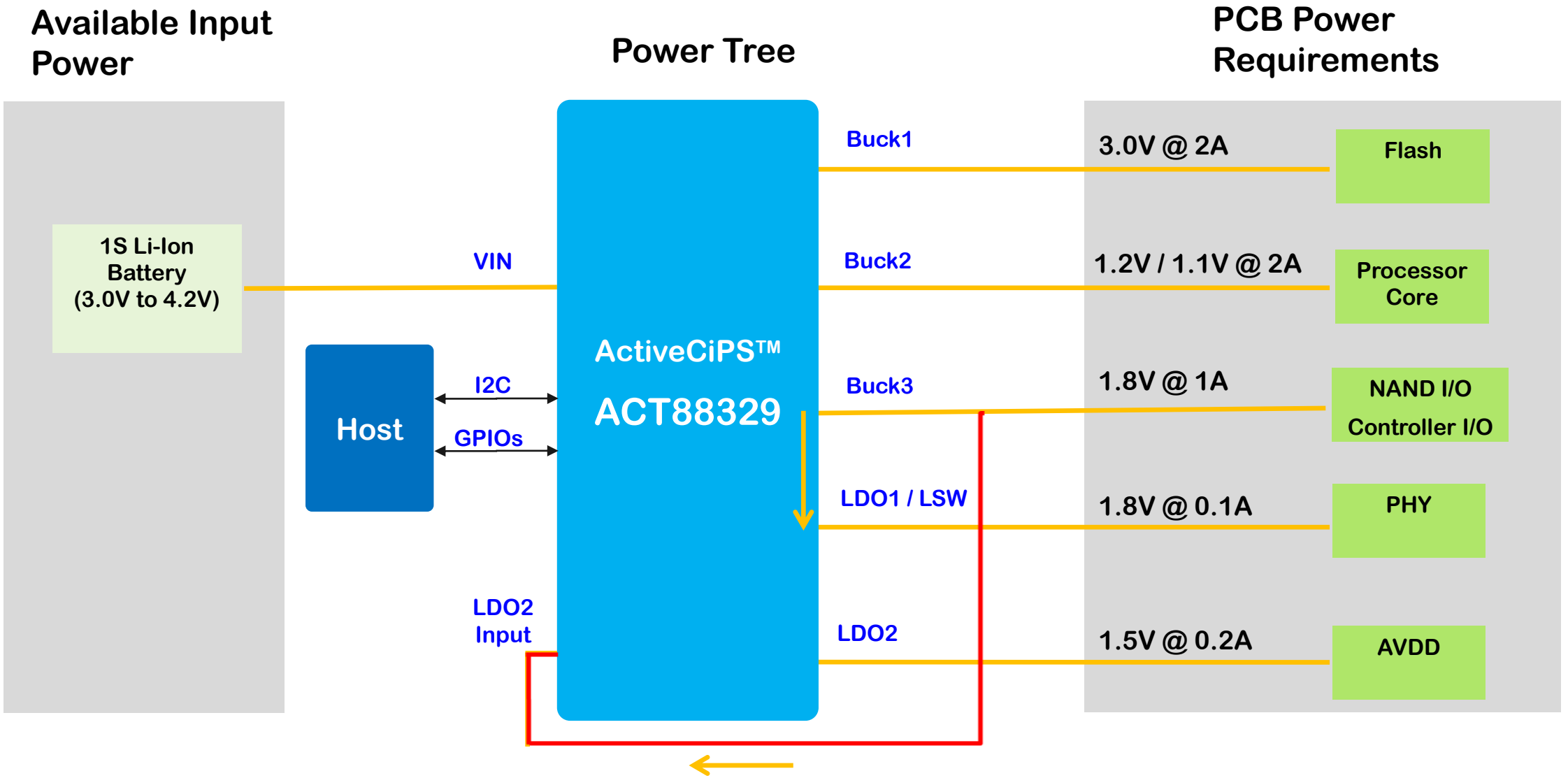
* Besides just Bucks & LDOs, other ICs, switches, and lots of RCs are needs in discrete solution

System Level Power Design



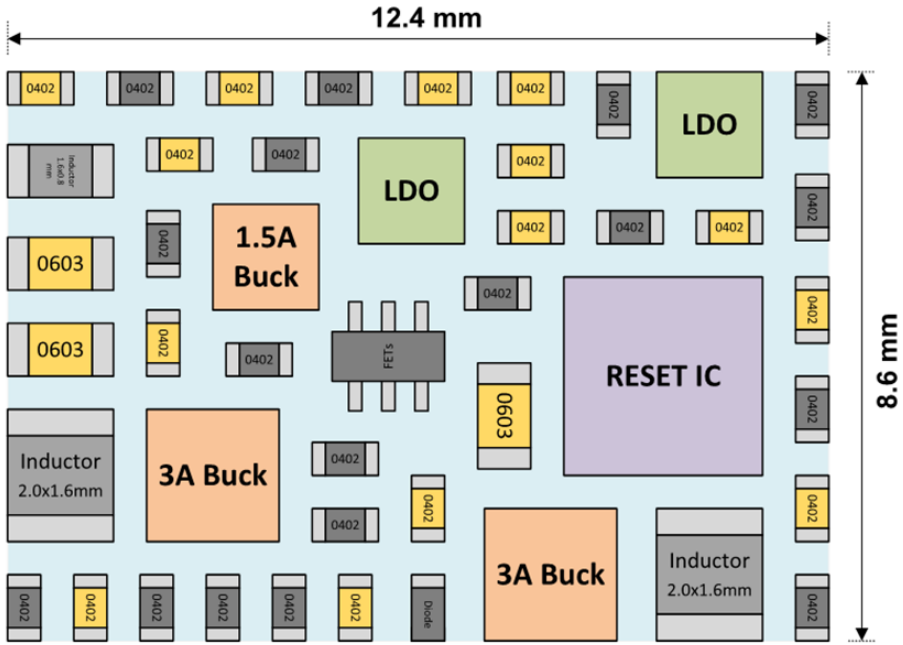
Every system needs power !

System Level Power Design



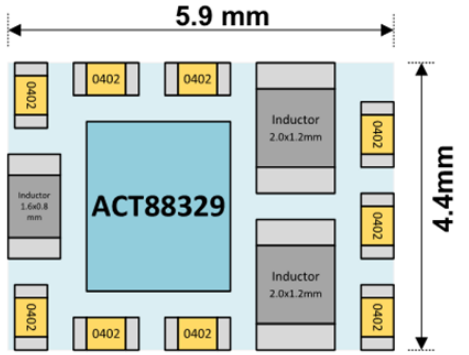
ACT88329/1 Vs. Discrete - Size and cost savings

- ✓ Smaller FF design
- ✓ PCB cost savings
- ✓ Assembly cost savings
- ✓ Ease on supply chain

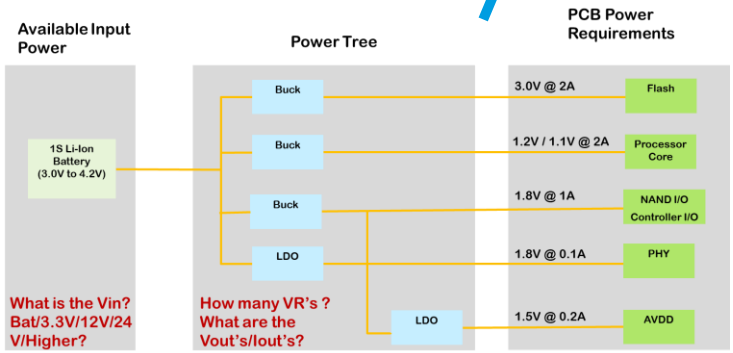


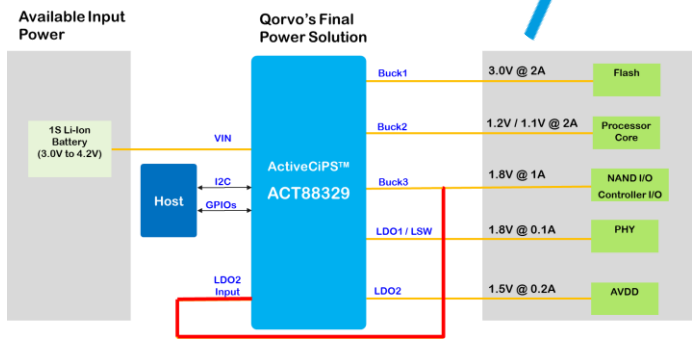
Discrete
*solution size: **106.64**mm2*
*Component count: **46***

75% smaller solution



Discrete
*solution size: **25.96**mm2*
*Component count: **13***





Highlighted PMICs

3.3V/5V Medium Power

ACT88760
7 Bucks / 6 LDOs PMIC in CSP Packages, combine 2 phase in one output

ACT88430
4 Bucks / 3 LDOs PMIC with 0.6V Minimum Output

ACT88420
4 Bucks / 2 LDOs PMIC with Input OVP / Inrush Control

ACT88325/6/9/1
3 Bucks / 2 LDOs PMIC with 0.5V, Small CSP Package and low cost

12V Higher Power

ACT86600
High Voltage and multiphase + Buck/Boost for Enterprise SSDs, Servers, Data Centers, etc.

ACT85610
High Voltage Buck/Boost and Power Loss Protection for Enterprise SSDs, Servers, Data Centers, etc.

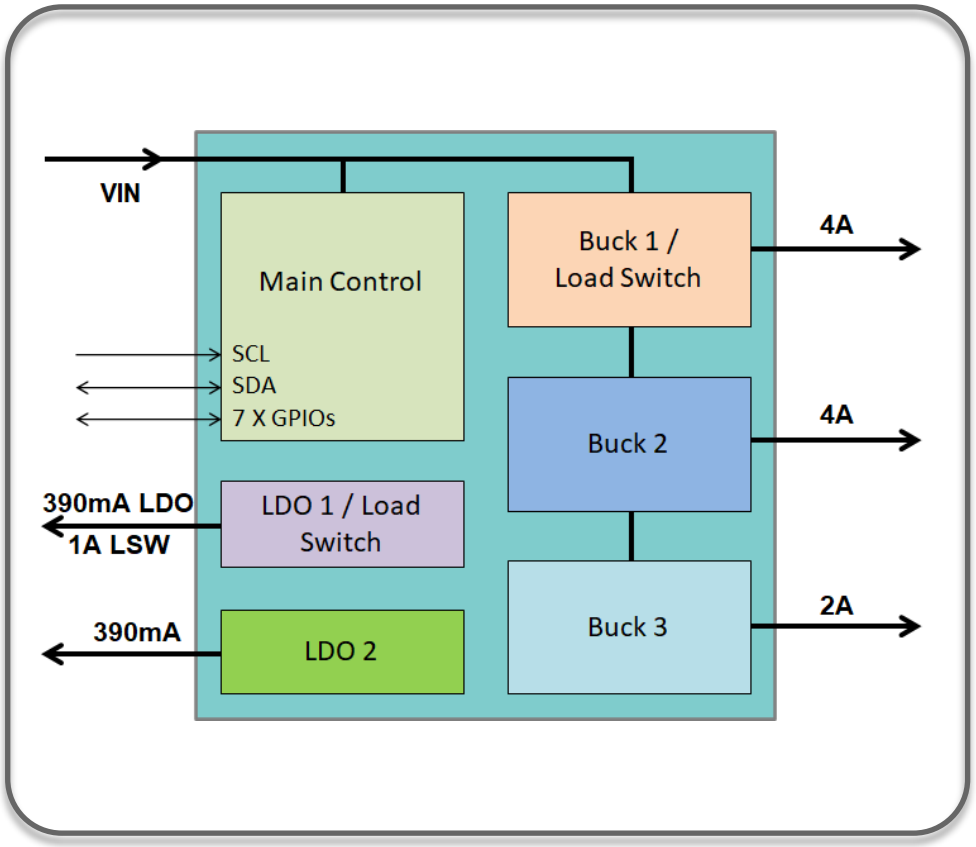
ACT85410
Up to 10A peak current per buck output, High Voltage Buck/Boost and Power Loss Protection.

3.3V/5V Low Power

ACT81460
Low Power PMU with Linear Charger, 2 Bucks, Buck/Boost, HV Boost, 2 LDOs and LSWs in small CSP package

ACT88329

New Gen. PMIC



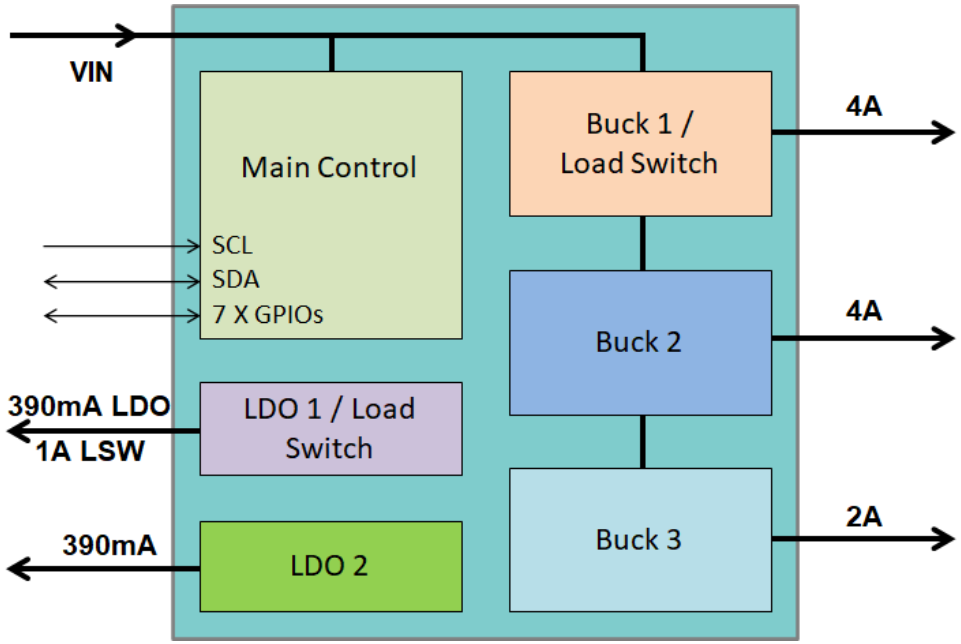
High Integration PMIC

- Optimized Transient Performance with COT Control
- Buck 1: 4A Buck / Load Switch, 0.6V Minimum Output (Current Mode)
- Buck 2: 4A, 0.5V Minimum Output (COT)
- Buck 3: 2A, 0.5V Minimum Output (COT)
- All Buck Work with 0.47uH Inductor /22uF caps.
- LDO1: 390mA , 1A in Load Switch Mode.
- LDO2: 390mA LDO

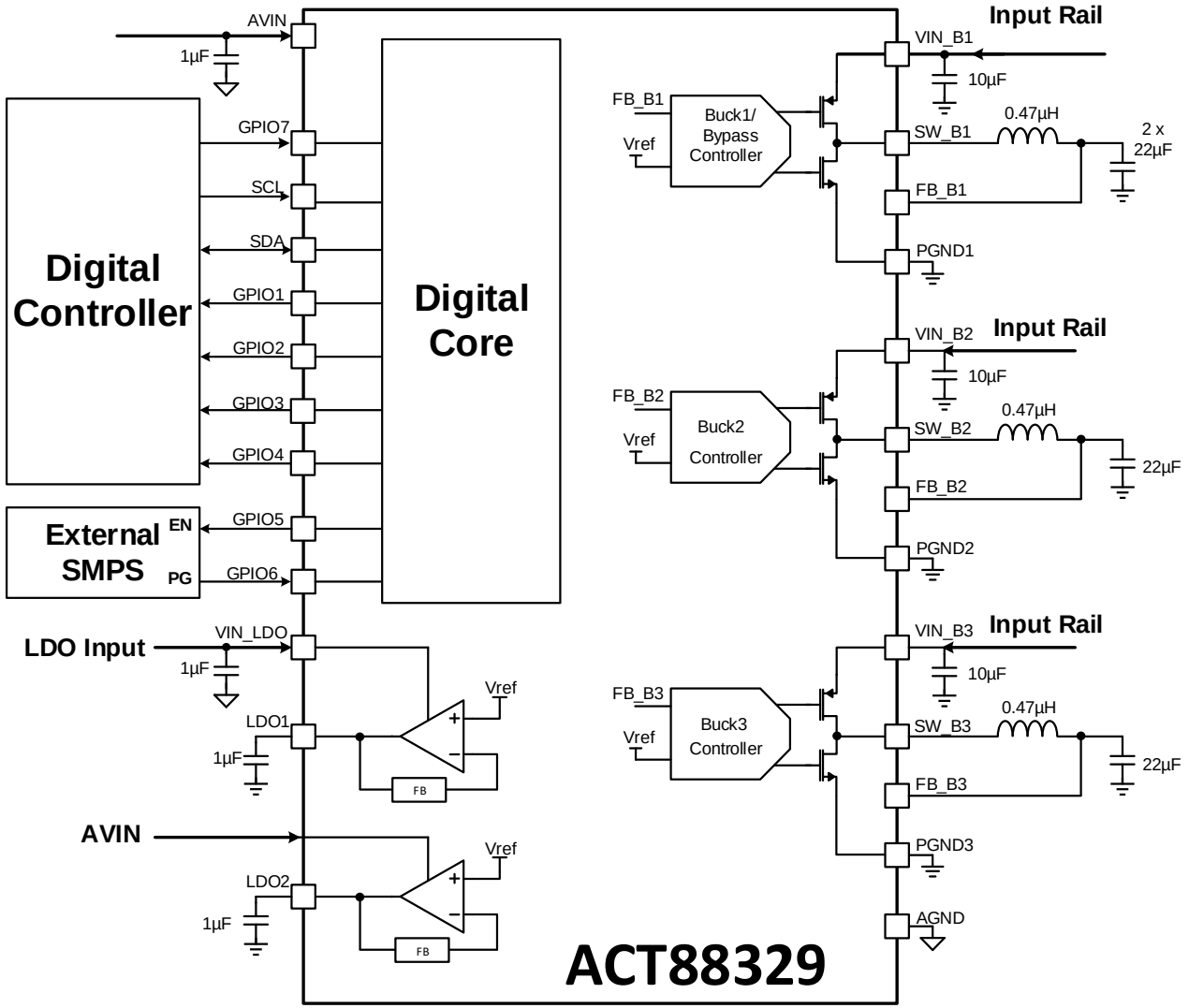
High System Configurability

- I²C Serial Interface for Monitoring and Control
- 7 GPIOs
- Interrupt Controller for Faults & Status Monitoring.
- Highly Configurable for Voltages, Power Sequencing (Up & Down) and GPIO Functionality.
- Multiple Sleep Modes
- 2.6mm x 2.2mm WLCSP Package

PMIC Size

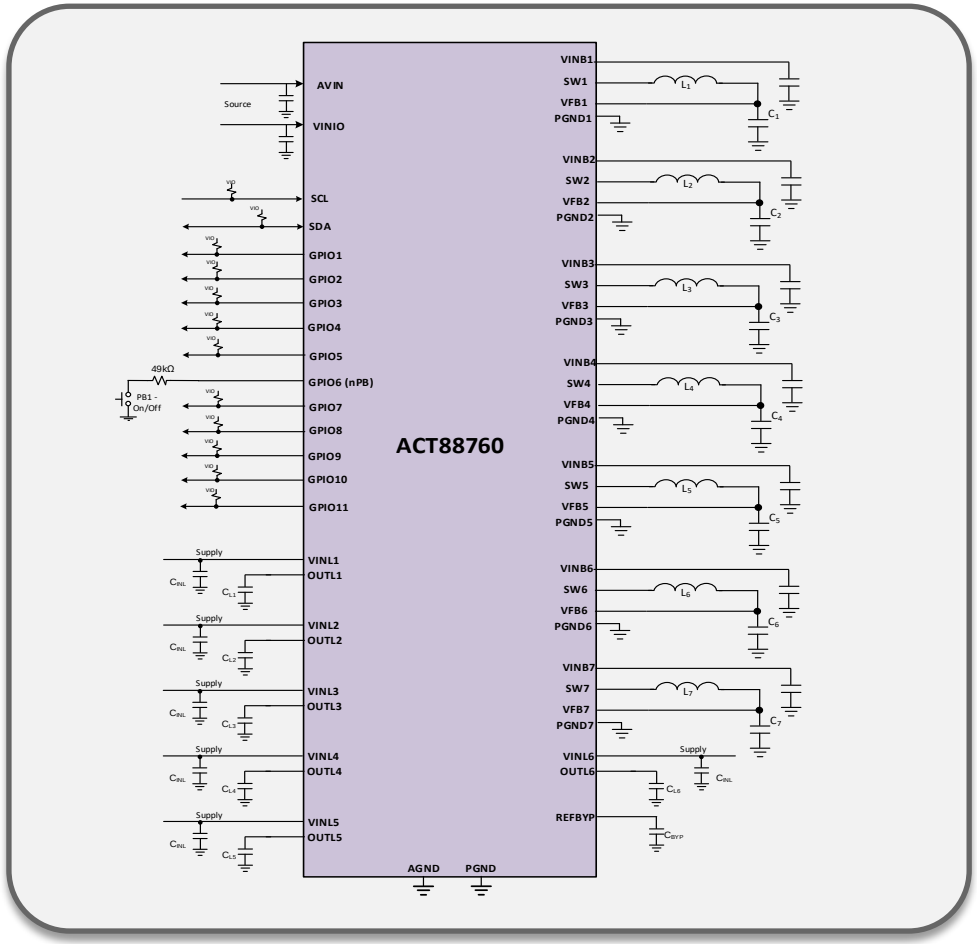


Application Block Diagram



ACT88760

High integrated PMIC for Video/AR/VR application



Wide input voltage range

- Vin= 2.7V to 5.5V

Complete integrated power solution

- 3×4A DC-DC step down (Buck) regulators
- 2×3A DC-DC step down (Buck) regulators
- 2×2A DC-DC step down (Buck) regulators
- Parallelable Bucks for high current
- 2×800 mA high PSRR LDOs
- 4×400 mA general purpose LDOs
- LDO load switch mode

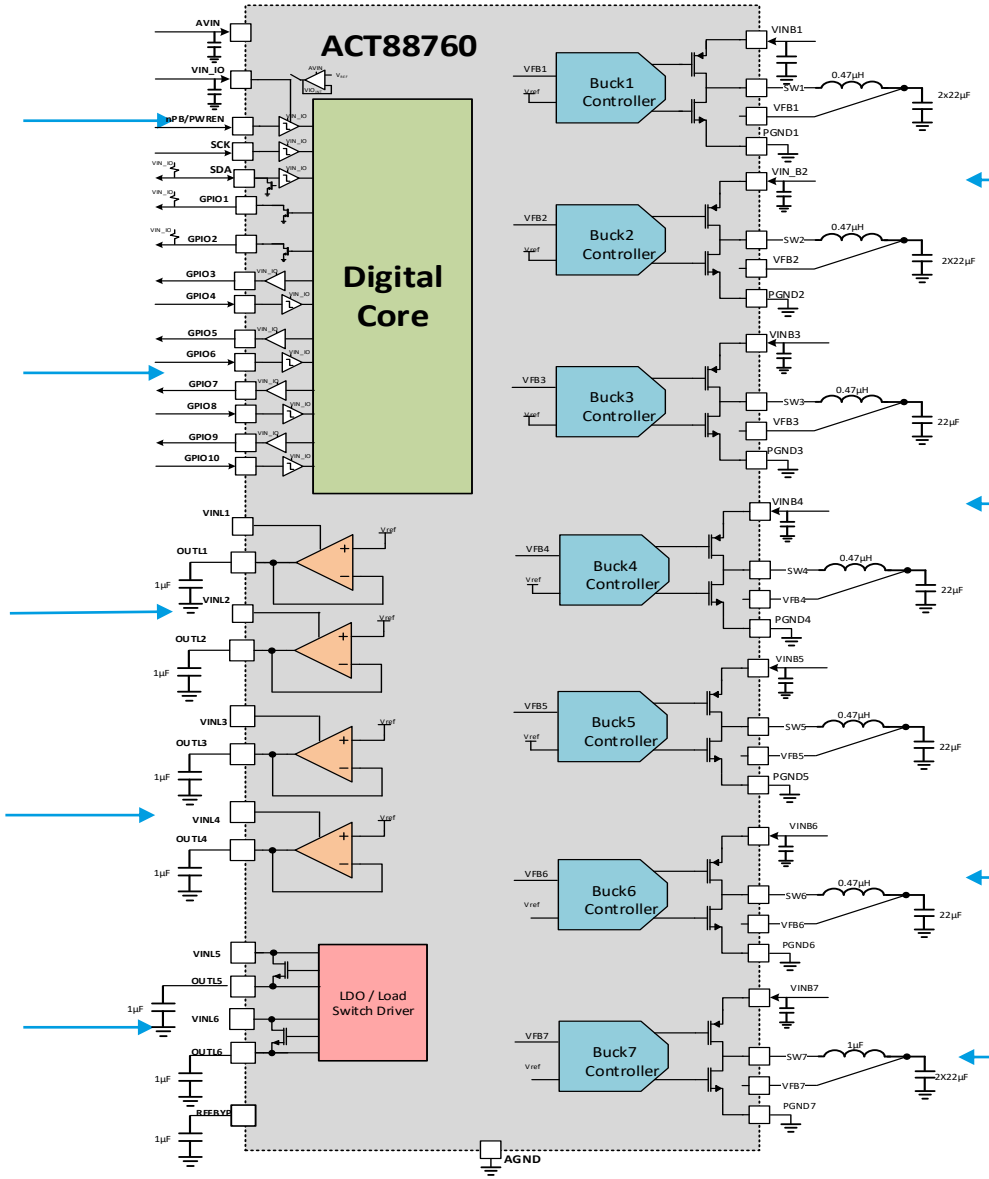
Space savings

- Fully integrated
- High Fsw = 1.125MHz to 2.25MHz
- Optimized for 0.47uH inductor

Easy system level design

- Configurable sequencing
- Multiple sleep modes and wake up triggers with GPIOs
- 11 programmable GPIOs

ACT88760 Functional Block Diagram



Push Button (nPB) / PWREN Function

10 GPIOs + I²C Bus

LDO 1, 2 (Up to 800mA)
High PSRR (> 70dB)

LDO 3, 4 (Up to 400mA)

LDO 5, 6 (Up to 400mA) or Load Switch 5 & 6 (Up to 1.5A)

2X4A Regulators. High efficiency with low VOUT (<1.0V). Up to 5A peak.
(Combined 2-phase up to 8A)

2X3A Regulators (up to 4A peak).
(Combined 2-phase up to 6A)

2X2A Regulators - General Purpose Regulators (up to 3A peak).

1X4A Regulators. High efficiency with low VOUT (<1.0V). Up to 5A peak.

ACT88760 Performance (compared to ACT8846)

Function	ACT88760	ACT8846
• Package	❑ 3.85mm x 3.85mm WLCSP	➢ 6mm x 6mm TQFN
• Voltage Range	❑ 2.6V – 5.8V	➢ 3.0V – 5.5V
• Total I_{OUT}	❑ Up to 25A (All Regs), High System Efficiency & longer battery life.	➢ Up to 10A (All Regs), Low System Efficiency and shorter battery life.
• # of Buck Regs	❑ 7	➢ 4
• # of LDO Regs	❑ 7 (Including 1.8V VIO)	➢ 9
• Buck LP Mode I_Q	❑ ~10 µA with advanced PFM and Fixed On-Time Operating Mode	➢ ~1000 µA
• 2-phase Option	❑ 2-phase Option Available for up to 8A output current.	➢ No

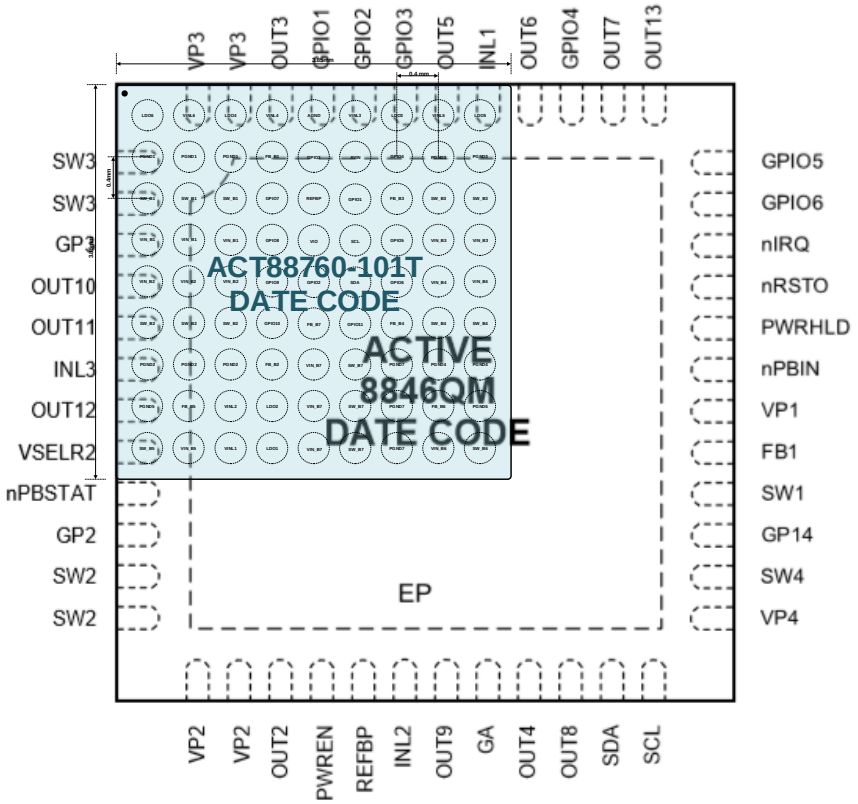
Performance / Parameter →	Availability		Efficiency Normal Mode (L_{DCR} = 15mΩ) (V_{IN} = 3.6V, V_{OUT} = 1.0V, I_{OUT} = 1.5A)		V_{OUT} Range & Max I_{OUT}		RDS_{ON} HS / LS (mΩ) (Drop Out for LDOs @ 0.15A)		Efficiency in LPM (L_{DCR} = 15mΩ) (V_{IN} = 3.6V, V_{OUT} = 1.0V, I_{OUT} = 1mA)	
Function	**ACT88760**	**ACT8846**	**ACT88760**	**ACT8846**	**ACT88760**	**ACT8846**	**ACT88760**	**ACT8846**	**ACT88760**	**ACT8846**
High Current Buck	**3 (BUCK1,2,7)**	- None -	~90%	--	0.5 – 3.6V, 4A	--	**30 / 12 mΩ**	--	**> 80%**	< 40%
Medium Current Bucks	**2 (BUCK3,4)**	2 (REG2,3)	~88%	~81%	0.5 – 3.6V, 3A	0.6 – 3.9V, 2.8A	**50 / 25 mΩ**	70 / 80 mΩ	**> 80%**	< 40%
Low Current Bucks	**2 (BUCK5,6)**	2 (REG1,4)	~85%	~78%	0.5 – 3.6V, 2A	0.6 – 3.9V, 1.5A	**80 / 35 mΩ**	110 / 80 mΩ	**> 80%**	< 40%
Low Input LDOs	**2 (LDO1,2)**	2			0.5 – 2.0V, 0.8A	0.6 – 3.9V, 0.15A	**150 mV**	200 mV		
Low Noise LDOs (HC)	**4 (LDO 3-6)**	5			0.5 – 3.6V, 0.4A	0.6 – 3.9V, 0.35A	**200mV**	280 mV		
Low Noise LDOs (LC)	**--**	1			0.5 – 3.6V, 0.4A	0.6 – 3.9V, 0.15A	--	280 mV		
LDO / LSW Option	**2 (LDO5,6)**	- None -			0.5 – 3.6V, 1.5A	--	**< 25 mΩ**	-None-		
GPIOs	**10**	7								
Always On LDOs / CC	**1**	2			1.8V, 50mA	1.2 – 3.9V, 50mA	--			--
On Sequence **Off Sequence** **Low Power Modes** **Watch Dog, Interrupts** **System, Fault Monitor** **I²C Bus** **Control Ext Regs** **nRESET Output** **PGOOD Output**	○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes**	○ **Yes** ○ **No** ○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes** ○ **Yes** ○ **No**								

ACT88760 Size (compared to ACT8846)

Function	ACT88760	ACT8846
• Package • Voltage Range • Total I_{OUT} • # of Buck Regs • # of LDO Regs • Buck LP Mode I_Q • 2-phase Option	❑ 3.85mm x 3.85mm WLCSP ❑ 2.6V – 5.8V ❑ Up to 25A (All Regs), High System Efficiency & longer battery life. ❑ 7 ❑ 7 (Including 1.8V VIO) ❑ ~10 µA with advanced PFM and Fixed On-Time Operating Mode ❑ 2-phase Option Available for up to 8A output current.	➢ 6mm x 6mm TQFN ➢ 3.0V – 5.5V ➢ Up to 10A (All Regs), Low System Efficiency and shorter battery life. ➢ 4 ➢ 9 ➢ ~1000 µA ➢ No

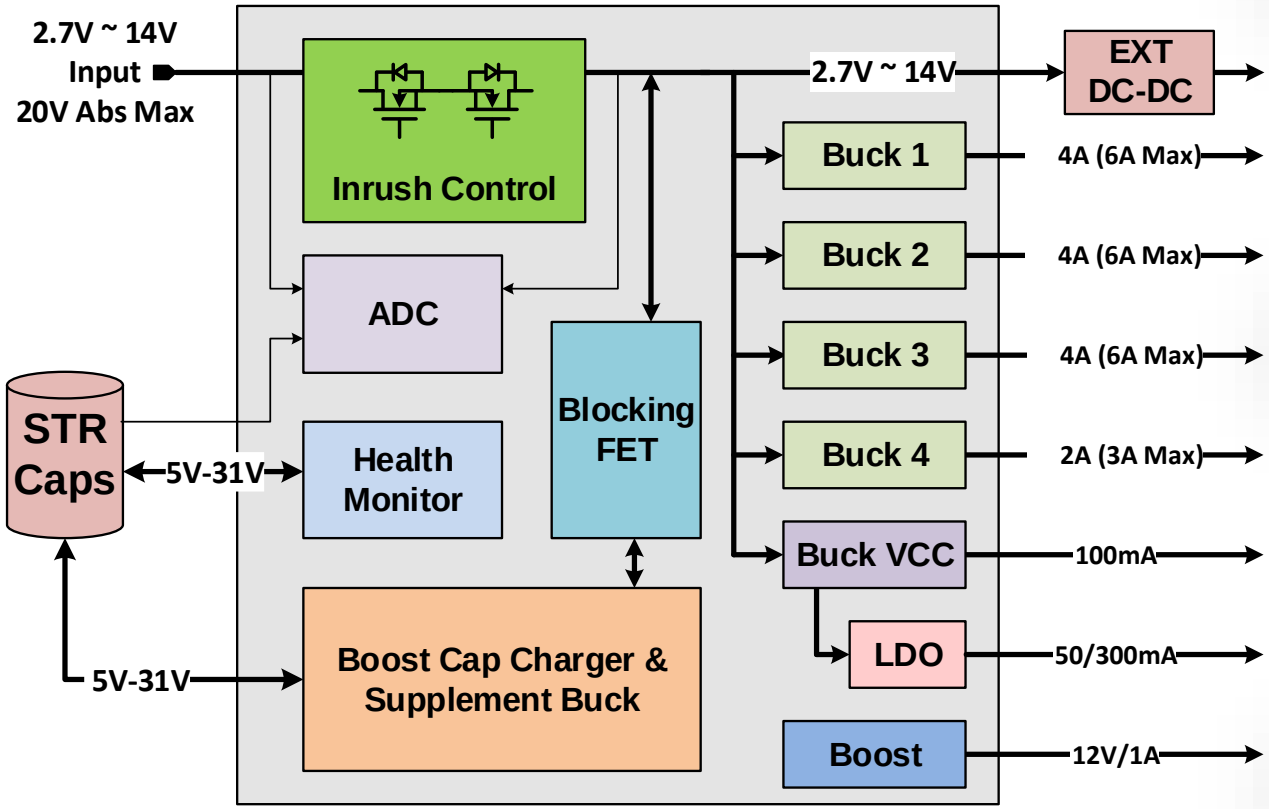
Package Size Comparison

- 6mm x 6mm QFN (ACT8846)
- 3.8mm x 3.8mm WLCSP (ACT88760)
- More than 50% size reduction.
- Significantly Higher Performance.



ACT85610

PLP+PMIC



High Voltage PLP

- 2.7V~14V Operation input with 20V Max Blocking
- Programmable input UV/OV/OC/SC & Inrush control
- Integrated low Rds(on) Back-to-Back FETs
- 5V~31V Boost Cap Charger
- 31V/8A Synchronous High Efficiency Buck

High Voltage PMIC

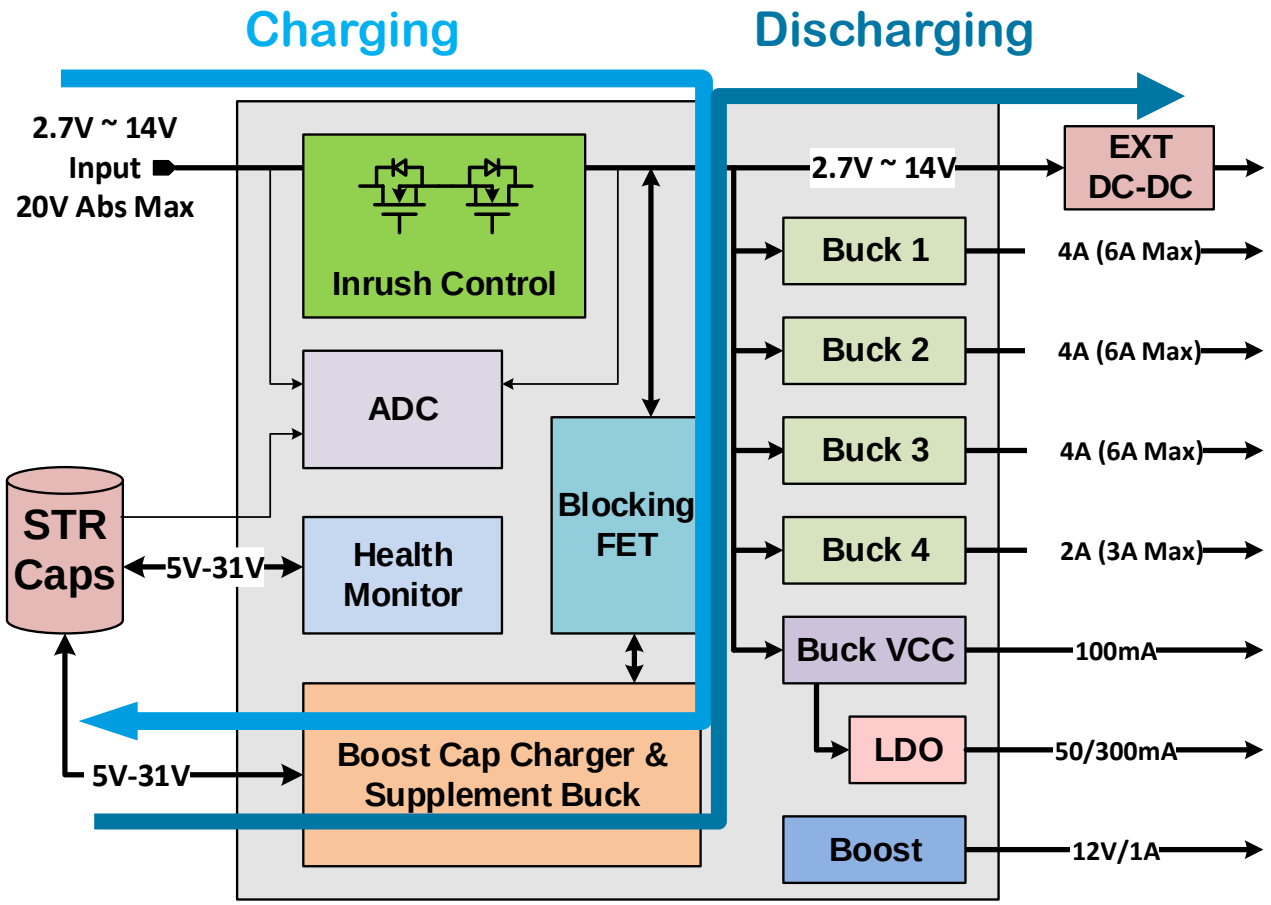
- 3×4A(6A peak) Bucks with 28/16 mΩ FETs
- 1×2A(3A peak) Buck with 60/30 mΩ FETs
- 1×12V/1A Boost
- 1×100mA Buck Vcc
- 1×300/50mA LDO
- COT Based Control for High Efficiency & Fast Transient

High Configurability

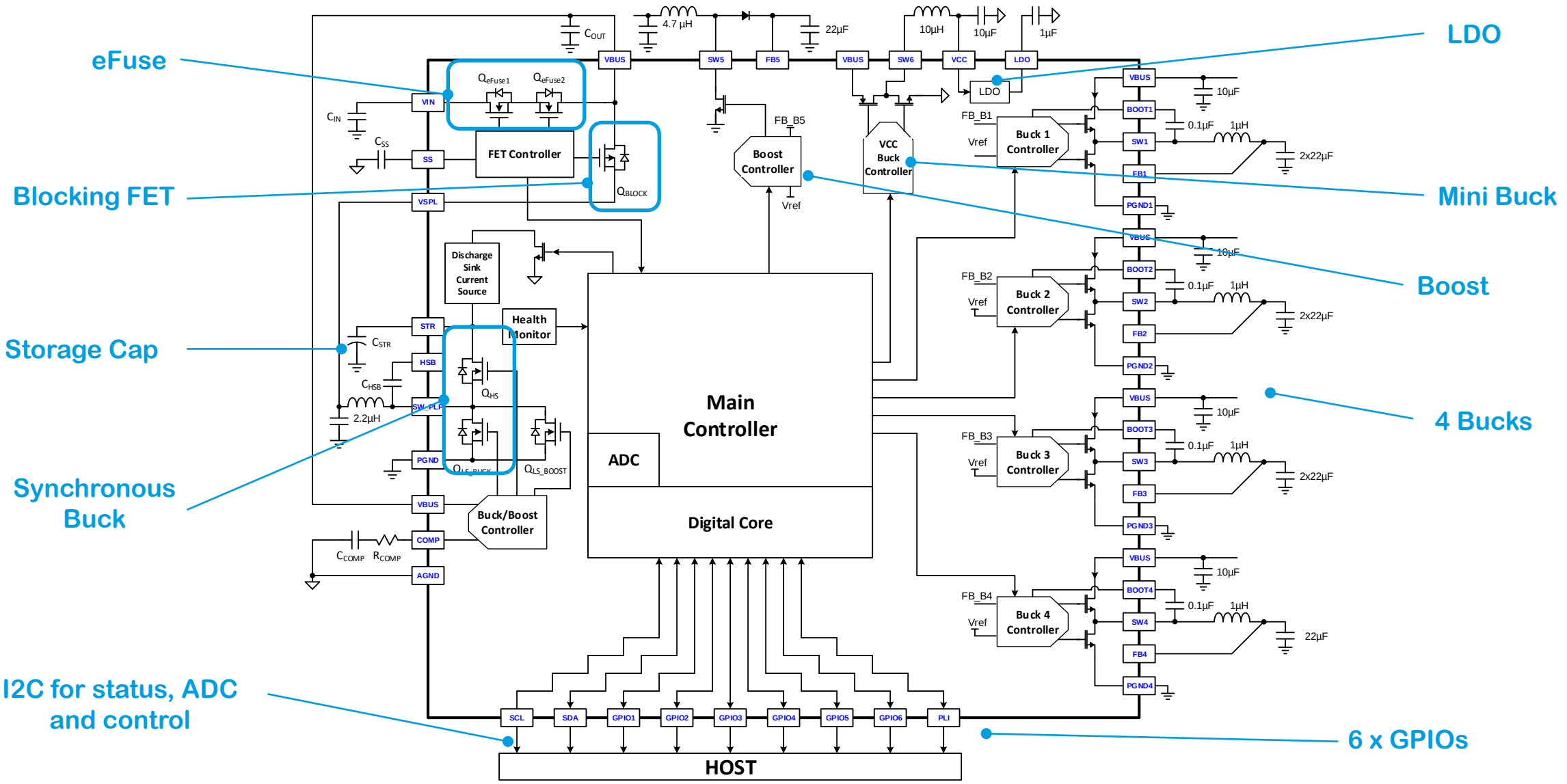
- 6 Configurable GPIOs
- 12 Bit ADC for System Monitoring
- Autonomously Monitor Cap Capacitance & ESR
- 6×6 mm 52 Pins FCOL QFN Package

ACT85610

PLP+PMIC

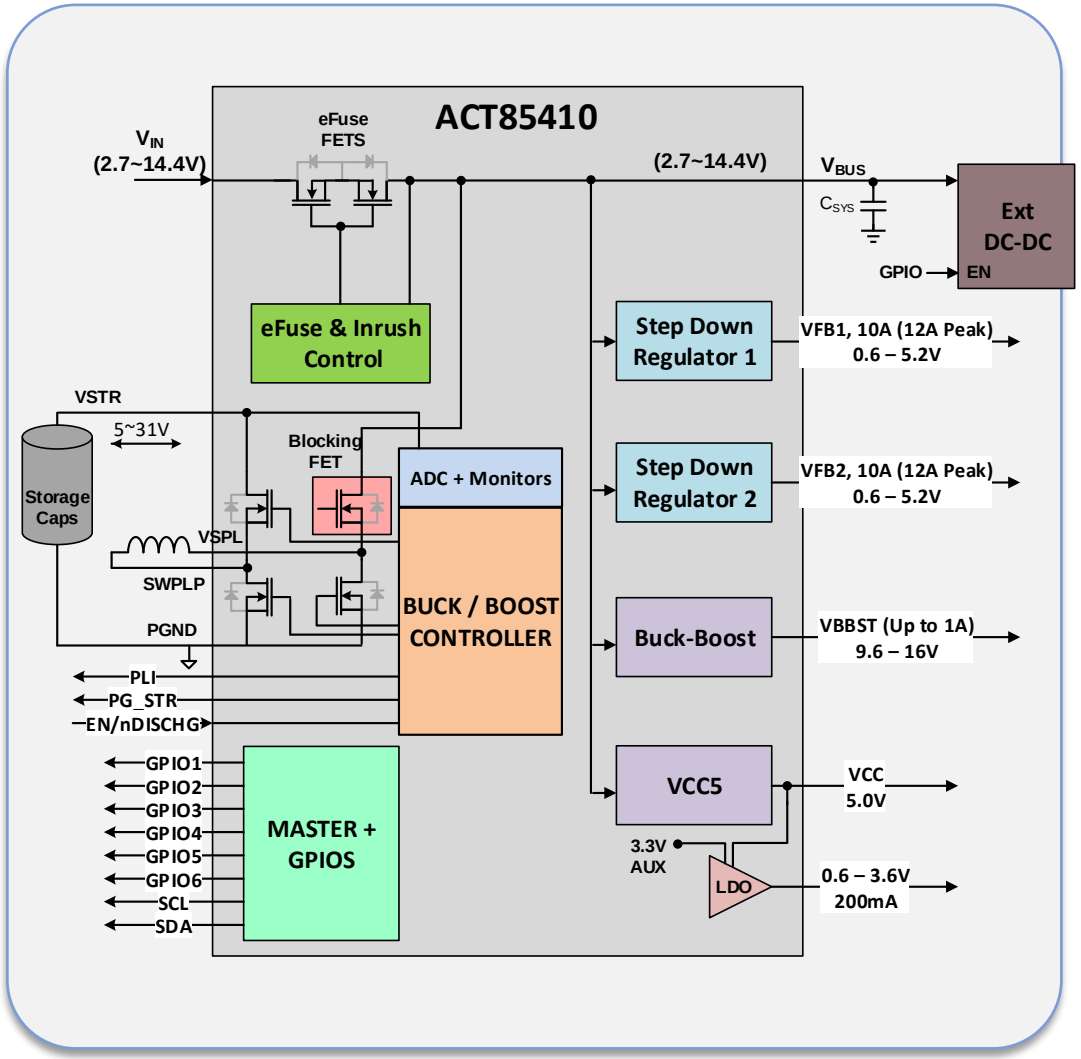


Application Block Diagram



ACT85410

High Integration PMIC with 0.5V Regulators



High Integration PLP + Power Management

- 2.7V ~ 14.8V Input Voltage Range (V_{SYS})
- eFuse with programmable current limit, 17mΩ R_{ON}
- **Inrush Control with Configurable Soft Start Ramp**
- **Boost Storage with disconnect FET, Top Off Mode**
- **6A High Efficiency PLP Buck with programmable V_{OUT}.**
- **Autonomous Health Check and Configurable Power Loss Detect.**
- **Buck 1-2, 22mΩ HS FET and 8mΩ LS FET R_{ON}**
- BUCK1-2 High Efficiency Regulators, up to 12A peak current.
- 200mA LDO, with Selectable Dual Input Power Source.
- 1A Buck-Boost Regulator with “Buck-Only” Mode.

High System Configurability

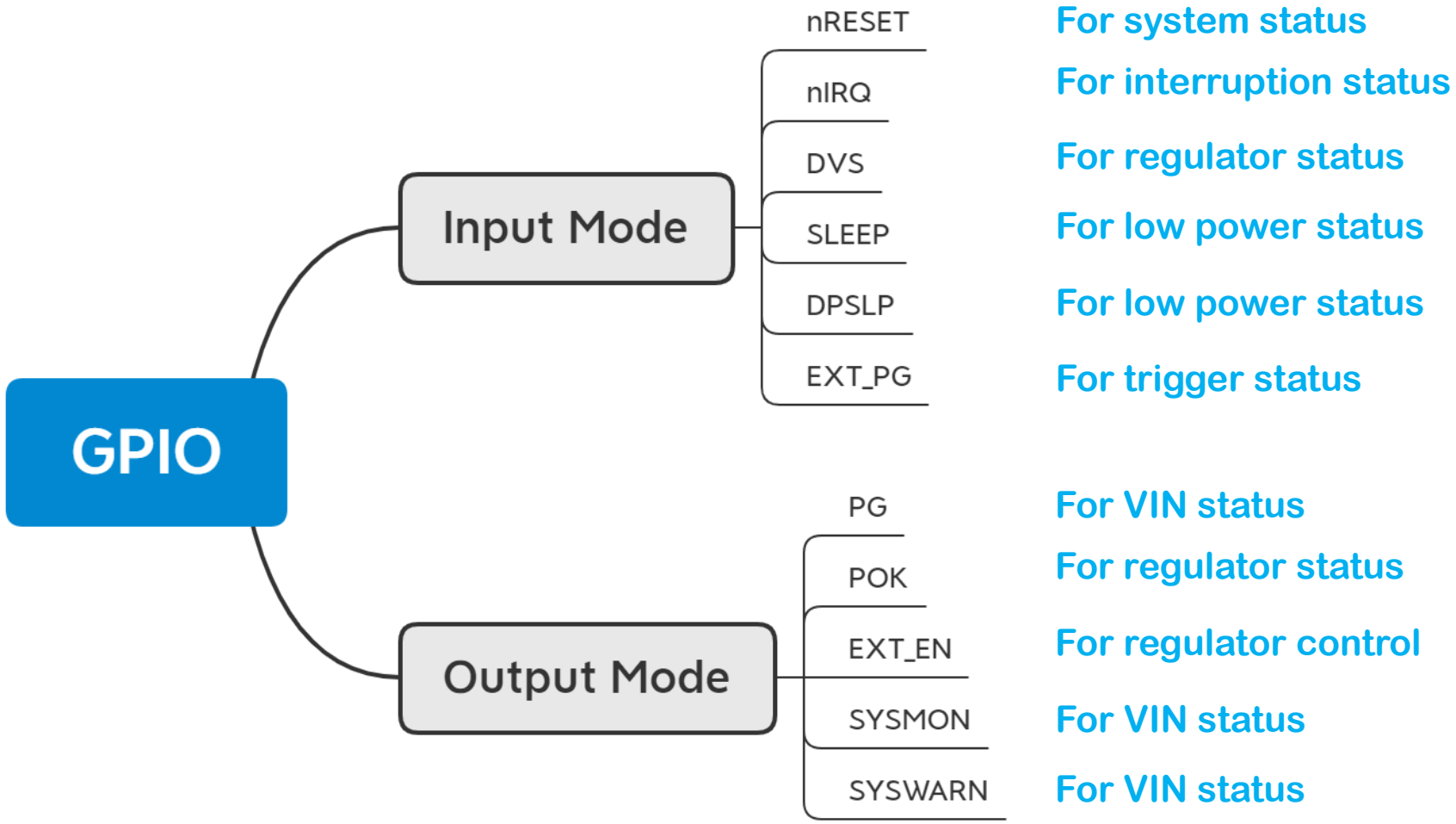
- **I^2C Serial Interface for Monitoring and Control**
- Fully sequenced regulators, GPIOs to sequence Ext Regs.
- 5.0V Generation with “Mini-Buck” used in System & PMIC.
- System Monitors, System Reset Int, Fault Detection, PLP Health Check, VAUX Detection, Input Current and Voltage
- 9x GPIOs, Interrupt Controller, Multiple Sleep Modes
- 6mm x 6mm FCOL 52 QFN Package, Compatible with Standard PTH PCB Board

Configurability

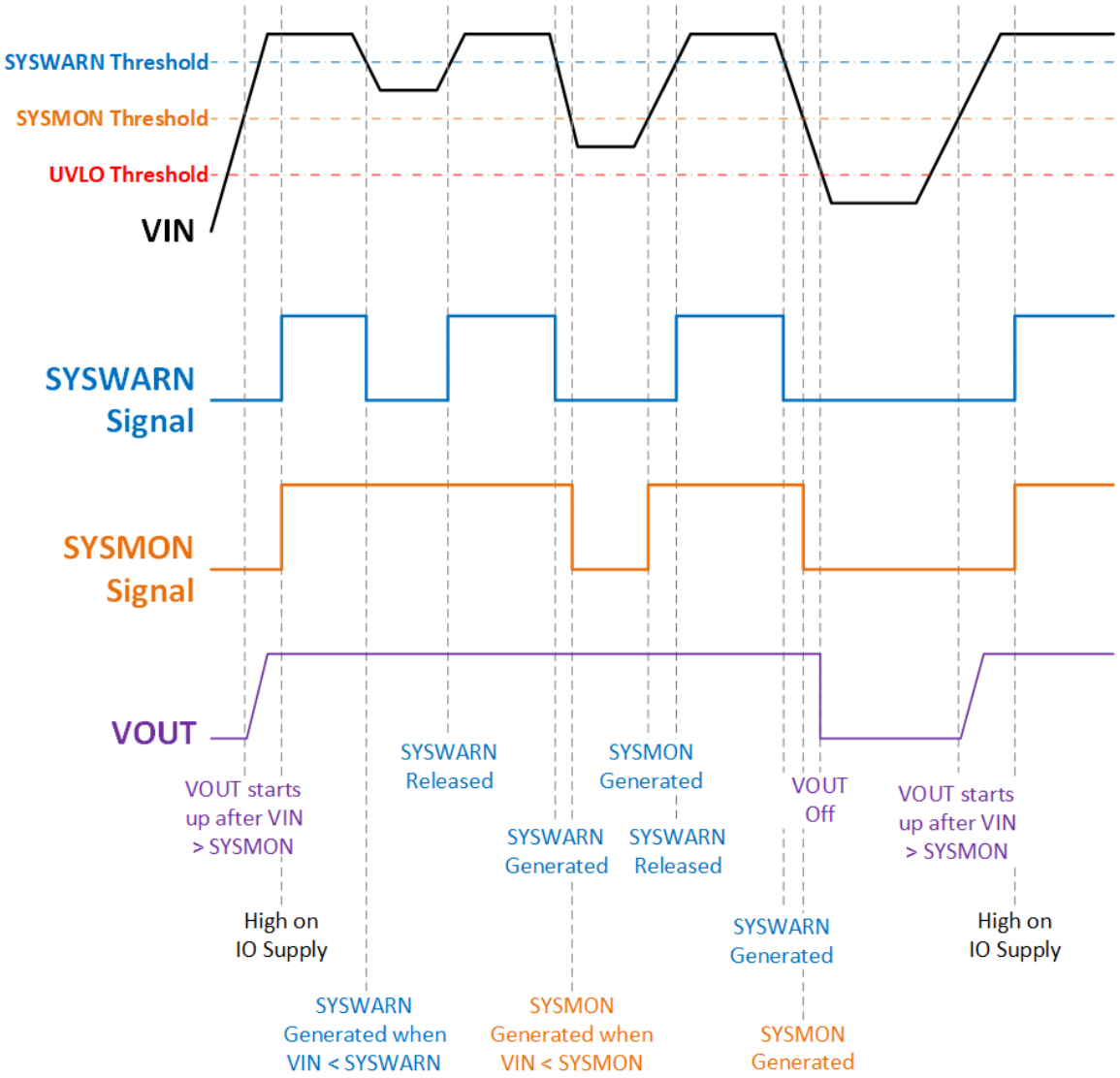
Features

Parameters	Qorvo PMIC	Note
Minimum Output Voltage	Lower to 0.5V	Can support low output applications like LPDDR5.
Control Type	Current Mode + COT	Optimized for full-range output voltages, better efficiency and transient.
Ultra Low Quiescent Current Mode	Yes	Very good light load efficiency
Buck Output Inductor	Lower to 0.47uH	Can choose either smaller size or lower DCR inductors, with same output capacitors.
Load Switch Current from LDO	1A	High current capability
Load Switch Dedicated Input Pin	Yes	Allow load switch takes any input as long as within voltage limit.
Load Switch Minimum Operation Voltage	0.4V	Can support many rails inside system
Configurable GUI	Yes	Flexible to adjust function on board
Suitable PCB Board	PTH	Lower BOM cost
Programmable Input Voltage Monitoring	SYSWARN & SYSMON	Provide extra level input voltage monitoring, improve system safety
Package	2.6 * 2.2 mm WLCSP	Smaller solution size

Flexible Functions of GPIO



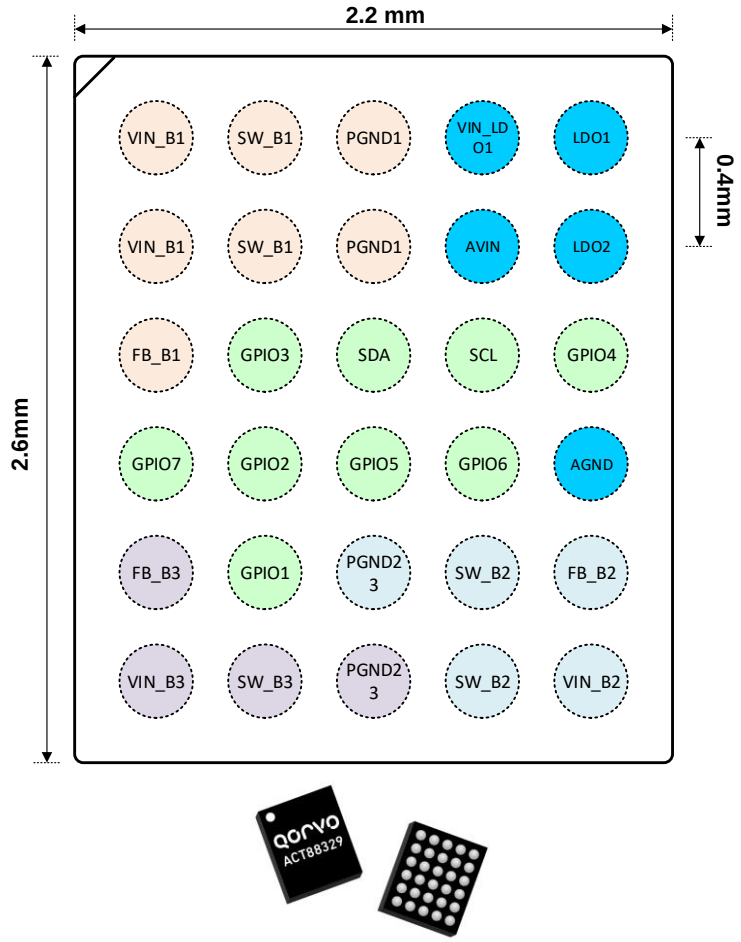
Two Level Input Voltage Monitoring



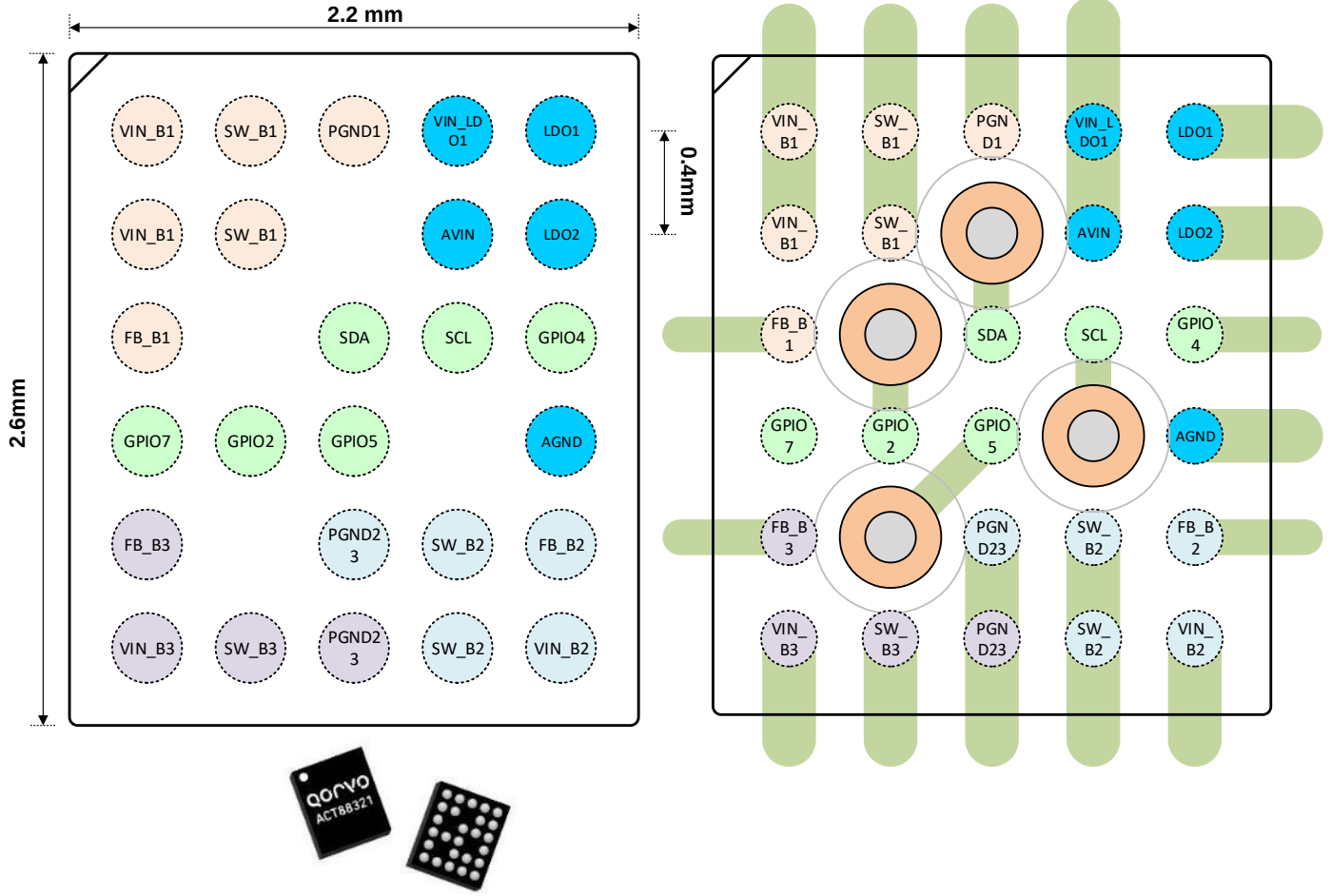
ACT88329 has a two-level input voltage monitor. When the input voltage drops below the programmable thresholds, warning signals will be generated and send to host through I^2C and GPIO output.

PTH PCB Compatible Option

4mil vias for HDI board



Removed 4 balls to fit in TH vias for PTH board



Register Map

Slave I2C Add	ADDR (HEX)	ADDR (DEC)	7	6	5	4	3	2	1	0
I2C ADD1 (option set by 0x16[7:6] of MSTR)	40	0	POK	OV	ILIM	ILIM_WARN	UV_FLTMSK	OV_FLTMSK	ILIM_FLTMSK	ILIM_WARN_FLTMSK
	41	1	FORCE_LPM_FONT	DIS_LPM_FONT	PULL_UP_GPIO2	DIS_PULLDOWN	PULL_UP_GPIO6	EN_MINPK_LPM	DRV_ADJ[1:0]	
	42	2	EN_OutPD	VSET0[6:0]						
		2_2	IPD_SET[0]	VSET2[6:0]						
	43	3	RFU	VSET1[6:0]						
		3_2	IPD_SET[1]	VSET3[6:0]						
	44	4	ON	PBINEN	QLTCH	SLEEP EN	AUXIN EN	DP SLEEP EN	ILIM_SET	FORCEPWM
	45	5	MODE	RST	DBQL			DBOK		
	46	6	DBON				SST	DISLPM	Vout_Range	RFU
	47	7	PULL_UP_GPIO11	PHASE	ON DELAY[2:0]			OFF DELAY[2:0]		
	48	8	TRIM HS ILIM[3:0]				TRIM ISNS[3:0]			
	49	9	TRIM_POK[2:0]			TRIM_ZC[4:0]				
	4A	10	ENMINPK	TRIM MINPK[1:0]		TRIM OUT				
	4B	11	TRIM MINSCL [3:0]				TRIM RI[2:0]			EN_HSILIM2
	4C	12	FREQ_SET[1:0]		TRIM SLOPECOMP[1:0]		TRIM SNSOFST[3:0]			
		12_2	EN_ILIM_FB	LS_ASYNC	EN_LSILIMFLT	EN_FET_DIV5	EN_TMIN	OPT_DT	DT_H2L	DT_L2H
	4D	13	ADJ_RCOMP[2:0]			EN_MTP	LP_MODE	AdjTFONT	LS_ASYNC_LPM	TRIM_ZC[5]
		13_2	RFU	RFU	RFU	EN_MINOFF	Opt_Clkgaetz	ILIMSD_opt	OPT_CLKDL	EN_COMPRS15n
	4E	14	LPM_LOWIQ	EN_VERR_CLPH	EN_LPM_FONT_ZC	LPM_FONT_HYS	TRIM_VOUT_LP[3:0]			
	4F	15	EN_LSILIM	TRIM_LSILIM[3:0]				TRIM_VOOV[2:0]		
	50	16	DVS_SET[1]	DVS_SET[0]	GEAM_2X[1:0]		on_delay_range_sel_B1	off_delay_range_sel_B1	MUX TILE ON to POK	EN_EALIQ
	5D	17	TM ANALOG	TMBRSTON	TMLSON	TMHSON	TM			
	5E	18	TMMinONBURST	TM Isense	TM FETdiv5	TM_MUX_VOUT	TM_VOUT_CLOOP	YFERASE	YFPROG	YFREAD
	5F	19	DMUX_DB_SEL[1:0]		RFU[5:2]				TM_DMUX_LTCH	nCLR_LTCH

Example:

Total 253 registers in ACT88760

Active CiPS™ Programming Tool

ActiveCiPS™ —Programing board CMI (Coding Matrix Information)

- **CMI (Coding Matrix Index) – Factory preconfigured default settings.**

These settings define the voltages, sequencing, low power modes, protection levels, etc..

If the system loses power, the PMIC goes back to its default settings (CMI).

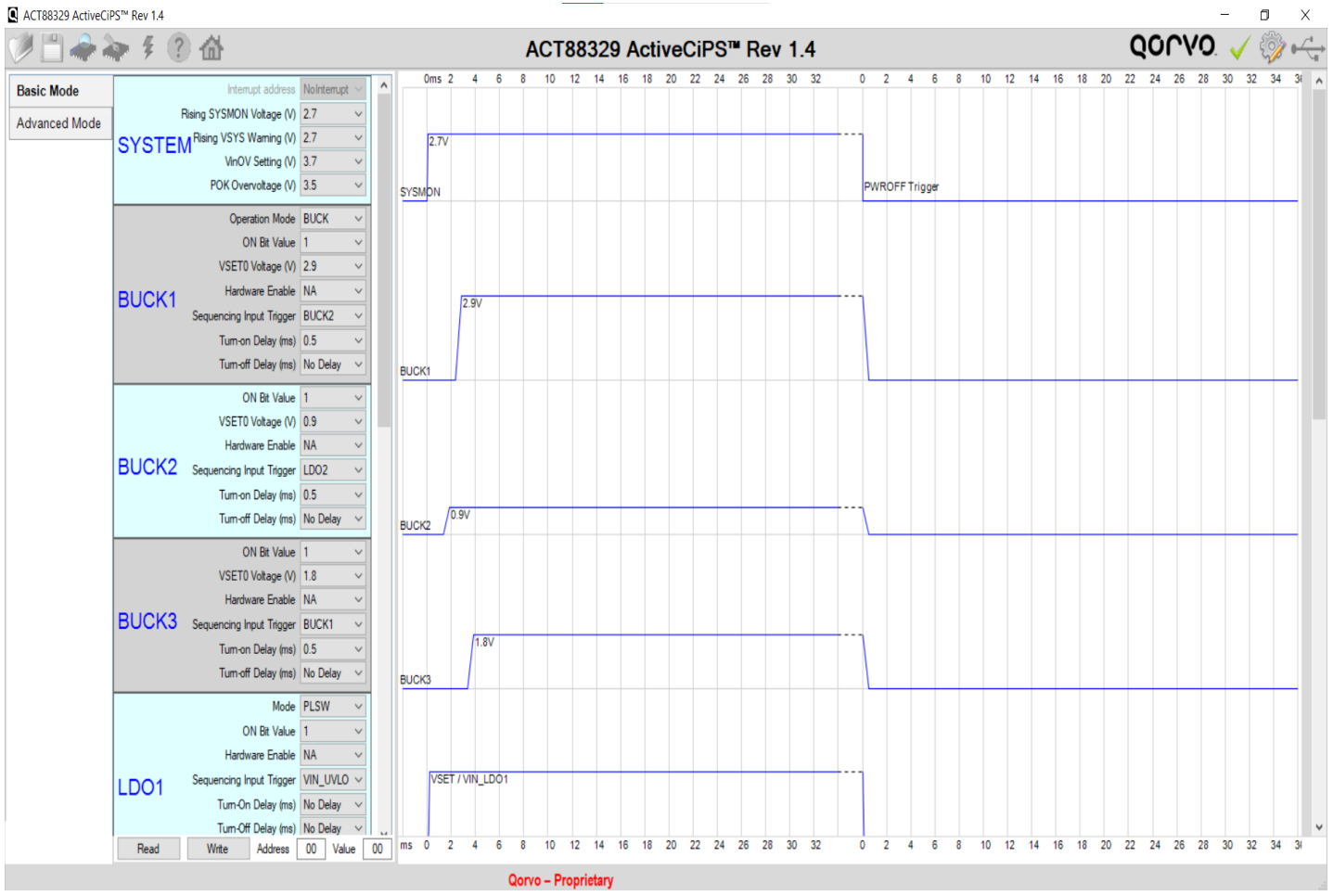
CMI #

The CMI settings are factory preconfigured and are stored in a nonvolatile section of the PMIC.

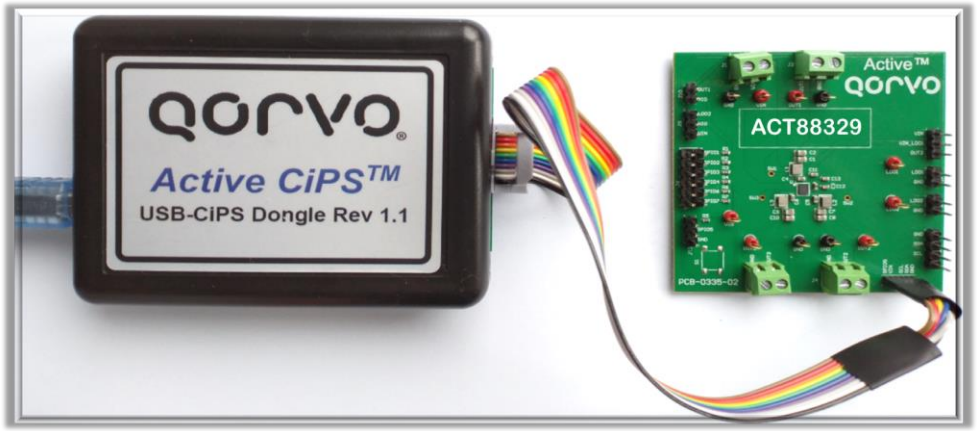
- **I2C Setting - After power is applied to the system, customer can make many changes to the settings .**

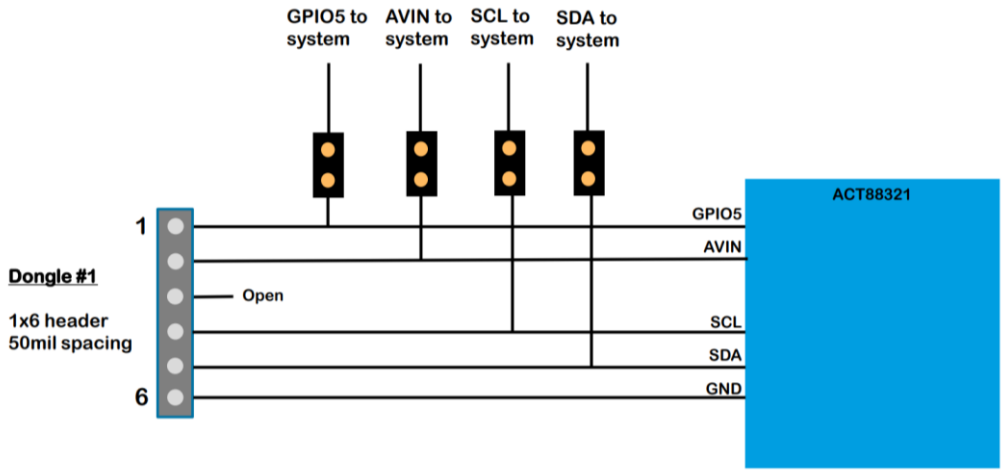
Supported with the ActiveCiPS™ Dongle and GUI

ActiveCiPS™ Dongle enables you to debug your design and change the PMIC default settings on the spot.



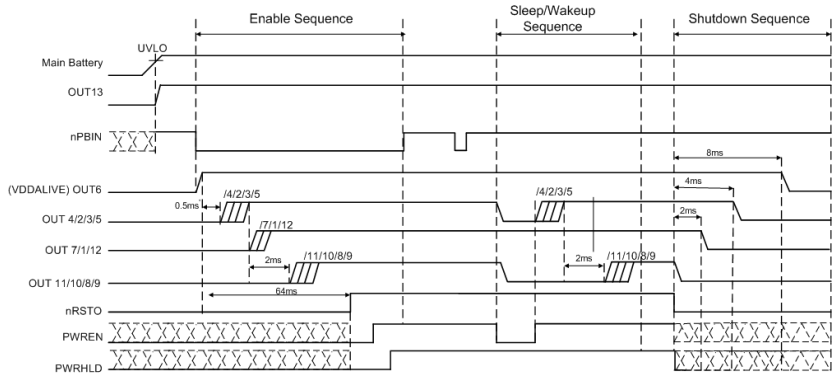
ActiveCiPS™ Dongle **EVK/Customer PCB**



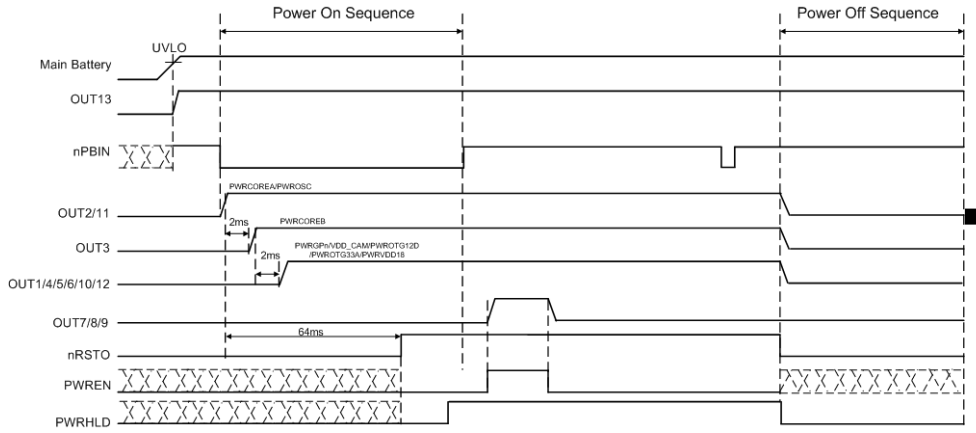


CiPS™ – Quick Customization

Optimized solutions specific to your system => shorten your development time



Original Configuration



New Customized Configuration

2nd Week - Samples Ready!

1st Week- Develop New Configuration

Same PMIC used in different end application just by changing its configuration.