ANALOG DEVICES

AHEAD OF WHAT'S POSSIBLE™

ADI Power Solution

Sunny Yu

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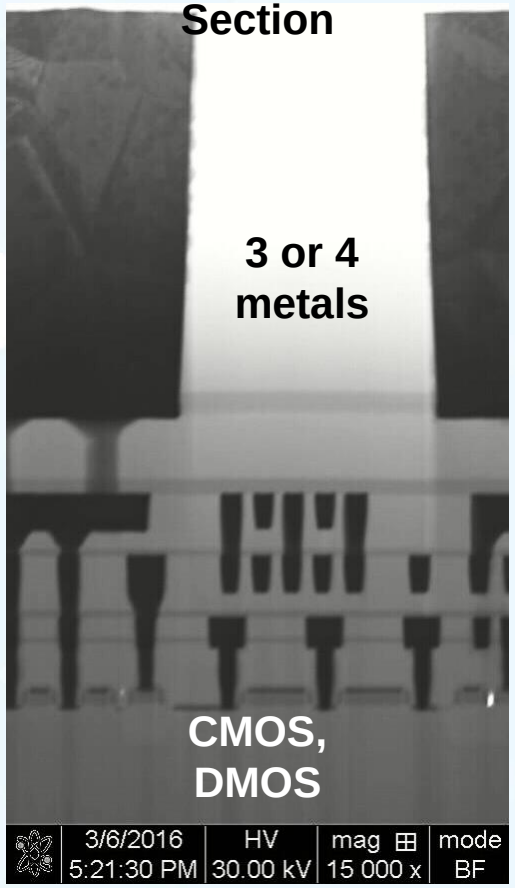
P90 brief introduction

What is P90?

P90 is ADI's high volume advanced power platform technology

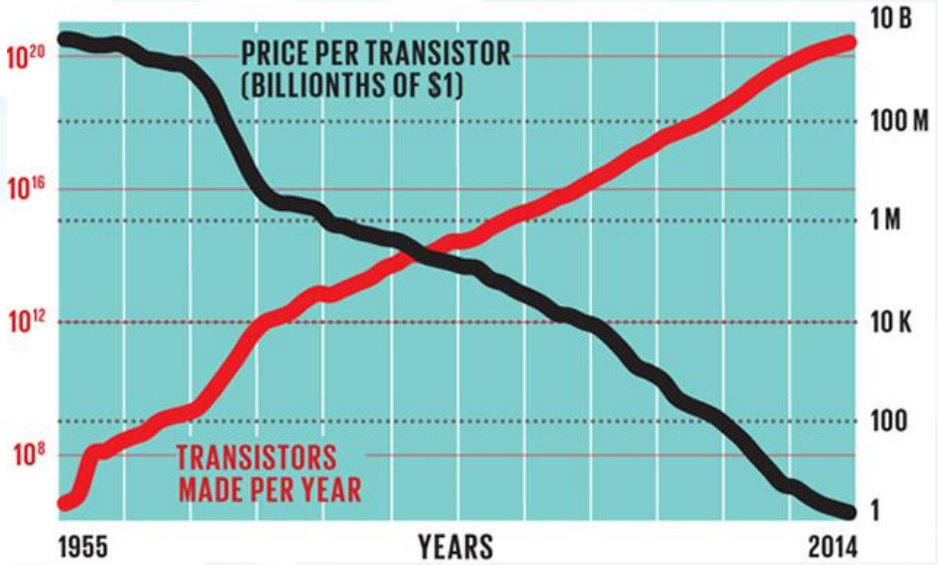
- 5V-80V Industry leading RA density for high efficiency & low cost
  - RA density is resistance* area of a transistor → lower is better
- Low wafer cost: 30% fewer masks than S90 and 10% less than S18
- 1.8V and 5V CMOS for logic and analog
  - Option to run CMOS at 1.2V
- MTP 32KB (Byte) integrated flash memory
  - MTP = Multi-Time Programmable Nonvolatile Memory
- Copper interconnect for high density, lower resistance and higher EM limits

P90 Cross Section



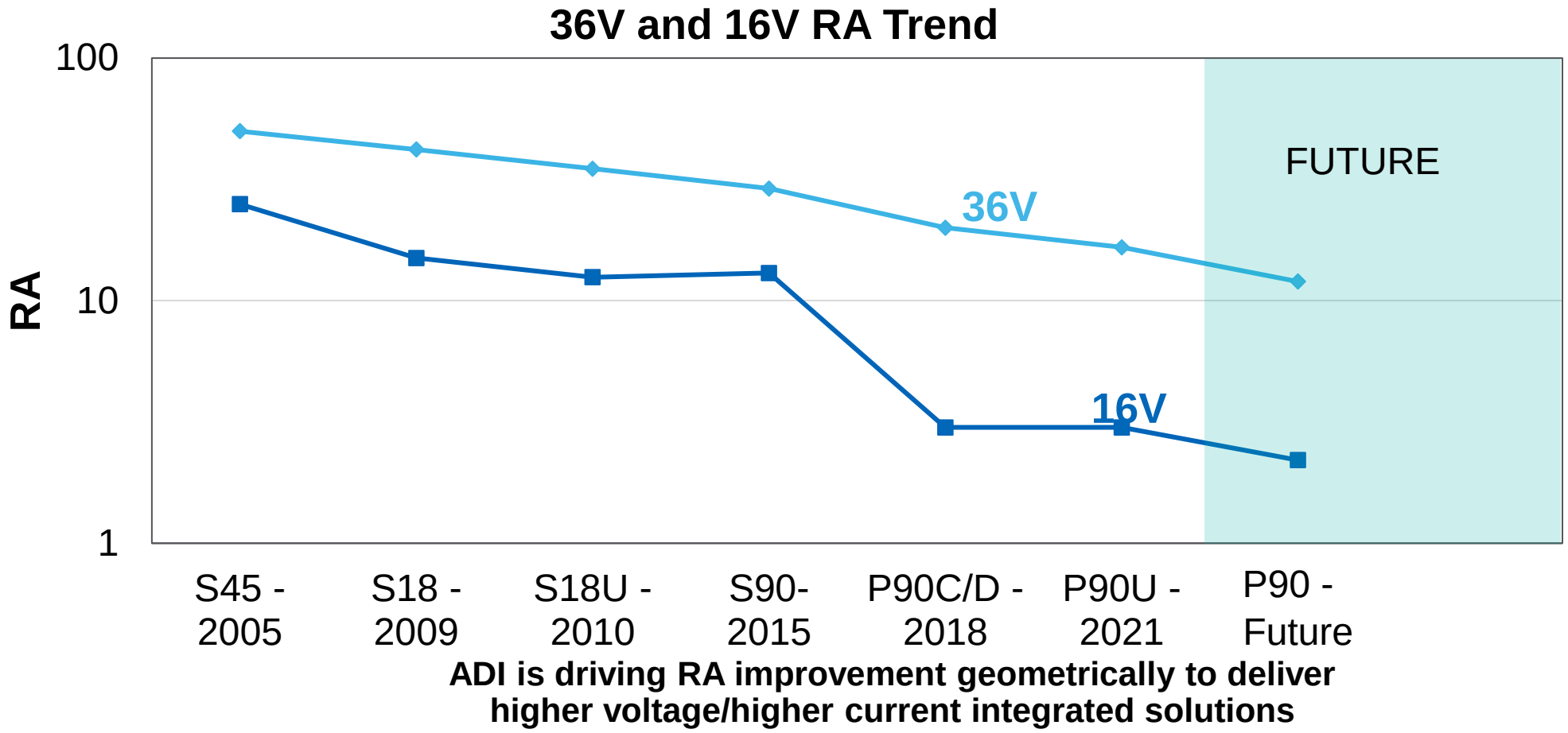
Moore’s Law Cost Benefit

- Moore's Law states that the number of transistors on a microchip doubles about every two years, though the cost of computers is halved.
- Leading to dramatically lower cost per transistor
  - Or more transistors for the same price
- Power technology has been advancing at a slower but still geometric rate
- In 2021 logic is at the 5nm node at ~0.7V operation
  - **ADI is running P90 with 5V-80V operation**



Source: http://www.semiconductorscentral.com/moores_law.html

Moore’s Law at ADI-Maxim: DMOS RA Scaling



P90 DMOS Core Concepts, Quality and Manufacturability

Best in Class RA Density
Solid leadership from 10V-36V
Among the best at 5V and 48-80V

2V Gate DMOS
Unified power supply with CMOS logic & analog
Low RA + low Qg & Qrr delivers leadership efficiency over the 5-80V range

Low Qg
Reduces switching losses at higher frequency

Low Qrr
Channel conducts at negative Vds
Reduces losses for higher voltage products

Copper interconnect
Lower resistance losses & higher EM limits
ILD tuned for high voltage

Unified PDK for all P90 Versions
Consistent design experience
Allows shared IP among all power BU teams

Design flow ensures quality
Automatic Design for Manufacturing
Quality Electrical Rule Checks

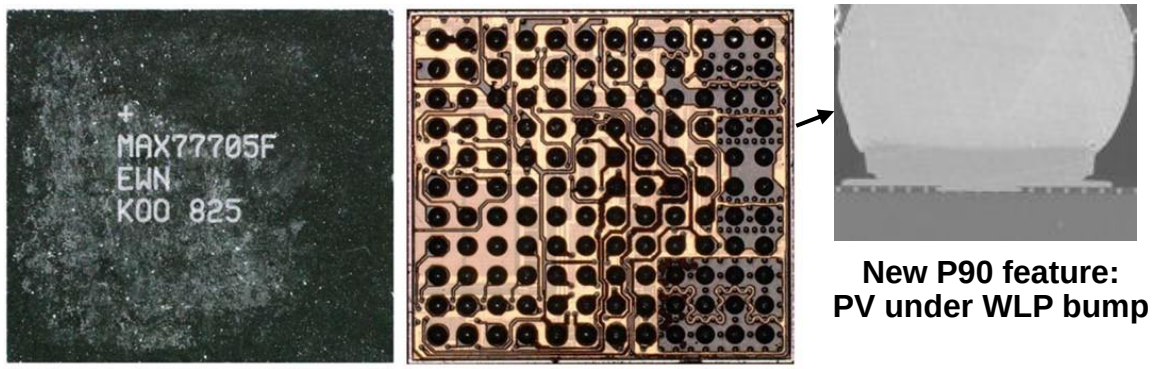
Focus on Quality Manufacturing
Well engineered modules

World Class Tool Set
Up to date 300mm fab partners

Manufacturing Track Record
Over 200M shipped with <<1PPM quality

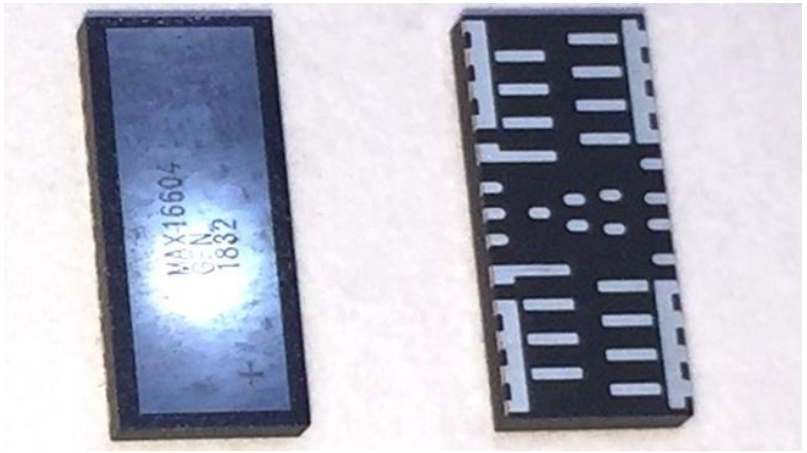
P90 Package Envelope: Flip Chip Options

MD05 WLP-ALP

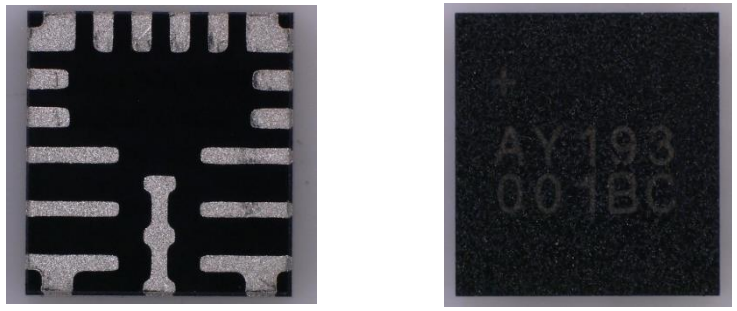


New P90 feature:
PV under WLP bump

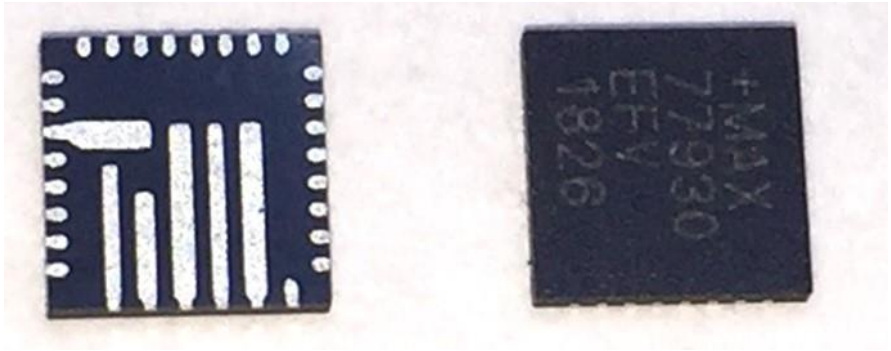
VT63 FC2QFN-1P2M Exposed Die with MIS Leadframe



AY19 FC2QFN-Direct Bump (1P1M)
Standard Etched Leadframe



BC52 FC2QFN-2P2M
Standard Etched Leadframe

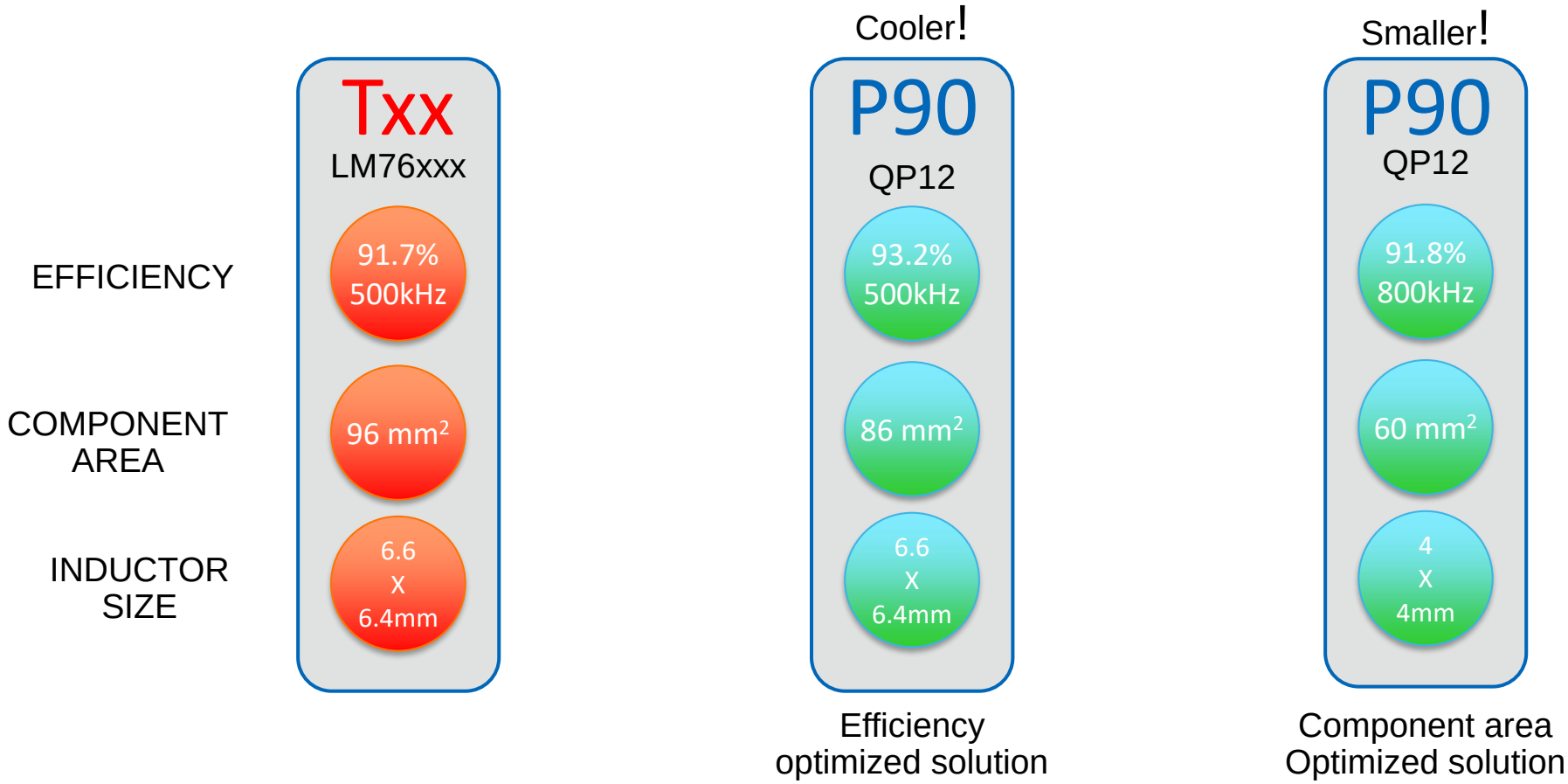


P90 Product Efficiency Record

Products which value efficiency can achieve significant improvement in P90

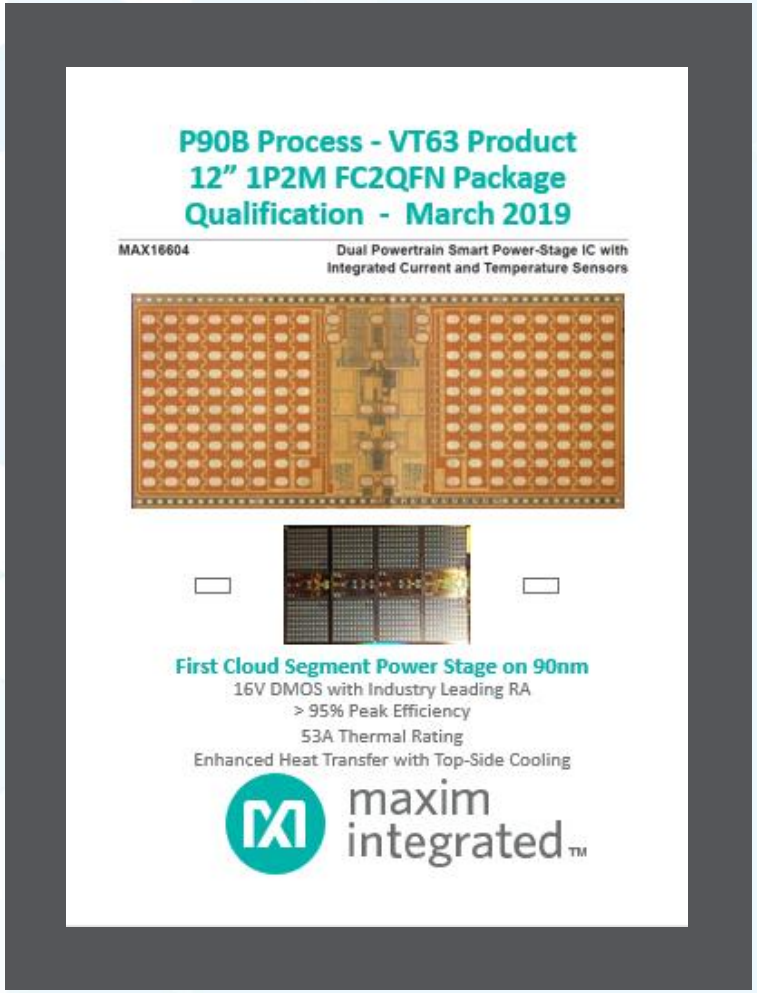
Product	Efficiency	Power Loss	Comments
MD05 14V	93% @3A vs CL65 88.8% 93% @3A vs CL33 91.7%	**37% lower** **16% lower**	MD05/P90 uses 14V MOV CL33/S90 uses 10V MOV
MD03 14V	94.3% vs PB56 92% peak at V_{IN} = 5-7V 93% vs PB56 88.2% peak at V_{IN}=12V	**30% lower** **40% lower**	22% die size reduction
VT63B vs VS83 16V	+ 0.35% peak (95.4 vs 95.0%) + 1.8% @25A/phase (93.1% vs 91.3%)	**8% lower** **21% lower**	
PI67 vs PI43 36V	+0.9% peak +0.5% at 2A	**12% lower** **5.4% lower**	22% die size reduction
AE01 vs AE04 36V	90.6% @8A vs AE04 84.8% @2.1MHz 3.3V_{OUT} 91.5% @8A vs AE04 88.1% @400KHz 3.3V_{OUT}	**38% lower** **29% lower**	15% die size reduction

The P90 Advantage, 60V 3.5A Buck

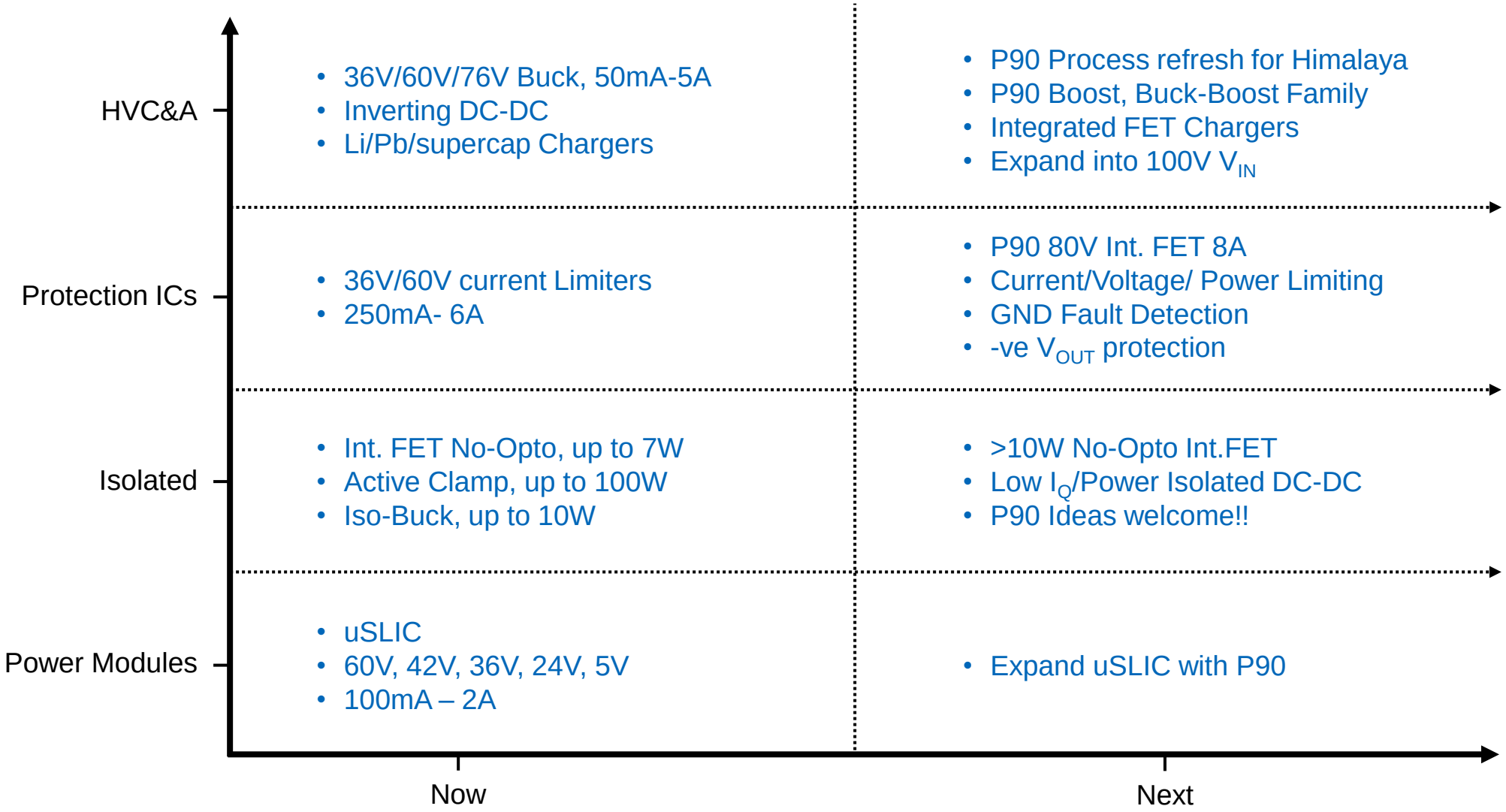


Delivering P90 Platform Technology into Use

- P90C qualification : Sep 2017 – Mobile PMIC with Flash
- P90B qualification: Mar 2019 – Cloud
- P90D qualification: Sep 2019 – 36V Auto/Industrial/Mobile
- P90U qual: SP50 7/2020; RX06 12/2020; BP30 8/2021
- P90CS qualification: anticipated in Dec 2021

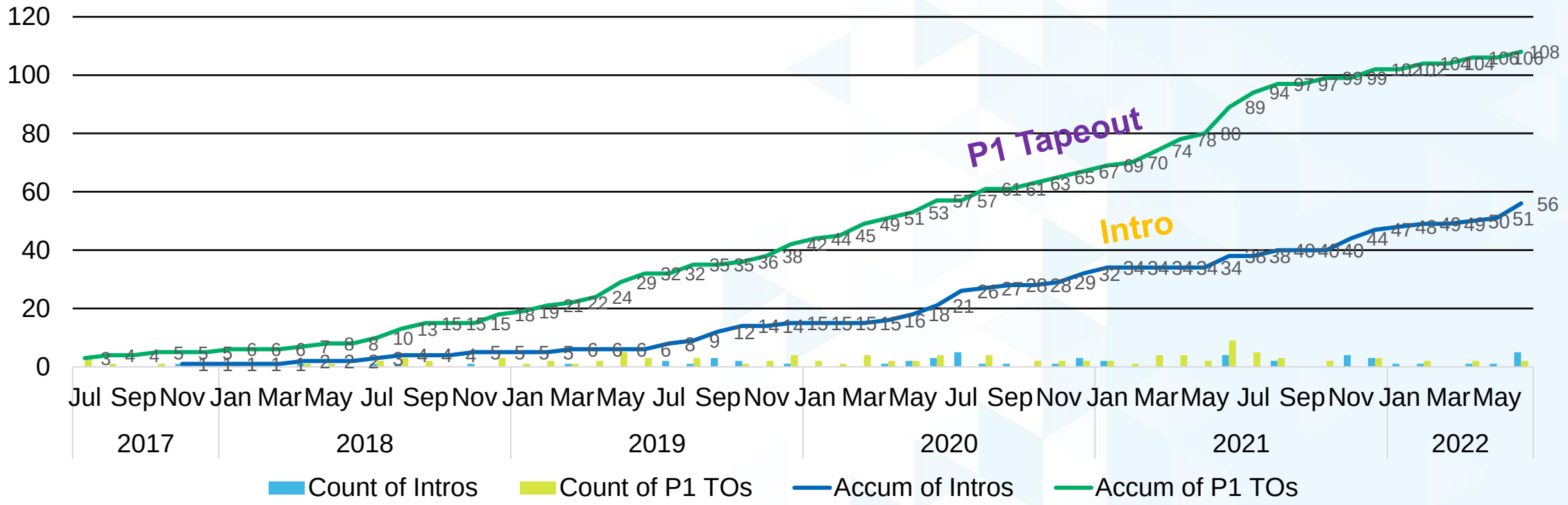


High Level Product & Technology Roadmap



P90 Product Ramp Up

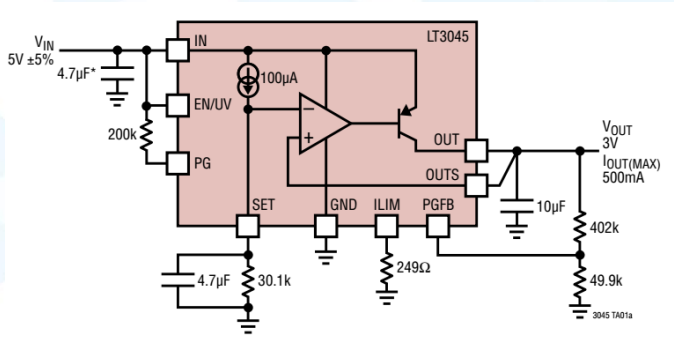
- Reached 89 P1 tapeouts in Jul 2021
- 38 products introduced

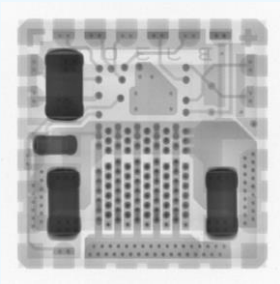


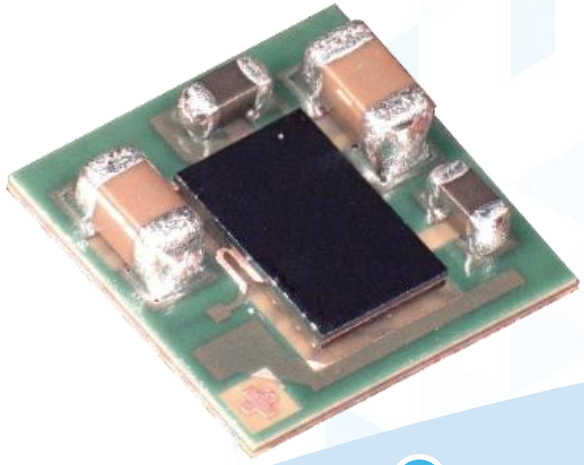
Silent Switcher 3

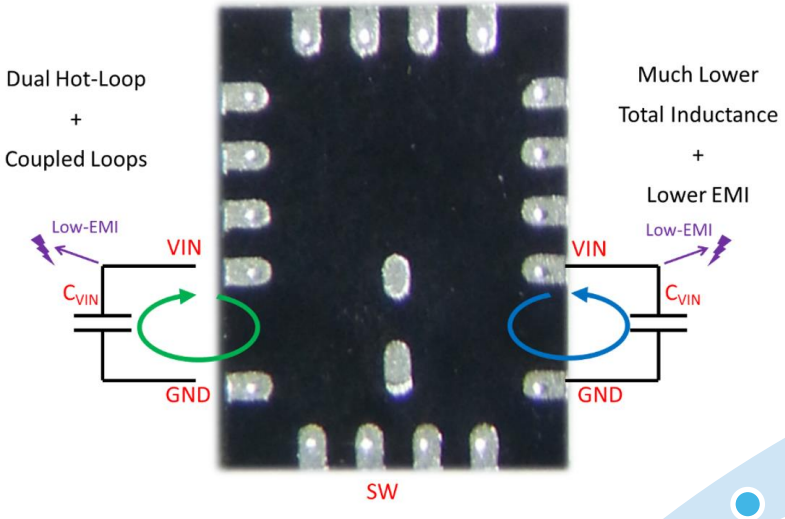
New Silent Switcher®3

- Exceptional EMI performance
- High Efficiency at High Switching Frequencies
- Easy PCB layout
- **Ultralow LF Noise (10Hz to 100kHz)**
- **Ultrafast Transient Response**









Silent Switcher 3: Ultralow Noise Introduction

- Why Silent Switcher 3?
  - Improve LF (10Hz-100kHz) noise performance of Silent Switcher
  - Applications that require low noise supplies are increasing to current levels where using LDO postfilters become impractical
- What applications/markets are targeted with this part?
  - RF Power Supplies (PLLs, VCOs, Mixers, LNAs, PAs, etc)
  - Low Noise Instrumentation
  - High Speed/High Precision ADCs/DACs

Best Low Noise LDO

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LT3045

20V, 500mA, Ultralow Noise, Ultrahigh PSRR Linear Regulator

FEATURES

- **Ultralow RMS Noise: 0.8μV_{RMS} (10Hz to 100kHz)**
- **Ultralow Spot Noise: 2nV/√Hz at 10kHz**
- **Ultrahigh PSRR: 76dB at 1MHz**
- **Output Current: 500mA**
- **Wide Input Voltage Range: 1.8V to 20V**
- **Single Capacitor Improves Noise and PSRR**
- **100μA SET Pin Current: ±1% Initial Accuracy**
- Single Resistor Programs Output Voltage
- High Bandwidth: 1MHz

DESCRIPTION

The LT®3045 is a high performance low dropout linear regulator featuring LTC's ultralow noise and ultrahigh PSRR architecture for powering noise sensitive applications. Designed as a precision current reference followed by a high performance voltage buffer, the LT3045 can be easily paralleled to further reduce noise, increase output current and spread heat on the PCB.

The device supplies 500mA at a typical 260mV dropout

Silent Switcher 3

ANALOG DEVICES | ADI Power by Linear™

LT8625S

18V/8A Step-Down Silent Switcher 3 with Ultralow Noise Reference

FEATURES

- **Silent Switcher®3 Architecture**
  - **Ultralow RMS Noise (10Hz to 100kHz): 4μV_{RMS}**
  - **Ultralow Spot Noise: 4nV/√Hz at 10kHz**
  - **Ultralow EMI Emissions on Any PCB**
  - **Internal Bypass Capacitors Reduce Radiated EMI**
- **High Efficiency at High Frequency**
- **Ultrafast Transient Response with High Gain Error Amplifier**
- **Input Voltage Range: 2.7V to 18V**

DESCRIPTION

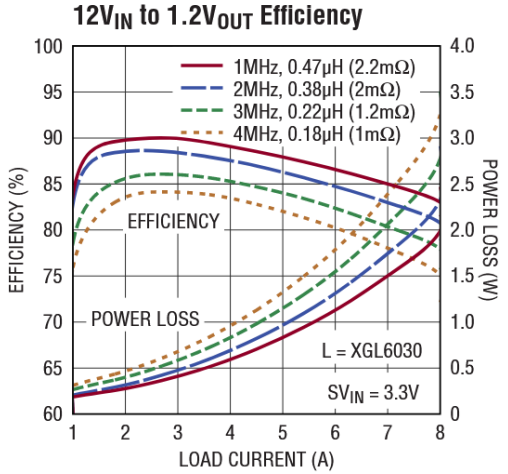
The LT®8625S synchronous step-down regulator features third-generation Silent Switcher technology which is uniquely designed to combine an ultralow noise reference with Silent Switcher architecture in order to achieve both high efficiency and excellent wideband noise performance.

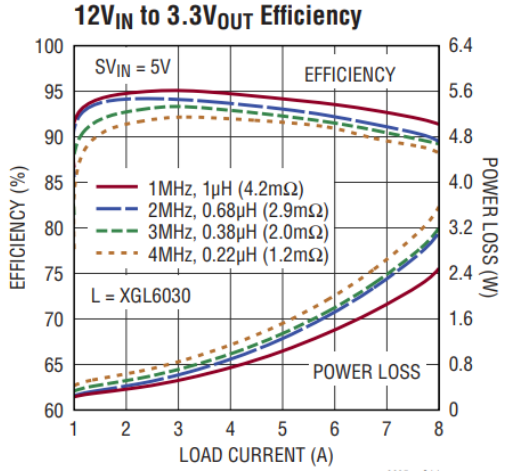
The innovative ultralow noise architecture provides exceptional low frequency (0.1Hz to 100kHz) output noise performance in a switching regulator. The output voltage can

LT8625X Silent Switcher 3 Feature Highlights

High Efficiency at High Frequency

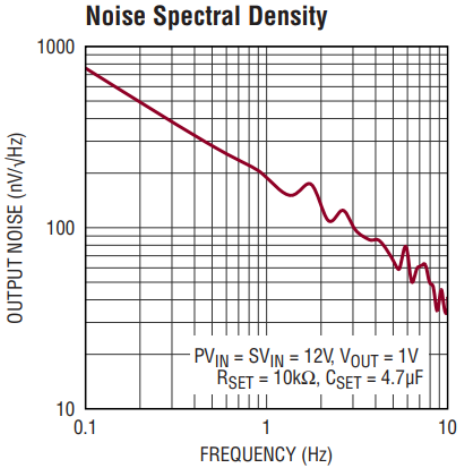
Next Gen Power FETs (Improved LT8642S)

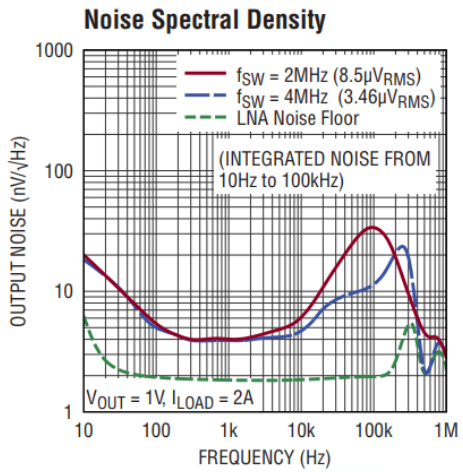




Ultralow LF Noise

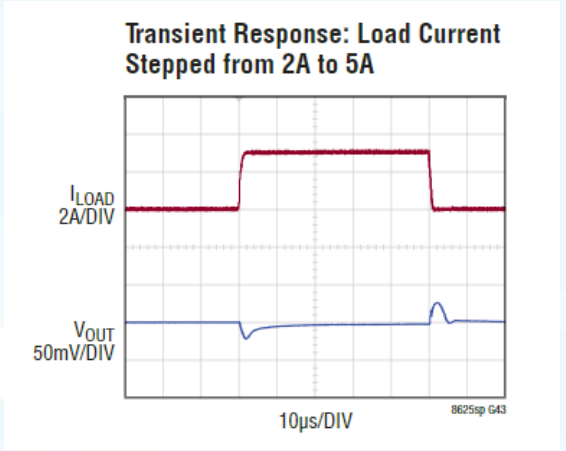
RMS Noise (10Hz to 100kHz): 3.5µV_{RMS}
Spot Noise: 4nV/√Hz at 10kHz

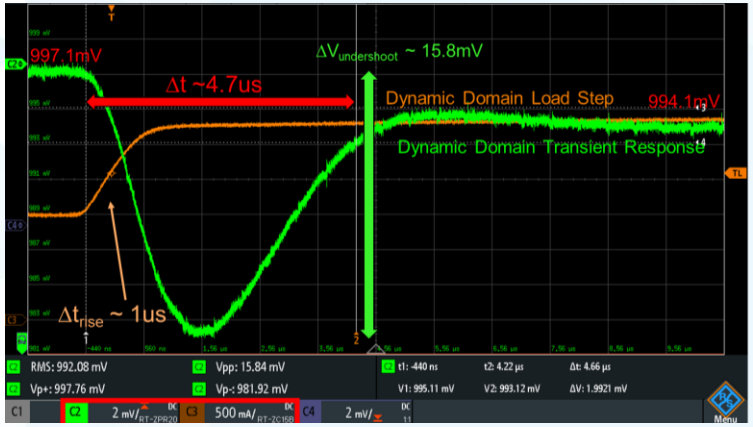




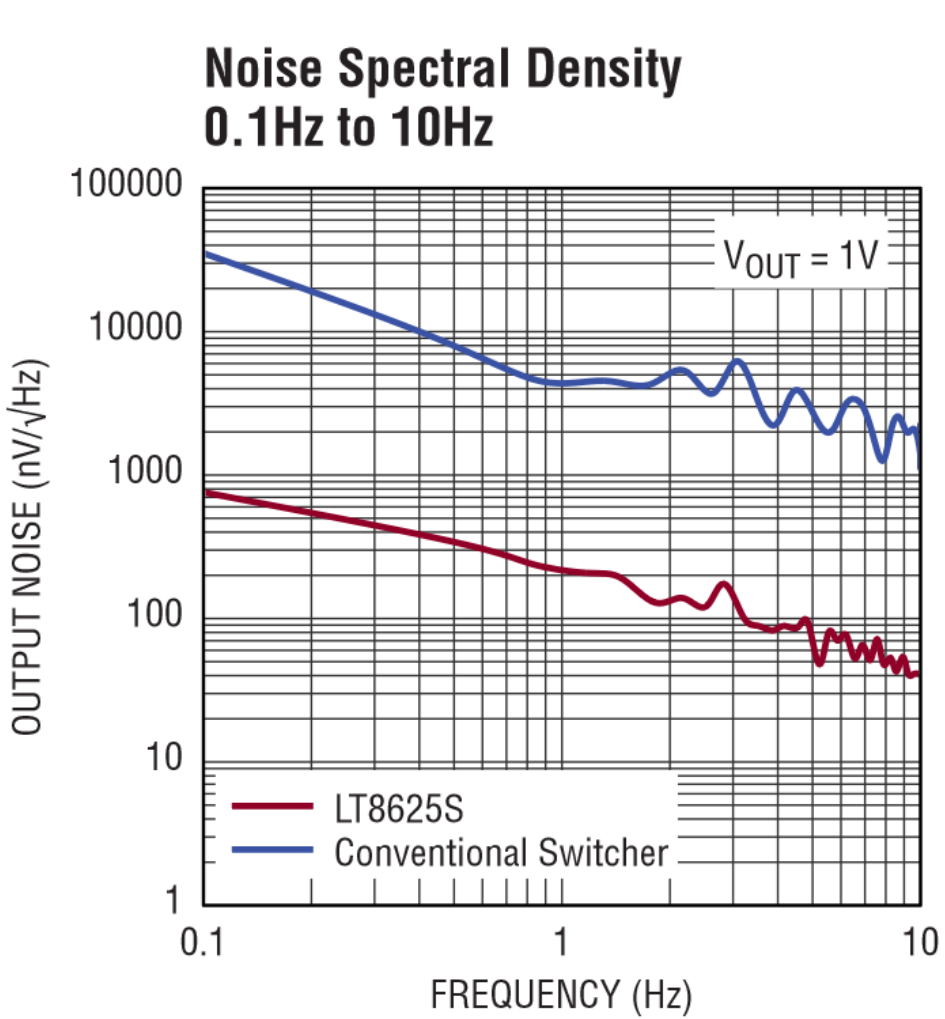
Super Fast Transient Response

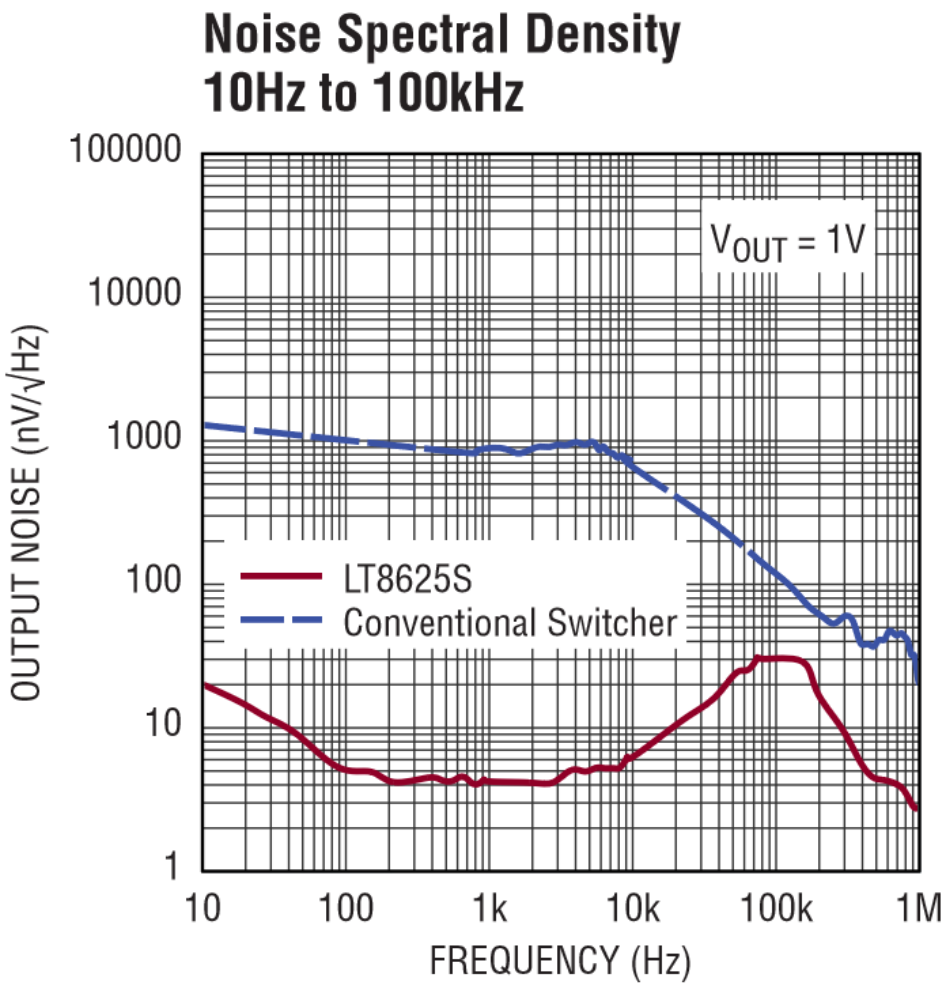
High Gain Error Amplifier
Unity Gain Feedback



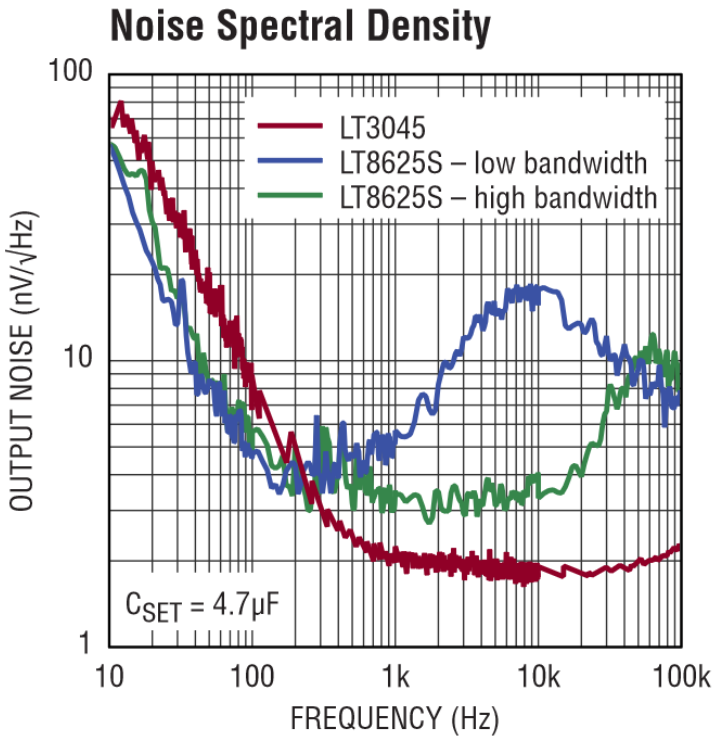


Noise Spectral Density
LT8625S vs. Conventional Switcher





LT8625S vs LT3045 (20V, 500mA LDO)



- Note: LT3045 is one of the lowest noise LDOs on the market!

Integrated Noise from 10Hz-100kHz				
LT3045	Li-ion battery	LT8625S (high bandwidth)	LT8625S (low bandwidth)	LT8643S (unity gain)
$0.8\mu V_{RMS}$	$2.7\mu V_{RMS}$	$2.7\mu V_{RMS}$	$3.7\mu V_{RMS}$	$123\mu V_{RMS}$

Design Resources

- Final Data Sheets: Available under NDA
- Evaluation Board: Available Upon Request
  - DC3219A (LT8625S, 8A)
  - DC3220A (LT8625SP/SP-1, 8A)
  - DC3147A (LT8627SP, 16A)
- LTSpice: Request from Applications (Requires NDA)
- LTPowerCAD: Available through ADI Internal Access. *.ltpc file can be shared with customers under NDA
- EngineerZone®: https://ez.analog.com/community/power
- Product Home Pages*
  www.analog.com/LT8625S
  www.analog.com/LT8625SP
  www.analog.com/LT8627SP

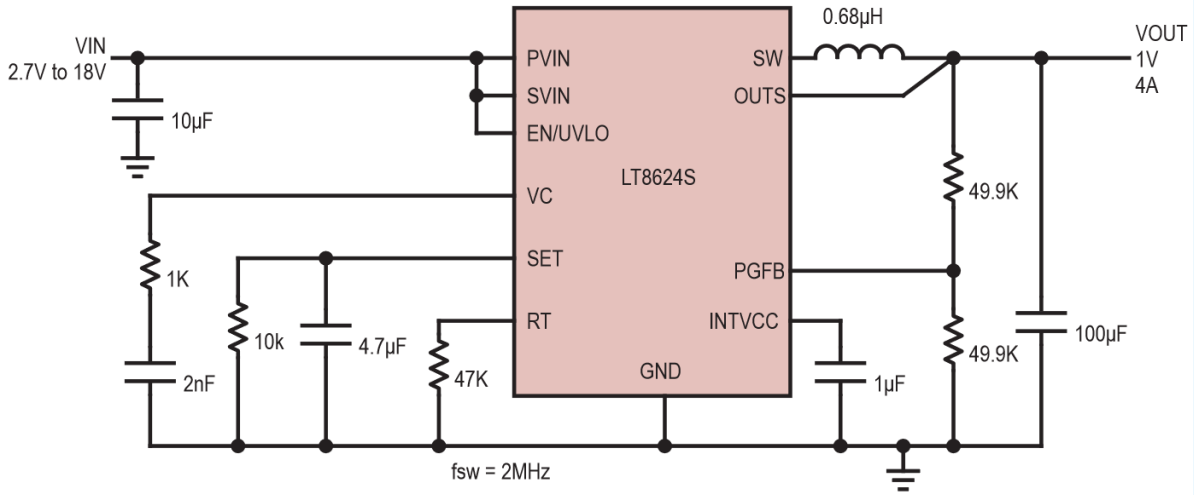
	PACKAGE SIZE	MAX TEMP	EXPOSED BACK	$INTV_{CC}$ CAPACITOR	OUTPUT CURRENT
LT8625S	4mm x 3mm	125°C	No	Internal	8A
LT8625SP	4mm x 3mm	150°C	Yes	External	8A
LT8625SP-1	4mm x 4mm	150°C	Yes	External	8A
LT8627SP	4mm x 4mm	150°C	Yes	External	16A

* Request Full Datasheet from Marketing with NDA (Fully Executed in Conga).

LT8622S/LT8624S: 18V, 2A/4A Silent Switcher 3 with Low Noise Reference

- Silent Switcher®3 Architecture
  - Ultralow RMS Noise (10Hz to 100kHz): 4µVrms
  - Ultralow Spot Noise: 4nV/√Hz at 10kHz
  - Ultralow EMI Emissions on Any PCB
  - Internal Bypass Capacitors Reduce Radiated EMI
- Wide Frequency Range & Fast Response
  - Ultrafast Transient Response with High Gain Error Amplifier and External Compensation
  - Fast Minimum Switch On-Time: 15ns
  - Fixed-Frequency Peak Current Mode, Adjustable and Synchronizable: 300kHz to 4MHz
- Flexible and Rugged Applications Focused
  - Input Voltage Range: 2.7V to 18V
  - 2A/4A Pin-to-Pin Compatible Family with LT8625S (8A)
  - Precision Reference: ±0.8% Over Temperature with Remote Sense
  - Current Sharing up to 12 Phases
  - 20-pin 4mm x 3mm LQFN with Internal Caps (PV_{IN}, BST, $INTV_{CC}$)

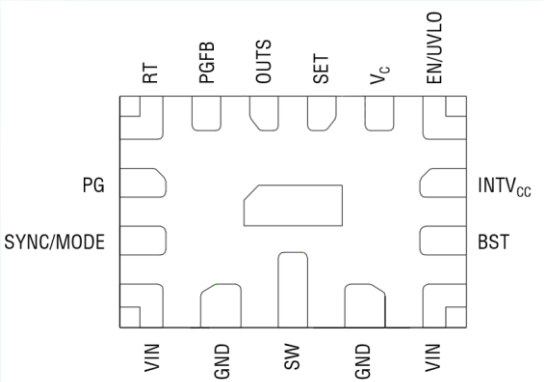
- Applications
  - RF Power Suppliers: PLLs, VCOs, Mixers, LNAs, PAs
  - Industrial & Communication Power Supplies
  - High Speed/High Precision ADC/DACs
  - Low Noise Instrumentation
- Schedule
  - Samples: Now / Release: Nov 2022

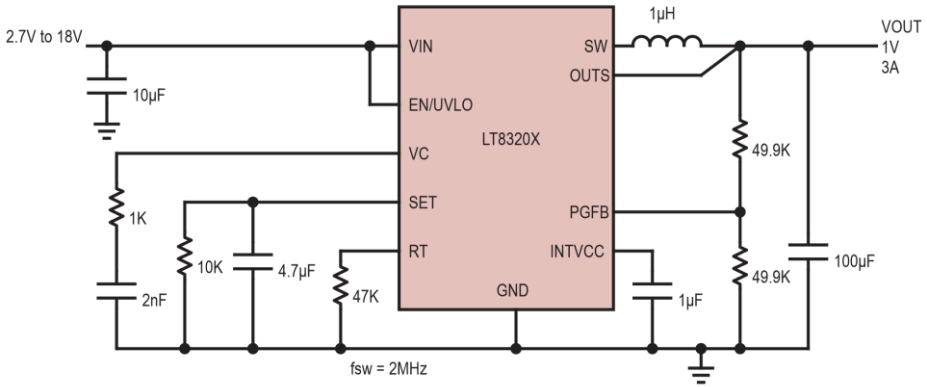


LT83201/03/05: 18, 1A/3A/5A Silent Switcher 3 with Low Noise Reference

- Silent Switcher®3 Architecture
  - Ultralow RMS Noise (10Hz to 100kHz): 4µVrms
  - Ultralow Spot Noise: 4nV/√Hz at 10kHz
  - Ultralow EMI Emissions
- Wide Frequency Range & Tiny Package
  - Ultrafast Transient Response with High Gain Error Amplifier and External Compensation
  - Fast Minimum Switch On-Time: 15ns
  - Fixed-Frequency Peak Current Mode, Adjustable and Synchronizable: 300kHz to 4MHz
  - Tiny 2x3mm FCQFN package
- Flexible and Rugged Applications Focused
  - Input Voltage Range: 2.7V to 18V
  - 1A/3A/5A pin-to-pin Compatible Family
  - Precision Reference: ±0.5% Over Temperature with Remote Sense

- Applications
  - RF Power Suppliers: PLLs, VCOs, Mixers, LNAs, PAs
  - Industrial & Communication Power Supplies
  - High Speed/High Precision ADC/DACs
  - Low Noise Instrumentation
- Schedule
  - Samples: Jan 2022
  - Release: Nov 2023





Automotive Power ASIL basic

ASIL & ISO 26262

What?

ASIL = **A**utomotive **S**afety **I**ntegrity **L**evel
ISO 26262 “Road Vehicles – Functional Safety” provides a framework for developing products that must meet a specified ASIL

- Started out of IEC 61508, similar to aviation standards (DO-178/254) or rail standards (CENELEC 50126/8/9)

Why?

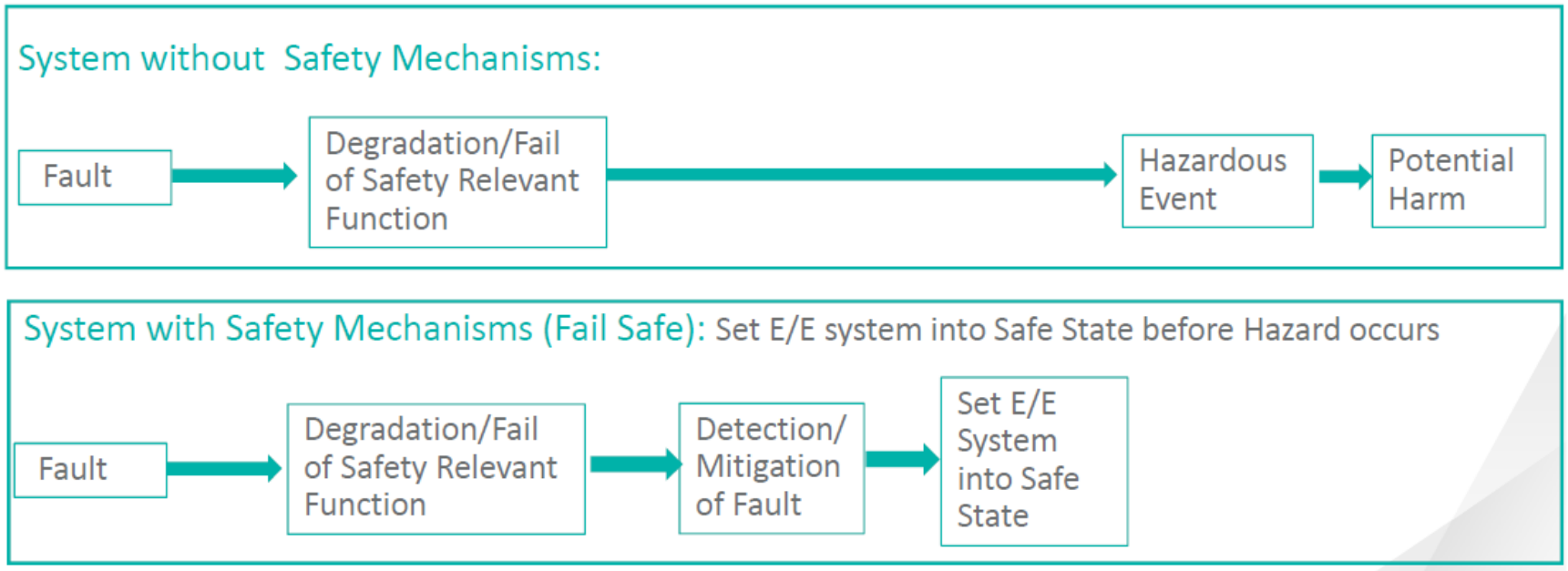
More and more ECUs are been used.
Driven by **A**utonomous **D**rive **A**ctive **S**afety market where systems affecting human safety require high reliability

How?

Special procedures and requirements for automotive life cycle (design & production)
Evidence that the framework is followed are called “Work Products” (e.g. safety manual, FMEDA)

ISO 26262 Scope – Unprotected vs Protected System

- Functional Safety:
  - Absence of unreasonable risk due to hazards caused by malfunctioning behavior of E/E systems.
- Strategy:
  - Implement a proper Safety Concept including Safety Mechanisms to detect/mitigate and control faults and to set the E/E system into a Safe State.



ISO 26262 Overview

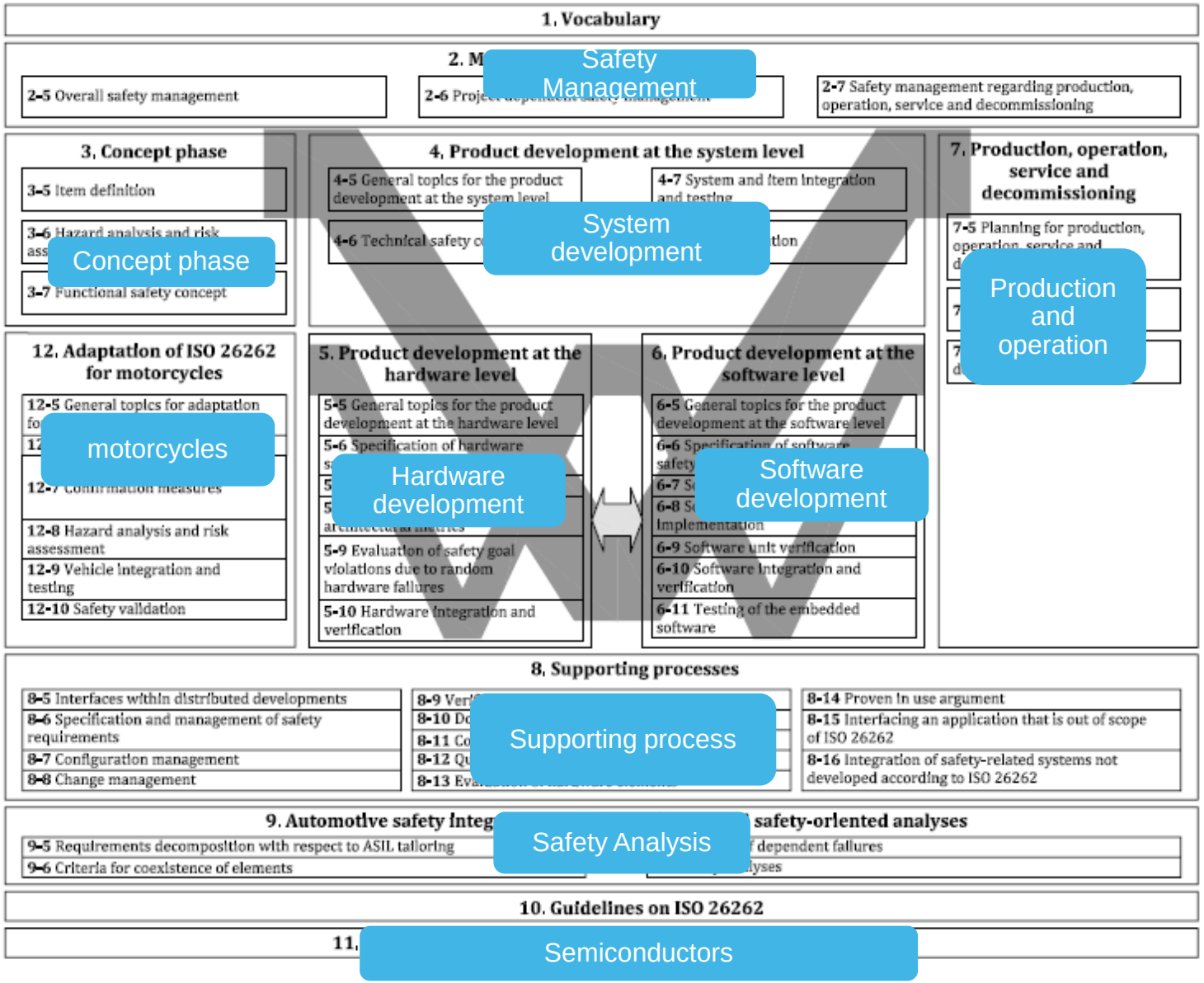


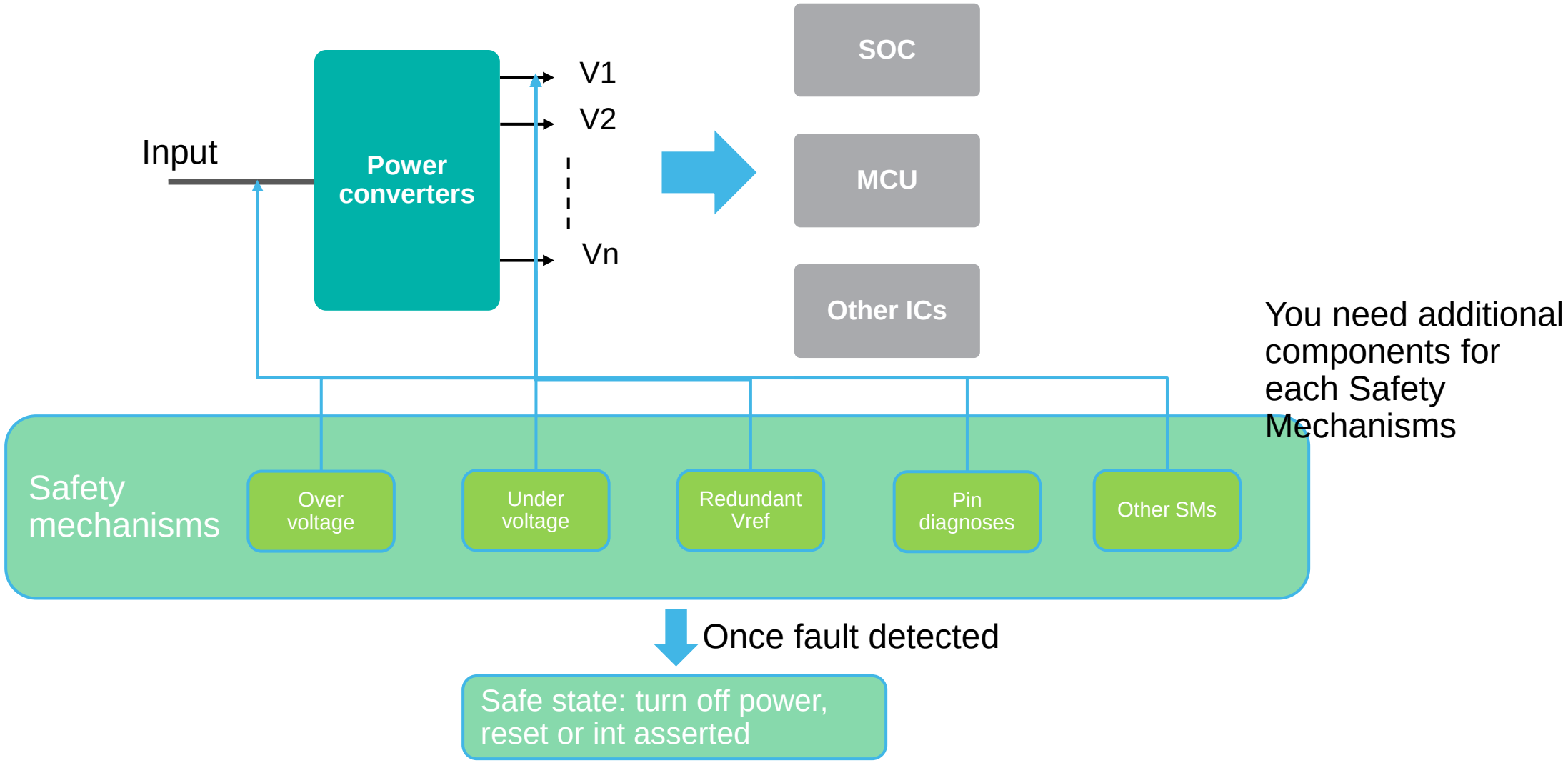
Figure 1 — Overview of the ISO 26262 series of standards

Product Development at the Hardware Level ISO 26262 part 5

	ASIL B	ASIL C	ASIL D
Single-point fault metric (SPFM)	≥90%	≥97%	≥99%
Latent fault metric (LFM)	≥60%	≥80%	≥90%

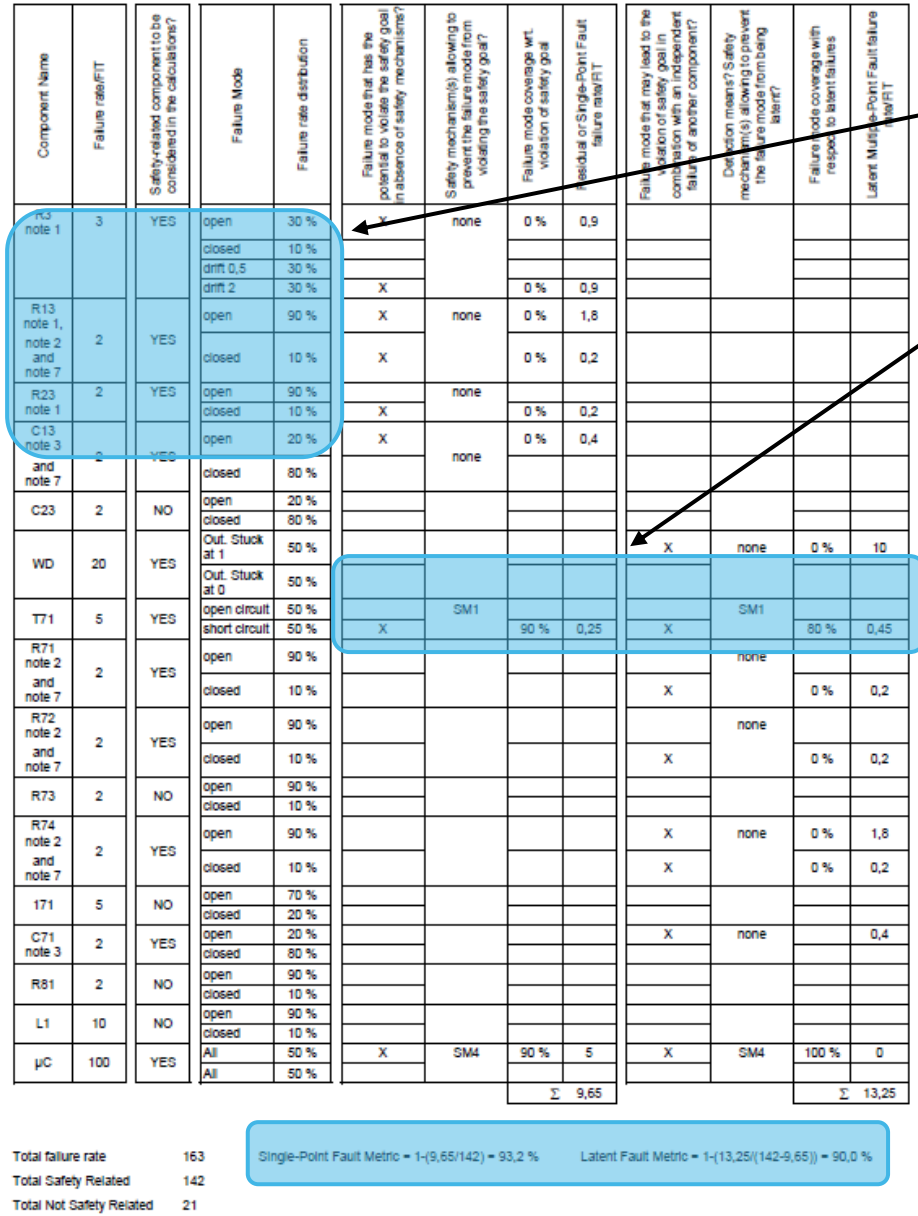
- The above table are target “coverage” values for different ASIL classifications
- It is common practice to target SPFM and LFM for a device that is a System Element out of Context (i.e., ADI’s devices).
- Besides SPFM/LFM, higher ASIL rating also requires higher independency level, more detailed analysis tools(FTA etc), and others.

ASIL design for QM power



You need additional components for each Safety Mechanisms

ASIL design with QM parts



Component Name	Failure rate/FIT	Safety-related component to be considered in the calculations?	Failure Mode	Failure rate distribution	Failure mode that has the potential to violate the safety goal in absence of safety mechanisms?	Safety mechanism(s) allowing to prevent the failure mode from violating the safety goal?	Failure mode coverage wrt. violation of safety goal	Residual or Single-Point Fault failure rate/FIT	Failure mode that may lead to the violation of safety goal in combination with an independent failure of another component?	Detection means? Safety mechanism(s) allowing to prevent the failure mode from being latent?	Failure mode coverage with respect to latent failures	Latent Multiple-Point Fault failure rate/FIT
R3 note 1	3	YES	open	30 %	X	none	0 %	0,9				
			closed	10 %								
			drift 0,5	30 %								
			drift 2	30 %	X		0 %	0,9				
R13 note 1, note 2 and note 7	2	YES	open	90 %	X	none	0 %	1,8				
			closed	10 %	X		0 %	0,2				
R23 note 1	2	YES	open	90 %		none						
			closed	10 %	X		0 %	0,2				
C13 note 3 and note 7	2	YES	open	20 %	X	none	0 %	0,4				
			closed	80 %								
C23	2	NO	open	20 %								
			closed	80 %								
WD	20	YES	Out. Stuck at 1	50 %					X	none	0 %	10
			Out. Stuck at 0	50 %								
T71	5	YES	open circuit	50 %		SM1				SM1		
			short circuit	50 %	X		90 %	0,25	X		80 %	0,45
R71 note 2 and note 7	2	YES	open	90 %						none		
			closed	10 %					X		0 %	0,2
R72 note 2 and note 7	2	YES	open	90 %						none		
			closed	10 %					X		0 %	0,2
R73	2	NO	open	90 %								
			closed	10 %								
R74 note 2 and note 7	2	YES	open	90 %					X	none	0 %	1,8
			closed	10 %					X		0 %	0,2
171	5	NO	open	70 %								
			closed	20 %								
C71 note 3	2	YES	open	20 %					X	none		0,4
			closed	80 %								
R81	2	NO	open	90 %								
			closed	10 %								
L1	10	NO	open	90 %								
			closed	10 %								
µC	100	YES	All	50 %	X	SM4	90 %	5	X	SM4	100 %	0
			All	50 %								
							Σ	9,65			Σ	13,25

Total failure rate 163
Total Safety Related 142
Total Not Safety Related 21

Single-Point Fault Metric = 1-(9,65/142) = 93,2 % Latent Fault Metric = 1-(13,25/(142-9,65)) = 90,0 %

Important steps:

1. Find FIT, failure distribution, for **every** components on board: resistor/capacitors/ICs/diodes/MOS
2. Define and design necessary SMs(safety mechanisms) – reference, OV/UV comparators etc.
3. Diagnostic coverage of each SMs
4. Calculation of the overall coverage. If target not meet, will need more SMs.

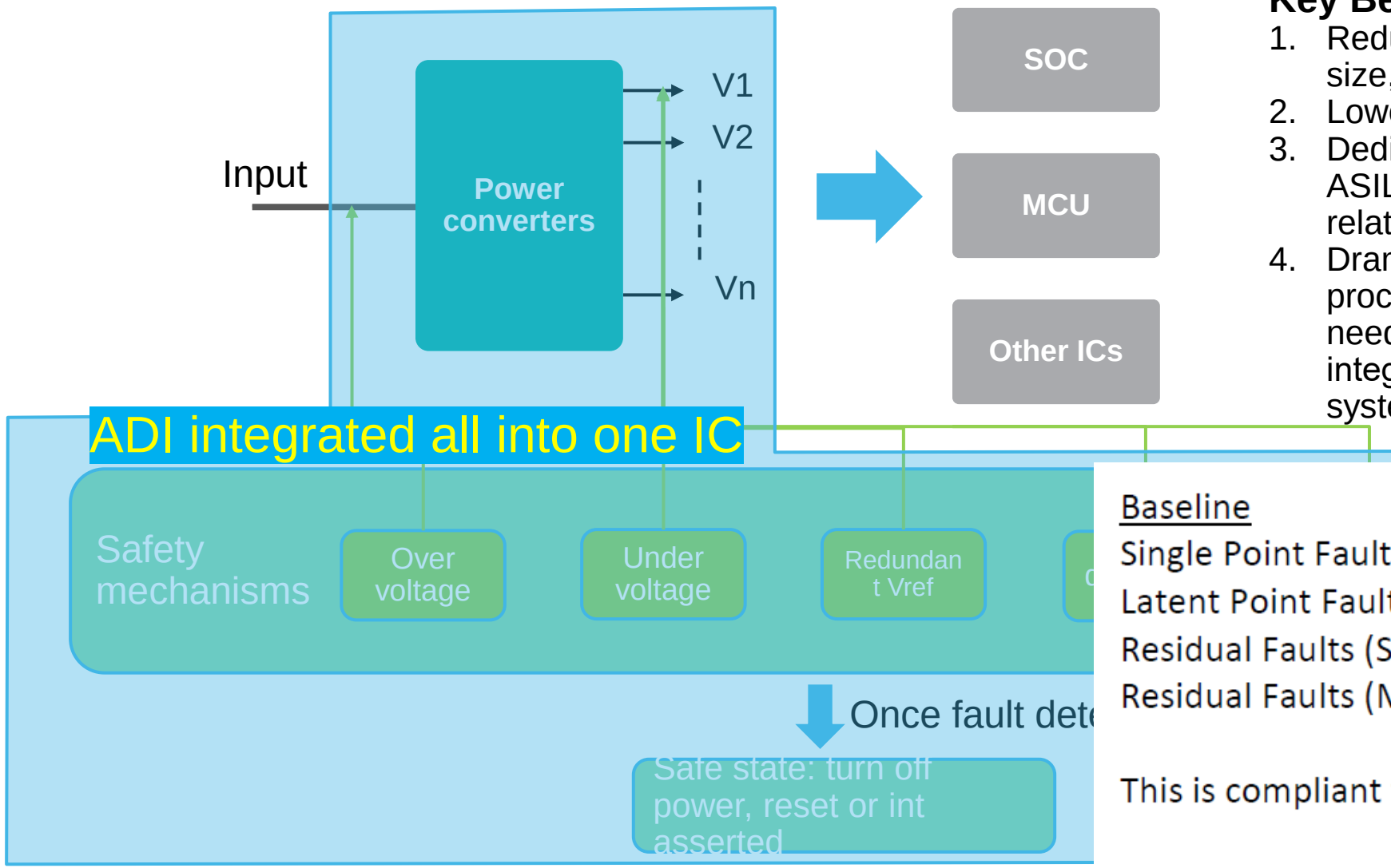
Obstacles:

1. All these data are not very easy to come by, and take tremendous time and effort to go through every components

2. Difficult to do Pin level diagnoses

3. Typically dedicated safety engineer is required.

ADI ASIL power – integrated all necessary SMs



Key Benefit:

1. Reduce bom count, smaller solution size, and lower cost
2. Lower FIT due to fewer components
3. Dedicated development to ensure ASIL compliant, and complete ASIL related work products
4. Dramatically reduce the ASIL design process – ADI provide all data needed for safety engineers to integrate our part into customer's system: SPFM,LPFM etc.

Baseline

Single Point Fault Metric SPFM = 98.03 *[%]*

Latent Point Fault Metric LPFM = 91.55 *[%]*

Residual Faults (Single Point): FIT = 0.228

Residual Faults (Multiple Points): FIT = 1.189

This is compliant to ASIL C

Typical safety mechanisms for power

Safety Measures	ISO26262 Reference Chapter 5/Annex D	Faults to be detected
UV-Comparator	D.2.8.2 (Output Voltage or Current Monitoring)	Undervoltage
OV-Comparator	D.2.8.2 (Output Voltage or Current Monitoring)	Overvoltage
Alternative Reference/Redundant Bandgap	D.9 (Detection of Drift)	Drift
UV/OV-Comparator dedicated and fast related to the feedback loop	D.9: Detection of Power Spikes and Oscillations	Oscillation and Power Spikes
Input Voltage Monitoring	D.2.8.1 (Input Voltage or Current Monitoring)	Input Voltage Range
Diagnostics for OV and UV (ABIST)	Latent Fault Detection: 7.4.3.2 (Chapter 5)	Latent Fault Coverage: Errors in OV and UV

ADI safety culture

Internal Procedure and Business Process:

Maxim has an established safety culture and defined a dedicated automotive procedure for ASIL products. Certified by TUD at ASIL D level.

Download link: https://www.maximintegrated.com/content/dam/files/design/qa-reliability/certifications/ISO26262_Process.pdf

Work Product Management and Confirmation review:

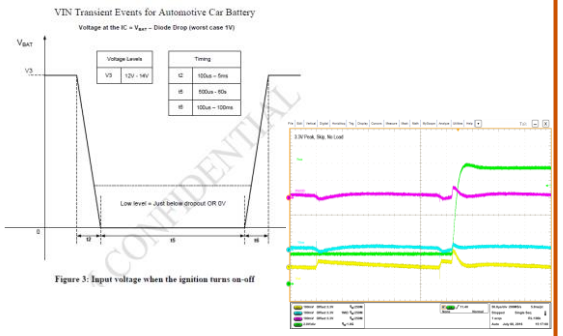
Work products as defined in the Safety Plan are subject to document control and a dedicated approver loop. Confirmation reviews are performed at defined stages according to ISO26262. Each project is undertaken a final Functional Safety Assessment by independent department (i3 – criteria).

Deliverable (Work Product)	Maxim Safety Plan - Phase	Shared with Customer	Comments
1 Development Interface Agreement/DIA	Definition Phase	yes	For joint development only. Agreement on safety related activities and work products to be exchanged
2 Item Definition	Definition Phase	Review (Summary in Safety Manual)	Description of an application at the vehicle level including system functions
3 Hazard Analysis	Risk Phase	Review (Summary in Safety Manual)	Determines the risk of the Item to the human due to the possible Malfunctions
4 Functional Safety Concept	Concept Phase	Review (Summary in Safety Manual)	Define the Functional Safety Requirements and Safety Goals
5 Technical Safety Concept	Concept Phase	Review (Summary in Safety Manual)	the realization of the Functional Safety Concept at the hardware level
6 Validation Plan	Concept Phase	Review (Summary in Safety Manual)	specify the validation procedures, test cases and acceptance criteria related to verify the effectiveness of safety measures
7 FTA (Fault Tree Analysis)	Concept Phase	Review (Summary in Safety Manual)	helps to understand which component failures contribute to a violation of a Safety Goal
8 FMEDA and Common Cause Failure Analysis	Development Phase	Review (Summary in Safety Manual)	Calculate fault mode coverage to verify compliance level
9 Hardware Integration and Testing Report	Verification Phase	Review (Summary in Safety Manual)	Verify design by testing
10 Safety Manual	**Verification Phase**	**yes (NDA required)**	**Provided to customers and summarizes the work products**
11 Confirmation Review Reports	All Phases	no (result only)	by independent department (i3 – criteria)
12 Functional Safety Assessment	Verification Phase	no (result only)	

Automotive Power Management

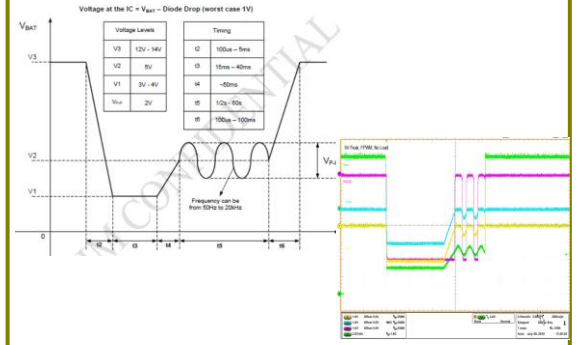
Power: Designed for Automotive

Voltage Dips and Drops



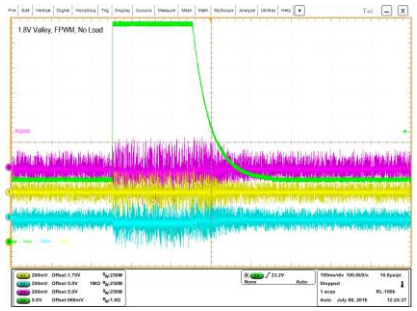
Ensure regulated/defined output under all automotive voltage conditions

Cold Crank



Low operating V_{IN} Bucks & Buck-Boost Converters ensure regulation during extreme low V_{batt}

Load Dump

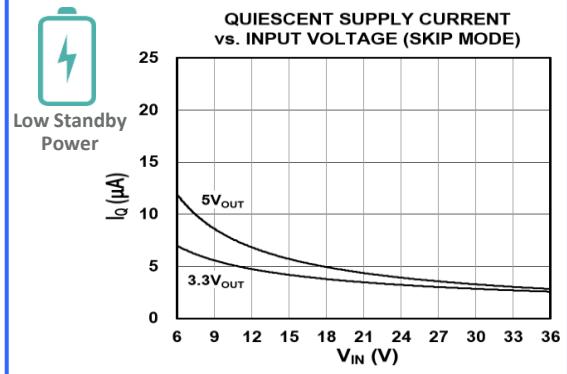


High operating voltages up to 42V & 80V for 12V/24V/48V automotive system transients

Low Minimum On-Time

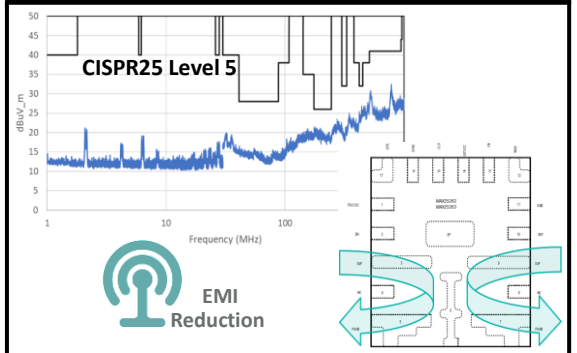
Industry leading minimum on-time for true 4MHz operation under all V_{IN} conditions

Low Quiescent Current



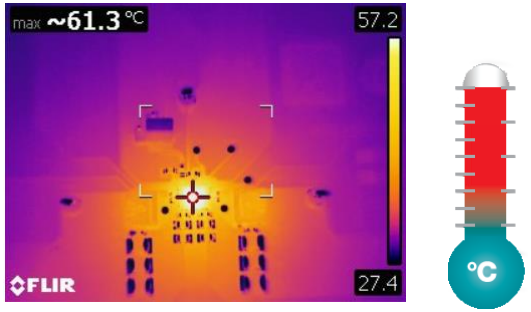
Industry leading quiescent current ensure always-on long battery life

Low EMI



Flip-chip symmetrical pinout & ±6% spread spectrum to meet stringent EMI requirements

150ºC Junction Temp



Designed to operate up to 125°C ambient and 150°C junction temperatures

ASIL

ASIL-B to ASIL-D Power Solutions for ADAS

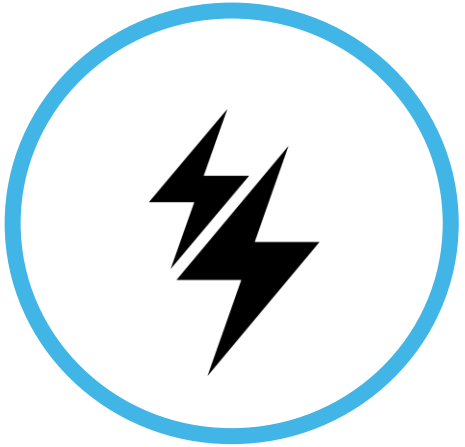
ASIL dedicated functional safety development procedure based on ISO26262

Our Product Strategy

High Performance:
High efficiency
Low Iq
Low noise

ASIL solutions for ADAS

Trusted Advisor & Joint Definition



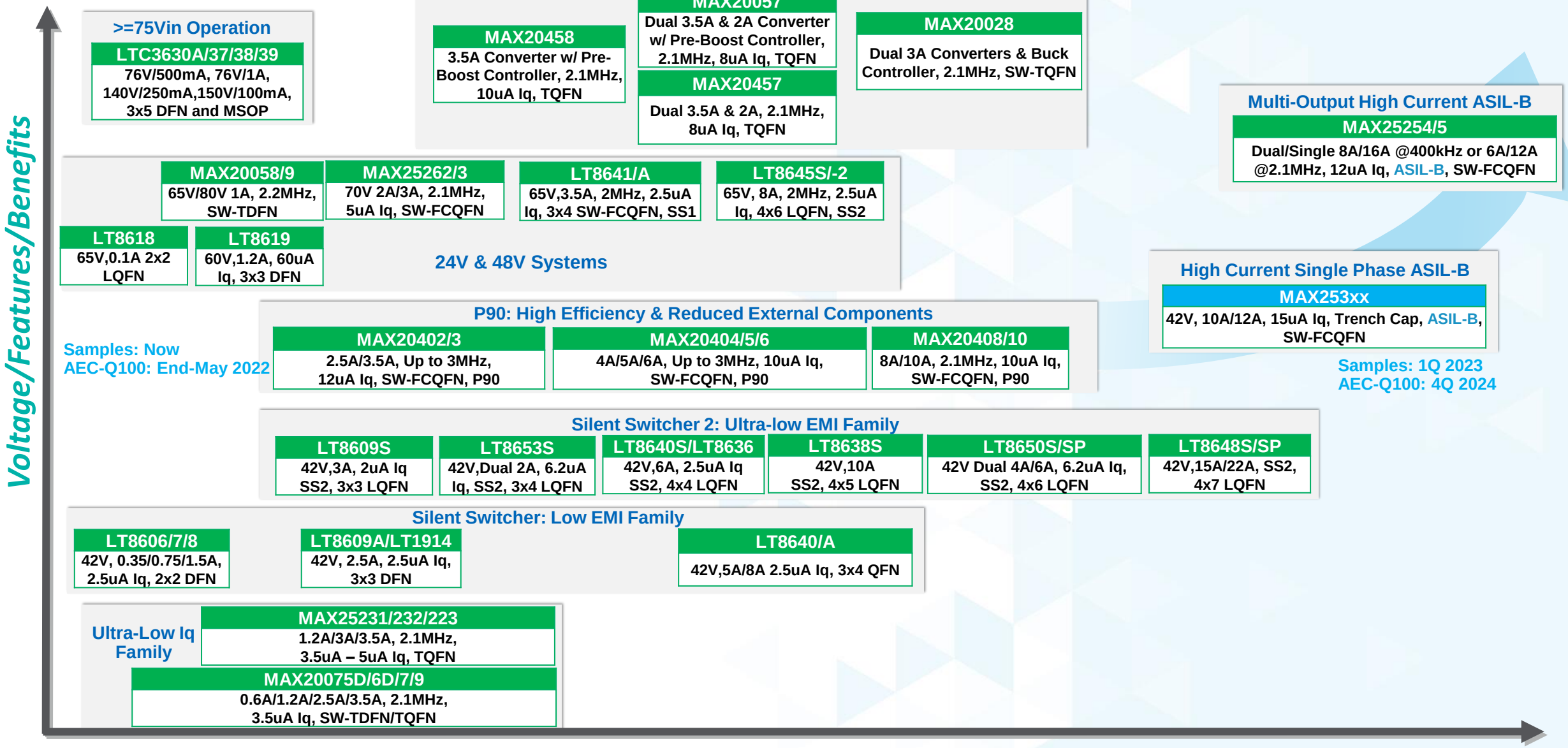
Scalable high-power density

Small sol. size & BOM optimization

Table of Contents

Overview

High Voltage Synchronous Buck Converters



Production | Development

HV Monolithic Buck Positioning Table: 350mA-1.2A

Parameter / Device	MAX25231	MAX20075D/76D	LT8606/7/8
Topology	single buck	single buck	single buck
Input Voltage	3.5V to 40V	3.5V to 40V	3V to 42V
Output Voltage	3.3V, 5V, Adj (3V to 10V)	3.3V, 5V, Adj (3V to 10V)	up to 99%*Vin
Max Output Current (A)	1.2A	0.6A / 1.2A	0.35A/0.75A/1.5A
Switching Frequency	2.1MHz and 400kHz	2.1MHz	200kHz-2.2MHz
Efficiency (12Vin to 5Vout)	~90% @14Vin at 1A, fsw= 2MHz	~90% @14Vin at 1A, fsw = 2MHz	92% @ 1A at 2MHz
I_Q in standby (Vo=3.3V)	3.5µA	3.5µA	2.5µA
Minimum on time (typ)	65ns	20ns	35ns
Silent Switcher	no	no	no
Spread spectrum	Yes	Yes	Yes
EMI radiated	passes CISPR25-5	passes CISPR25-5	passes CISPR25-5
Features	SYNC IN, PG, TSD, CL, OVP	SYNC IN, PG, TSD, CL, OVP	SS, Tracking, CL, SYNC, pin to pin compatible
Package / Size (mm)	3x3 TQFN-12	3x3 TDFN-12 3x3 SWTDFN-12	2x2 DFN-8, MSOP-10
Summary Positioning	lowest cost	low cost, lowest minimum on time	smallest footprint, highest efficiency

HV Monolithic Buck Positioning Table: 2A-3A

Parameter / Device	MAX20402/3	LT8609S	LT8609/A	LT8653S
Topology	single buck	single buck	single buck	dual buck
Input Voltage	3V to 42V	3V to 42V	3V to 42V	3V to 42V
Output Voltage	3.3V, 5V, ADJ (0.8V to 12V)	up to 99%*Vin	up to 99%*Vin	5V, 3.3V. 1.8V
Max Output Current (A)	2.5A/3.5A	2A cont / 3A peak	2A cont / 3A peak	2 x 2A
Switching Frequency	2.1MHz and 400kHz	200kHz-2.2MHz	200kHz-2.2MHz	300kHz-3MHz
Efficiency (12Vin to 5Vout)	95.5% @ 400kHz, 93% @ 2.1MHz, 12VIN, 3.3VOUT	90% @ 2.5A at 2MHz, 91% @ 2A at 2MHz	87.5% @ 3A at 2MHz, 90.5% @2A at 2MHz	88% at 3A at 2MHz
I_Q in standby	12µA	2.5µA	2.5µA	6.2µA
Minimum on time (typ)	35ns	45ns	45ns	30ns
Silent Switcher	no	SS2	no	SS2
Spread spectrum	Yes, +/-6%	yes	yes	yes
EMI radiated	low	ultra-low	low	ultra-low
Features	SYNC IN, PG, CL, TSD, OVP	SS, Tracking	SS, Tracking	ext VC (fast trans resp), SYNC
Package / size (mm)	3x3 SW FC2QFN-15	3x3 LQFN-16	3x3 DFN-10, MSOP-10	3x4 LQFN-20
Summary Positioning	highest efficiency, lowest cost	lowest EMI	low cost	lowest EMI

HV Monolithic Buck Positioning Table: 4A-6A

Parameter / Device	MAX20404/05/06	LT8653S	LT8640S/43S	LT8640A	LT8636	LT8650S
Topology	single buck	dual buck	single buck	single buck	single buck	dual buck
Input Voltage	3~36V (42V max)	3~43V	3.4~42V	3.4~42V	3.4~42V	3~42V
Output Voltage	3.3V, 5.0V, Adj (0.8V to 10V)	1.8V, 3.3V, 5V	up to 99%*Vin	up to 99%*Vin	up to 99%*Vin	up to 99%*Vin
Max Output Current (A)	4/5/6	2 x 2A	6	5A cont / 8A peak	5A cont / 7A peak	2 x 4A
Switching Frequency	400kHz/2.1MHz/3MHz	300kHz-3MHz	200kHz~3MHz	200kHz~3MHz	200kHz~3MHz	300kHz-3MHz
Efficiency (12Vin to 5Vout)	93% @ 400kHz, 5A, 92% @ 2.1MHz, 5A	88% @ 3A at 2MHz	92% @ 6A at 2MHz	92.5% @ 5A at 2MHz	92% @ 5A at 2MHz	90% @ 6A, at 2MHz; 93.5% @ 4A, at 2MHz
Quiescent Current (uA)	10	6.2	2.5	2.5	2.5	6.2
Minimum On Time typ (ns)	35	30	30	30	30	40
Silent Switcher (SS1/SS2)	no	SS2	SS2	SS1	SS1	SS2
Spread Spectrum	yes	yes	yes	yes	yes	yes
EMI radiated	low	ultra-low	ultra low	low	low	ultra-low
Features	PG, CL, TSD, pin-to-pin compatible	ext VC (fast trans resp), SYNC	Tracking, SS, FCM, external comp and fast trans resp (LT8643S)	Tracking, SS	Tracking, SS, FCM	SS, ext VC (fast trans resp)
Package / Size (mm)	3.5x3.75 SW-FC2QFN-17	3x4 LQFN-20	4x4 LQFN-24	3x4 SWQFN-18	3x4 LQFN-20	4x6 LQFN-32
Summary Positioning	lowest cost, pin compatible family	ultra-low EMI, space efficient (dual output)	higher cost for ultra low EMI, fast transient response	cost effective, low EMI, fast transient response	reduced size (external caps) LT8640S	ultra-low EMI, dual output space efficient

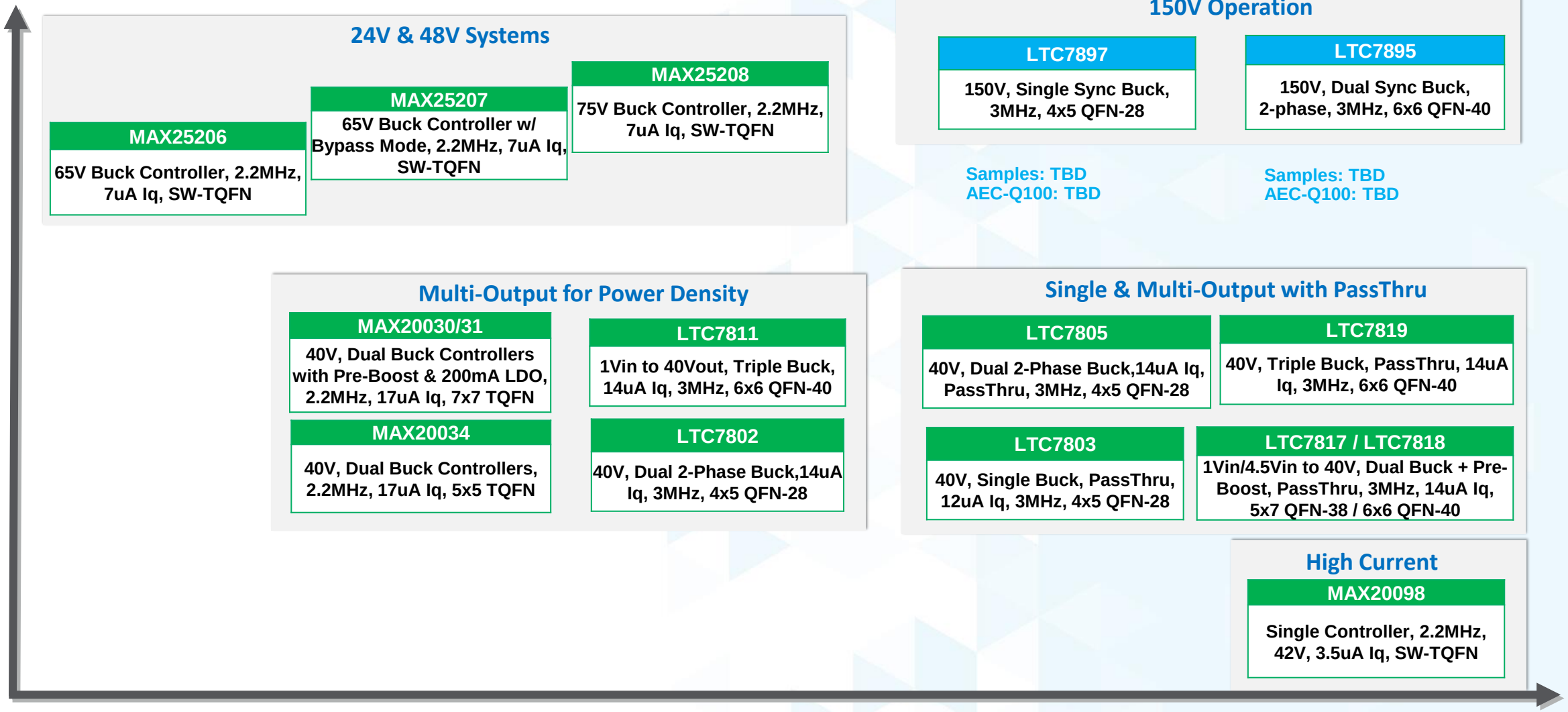
HV Monolithic Buck Positioning Table: 8A-10A

Parameter / Device	MAX20408/10	LT8645S	LT8650S	LT8638S	MAX25255	MAX20408/10 Dual Phase	LT8648S
Topology	single buck	single buck	dual buck	single buck	Dual 8A Buck with ASIL-B	dual phase buck	single buck
Input Voltage	3~42V	3.4~65V	3~42V	2.8~42V	3-42V	3~42V	3~42V
Output Voltage	Fixed 3.3V, 5V, Adj: 0.8V – 10V (400kHz), 0.8 – 6V (2.1MHz)	0.97V to 99%*Vin	up to 99% * Vin	up to 99%*Vin	3.3V, 5V, Adj (0.8V to 14V)	Fixed 3.3V, 5V, Adj: 0.8V – 10V (400kHz), 0.8 – 6V (2.1MHz)	up to 99% * Vin
Max Output Current (A)	8/10	8	2 x 4A	10A cont / 12A peak	Each buck 6A@2.1MHz, 8A@400KHz	16-20	15
Switching frequency	400kHz/2.1MHz	200kHz-2.2MHz	220kHz-2.2MHz	200kHz-3MHz	400kHz to 2.1MHz	400kHz/2.1MHz	220kHz-2.2MHz
Efficiency (12Vin to 5Vout)	94% @ 2.1MHz, 8A 92% @ 2.1MHz, 10A	91% @8A at 2MHz	90% @ 6A at 2MHz; 93.5% @ 4A at 2MHz	92% @10A at 2MHz	93% @ 2MHz, 6A	94% @ 2.1MHz, 8A	92% @14A at 2MHz
Quiescent current (µA)	7.5	2.5	6.2	90	12µA	7.5	20
Minimum on time typ (ns)	34	55	40	25	24	34	25
Silent Switcher	no	SS2	SS2	SS2	no	no	SS2
Spread Spectrum	yes +/-3%	yes	yes	yes	±6%	yes +/-3%	yes
EMI radiated	low	ultra low	ultra low	ultra low	low	low	ultra low
Features	PG, CL, TSD	SS, Tracking	SS, ext VC (fast trans resp)	SS, PG	SYNC in, die temp monitor, ASIL B	PG, CL, TSD	SS, PG
Package / Size (mm)	3.5 x 3.75 SW-FC2QFN-17	4 x 6 LQFN-32	4 x 6 LQFN-32	4 x 5 LQFN-28	4.5 x 5.75 FC2QFN-23	3.5 x 3.75 SW-FC2QFN-17	4 x 7 LQFN-36
Summary Positioning	lowest cost, pin compatible family	only 65V 8A device, lowest EMI	lowest EMI	lowest EMI	high current (phasable), ASIL B capability, low EMI	highest current (phasable), low EMI	lowest EMI

HV Monolithic Buck Positioning Table: >10A

Parameter / Device	LT8650S	LT8650SPA	MAX25255	LT8648S
Topology	dual buck	dual buck	Dual 8A Buck with ASIL-B	single buck
Input Voltage	3-42V	3-42V	3-42V	3-42V
Output Voltage	up to 99% * Vin	up to 99% * Vin	3.3V, 5V, Adj (0.8V to 14V)	up to 99% * Vin
Maximum Output Current	2 x 4A	2 x 4A	Each buck 6A@2.1MHz, 8A@400KHz	15
Switching Frequency	220kHz-2.2MHz	220kHz-2.2MHz	400kHz to 2.1MHz	220kHz-2.2MHz
Efficiency (12Vin to 5Vout)	90% @ 6A at 2MHz; 93.5% @ 4A at 2MHz	90% @ 6A at 2MHz	94% @ 400kHz, 8A, 93% @ 2MHz, 6A	92% @14A at 2MHz
Quiescent Current (uA)	6.2	6.2	12	20
Minimum ON-Time typ (ns)	40	40	24	25
Silent Switcher	SS2	SS3	no	SS2
Spread Spectrum	yes	yes	±6%	yes
EMI radiated	ultra low	ultra low	low	ultra low
Features	SS, ext VC (fast trans resp)	SS, ext VC (fast trans resp)	SYNC in, die temp monitor	SS, PG
ASIL Grade	n/a	n/a	**ASIL-B**	n/a
Package / Size (mm)	4 x 6 LQFN-32	4 x 6 LQFN-32 exposed back	4.5 x 5.75 FC2QFN-23	4 x 7 LQFN-36
Summary Positioning	lowest EMI	lowest EMI, Silent Switcher 3	highest current (phasable), ASIL B capability, low EMI, lowest cost	lowest EMI, high current single phase

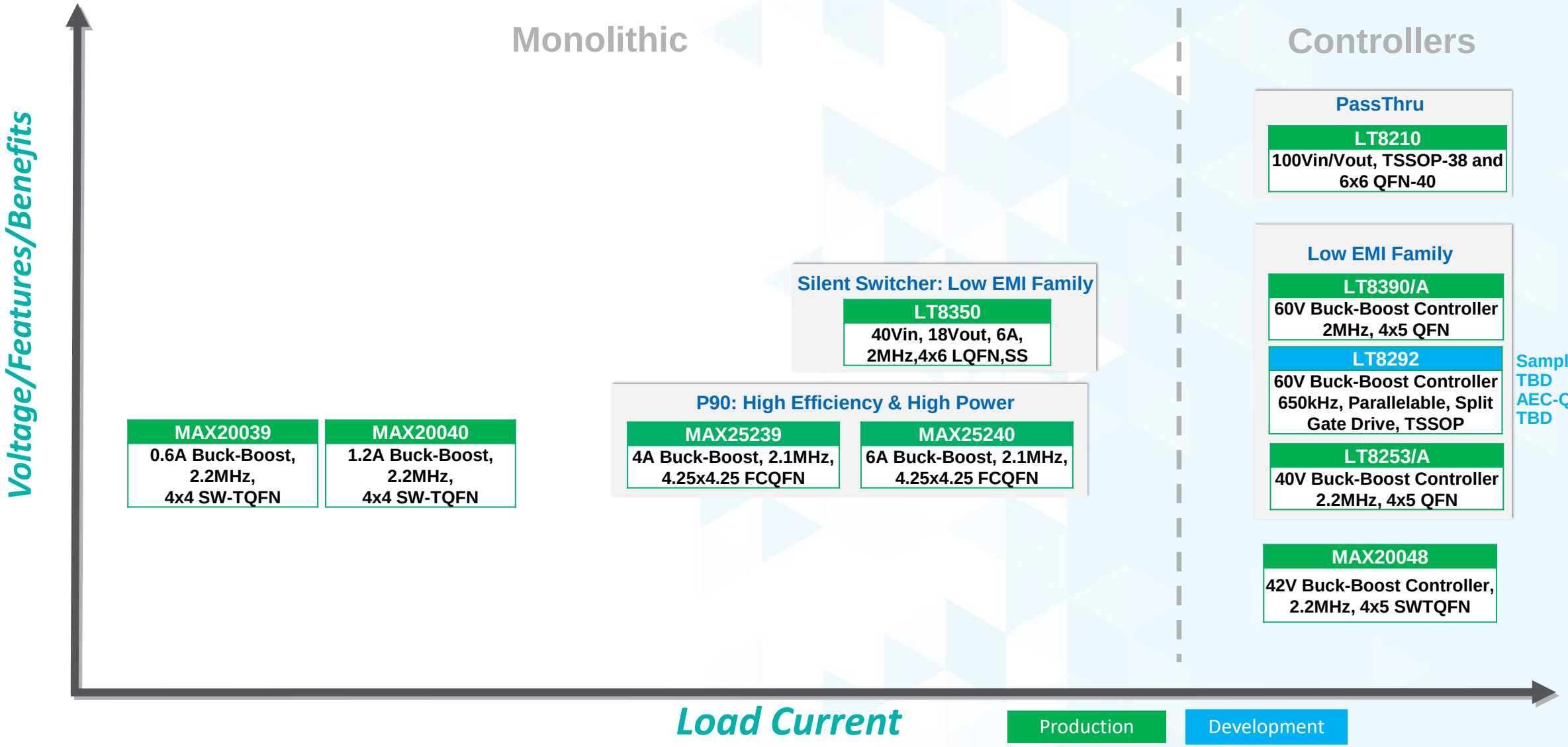
High Voltage Buck Synchronous Controllers



Synchronous Buck Controller Positioning Table

Parameter / Device	MAX20034	LTC7805	LTC7802	MAX20098	LTC7803	MAX20030/31	LTC7817	LTC7818
Topology	dual output	dual 2-phase buck	dual 2-phase buck	single buck	single phase buck	dual buck + non-sync boost + LDO	dual buck + sync boost	dual buck + sync boost
Input Voltage	3.5V - 36V (42V max)	4.5-40V	4.5-40V	3.5V - 36V (42V max)	4.5-40V	3.5V - 36V (42V max)	4.5-40V	4.5-40V
Output Voltage	3.3V, 5V, Adj (1V to 10V)	0.8V to Vin	0.8V to Vin	3.3V, 5V, Adj (1V to 10V)	up to 40V	3.3V, 5V, Adj (1V to 10V)	0.8V to 40V	0.8V to 40V
Switching Frequency	220kHz-2.2MHz	100kHz-3MHz	100kHz-3MHz	220kHz-2.2MHz	100kHz-3MHz	220kHz-2.2MHz	100kHz-3MHz	100kHz-3MHz
Quiescent Current (uA)	VOUT=5V: 25µA; VOUT=3.3V: 17µA	14	12	3.5	12	17uA with 3.3V buck on; 65uA all ch enabled	14	14
Minimum ON-Time typ (ns)	50	40	40	50	40	50	40	40
Spread Spectrum	yes	yes	yes	yes	yes	yes	no	yes
Features	SYNC input, DCR sense	PassThru, PG, internal LDO	PG, internal LDO, OVP	SYNC input, PG, OC, OVP, UVP, TSD, multi-phase capable	PassThru, Tracking, SS	SYNC input, PG, CL, OVP, UVP, TSD	PassThru, Rsense or DCR current sensing, internal LDO	PassThru, Rsense or DCR current sensing, internal LDO
Package / Size (mm)	5x5 SW-TQFN-EP-28	4 x 5 SWQFN-28	4 x 5 SWQFN-28	3x3 SW-TQFN-EP-16	3x3 QFN-16 and MSOP	7x7 SW-TQFN-EP-48	5x7 QFN-38	6x6 QFN-40
Summary Positioning	lowest cost, limited Vout range	PassThru	smaller version of MAX20034	lowest cost, high current, limited Vout range	PassThru, small package footprint	high integration, limited Vout range	high integration, synchronous boost	high integration, synchronous boost

High Voltage Synchronous Buck-Boosts

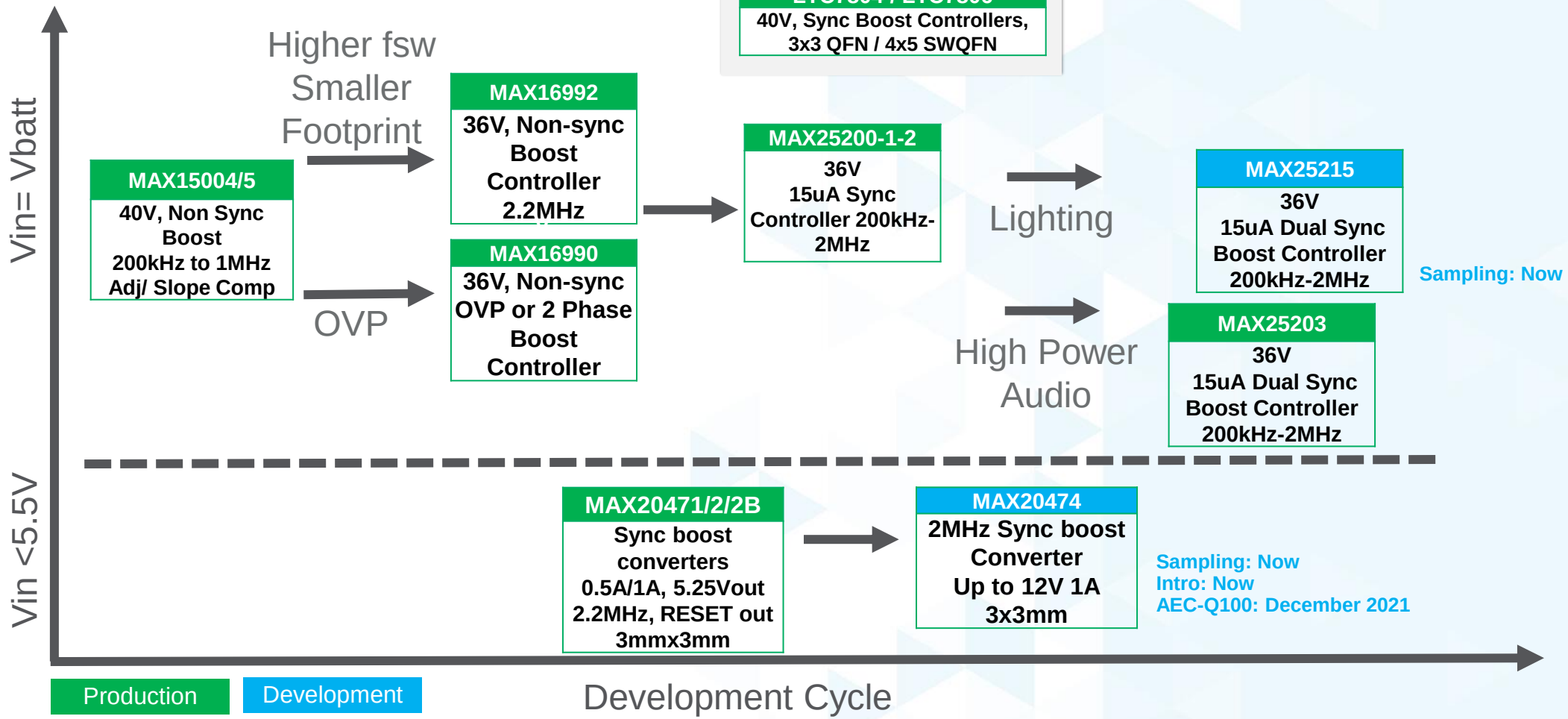


Buck-Boost Converter/Controllers Positioning Table

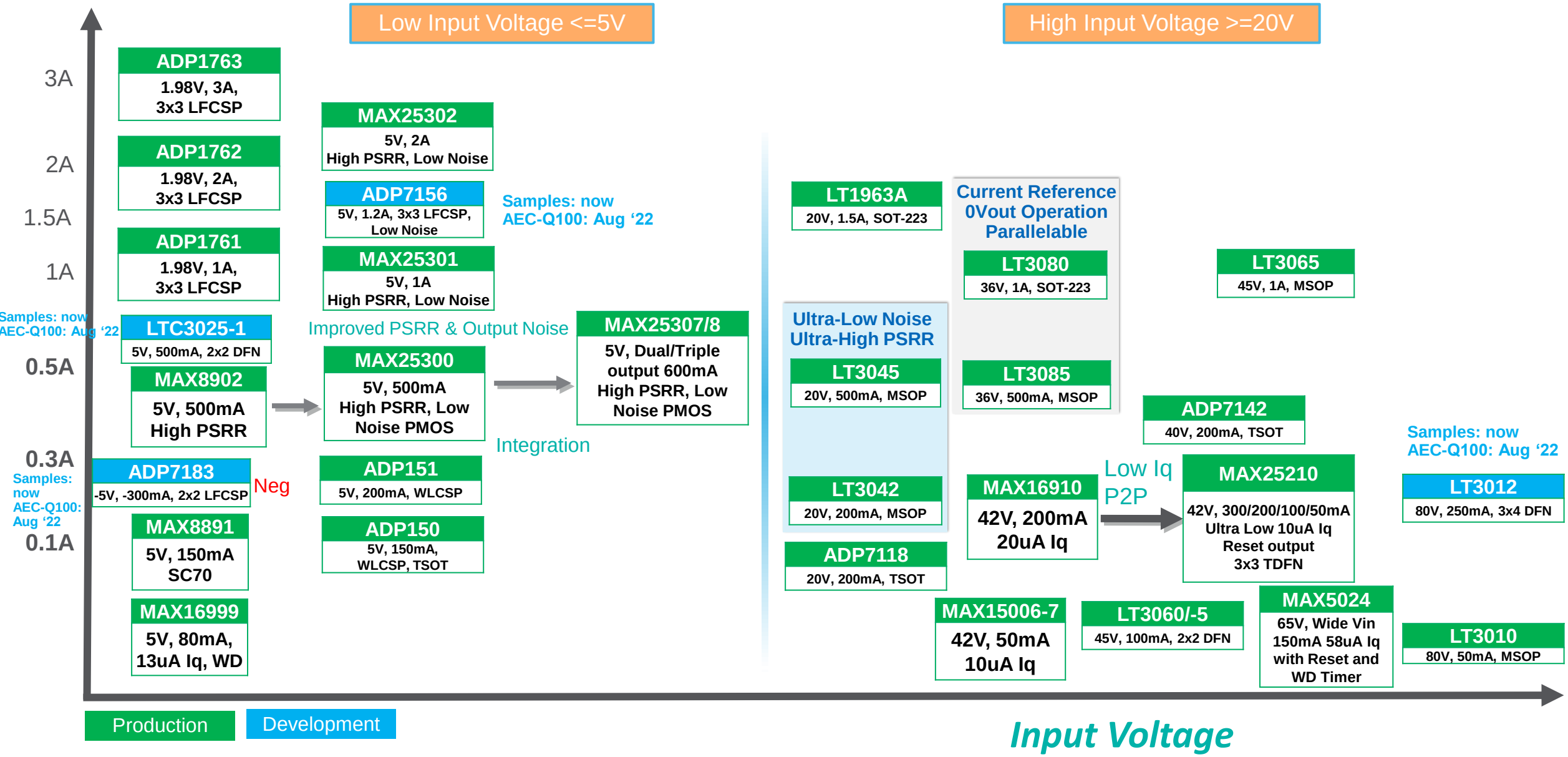
Parameter / Device	MAX25239/40	LT8350	MAX20048	LT8253/A
Topology	monolithic buck-boost	monolithic buck-boost	controller buck-boost	controller buck-boost
Input Voltage	2-36V (42V max)	3-40V	2V to 36V (42V max)	4-40V
Output Voltage	5V, 10.5V, 11.5V, Adj (3V to 20V)	1V to 18V	4V to 25V	1V to 25V
Maximum Output Current	4A/6A	6A	n/a	n/a
Switching Frequency	400kHz, 2.1MHz	220kHz-2MHz	220kHz-2.2MHz	400kHz / 2MHz
Efficiency	95% at 3A, 12VOUT from 12VIN at 2.1MHz	94% at 2A, 12VOUT from 12VIN at 2.MHz	n/a	n/a
Quiescent Current (uA)	95	3.5mA	55	2.1mA
Silent Switcher	no	SS1	no	no
Spread Spectrum	yes	yes	yes, +/-3%	yes
EMI radiated	low	low	low	low
Features	integrated H-Bridge, PGood, UVLO, OVP, CL, TSD	PG, in/out current monitor, short-circuit protected	SYNC in, PG, UVLO, OVP, TSD	USB-C, OVP, OCP, short-circuit protected
Package / Size (mm)	4.25 x 4.25 FC2QFN-22	4 x 6 LQFN-32	4 x 5 SW-TQFN-EP-24	4 x 5 SWQFN-28
Summary Positioning	lowest cost, small footprint monolithic	lowest EMI monolithic	lowest cost controller	lowest EMI controller

High & Low Voltage Boost

Controllers & Converters



Automotive LDO Roadmap



LDO Positioning Table

Positive LDO Regulators

Part No	Device Output	V_{IN} Range(V)	V_{OUT} (MIN)(V)	I_{OUT} (A)	Dropout Voltage (V)	Noise (µVRMS) @	I_Q(µA)	Output Voltage (V)	Max Junc Temp (˚C)	Package	Summary Postitioning
LT3010/-5	Single	3.0 to 80	1.275	50mA	0.30	100	30	Adj, 5	140	MSOP	Highest 80Vin
MAX25210	Single	3.5 to 40	0.5	50mA, 100mA, 200mA, 300mA	0.13, 0.50, 0.77	10	10	Adj (0.6 to 11), 3.3/5 fixed	150	8L TDFN 3x3, 8L SOIC 5x4	lowest Iq, low cost
LT3060/-5	Single	1.6 to 45	0.6	100mA	0.30	30	40	Adj, 5	150	2x2 DFN-8	small footprint, low cost
MAX5024	Single	6.5 to 65	0.5	150mA	1.5	N/A	58	Adj (2.5 to 11), 3.3/5 fixed	150	8L SOIC	High 65V Vin
ADP150	Single	2.2 to 5.5	1.8	150mA	0.105	9	10	Multiple Fixed	125	TSOT, WLCSP	Low Iq, WLCSP, low dropout, low cost
ADP151	Single	2.2 to 5.5	1.1	200mA	0.105	9	10	Multiple Fixed	125	TSOT, WLCSP	Low Iq, WLCSP, low dropout, low cost
ADP7118	Single	2.7 to 20	1.2	200mA	0.20	11	50	Multiple Fixed	125	TSOT	20Vin TSOT, low cost
ADP7142	Single	2.7 to 40	1.2	200mA	0.20	11	50	Multiple Fixed	125	TSOT	High 40Vin, low cost
LT3042 ^^	Single	1.8 to 20	0	200mA	0.35	0.8	2.0mA	Adj (0 to 15)	150	MSOP-10E	ultra low noise, ultrahigh PSRR
LT3012	Single	4 to 80	1.24	250mA	0.40	100	40	Adj (1.24 to 60)	140	3x4 DFN-12	Highest 80Vin, Low Iq
MAX25300	Single	1.7 to 5.5	0.5	500mA	0.3	12	365	Adj (0.6 to 5.3)	150	10L TDFN 3x3	low cost
LTC3025-1	Single	0.9 to 5.5	1	500mA	0.08	80	54	1	125	2x2 DFN	small footprint, high power density, low Vin, low cost
LT3045 ^^	Single	1.8 to 20	0	500mA	0.27	0.8	2.2mA	Adj (0 to 15)	150	MSOP-12E	ultra low noise, ultrahigh PSRR
LT3085	Single	1.2 to 36	0	500mA	0.275	33	1mA	Adj (0 to 35.7)	125	MSOP-8E	0Vout operation, paralellable
LT3065	Single	2.0 to 45	0.6	500mA	0.3	25	55	Adj (0.6 to 40)	150	MSOP-12E	High 40Vin
MAX25307	Dual	1.7 to 5.5	0.6	600mA / 300mA	0.155	37	1200	Adj (0.6 to 3.7875)	150	16L TQFN 3x3	dual output, low cost
MAX25308	Triple	1.7 to 5.5	0.6	600mA / 300mA / 300mA	0.155	37	1200	Adj (0.6 to 3.7875)	150	16L TQFN 3x3	triple output, low cost
ADP1761	Single	1.1 to 1.98	0.5	1	0.03	12	4.5mA	Multiple Fixed	125	LFCSP	low Vin, good power density
MAX25301	Single	1.7 to 5.5	0.5	1	0.3	12	365	Adj (0.6 to 5.3)	150	10L TDFN 3x3	good power density, low cost
LT3080	Single	1.2 to 36 ($40V_{MAX}$)	0	1.1	0.3 **	40	1mA	Adj (0 to 36) ***	125	SOT-223	0Vout operation, paralellable
ADP7156	Single	2.3 to 5.5	1.2	1.2	0.12	1.6	4mA	Multiple Fixed	125	LFCSP	low noise
LT1963/A	Single	2.1 to 20	1.21	1.5	0.34	40	1mA	Adj, 1.5, 1.8, 2.5, 3.3	125	SOT-223	robust, bulletproof PNP protection
MAX25302	Single	1.7 to 5.5	0.5	2	0.3	12	365	Adj (0.6 to 5.3)	150	10L TDFN 3x3	high Iout, low cost
ADP1762	Single	1.1 to 1.98	0.5	2	0.03	12	4.5mA	Multiple Fixed	125	LFCSP	low Vin, high Iout, low dropout
ADP1763	Single	1.1 to 1.98	0.5	3	0.03	12	4.5mA	Multiple Fixed	125	LFCSP	low Vin, highest Iout, low dropout

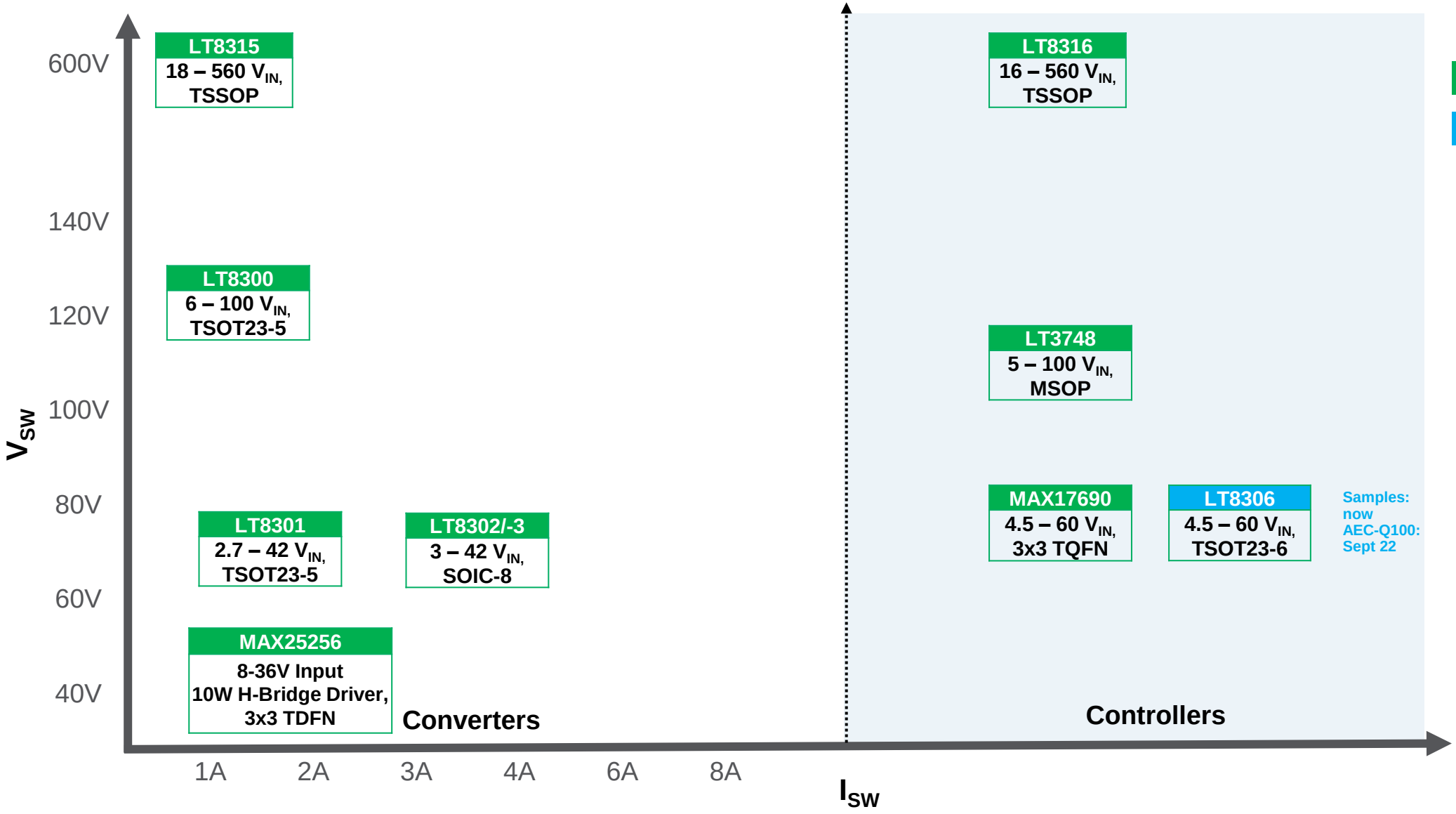
@ 10Hz to 100kHz ** in two-supply operation *** single resistor V_{OUT} set ^^ PSRR >70dB up to 4MHz

Negative LDO Regulators

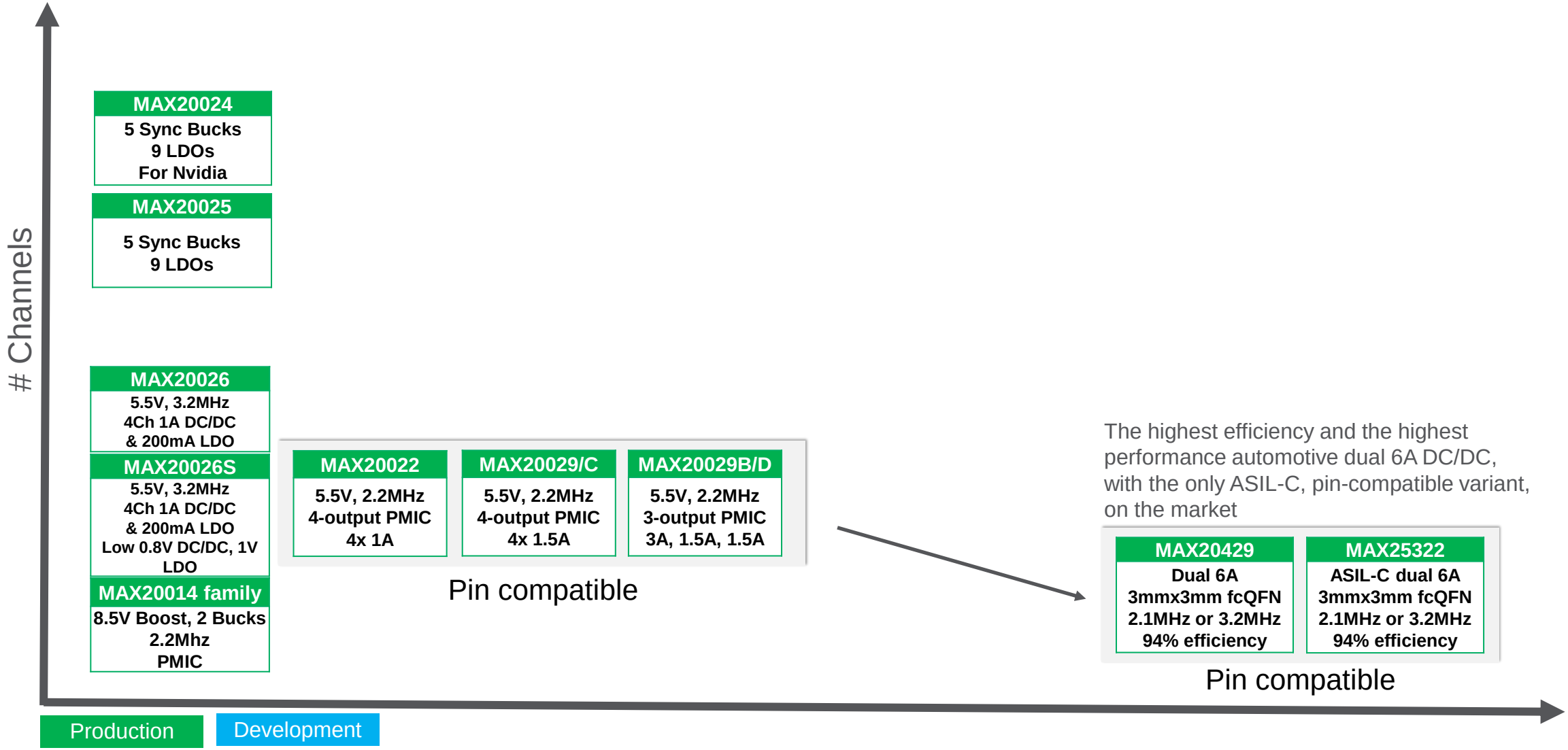
Part No	Device Output	V_{IN} Range(V)	V_{OUT} (MIN)(V)	I_{OUT} (A)	Dropout Voltage (V)	Noise (µVRMS) @	I_Q(µA)	Output Voltage (V)	Max Junc Temp (˚C)	Package	Summary Positioning
ADP7183	Single	-2 to -5.5	-0.5	300mA	0.13	5	600	Multiple Fixed	125	LFCSP	negative Vin/Vout

@ 10Hz to 100kHz

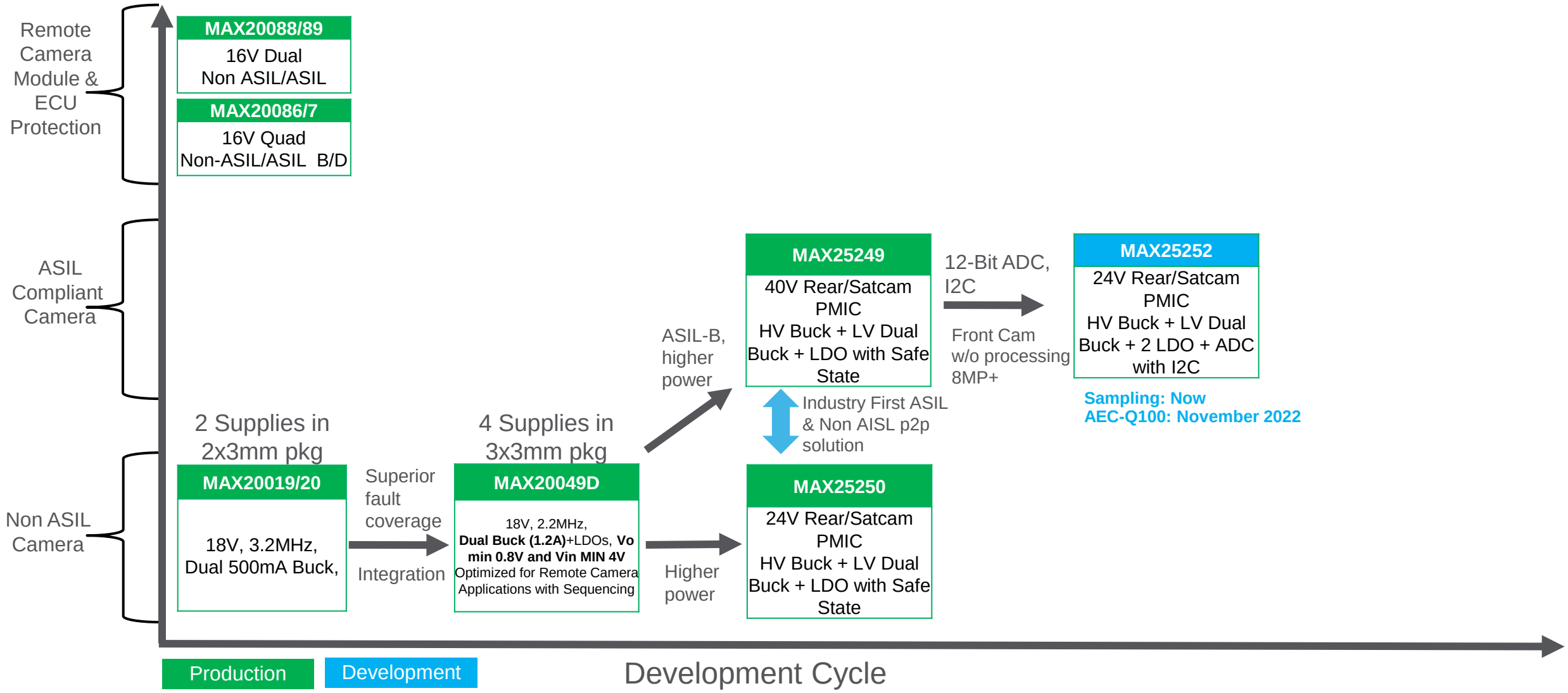
Isolated Flyback Converters & Controllers



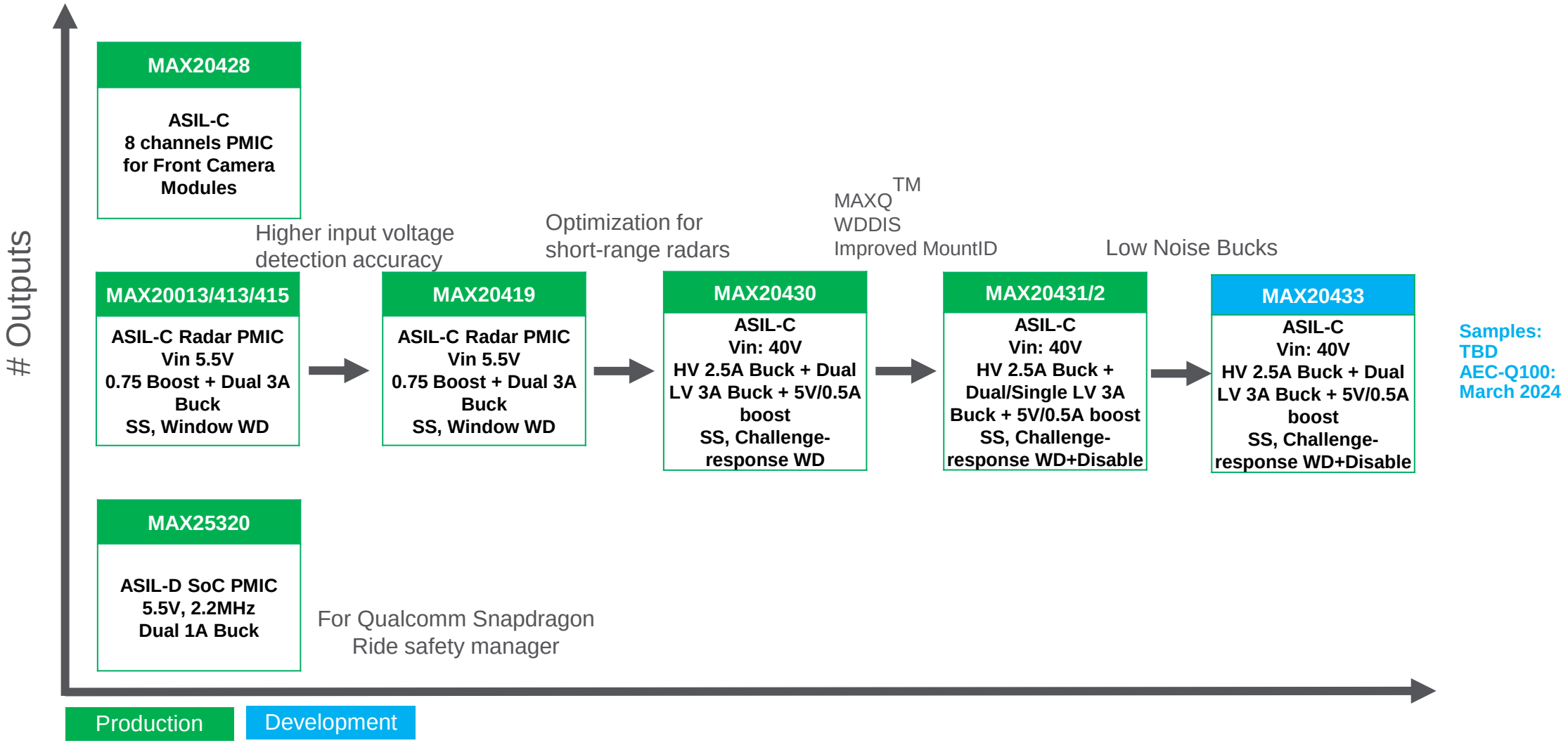
Low Voltage PMIC Roadmap



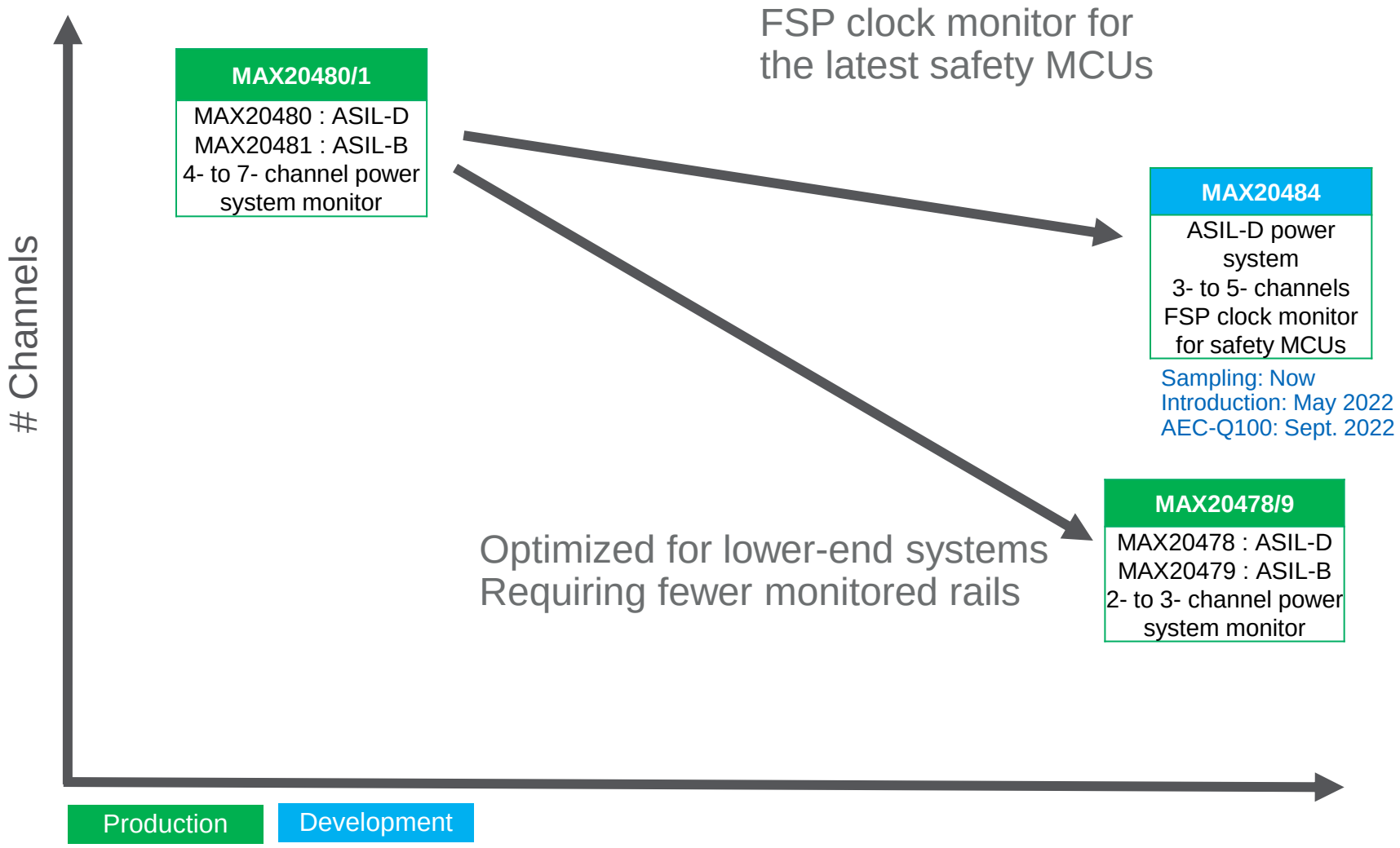
Camera Sensor Power & Protection Roadmap



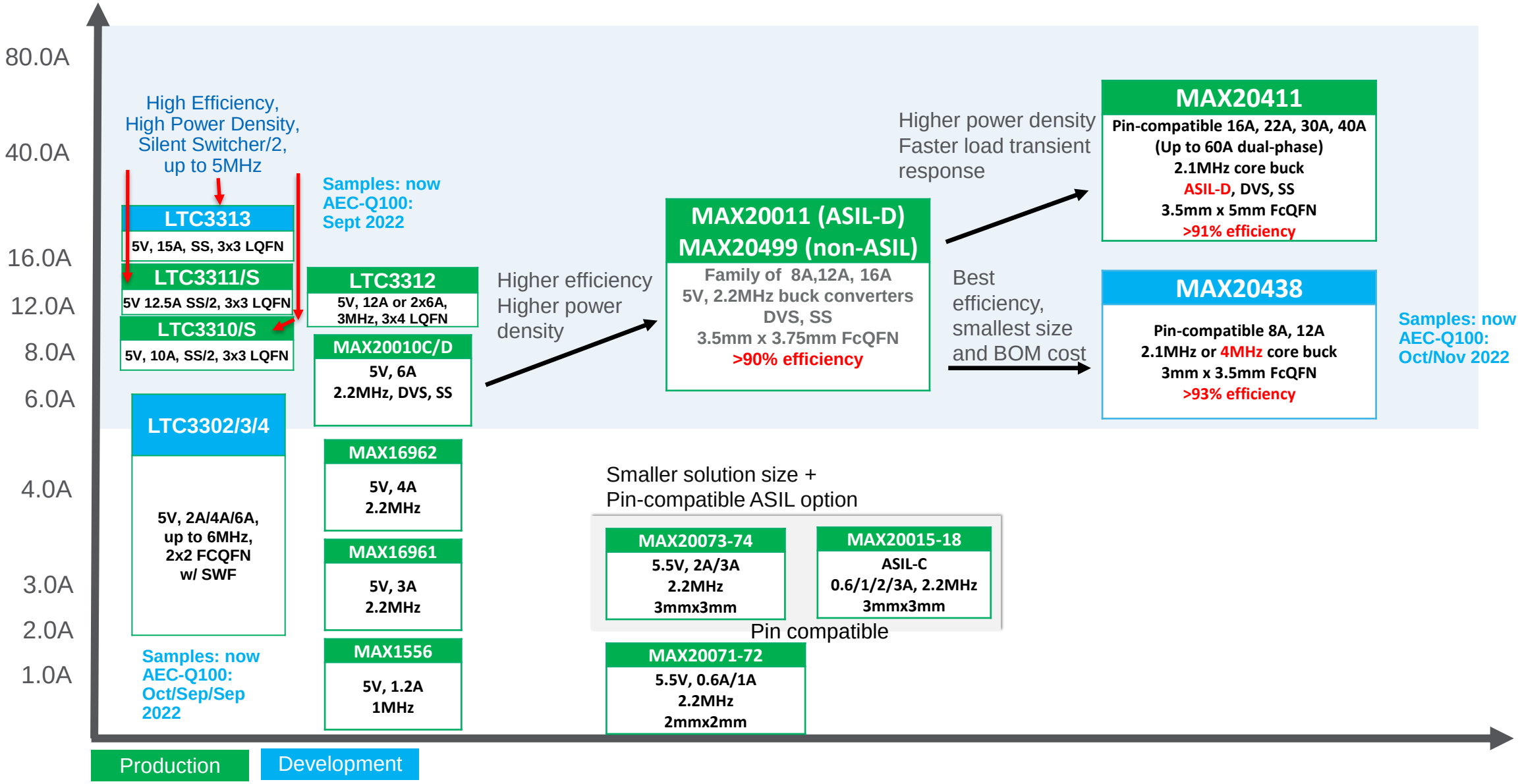
ADAS PMICs: SoC, Radar Sensor & Front Camera Module Power



ASIL-Compliant Power System Monitors



SoC Core Power Solutions



Low Current SoC Core Power Positioning Table

Parameter/Device	LTC3302	LTC3303	LTC3304	LTC3307A/B	LTC3308A/B	LTC3309A/B	MAX20073/74	MAX20010
Topology	Single Synchronous monolithic	Single Synchronous monolithic	Single Synchronous monolithic	Single Synchronous monolithic, Silent Switcher 1	Single Synchronous monolithic, Silent Switcher 1	Single Synchronous monolithic, Silent Switcher 1	Single Synchronous monolithic	Single Synchronous monolithic
V_{IN} Range	2.25V to 5.5V	2.25V to 5.5V	2.25V to 5.5V	2.25V to 5.5V	2.25V to 5.5V	2.25V to 5.5V	2.7V to 5.5V	3.0V to 5.5V
V_{OUT} Range	0.5V to 3.65V	0.5V to 3.65V	0.5V to 3.65V	0.5V to VIN	0.5V to VIN	0.5V to VIN	0.6V to Vin	0.5V to Vin (I2C)
Output Current	2A	4A	6A	3A	4A	6A	2A/3A	6A
Switching Frequency	A B C 2 / 4 / 6 MHz	A B C 2 / 4 / 6 MHz	A B C 2 / 4 / 6 MHz	A: 1MHz to 3MHz B: 3MHz to 10MHz	A: 1MHz to 3MHz B: 3MHz to 10MHz	A: 1MHz to 3MHz B: 3MHz to 10MHz	2.2MHz	2.2MHz
Efficiency	92% (3.3Vin / 1.2Vout / 2A) Fsw = 2MHz	92% (3.3Vin / 1.2Vout / 4A) Fsw = 2MHz	92% (3.3Vin / 1.2Vout / 6A) Fsw = 2MHz	88% (3.3Vin / 1.2Vout / 3A) Fsw = 2MHz	89% (3.3Vin / 1.2Vout / 4A) Fsw = 2MHz	86% (3.3Vin / 1.2Vout / 6A) Fsw = 2MHz	75% (3.3Vin / 1.2Vout / 3A) Fsw = 2.2MHz	72% (3Vin / 0.95Vout / 6A) Fsw = 2.2MHz
IQ Supply Burst Mode / non-Burst	90uA / 1.2mA	90uA / 1.2mA	90uA / 1.2mA	40uA / 1.3mA	40uA / 1.3mA	40uA / 1.3mA	<10µA	<10µA
Minimum On-Time	22ns	22ns	22ns	22ns	22ns	22ns	40ns	40ns
Silent Switcher	no	no	no	SS1	SS1	SS1	no	no
Spread Spectrum	no	no	no	no	no	no	yes	yes
EMI radiated	medium	medium	medium	ultra-low	ultra-low	ultra-low	low	low
Features	PG, SS, internal comp	PG, SS, internal comp	PG, SS, internal comp	PG, SS, internal comp	PG, SS, internal comp	PG, SS, internal comp	OTSD, OCL, Reset	programmable SS, OT, OC protection, PGood
Package	2mmx2mm custom L/F FC QFN-12 w SWF	2mmx2mm custom L/F FC QFN-12 w SWF	2mmx2mm custom L/F FC QFN-12 w SWF	1.6x1.6mm WLCSP-16 2mm × 2mm LQFN-12	2mm×2mm × 0.74mm LQFN-12	2mm×2mm × 0.74mm LQFN-12	3mm x 3mm TDFN-10	4mm x 4mm TQFN-20
Summary Positioning	SWF package for better BLR, low cost, high Fsw up to 6MHz capable C version	SWF package for better BLR, low cost, high Fsw up to 6MHz capable C version	SWF package for better BLR, low cost, high Fsw up to 6MHz capable C version	lowest EMI, high Fsw up to 10MHz capable B version	lowest EMI, high Fsw up to 10MHz capable B version	lowest EMI, high Fsw up to 10MHz capable B version	low cost non-SWF package, low current	low cost non-SWF package, high current
	pin compatible	pin compatible	pin compatible	pin compatible	pin compatible	pin compatible		

High Current SoC Core Power Positioning Table

Parameter / Device	MAX20411A/B/C/D	LTC3313	LTC3312S	LTC3311/S	MAX20438	MAX20499A-B / MAX20011A-B	LTC3310/S
Topology	Single Synchronous monolithic MAXQ™ Power Arch	Single Synchronous monolithic, Silent Switcher 1	Single Synchronous monolithic	Single Synchronous monolithic, Silent Switcher 1/2	Single Synchronous monolithic MAXQ™ Power Arch	Single Synchronous monolithic non-ASIL / ASIL	Single Synchronous monolithic, Silent Switcher 1/2
V_{IN} Range	3V to 5.5V	2.25V to 5.5V	2.25V to 5.5V	2.25V to 5.5V	2.5V to 5.5V	3V to 5.5V	2.25V to 5.5V
V_{OUT} Range	0.5V to 1.275V I2C	0.5V to VIN, 0.75V	0.5V to VIN	0.5V to VIN	0.5V to 1.2V	0.5V to 1.275V I^2C	0.5V to VIN
Output Current	16/22/30/40A	15A	12A or 2x6A	12.5A	12A	8A - 12A	10A
Switching Frequency	1.05MHz, 2.1MHz	500kHz to 5MHz	up to 3MHz	500kHz to 5MHz	2.1MHz, 4.2MHz	1.1MHz, 2.2MHz	500kHz to 5MHz
Efficiency (V_{IN}=12V, V_{OUT}=1.5V@xxA @+25C)	92% (3.3Vin / 0.875Vout / 5A) 2.1MHz	92% (3.3Vin / 1.2Vout / 5A) 2MHz	90% (3.3Vin / 1.2Vout / 5A) 2MHz	91% (3.3Vin / 1.2Vout / 5A) 2MHz	91.4% (3.3Vin / 0.75Vout / 4A) 2.1MHz	A/B: 88% 2.2MHz (3.3Vin / 0.8Vout / 5A) C/D: 90% 2.2MHz (3.3Vin / 0.825Vout / 5A)	91% (3.3Vin / 1.2Vout / 5A) 2MHz
I_Q Supply	2.5mA	1.3mA	1.3mA	1.3mA	1mA	2.5mA	1.3mA
Minimum On-Time	50ns	35ns	35ns	35ns	adaptive Ton	40ns	35ns
Silent Switcher	no	SS1	no	SS1 / SS2	no	no	SS1 / SS2
Spread Spectrum	yes	no	no	no	yes	yes	no
EMI radiated	low	ultra-low	medium	ultra-low	low	low	ultra-low
Features	OT, short circuit protected, programmable OV/UV	SS, Tracking, PG, die temp monitor	PG, Tracking, Programmable Soft-Start, Temp Monitor Output	SS, Tracking, PG, die temp monitor	OV/UV monitors, programmable SS / RESET, OTSD, CL	OT, short circuit protected	SS, Tracking, PG, die temp monitor
ASIL	ASIL D	no	no	no	no	MAX20011 = ASIL	no
Package	3.5 x 5 FC2QFN-21	3mm × 3mm × 0.94mm LQFN-18 *	3mm × 4mm × 0.94mm LQFN-22	3mm × 3mm × 0.94mm LQFN-18 ^	3 x 3.5 FCQFN-17	3.5 x 3.75 FC2QFN-17 with SWF	3mm × 3mm × 0.94mm LQFN-18 ^
Summary Positioning	MAXQ reduces Cout, higher current options B/C/D available	lowest EMI Silent Switcher, multi-phase capable, high Fsw up to 5MHz	dual phase capable, high Fsw up to 3MHz	lowest EMI Silent Switcher, multi-phase capable, high Fsw up to 5MHz	lowest cost, high effic, MAXQ reduces Cout, high Fsw 4.2MHz	ASIL option, low cost, use C/D for higher efficiency, SWF for better BLR	lowest EMI Silent Switcher, multi-phase capable, high Fsw up to 5MHz

* footprint compatible w/ LTC3310/S & LTC3311/S

^ pin compatible with LTC3310/S

^ pin compatible with LTC3311/S

Multi Market Power

Smart Power System SBU Portfolio and Roadmap

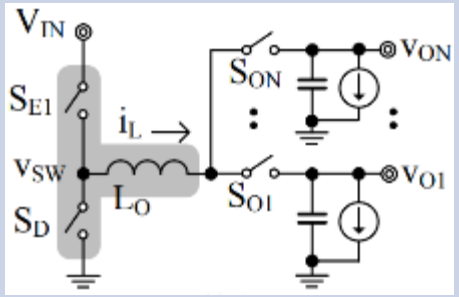
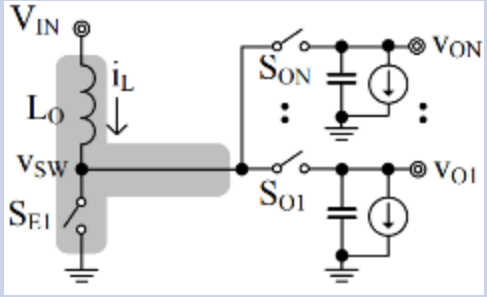
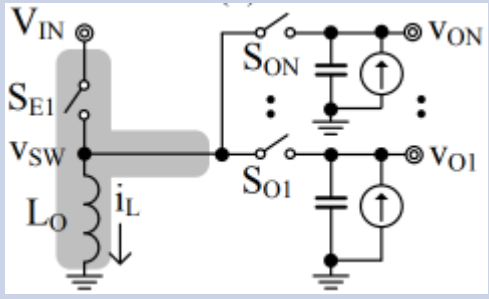
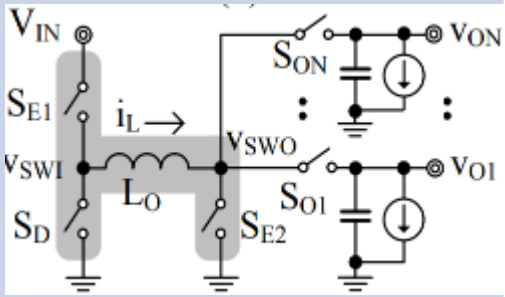
LDO, Boost, Buck-Boost, Voltage Reference, nanoPower

SPS Product Portfolio

- SIMO and CLP
- Monolithic Buck-Boost Regulators
- Monolithic Boost Regulators
- Linear Regulators
- NANOPOWER

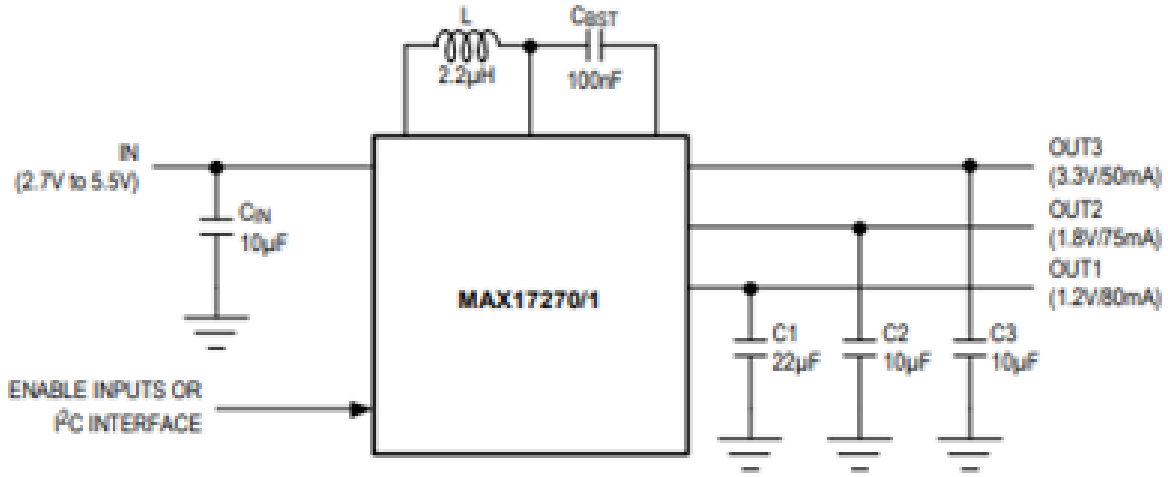
SIMO and Closed-Loop Power

Proprietary SIMO Topology Options

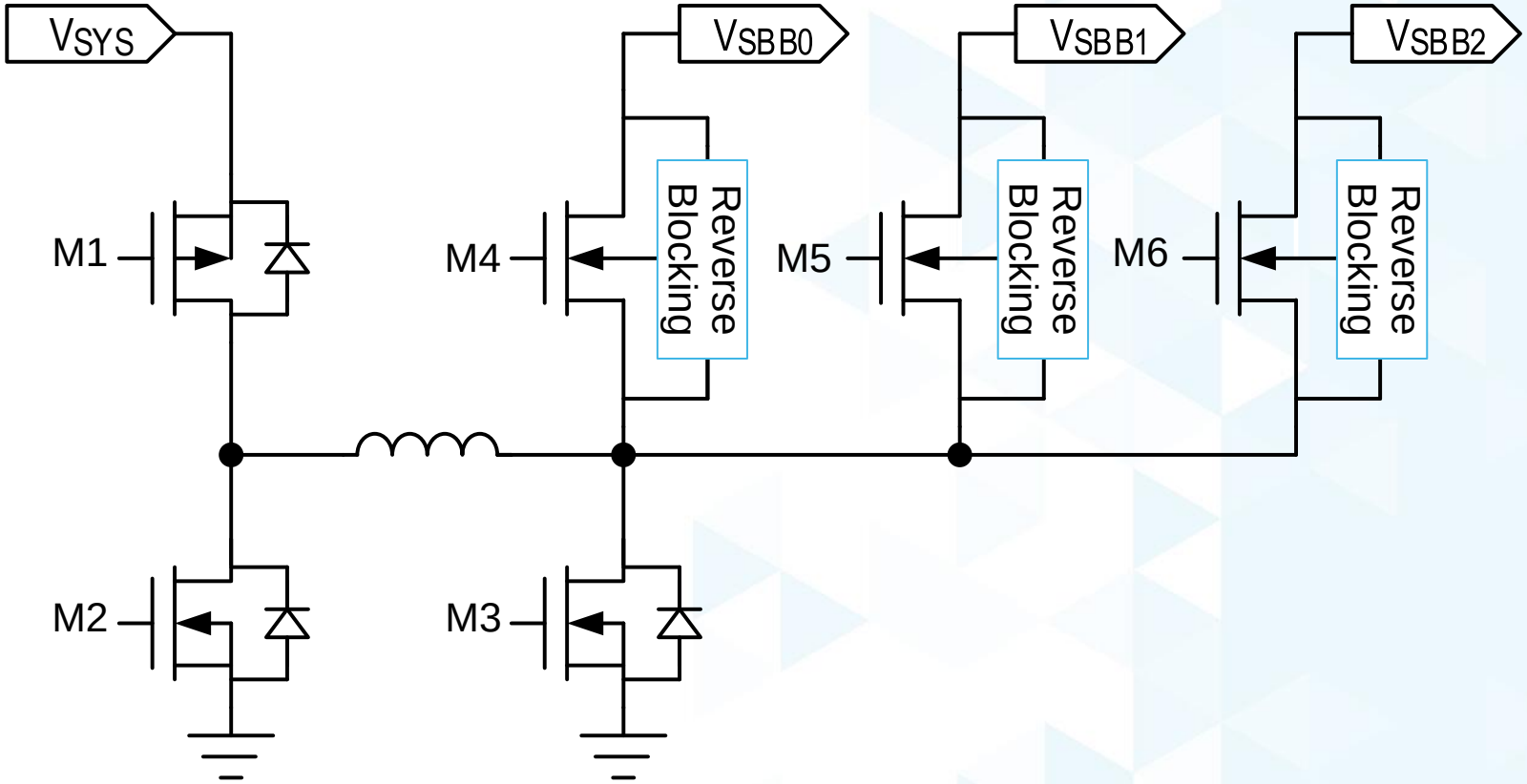
	Buck	Boost	Inverting Buck/Boost	Non-Inverting Buck/Boost
Topology				

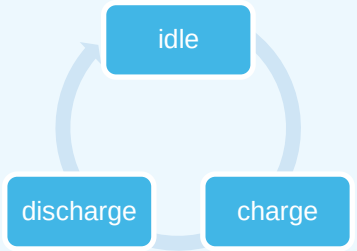
Facts on SIMO

- First gen SIMO are DCM only. Second gen will be CCM based
- DCM may allow low Iq
- Single rail best not to exceed 500mA
- First gen frequency to not exceed 500kHz
- Ideal for applications with multiple low current rail outputs like MCUs and sensors



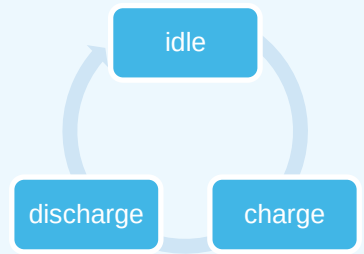
SIMO Block Diagram



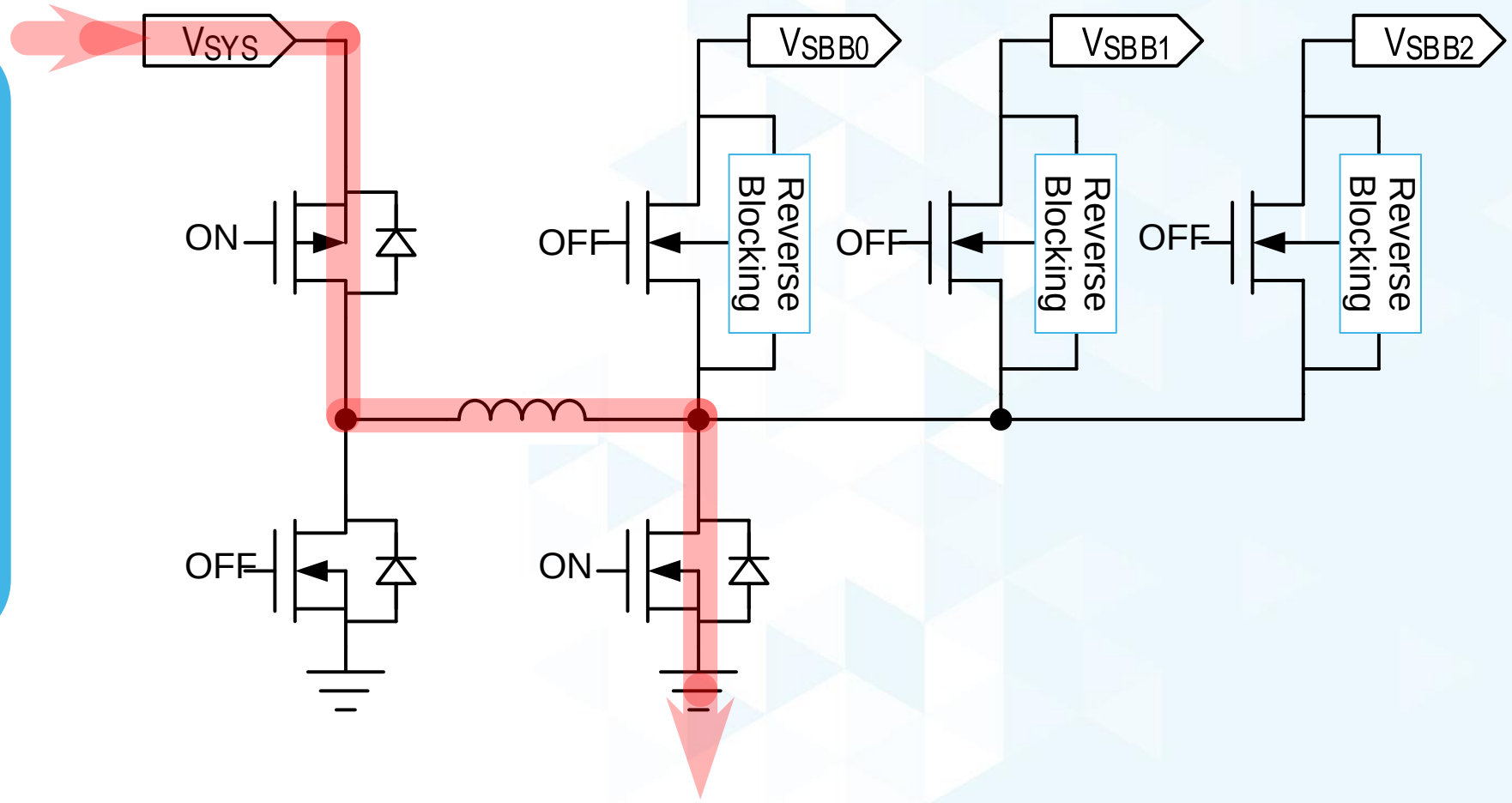


SIMO Buck-Boost Function

Inductor Charge

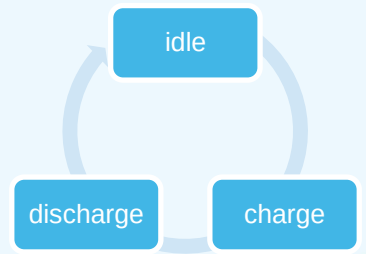


Inductor current increases to I_{PEAK}

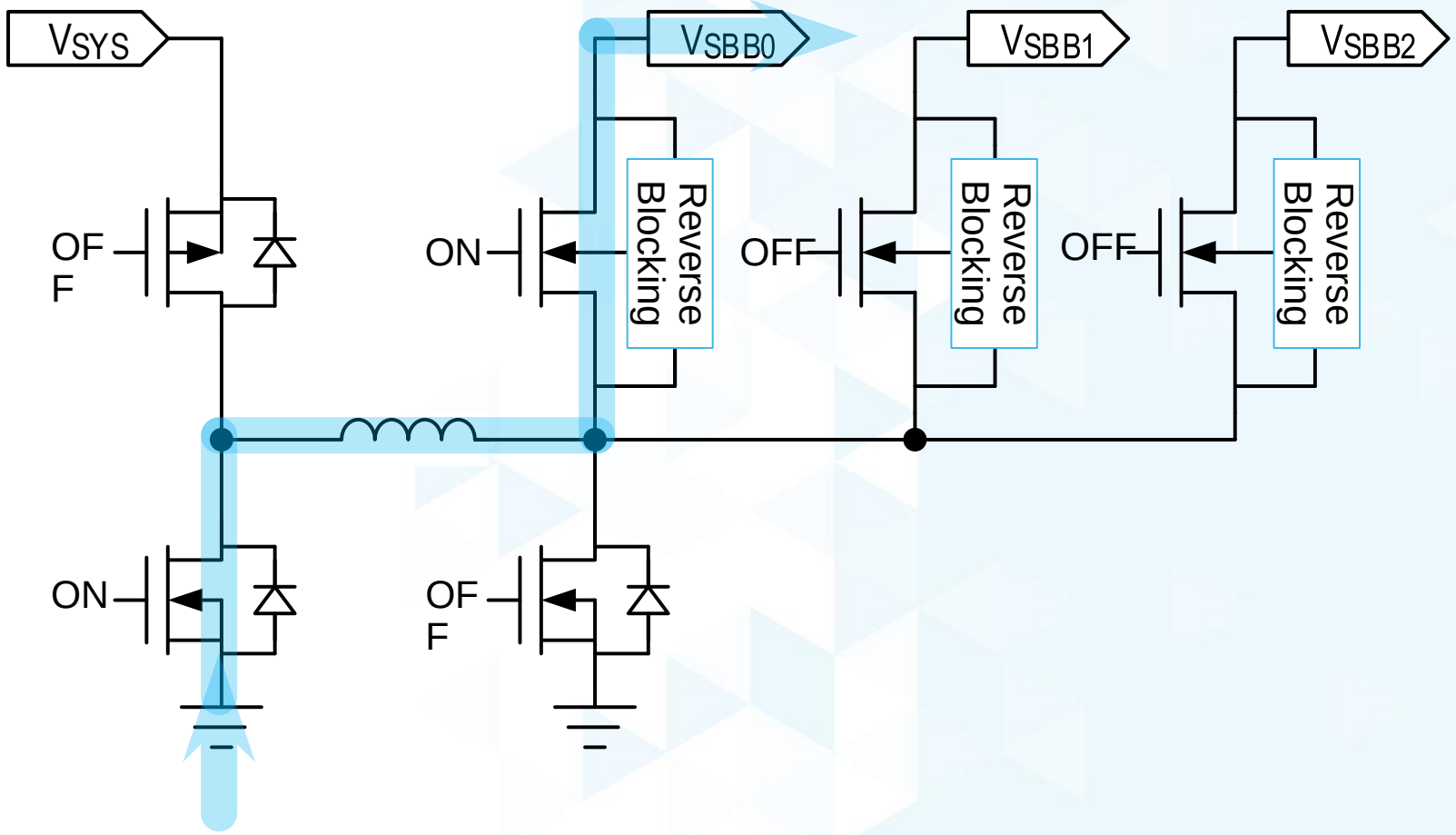


SIMO Buck-Boost Function

Inductor Discharge to SBB0

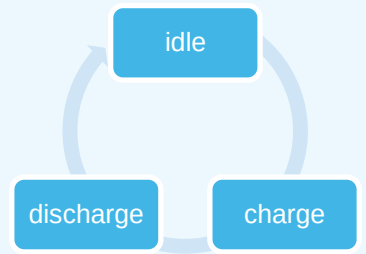


Inductor energy transferred to SBB0

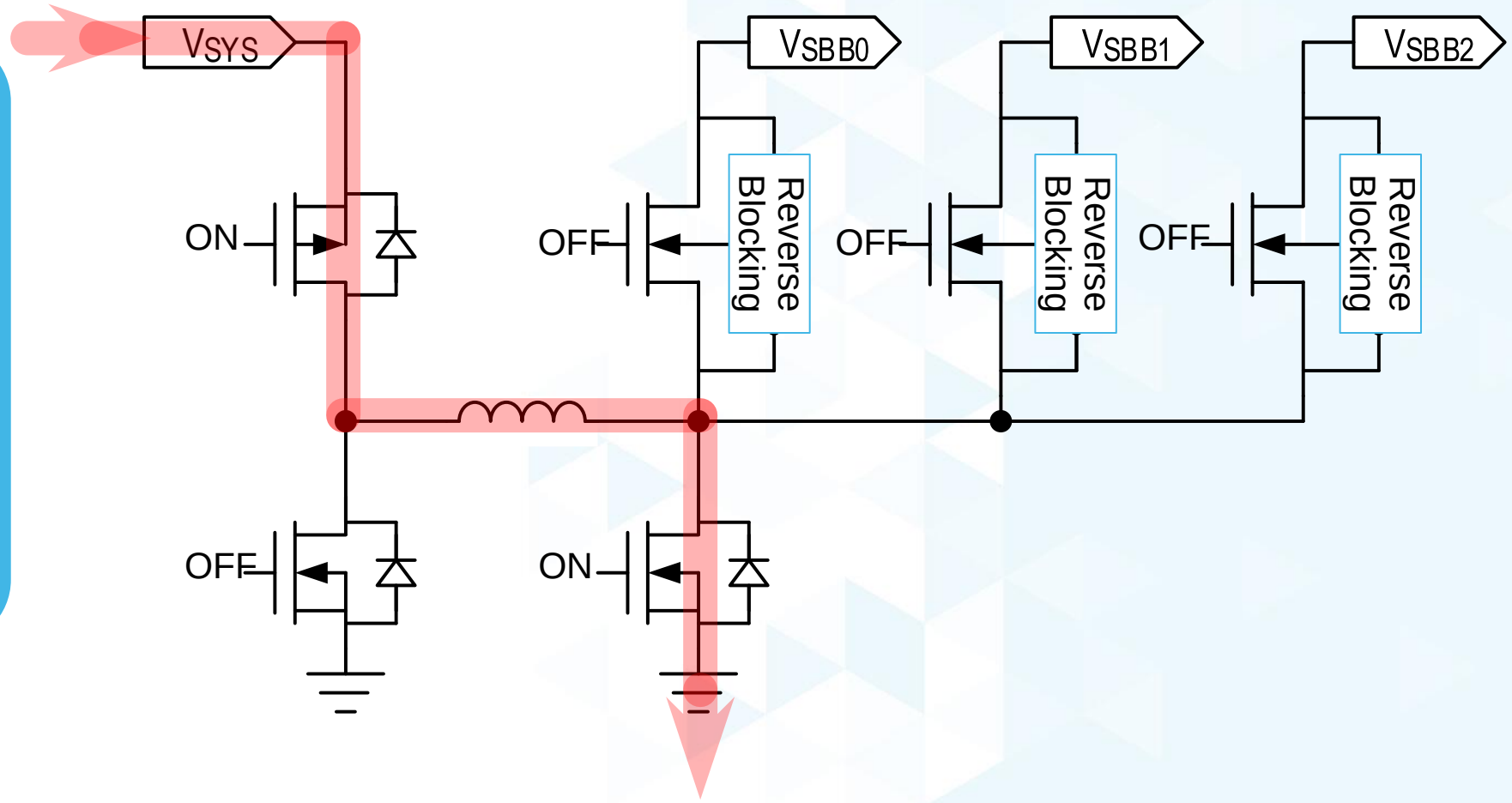


SIMO Buck-Boost Function

Inductor Charge

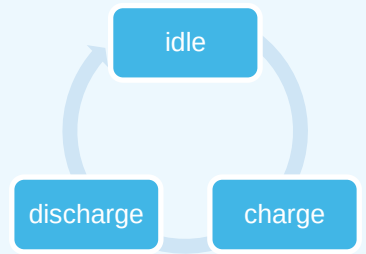


Inductor current increases to I_{PEAK}

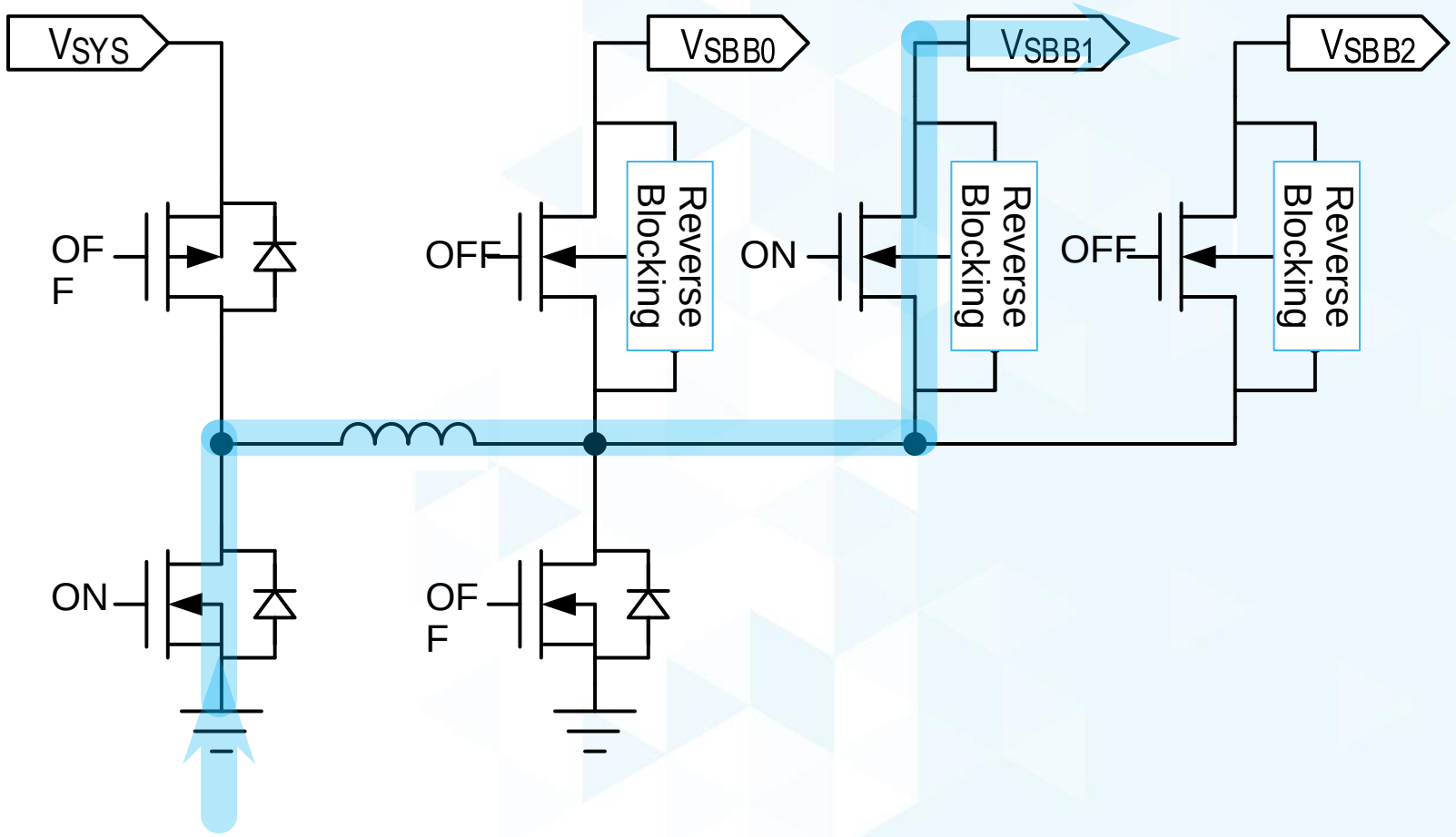


SIMO Buck-Boost Function

Inductor Discharge to SBB1

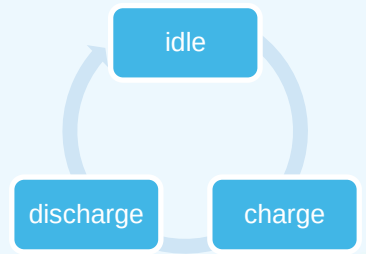


Inductor energy transferred to SBB1

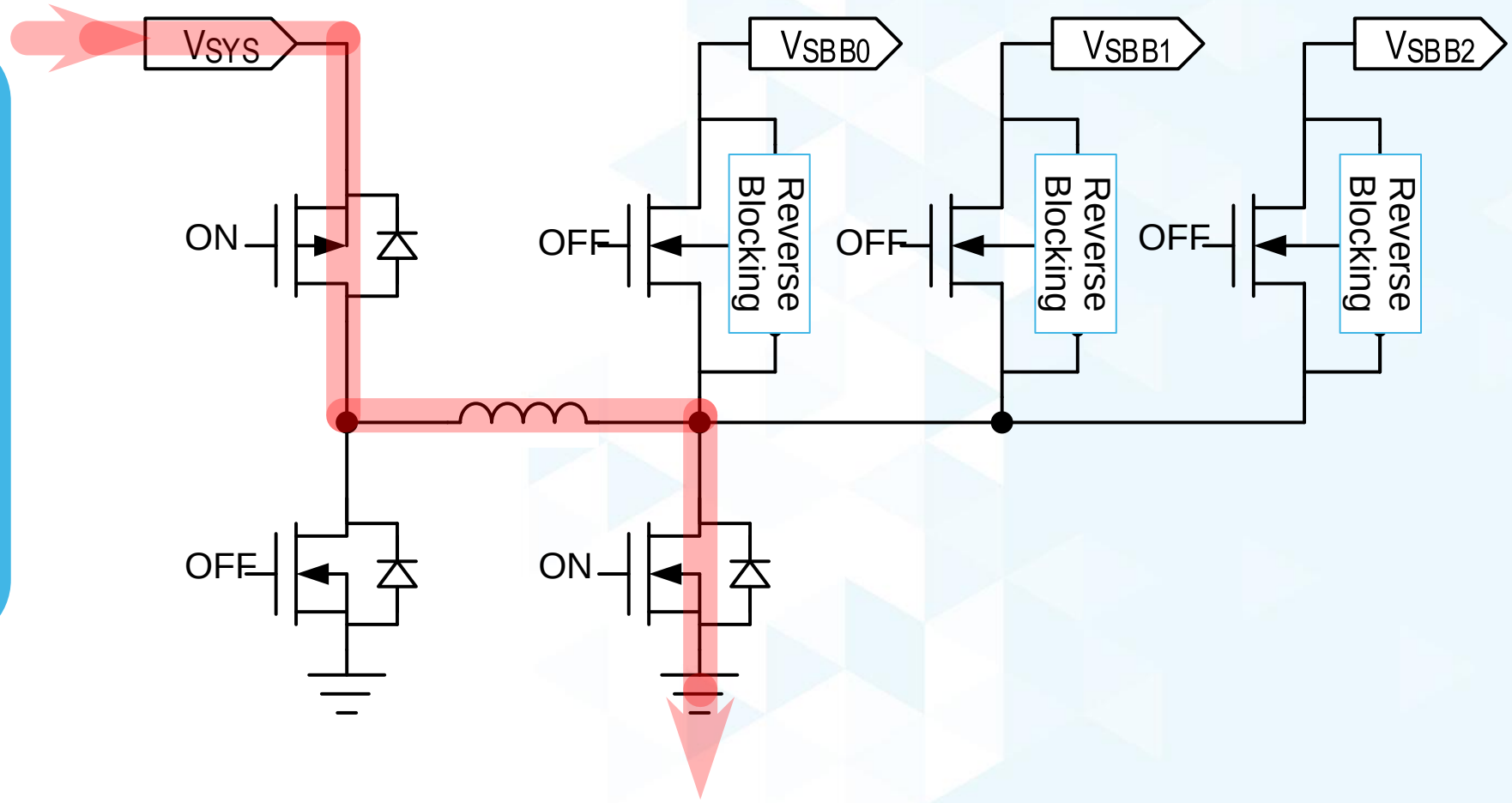


SIMO Buck-Boost Function

Inductor Charge

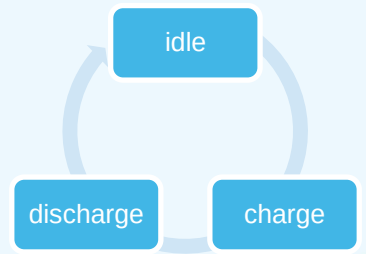


Inductor current increases to I_{PEAK}

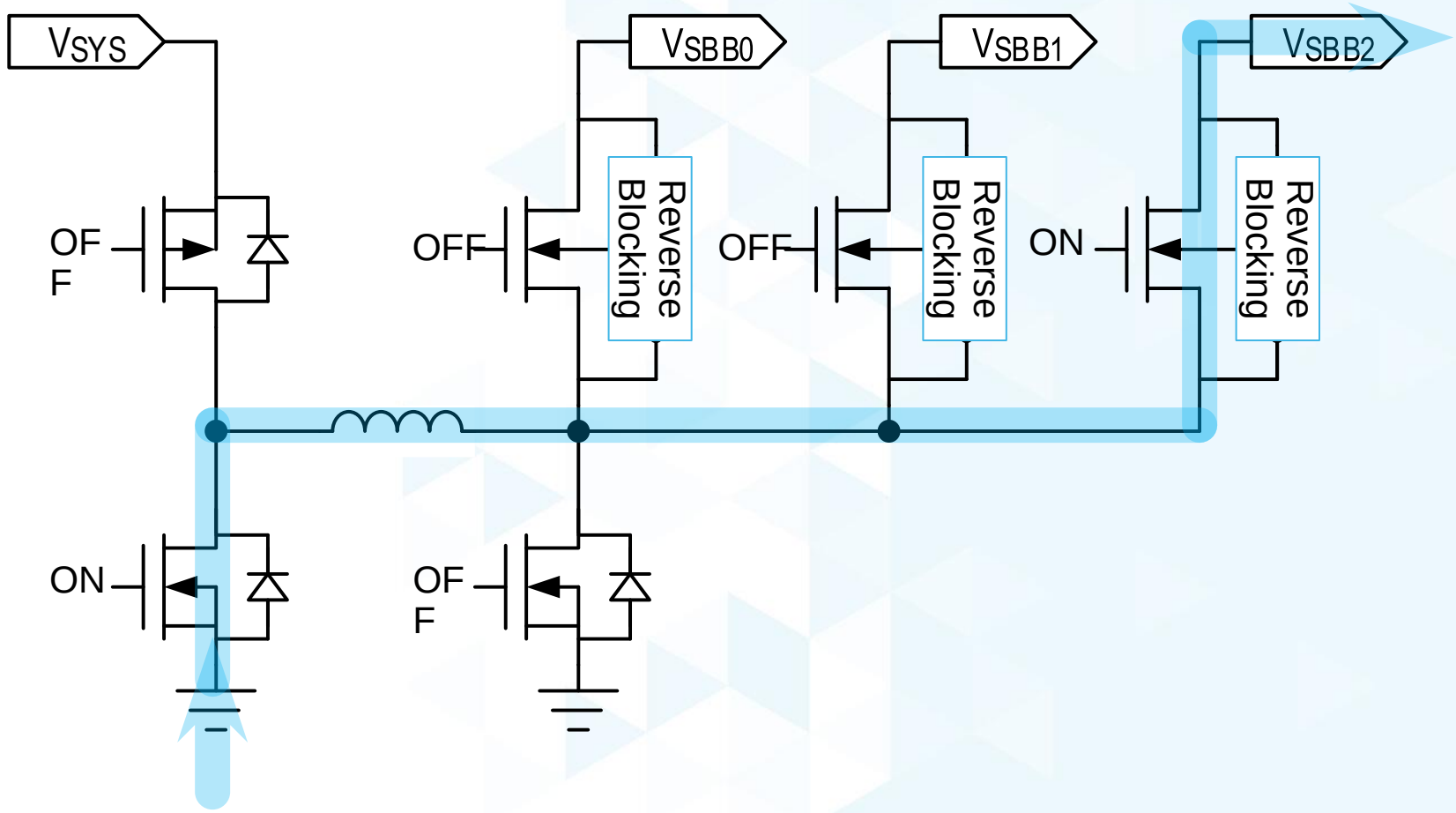


SIMO Buck-Boost Function

Inductor Discharge to SBB2

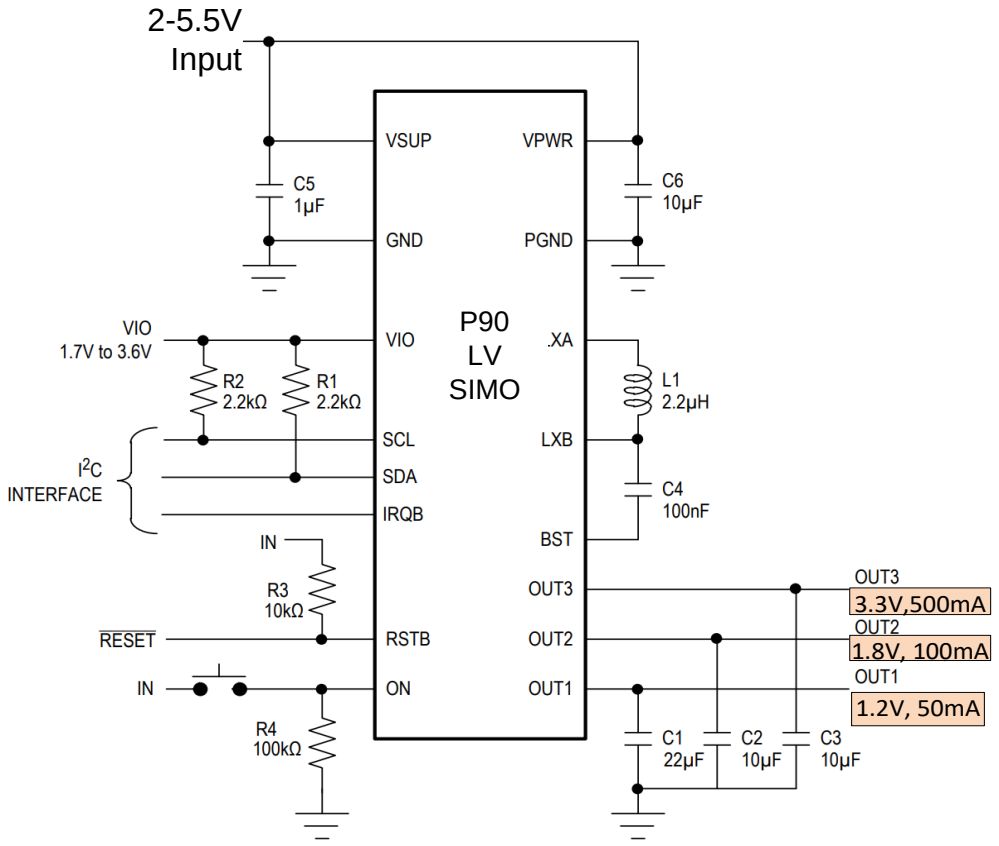


Inductor energy transferred to SBB2



SIMO and CLP Roadmap

SIMO01 - 5.5V_{IN}, 3-Channel Buck-Boost SIMO



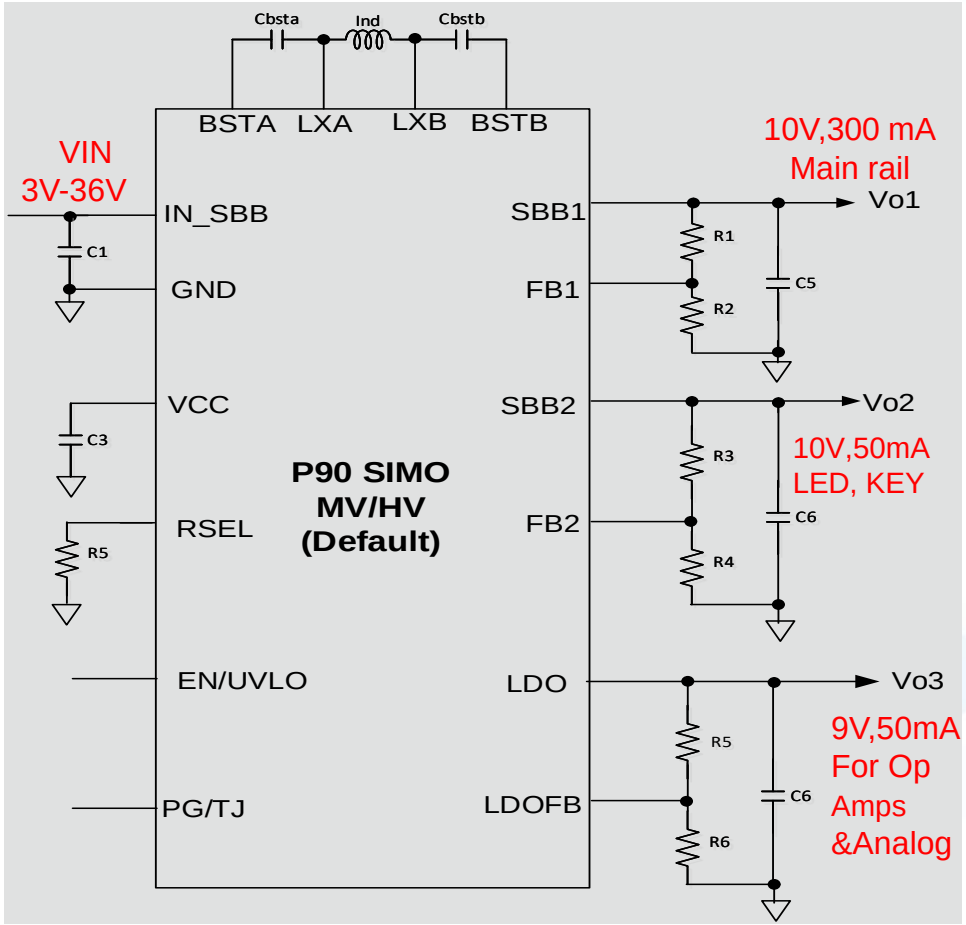
Features

- 3-Output, Single-Inductor, Multiple-Output (SIMO) Buck-Boost Regulator
- 2.7V to 5.5V Input Voltage Range
- Low-Power and Long Battery Life
- 1.3µA Operating Current (3 SIMO Channels)
- 330nA Shutdown Current
- 93% Efficiency at 3.3V Output
- I2C-Compatible Interface
- Programmable Output Voltage: 0.8V to 5.175V
- Programmable Peak Current Limit
- Soft-Start
- Overload Protection
- Thermal Protection
- Small Size
- TBD WLP Package
- 3mm x 3mm x 0.75mm, 16-Pin TQFN Package
- Small Total Solution Size

Applications

- Bluetooth Headsets
- Fitness Bands
- Watches
- Hearables
- Wearables
- Internet of Things (IoT)
- Health Monitors

SIMO02 - 36V , 3.5W, 2-Channel Buck-Boost with LDO



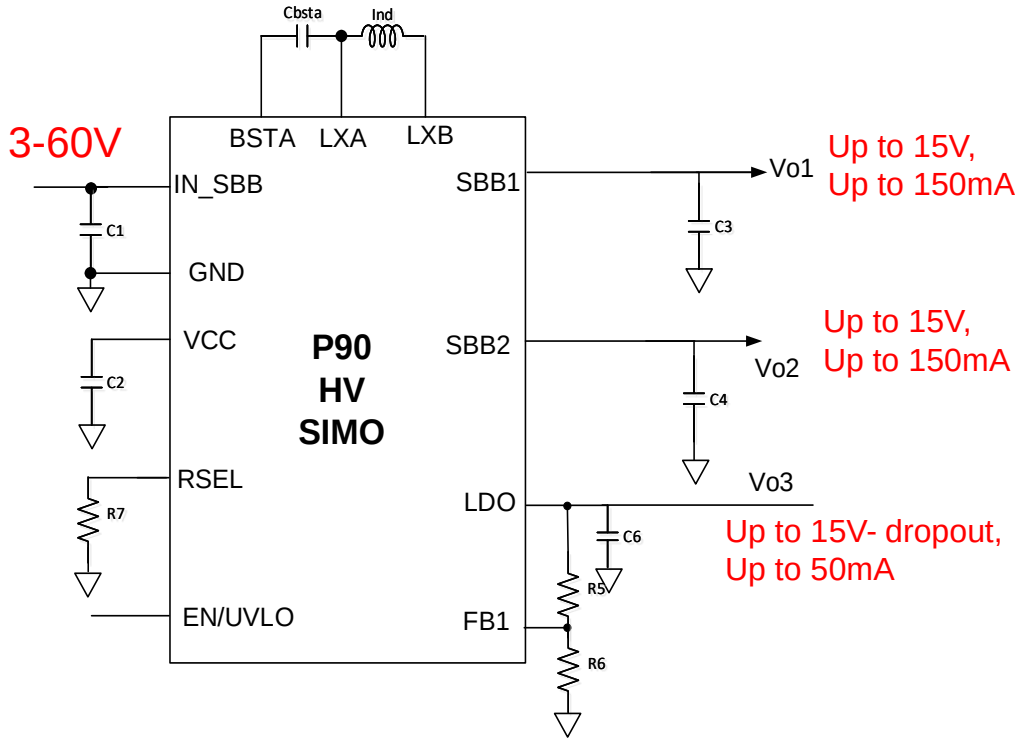
Features

- Wide Input Range 3V to 36V
- Up to 3.5W Combined Output Power
- 2 DC-DC for up to 15V O/p each + 1 LDO for up to 15V, 50mA
- Independent , In-built overcurrent protection on all rails
- Fully adjustable rails
- Wide -40˚C to +125˚C Operating Temperature Range
- 16 Pin TQFN-EP, 3mm x 3mm Package

Benefits

- Reduces solution size and system cost
- Flexible solution provides full adjustability of outputs
- Simple to implement, minimal components to design
- Highly integrated solution simplifies PCB layout

SIMO04 - 60V, 4W, 2-Channel Buck with LDO



Features

- Wide Input Range 3V to 60V
- Up to 4W Combined Output Power
- Low I_Q (< 5µA), Low $I_{SHUTDOWN}$ (< 1µA)
- Integrated LDO for Analog/Noise Sensitive Applications
- Programmable Output Voltages and Peak Current Limits (SELx)
- External Bias Input for Improved Efficiency (EXTVCC)
- PM Bus Interface for Configurability
  - > Programmable Output Voltage and Peak Current Limit
  - > Enables Sequencing and Tracking
  - > Programmable Soft Start Time
- 24 Pin TQFN-EP, 4mm x 4mm Package

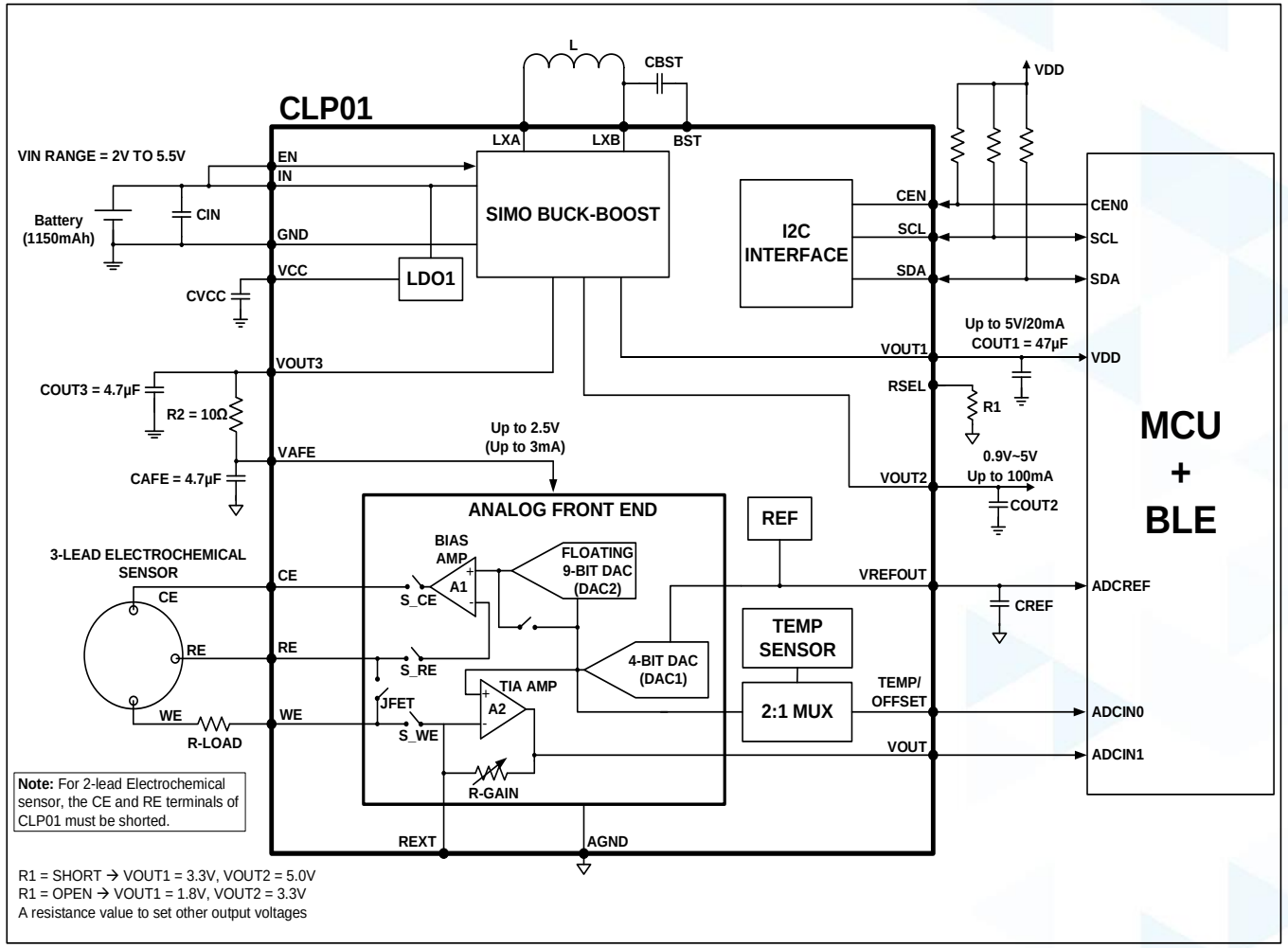
Benefits

- Smallest Solution Size for a Power Distribution Architecture (SIMO)
- Low EMI Emission

Applications

- IoT Power Distribution Supplies
- Industry 4.0 Cloud Integration
- Factory Automation
- Elevator Controls
- Smart Building and Home Automation, HVAC
- Industrial Sensors and Process Control

Electrochemical Sensor AFE with Integrated SIMO DC-DC



Features

- Single Cell Li-Ion input (VIN: 2V to 5.5V)
- Compatible with 2-lead and 3-lead Electro-Chemical sensors
- Configurable SIMO Buck-Boost powers rails for external MCU, any additional System rail, and Precision AFE
  - > Programmable VOUT1/100mA and VOUT2/100mA for MCU / Display
  - > Low Iq (<1µA)
- I2C interface for AFE gain, bias, offset, supply rail control
- Selectable VREFOUT for ADC
- On-Chip Temperature Sensor
- Available in a 24-pin 4mm x 4mm TQFN

Benefits

- Low Iq enables Extended Battery Life, smaller Battery
- High Integration and SIMO design for Smallest solution Size
- Precision AFE for multiple types of sensors (CO, SO2, Ethanol, O2, Cl O2)

Applications

- Industrial control monitors/safety : Various electrochemical gas detection equipment
- Multi-Market: Portable gas detection, Worker safety (body worn) for fighters, soldiers
- Consumer : Residential alarms for gas detection
- Smart Building and Home Automation, HVAC: Air quality monitoring stations in smart city, Buildings
- Medical: Breath analyzers, medical ventilators

Boost and Buck-boost Regulators

Boost and Buck-Boost Regulators

Performance:

- Industry wildest selection from <5V to 140V, 0.2A to 6A
- >800 customers
- 180 applications
- Small solution, high efficiency, low Iq, low noise

Design Win Examples in 2022

Service Robot ($300+ ADI content, entire powertrain)

Agricultural drone (high voltage, low noise, low Iq buck-boost)

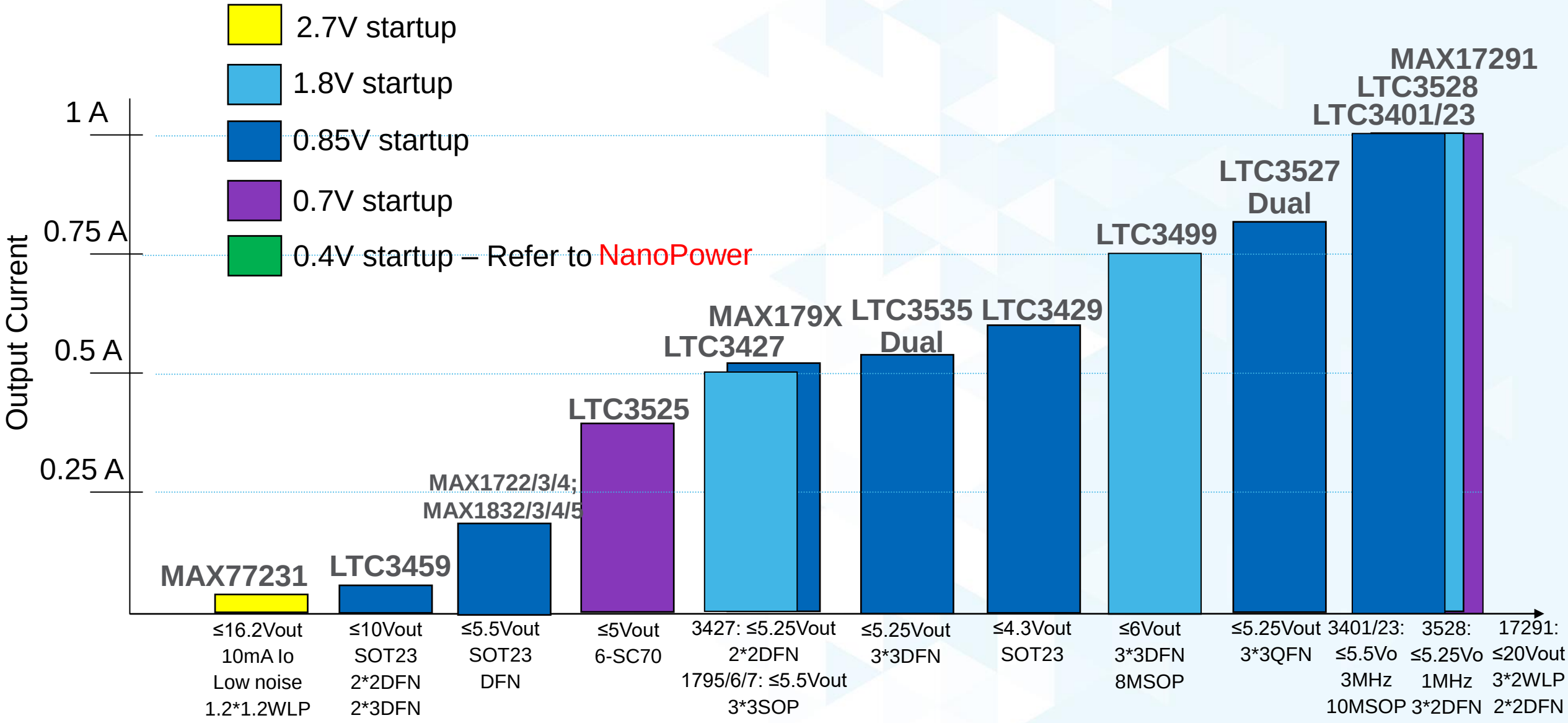
Satcom Modem (Wide Vin buck-boost)

Welding helmet (boost for LCD to adjust shade)

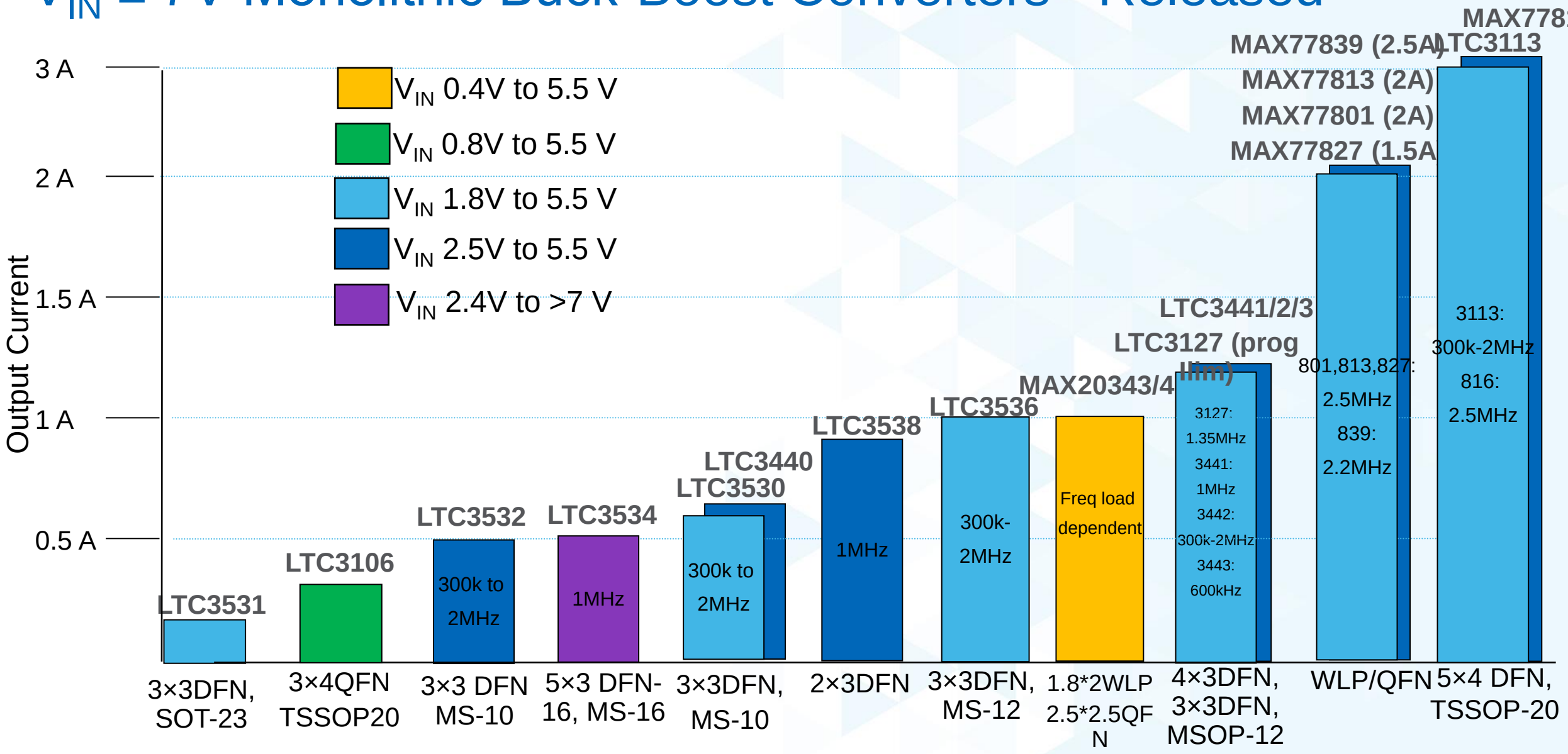
Optical communications (Boost from 3.3V)

Electric power distribution terminal (Best buck-boost for supercapacitor backup)

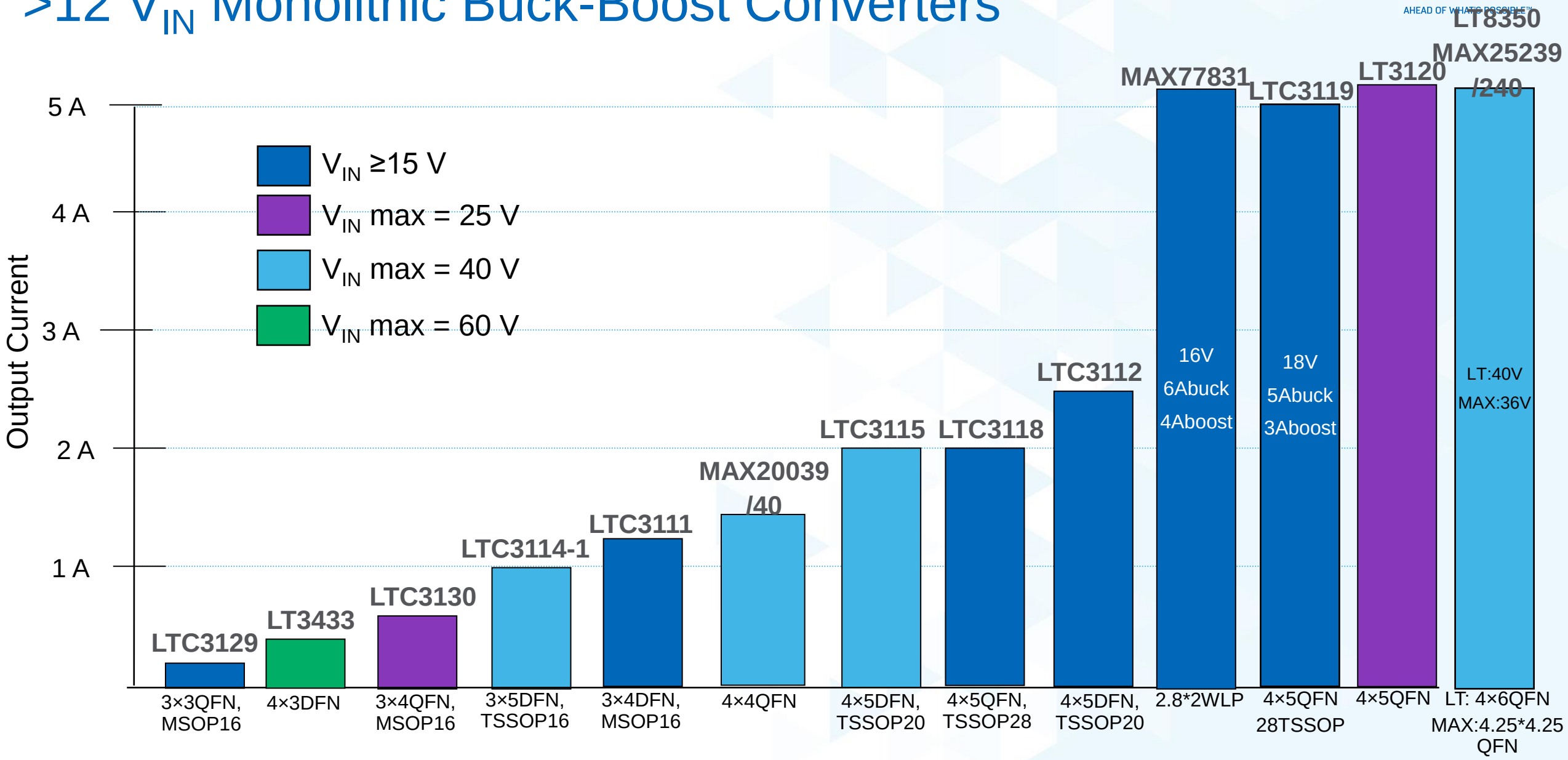
Low Voltage (≤5 V) Monolithic Boost Converters, ≤1 A Output Current



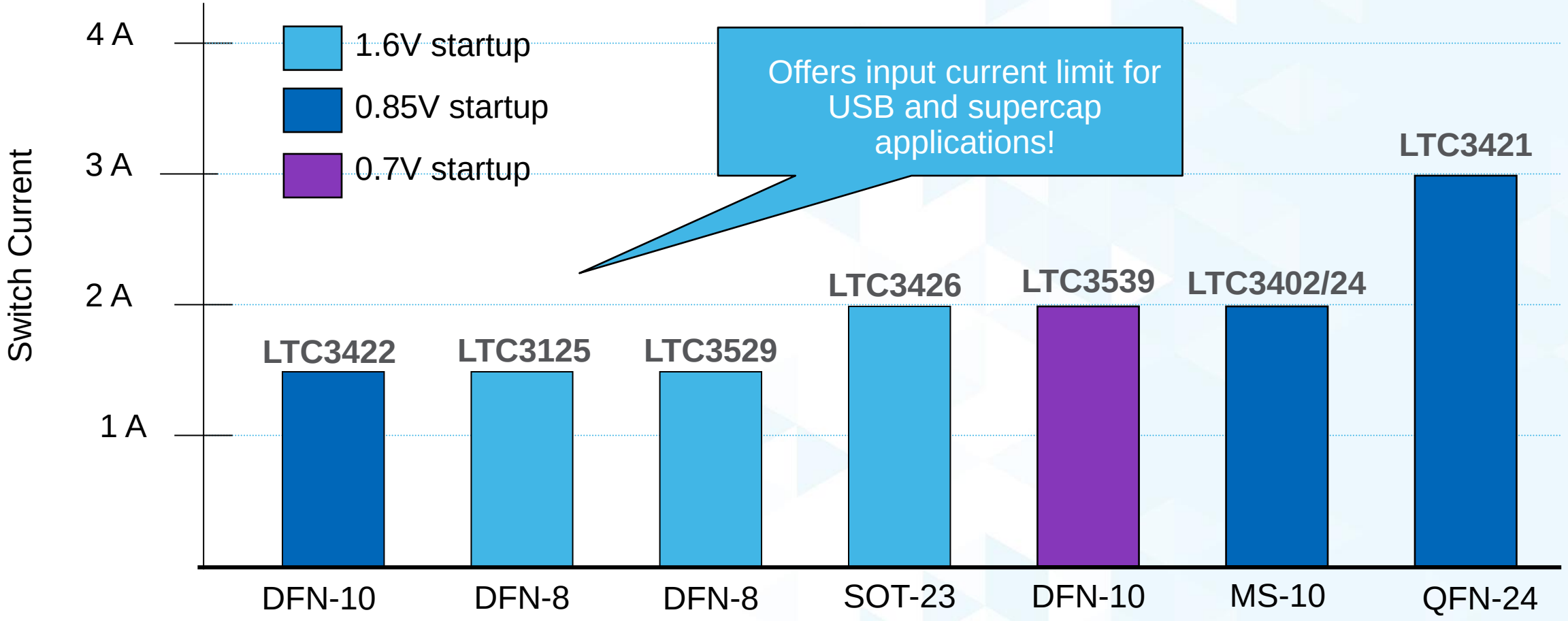
V_{IN} ≤ 7V Monolithic Buck-Boost Converters - Released



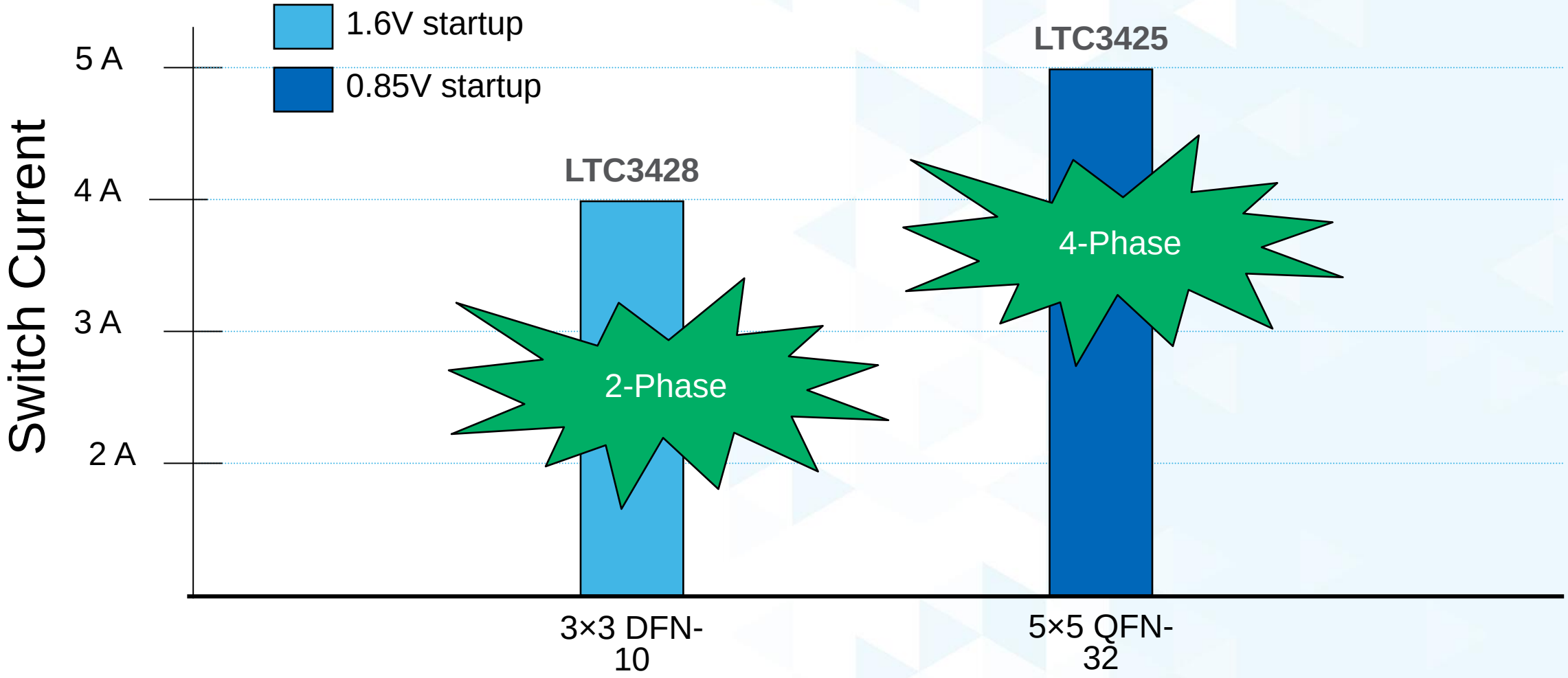
>12 V_{IN} Monolithic Buck-Boost Converters



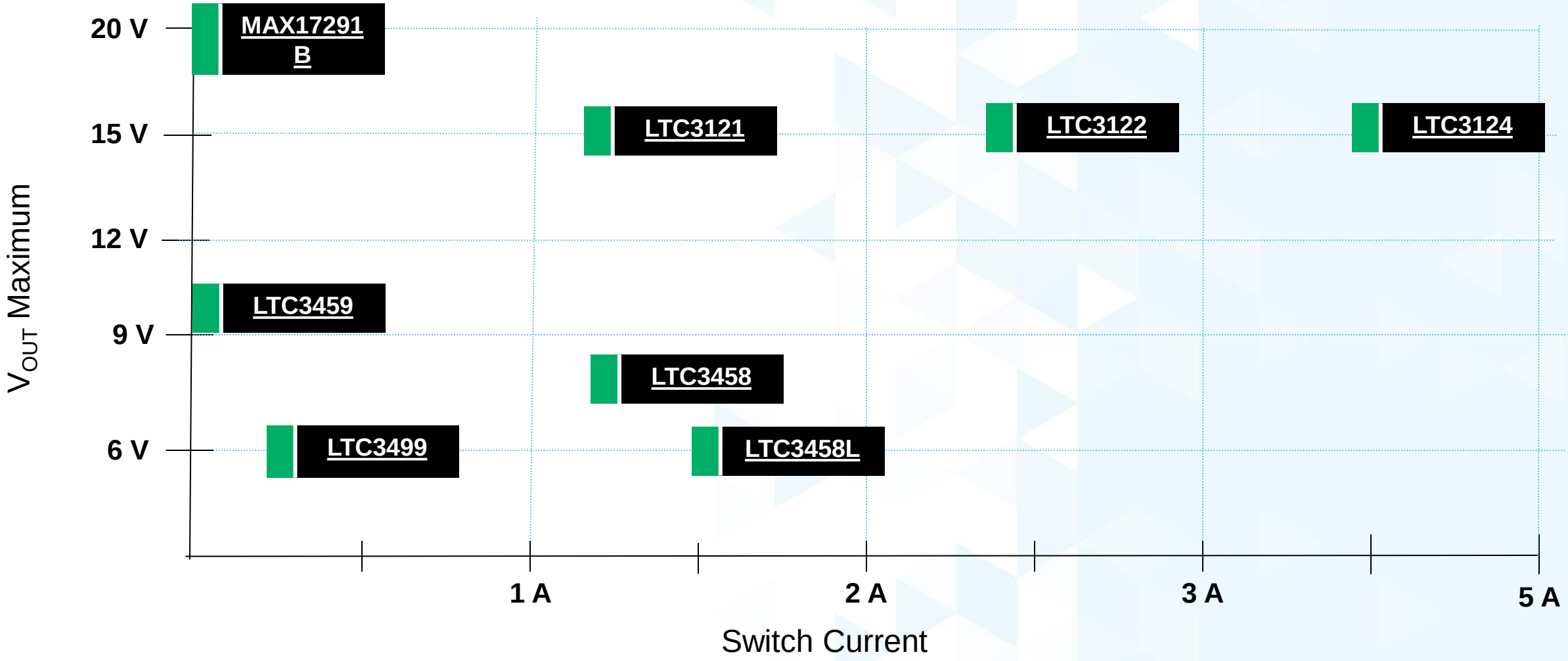
Low Voltage (≤ 5 V) Monolithic Boosts, 1.5 A to 3 A (LTC only, to be updated)



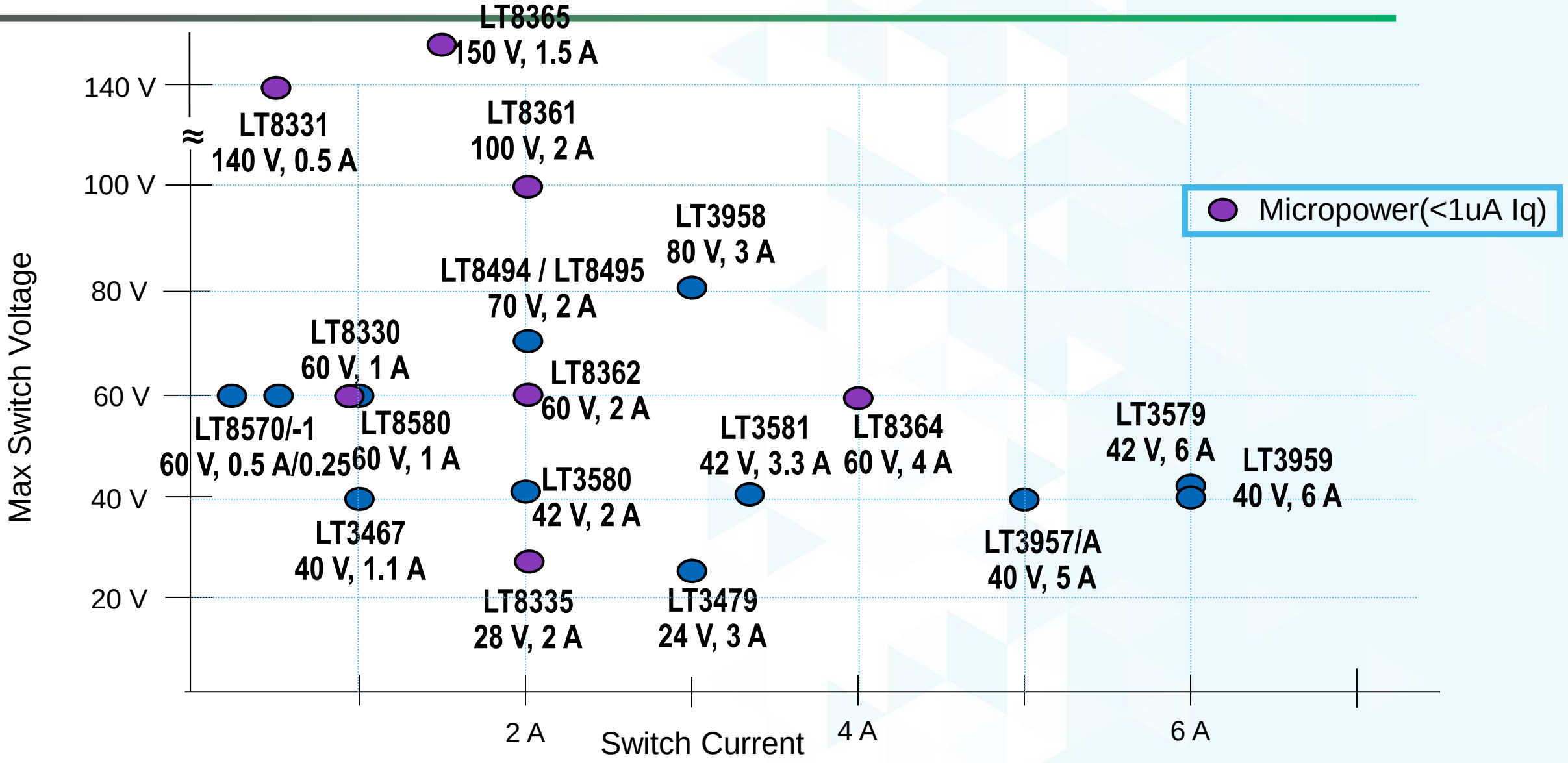
Multiphase Low Voltage (<5 V) Monolithic Boost



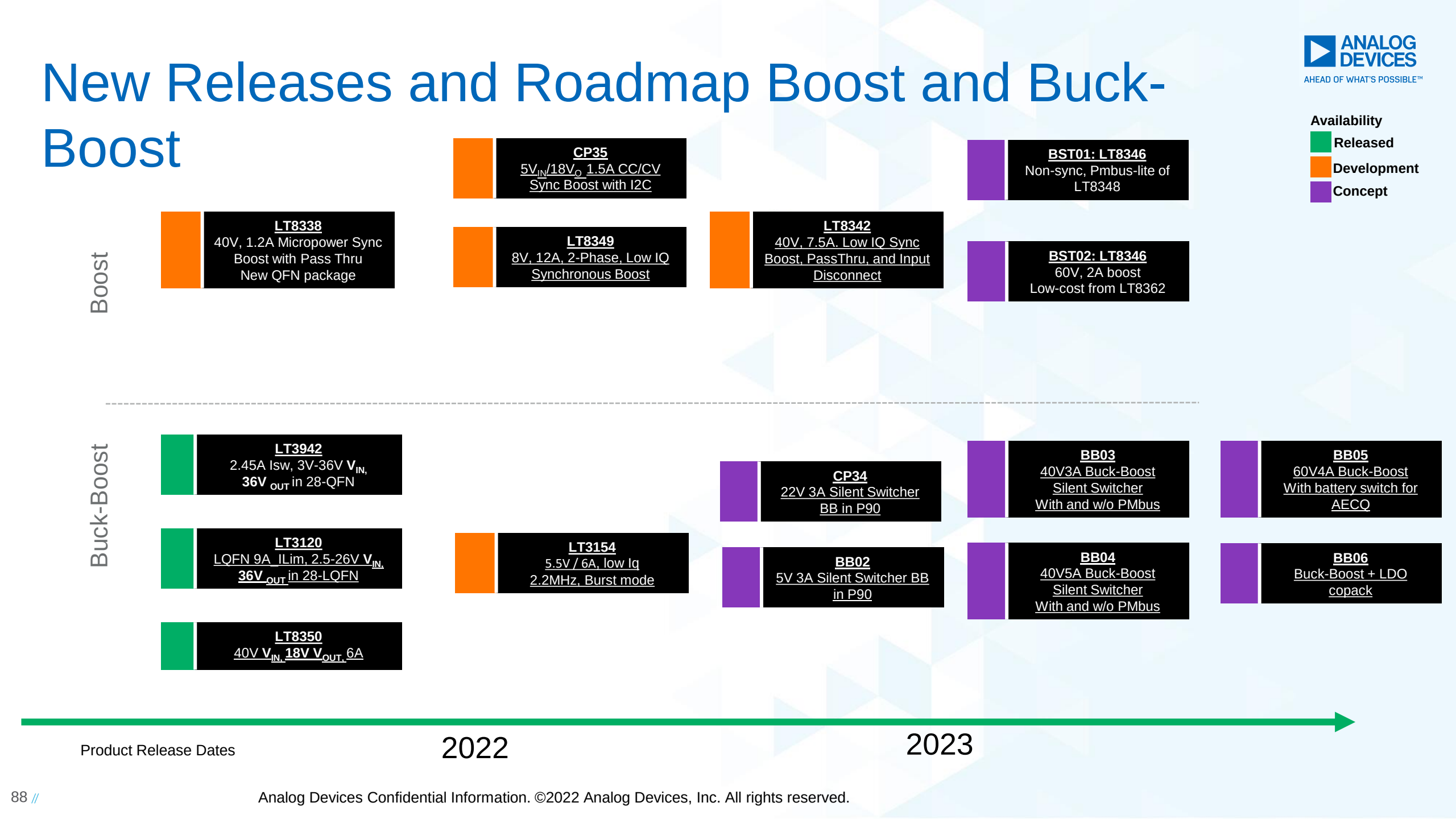
Medium Voltage (>5 V_{OUT}) Synchronous Monolithic Boosts



Multi-Topology Boost, SEPIC, Flyback, Inverting Converters



New Releases and Roadmap Boost and Buck-Boost



LT8349: 2.5V-5V_{IN} / up to 8$V_{OUT,}$ 12A, 2-Phase Low IQ Synchronous Boost Converter

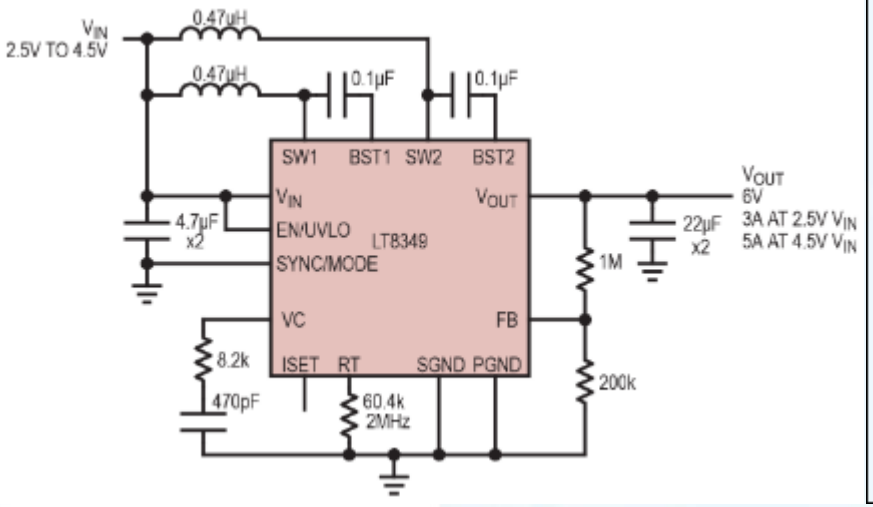
Features:

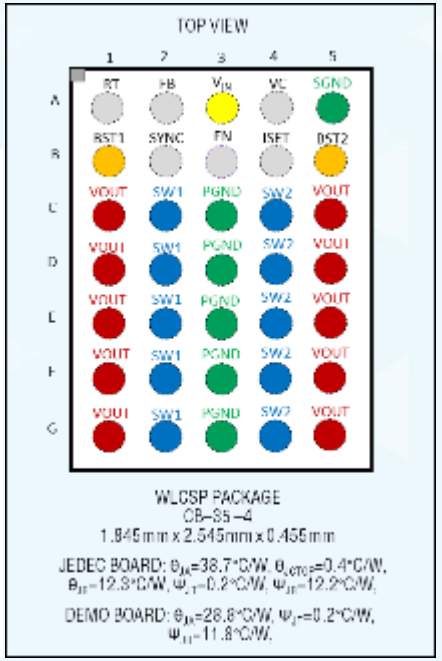
- Input voltage range: 2.5V to 5.5V
- Output Voltage Programmable Up to 8V
- 2-Phase Operation Reduces Required Input and Output Capacitance and Power Supply Induced Noise
- Stage Shedding™ and Optional Burst Mode® Operation for high efficiency at light load
- Low Quiescent Current
- Adjustable and Synchronizable: 300kHz to 4MHz

Applications:

- Handheld and Industrial Power Supplies

2.5V to 4.5V Input, 6V Output Boost Converter





In development
Sampling Q4'22

LT8350: 40V_{in}, 18V_{out}, 6A Synchronous Buck-Boost with Silent Switcher

Value Proposition

- High output current support up to 6A
- Silent Switcher architecture combined with SSFM and zero dead time switching
- Noise Free operation

Key Benefits

- Enables small form factor designs for high current applications
- Helps to lower EMI up to VHF/UHF range without compromising efficiency
- Reliable buck only or boost only mode of operation without unexpectedly switching to buck-boost region, thus having noise free operation. Also, clean transitions while switching modes.

Linear (Low Dropout) Regulator

LDOs

Performance:

- We own LDOs of the highest PSRR and lowest noise across industry
- Widest coverage from -36V to 80V, and from 20mA to 5A
- We also offer low dropout, low Iq, or AECQ LDOs
- >3000 customers
- 100 applications

Design Win Examples in 2022

DSLR (ultra low noise for image quality, low dropout for battery life)

Gaming Headphone (Low noise required for audio)

Printhead (high voltage LDO needed)

Thermal camera (ultra low noise)

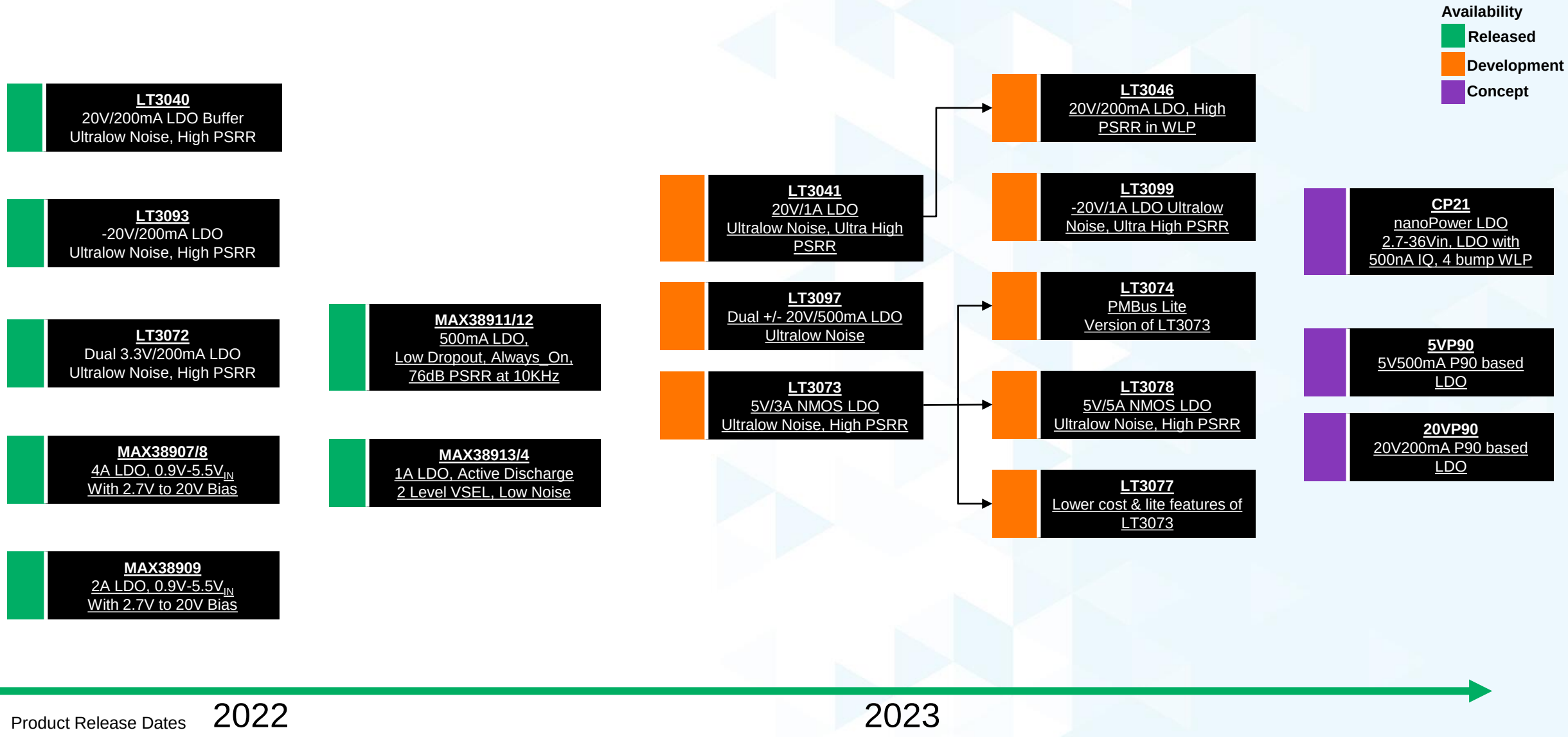
Flow Meter (high PSRR to reject external noise)

Fitness strap (low Iq, small size)

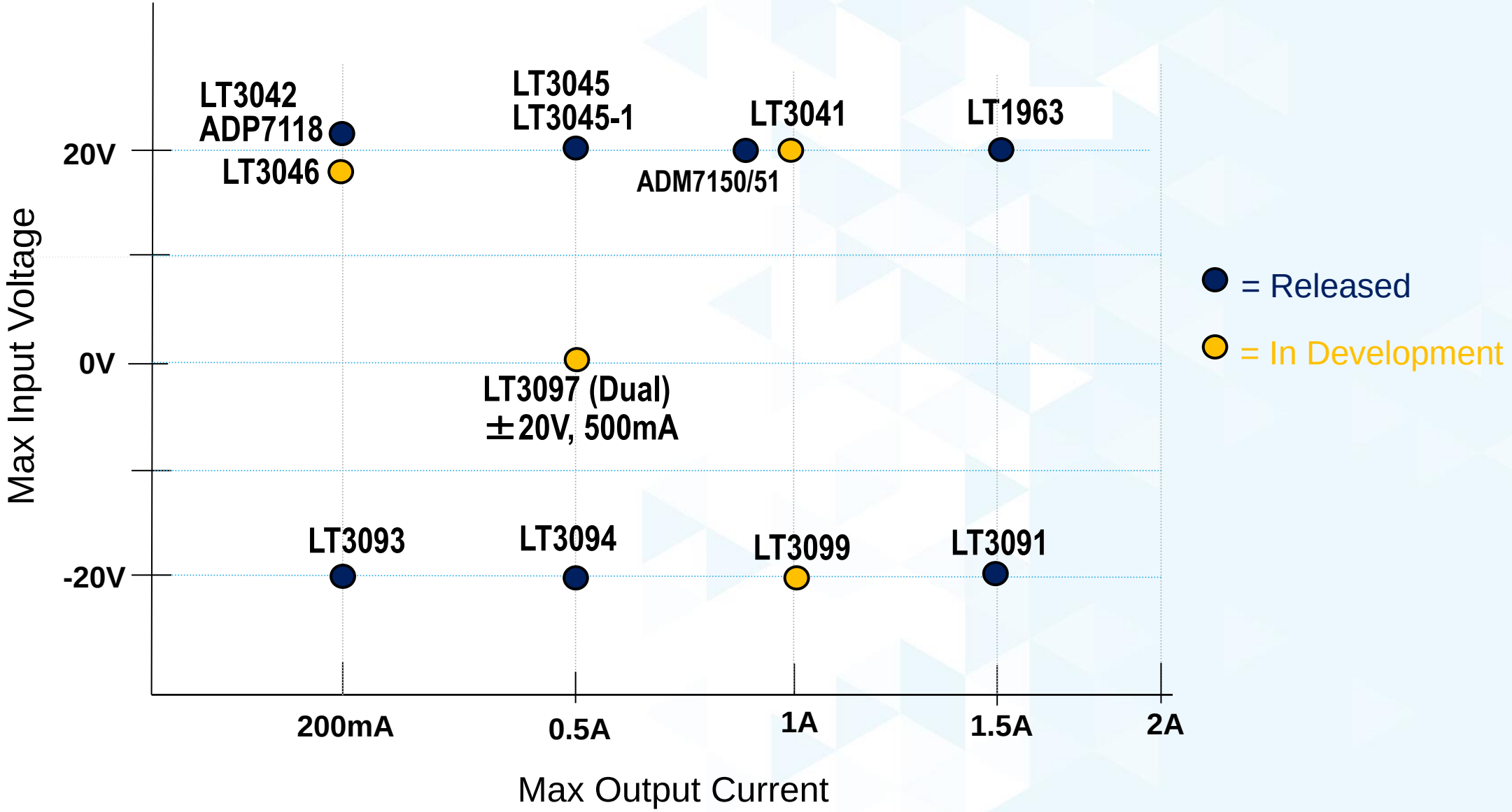
Medical (low noise, high PSRR)

LIDAR (ultra low noise 20V LDO)

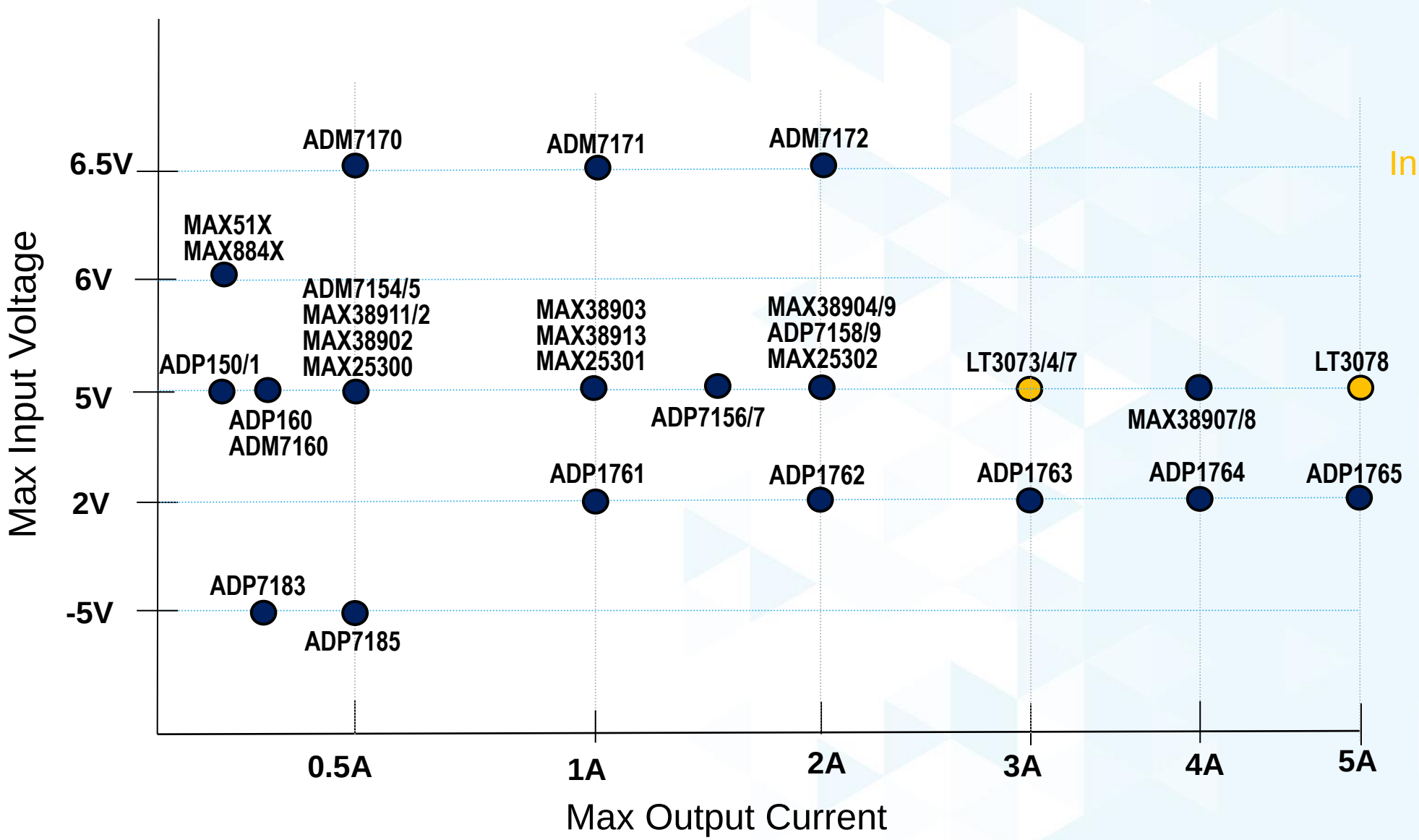
New Releases and Roadmap LDO



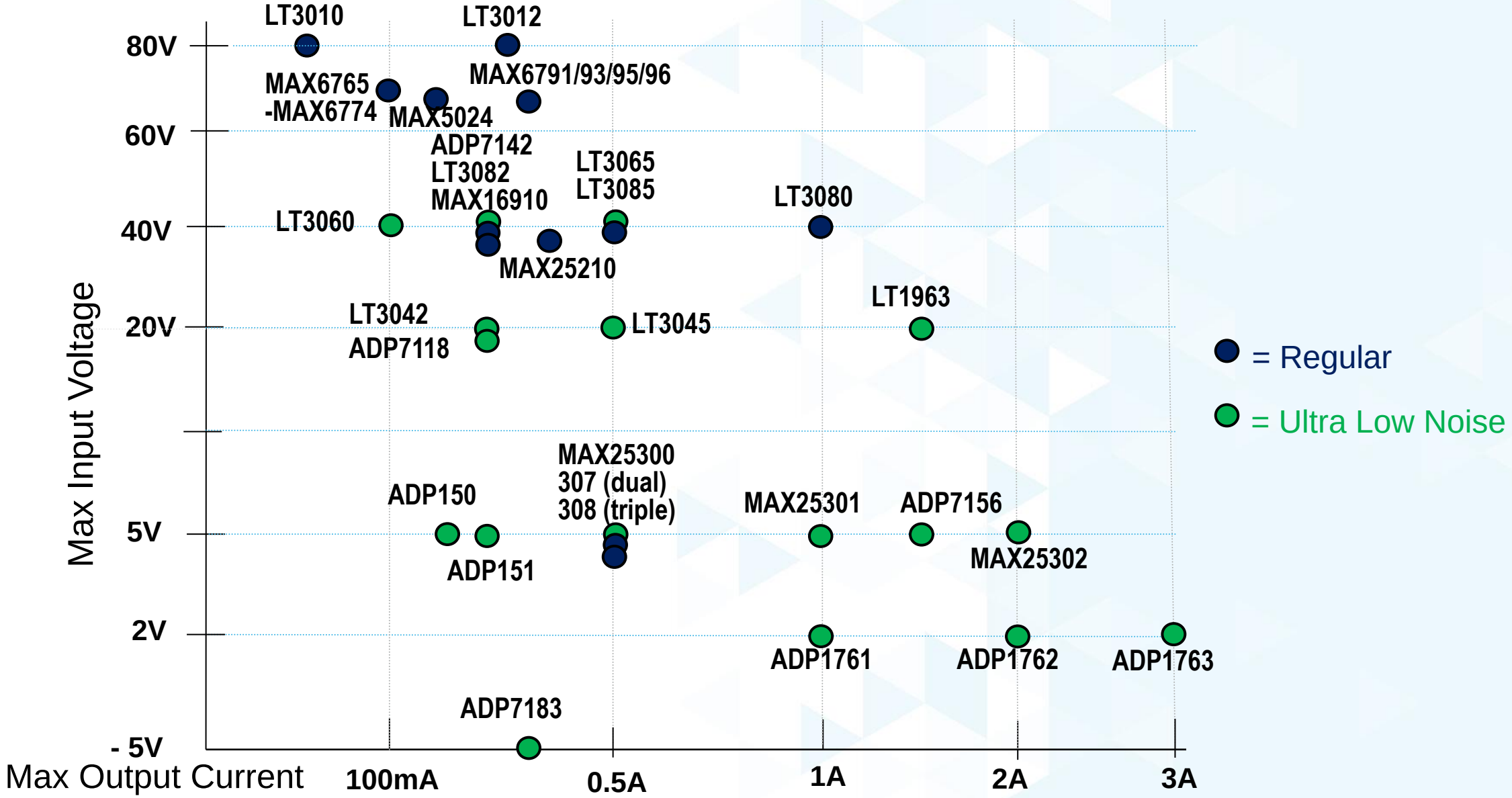
Ultralow Noise, Ultrahigh PSRR 20V LDO Landscape



Ultralow Noise, Ultrahigh PSRR 5V LDO Landscape

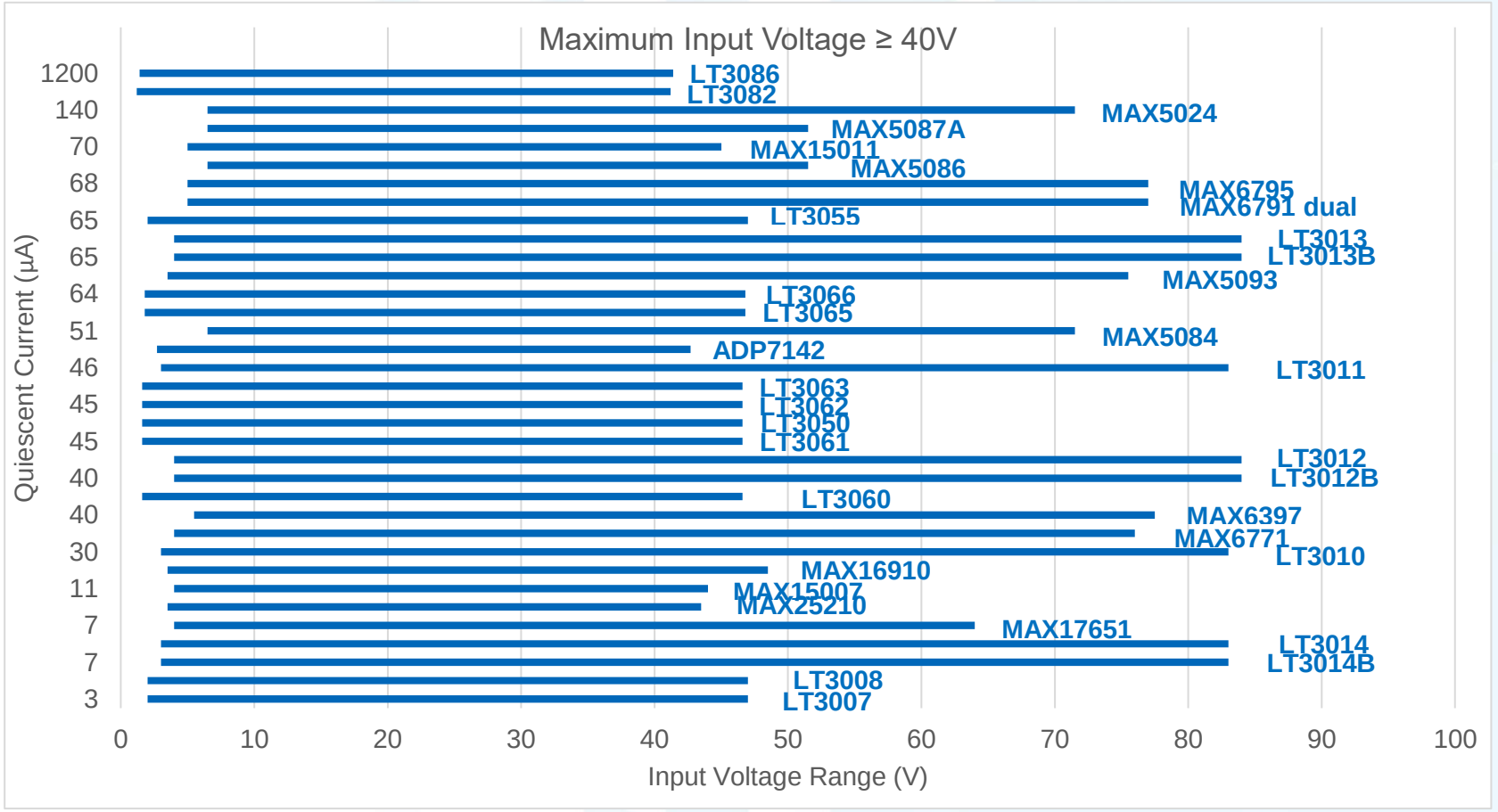


AECQ LDOs



LDO Selector Tool Guide

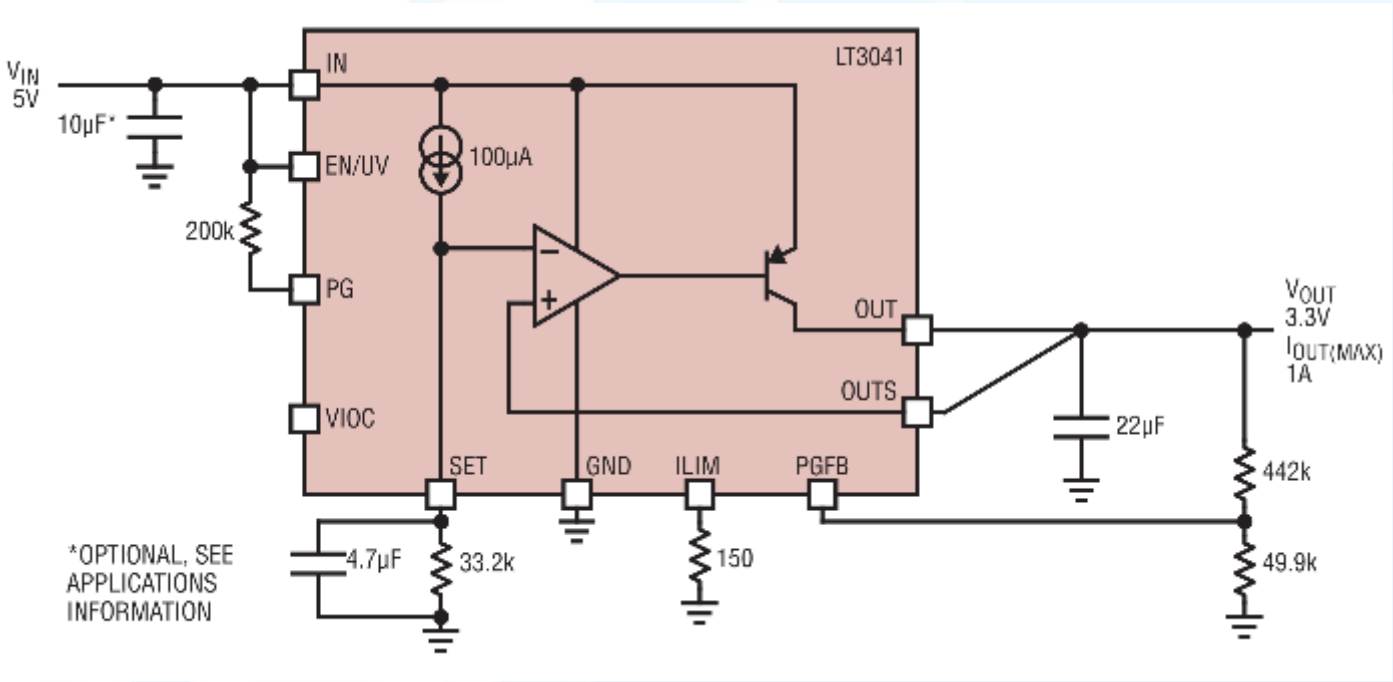
- **Ultra Low noise <2uVrms**
- **Low Noise (2uV-12uVrms)**
- **PSRR @1MHz**
- **Dropout**
- **Low Iq**
- **low VIN <=1.5V**
- **VIN max >= 40V**
- **Negative LDO**
- **Wafer Level Package**
- **And More on the Hyperion**



- LDO Selection by All Conditions
- LDO Selection by volts and amps

LT3041: 20V 1A Ultralow Noise and Ultrahigh PSRR LDO

- 1uVRMS Integrated Noise (10Hz to 100kHz)
- 1.5ppm$_{p-p}$ 0.1Hz to 10Hz & 2.2nV/rt(Hz) at 10kHz
- 1% ISET accuracy
- DC to 2.5MHz PSRR: >76dB
- VIOC Control: To Control Upstream Switcher
- Programmable Current Limit (and Current Monitor)
- Programmable Power Good, Fast Startup (10mA)
- 3x4mm DFN

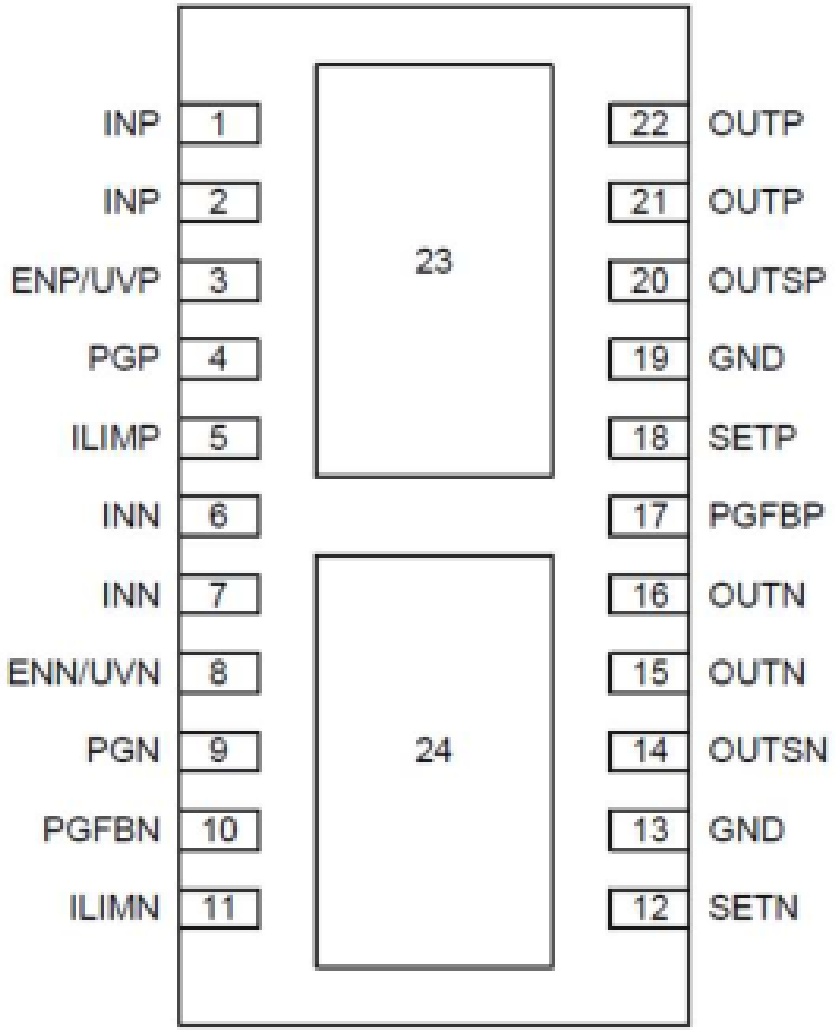


Sampling

Release Oct 2022

LT3097: Dual Pos/Neg 20V 500mA Ultralow Noise LDO

- Co-package version of LT3045 and LT3094
- 20x Lower noise and 3x higher current version of LT3032
- 0.8uVRMS Integrated Noise (10Hz to 100kHz)
- 1MHz PSRR: >74dB
- Programmable Current Limit (and Current Monitor)
- Programmable Power Good
- 3x6mm DFN

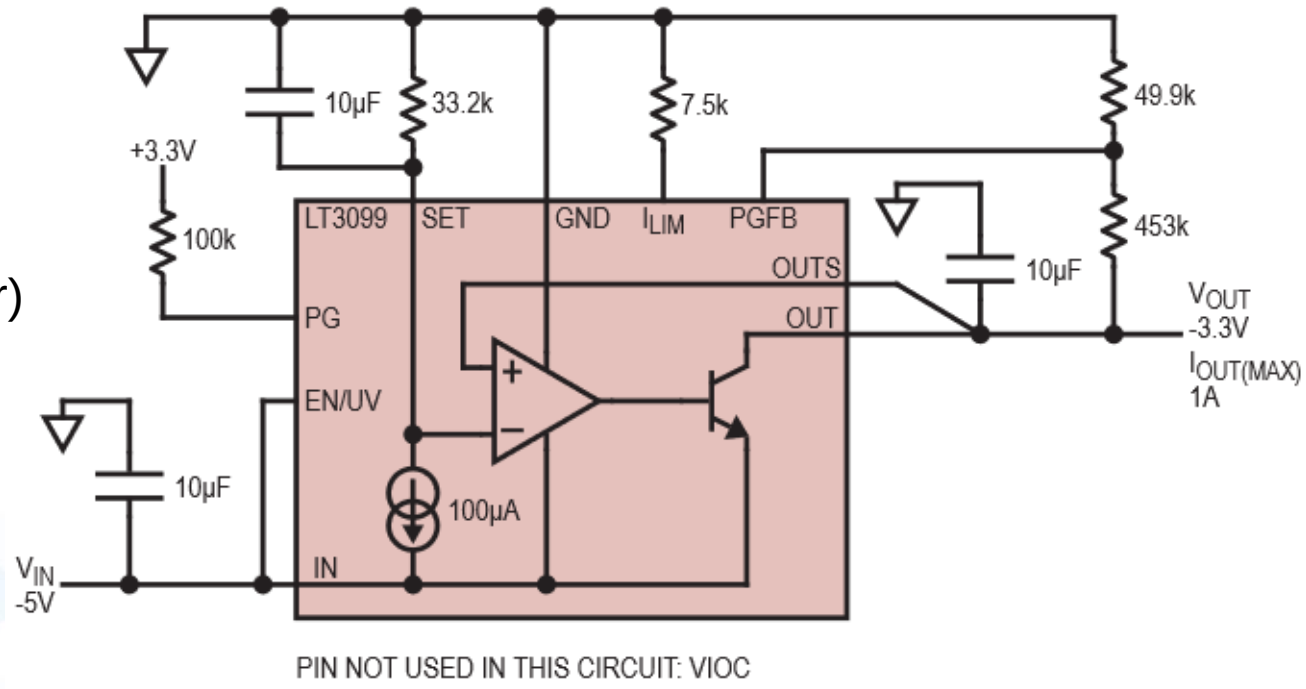


Sampling

Release Sept 2022

LT3099: Negative Version of LT3041

- 0.8uVRMS Integrated Noise (10Hz to 100kHz)
- 1.5ppm$_{p-p}$ 0.1Hz to 10Hz (>5x lower 1/f noise than LT3094!)
- 1.8nV/rt(Hz) at 10kHz
- DC to 2.5MHz PSRR: >60dB
- VIOC Control: To Control Upstream Switcher
- Programmable Current Limit (and Current Monitor)
- Programmable Power Good, Fast Startup (10mA)
- 3x4mm DFN

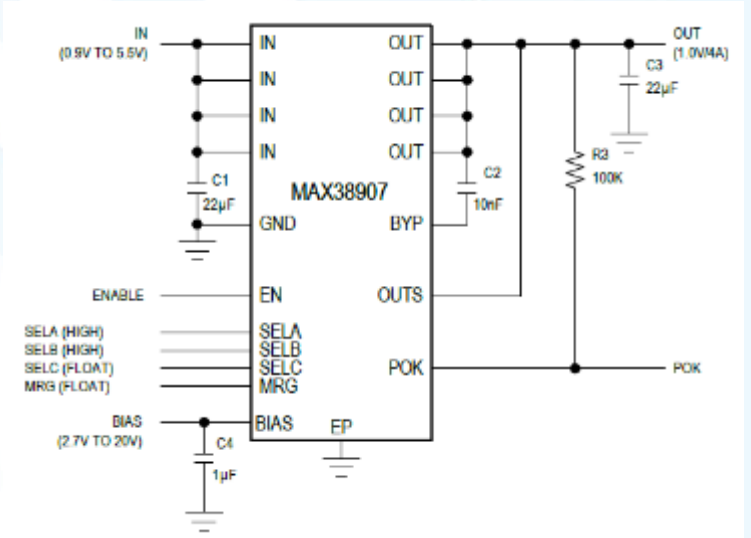


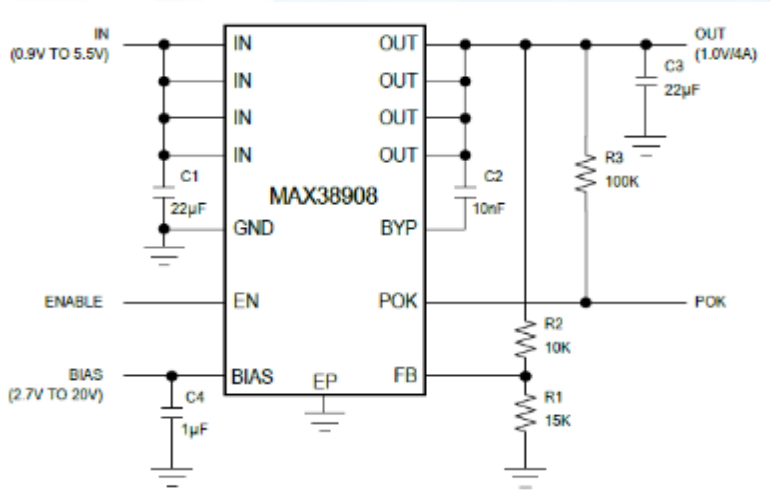
Under development

Release Jan 2023

MAX38907/8: Fast Transient Response, High Current, High Accuracy Post-regulation NMOS 4A LDO

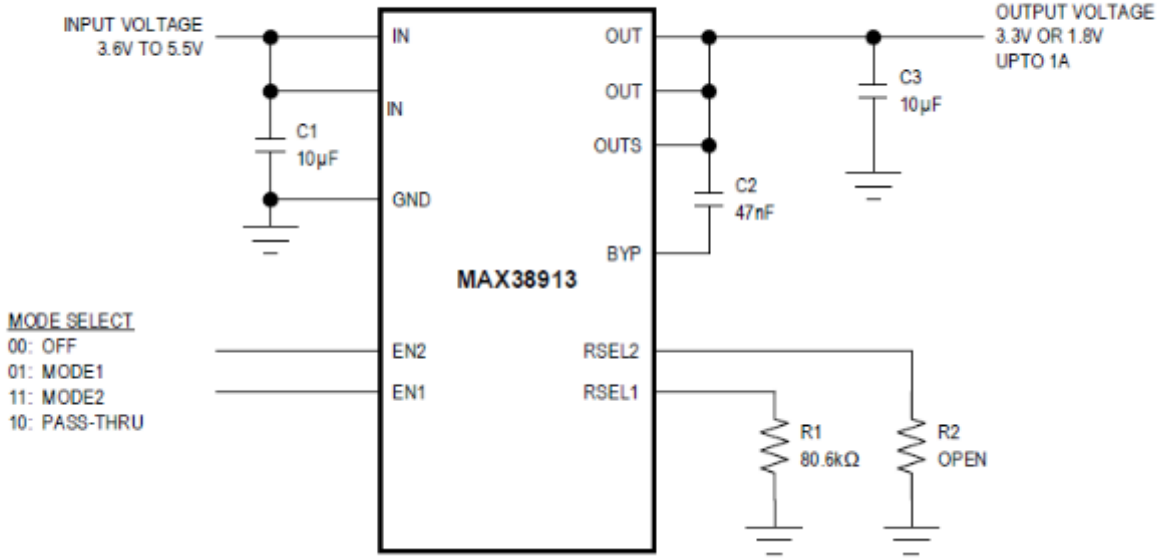
Benefits	• Fast Transient Response • High PSRR • Low Dropout • Low and wide Input Supply Range
Features	• 0.9V to 5.5V Input Supply Range • 0.6V to 5.0V Programmed Output Voltage • 2.7V to 20V Input BIAS Voltage Range • 79mV Dropout at 4A Load Current • 28mV load transient excursion • 90dB Bias PSRR at 1kHz • Stable with 10uF(min) Output Capacitance • +/-1.0% DC Accuracy over Load, Line and Temp • -40°C to +125°C Operation • MAX38908: 3mm x 3mm, 14 pin TDFN and 15-bump 5x3 0.4mm pitch WLP • MAX38907: 5mm x 5mm, 20 pin TQFN
Applications	• Communication System, Test Equipment • High Resolution Data Acquisition Systems • Digital Camera, Medical and Audio • Digital Loads: DSPs/FPGAs/SerDes supplies





MAX38913: 4µV Ultra Low Noise 1A LDO with 2-Level Output Voltage Selection

Benefits	• Smallest form factor • Lowest noise • Integrated features
Features	• V_{IN} → 1.8 to 5.5V; V_{OUT} → 0.6 to 5.0V • 33mV of dropout @ 3.6Vin and 1A load • 4µV of noise (10Hz to 100KHz) • 75dB PSRR @ 1-10KHz • 1% Accuracy over line, load and temperature • Dynamically change output voltage (2 level selection), or pass through or active discharge function • 12 bump WLP and 3 x 3mm 14-TDFN package • -40°C to 125°C operation
Applications	• CMOS image sensor and high frequency sensor • Mobile radios • IoT sensors • FPGA and processors



EN1	EN2	MODE
H	H	Low Noise Voltage 1 (RSEL1)
H	L	Low Noise Voltage 2 (RSEL2)
L	H	Pass Through Mode
L	L	Shutdown /Active Discharge

ANALOG DEVICES

AHEAD OF WHAT'S POSSIBLE™

NANOPOWER TECHNOLOGY™

NANOPOWER

nanoPower DC-DC converters deliver the industry's smallest solution size and longest battery life for low-power devices

Wide operating voltage

0.4V to 5.5V

Greater design flexibility

Tiny Package size

0.9 x 1.4mm

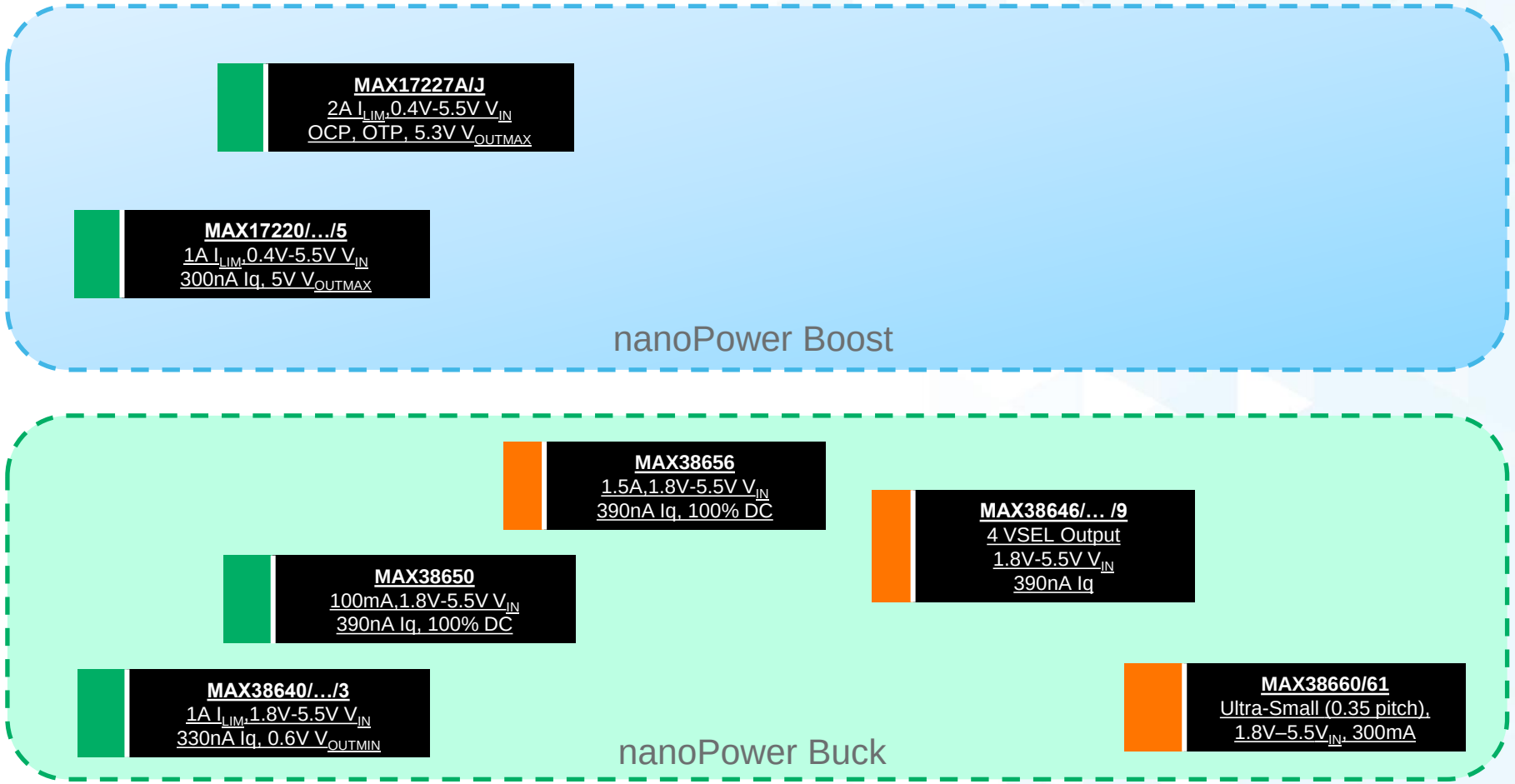
Reduces application footprint

Ultra-low Supply Current

300nA

Increases battery life

New Releases and Roadmap nanoPower Family

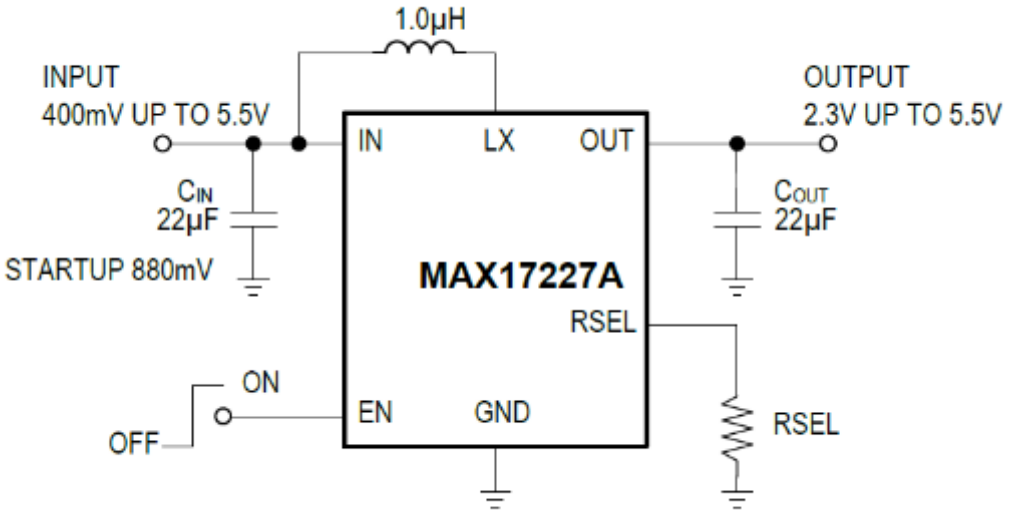


nanoPower Buck Converter Comparisons

Part Number	Product Description	VINMAX	IOUT	Iq	Status
MAX38640/1/2/3	Nano-power Buck Converter	5.5V	175mA-700mA	330nA	Released
MAX38650	Nano-power Buck Converter, 100% Duty cycle	5.5V	100mA	390nA	Released
MAX38656	Nano-Power Buck Converter, 100% Duty cycle	5.5V	1.5A	390nA	Sampling Release soon
MAX38646/7/9	Nano-Power Buck Converter, with dynamic VSEL	5.5V	175mA / 350mA / 700mA	420nA	Sampling
MAX38660/1	Ultra-Small (1.08mm*0.77mm), Nano-Power Buck Converter	5.5V	300mA	850nA	Under development

MAX17227A: 0.4V-5.5Vin, 5.5Vout nanoPower Boost

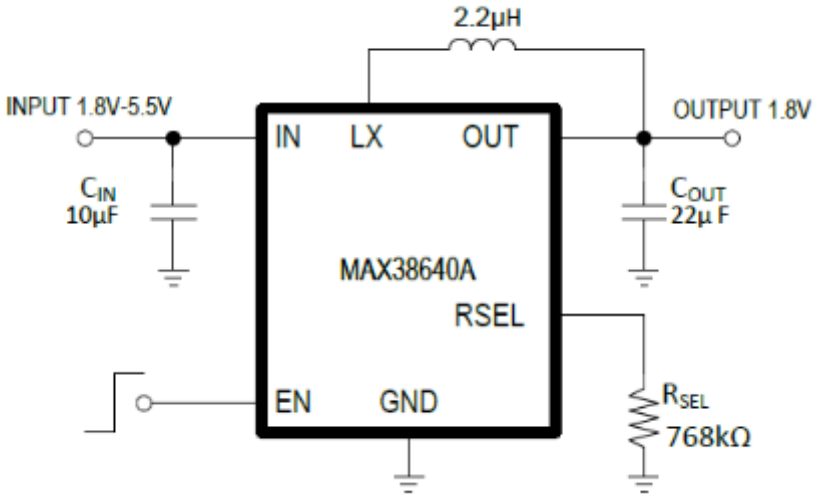
Benefits	• Small total solution size • Extend long battery life • True shutdown • Wide input and output range
Features	• 0.4V (0.88V start) to 5.5V input, up to 5.5V output • Low quiescent current (350nA) • Shutdown current (1nA) • 2A peak inductor current • Up to 1.5MHz switching frequency • Short circuit protection • 1.58 x 0.89mm 6-WLP and 2 x 2mm 8pin TDFN
Applications	• Wearable • NB IoT • IoT sensors • Medical and instrumentation



Pwr Src	VIN Range	Iout@5V
1xAA	0.8-1.6V	180mA
2xAA	1.6-3.4V	400mA
Li-ion	2.7-4.2V	700mA
Sys Bus	3.3V	1A

MAX38640/1/2/3: 330nA IQ, nanoPower Synchronous Buck Converter

Benefits	• Long battery life • Small solution size • Maximize design flexibility
Features	• 1.8V to 5.5V input range • Adjustable or pre-programmed output voltage • **330nA** ultra-low quiescent supply current • 5nA shutdown current • **96**% peak efficiency with 88% or higher at 10µA • 225mA / 500mA / 1A inductor peak current • 1.42mm x 0.89mm, 6-bump WLP; 2mm x 2mm 6-pin µDFN; • No Output Discharge (*MAX38642A/B Only)*
Applications	• Wearable devices • Ultra low power IoT modules • Portable space constrained consumer products • Battery powered medical products • Single lithium coin cell battery products • Single Li-ion battery products

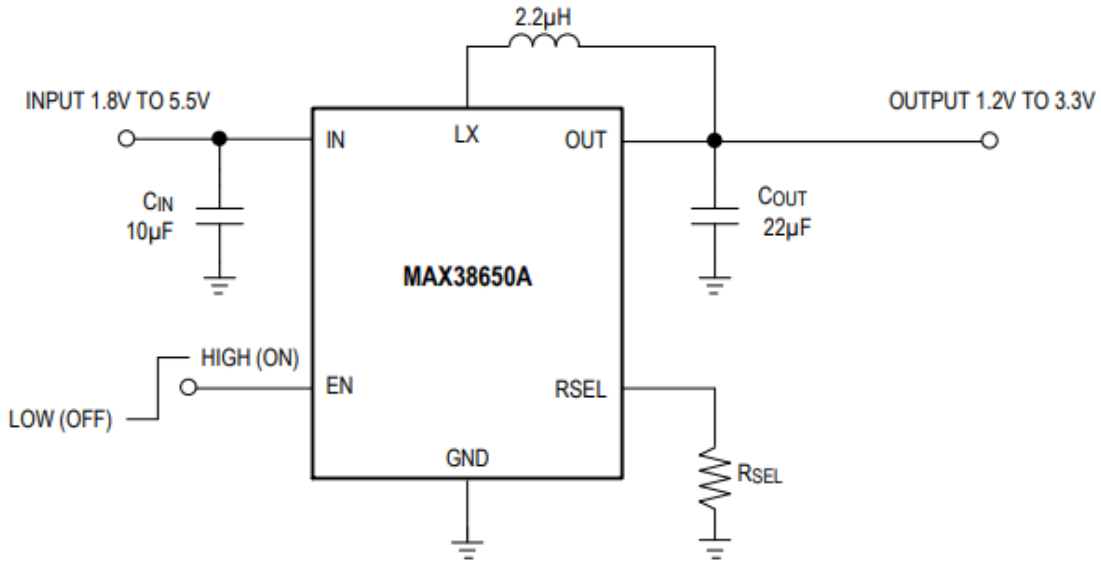


Peak Current, Part Number	Inductance Range
0.25A peak current MAX38640	2.2µH-4.7µH
0.50A peak current MAX38641/42	2.2µH
1.00A peak current MAX38643	1.0µH-1.5µH

A version	Single Resistor Adjustable VOUT (0.7-3.3V) and UVLO
B version	Preprogrammed VOUT (0.5-5.0V)

MAX38650: 1.8V to 5.5V Input, 390nA IQ, 100mA nanoPower Buck Converter with 100% Duty Cycle

Benefits	• Extend battery life with high efficiency and low I_Q • 100% DC operation for low dropout operation • Reverse-current blocking at shutdown
Features	• 1.8V to 5.5V input range, 1.2V to 5.0V output • 260mA peak inductor current (100mA DC current) • 390nA I_Q; 1.05µA I_Q at 100%DC; 5nA shutdown • 95% Peak efficiency and over 85% at 10µA • 1.58 x 0.89mm 6-WLP
Applications	• Portable • Utility (gas and meter) meters • IoT, asset tracking/management • Medical and instrumentation



Version	Description
A (Adjustable output)	With RSEL, user programmable output 1.2V to 3.3V
B (Fixed output)	Fixed output 1.2V to 5.0V

MAX38656: 1.8V to 5.5V Input, 330nA IQ, 1.5A nanoPower Buck Converter with 100% Duty Cycle

Benefits

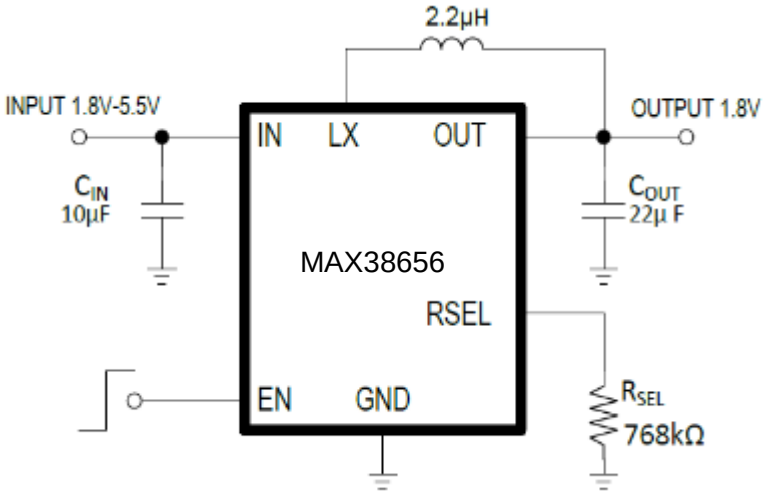
- Extends Battery Life with high eff and low Iq
- Easy to Use – Addresses Popular Vin/Vout/Iout
- Reverse-Current Blocking & Active Discharge Options
- **100% DC** operation

Features

- 1.8V to 5.5V Input Range, 0.5V to 5Vout
- **1.5A** Load Current
- 330nA Iq; 840nA Iq at 100%DC; 5nA Shutdown
- 96% Peak Efficiency and Over 88% at 10µA
- Active Discharge
- 6-WLP (1.58mm x 0.89mm) and 2x2 **8-TDFN**

Applications

- Utility (gas and meter) meters
- IoT, asset tracking/management
- Medical and instrumentation



Sampling now
Release in Sept 2022

MAX38646-49: 390nA IQ, nanoPower Synchronous Buck Converter with 4-Level Selectable Output (DVS)

Benefits

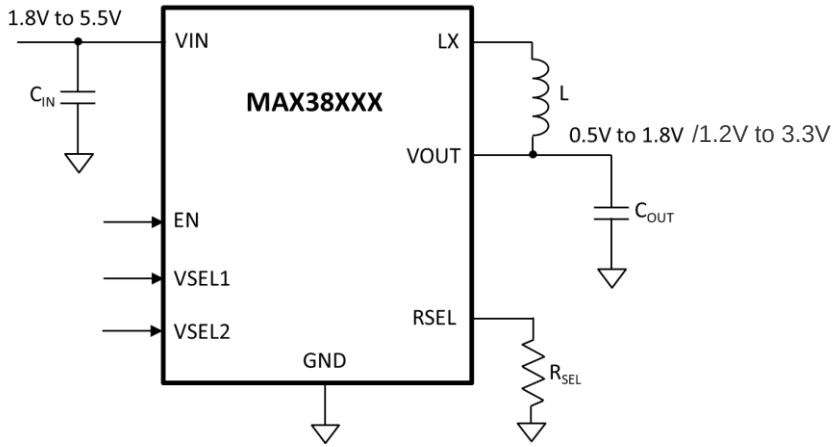
- Extend Battery Life
- Dynamically change output voltage
- High Efficiency

Features

- Input Range → 1.8V to 5.5V;
- Output Range → 0.5V to 1.8V (or) 1.2V to 3.3V
- 0.7A Max. I_{OUT} ; IQ = 390nA, 5nA shutdown current
- 96% peak efficiency with 88% or higher at 10µA
- Single RSEL to set 4 pre-programmed output voltages
- 8 Bump WLP and 2x3 10-pinTDFN

Applications

- Wearables and Portable Medical
- IoT devices
- Battery Operated devices



Sampling soon

MAX38660/1: Ultra-Small, 1.8V–5.5V Input, 850nA I_Q, 300mA nanoPower Buck Converter

Industry's smallest nanoPower Regulator

Benefits

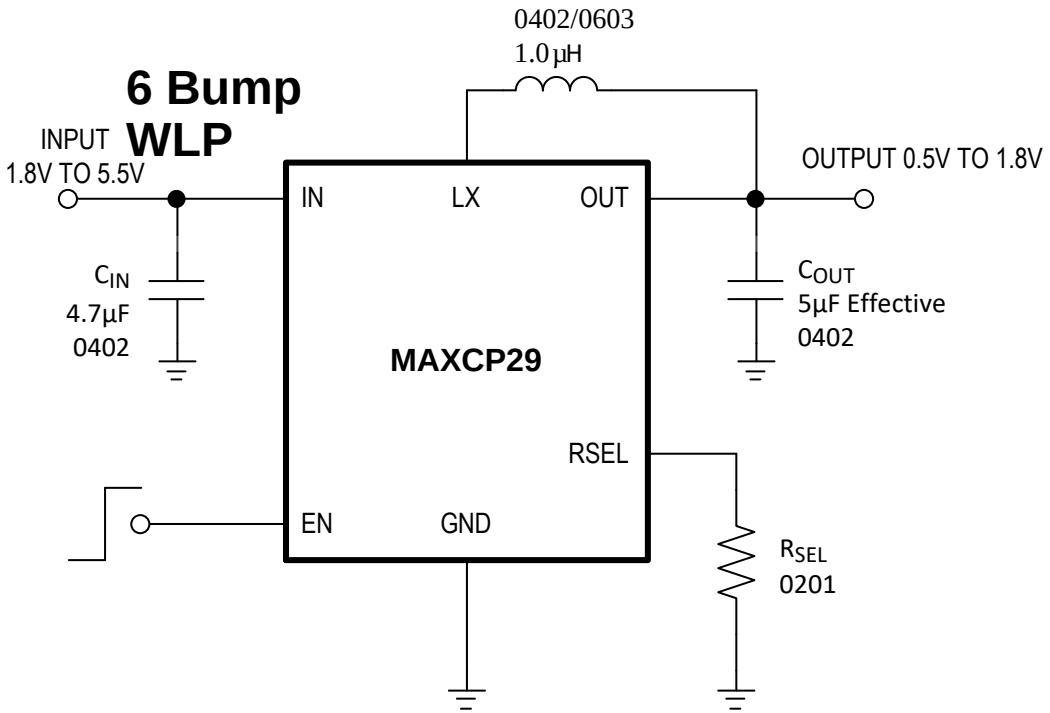
- Small solution size
- Extend battery life
- High efficiency with low output ripple

Features

- 1.8V to 5.5V_{IN}, 0.5V to 1.8V_{OUT}, 300mA I_{LOAD} and 850nA Iq
- 1% accuracy -20°C to 85°C, 1.5% -40 to 125C
- 10mV p-p ripple
- 92% peak efficiency and 80% at 0.6Vout and 1mA I_{LOAD}
- Small solution size enabled by 60ns min on-time and 2.5MHz fsw
- 1.08mm*0.77mm WLP (0.35 pitch) and 2mm x 2mm TDFN package

Applications

- Battery operated devices
- Wearables, Hearables
- Medical wearables, patches etc.
- IoT – battery-operated and wired



Under Development

Thank you

AHEAD OF WHAT'S POSSIBLE™

Q&A

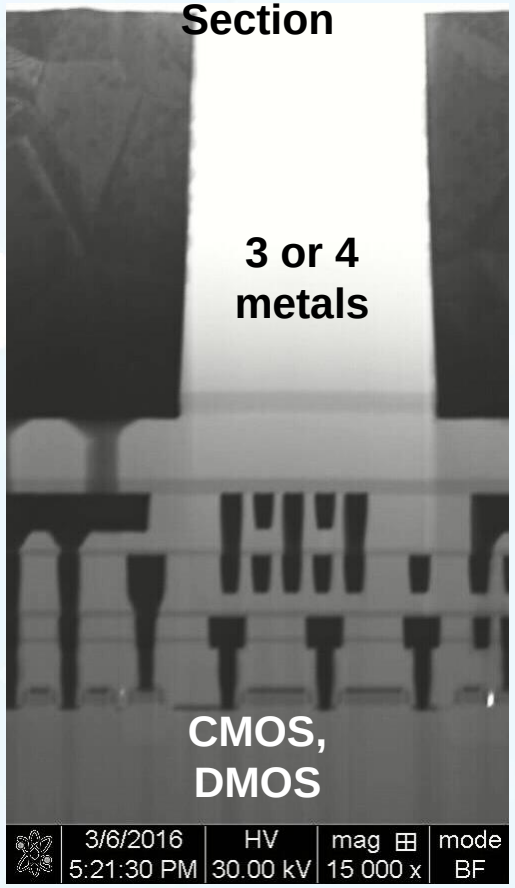
- P90工艺的最大特色是什么?

What is P90?

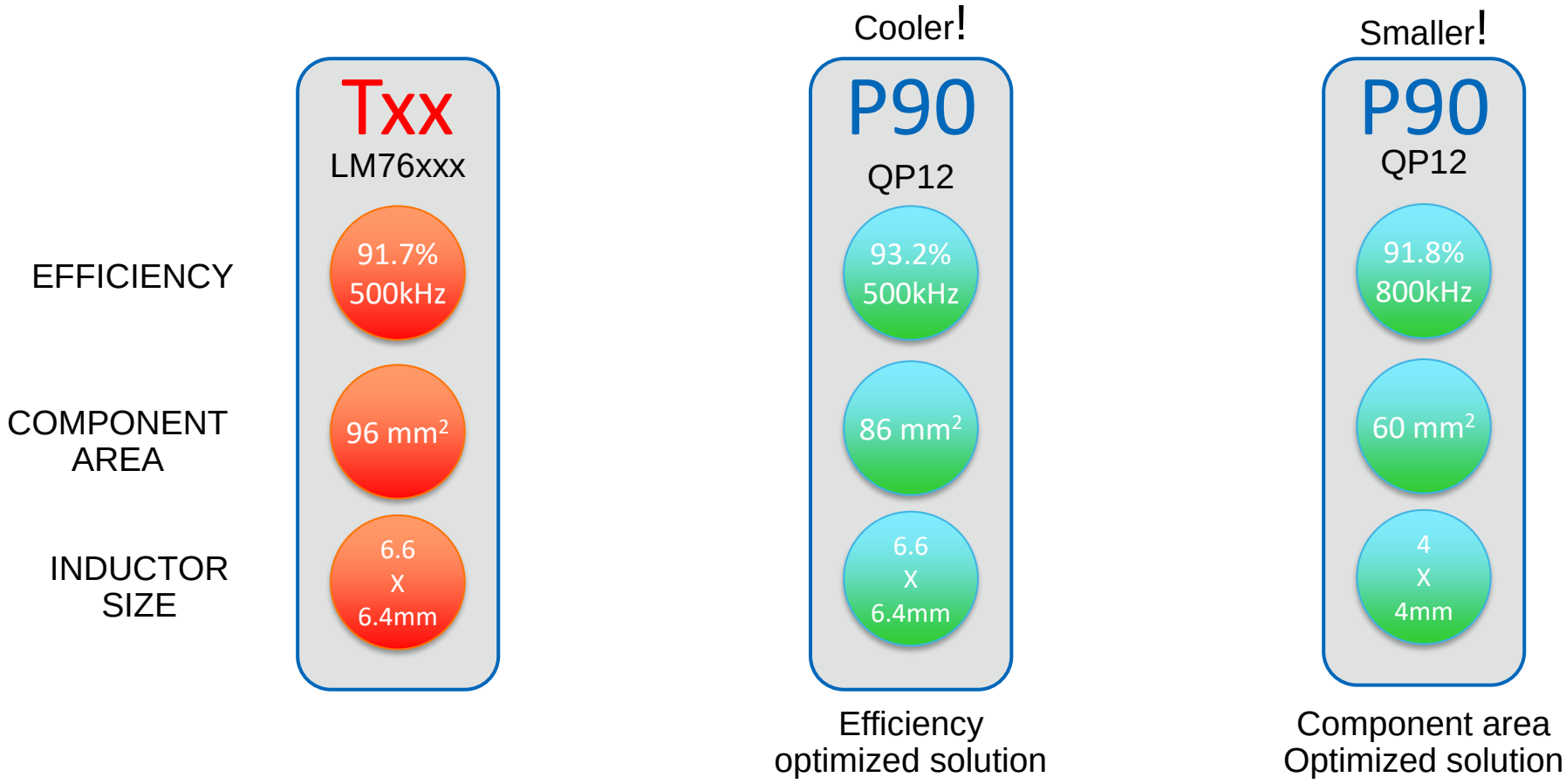
P90 is ADI's high volume advanced power platform technology

- 5V-80V Industry leading RA density for high efficiency & low cost
  - RA density is resistance* area of a transistor → lower is better
- Low wafer cost: 30% fewer masks than S90 and 10% less than S18
- 1.8V and 5V CMOS for logic and analog
  - Option to run CMOS at 1.2V
- MTP 32KB (Byte) integrated flash memory
  - MTP = Multi-Time Programmable Nonvolatile Memory
- Copper interconnect for high density, lower resistance and higher EM limits

P90 Cross Section



The P90 Advantage, 60V 3.5A Buck

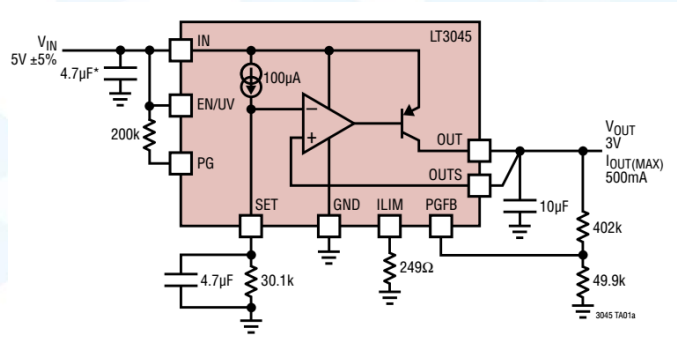


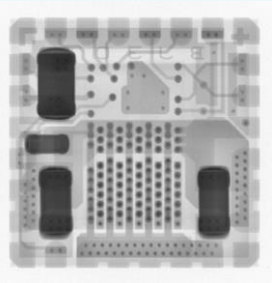
Q&A

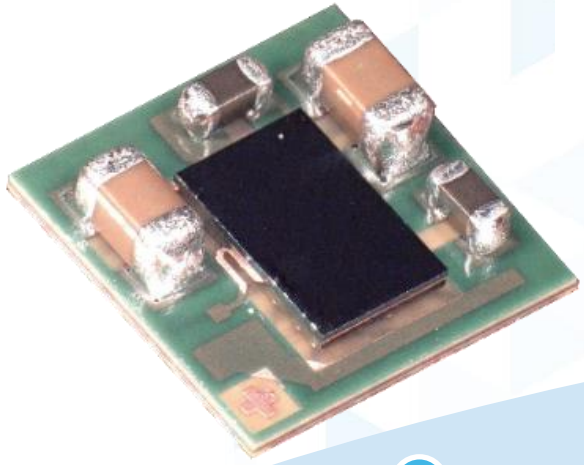
- 是不是所有芯片电源有对称管脚排列的都是Silent Switch?

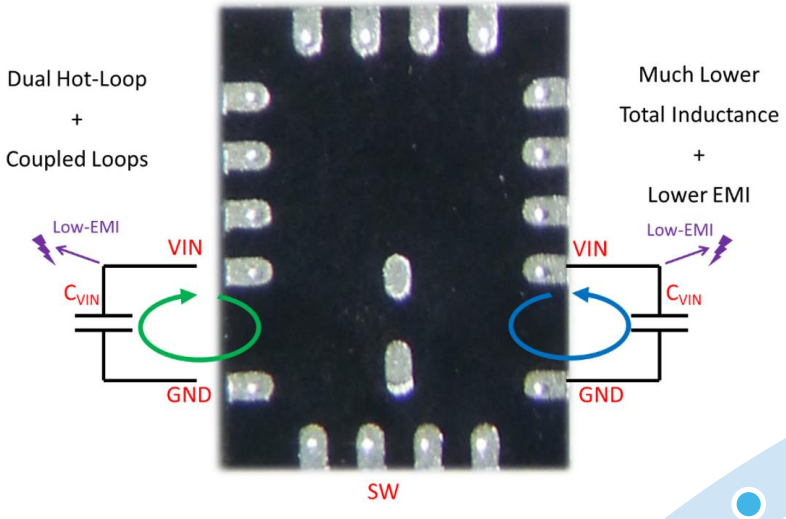
New Silent Switcher®3

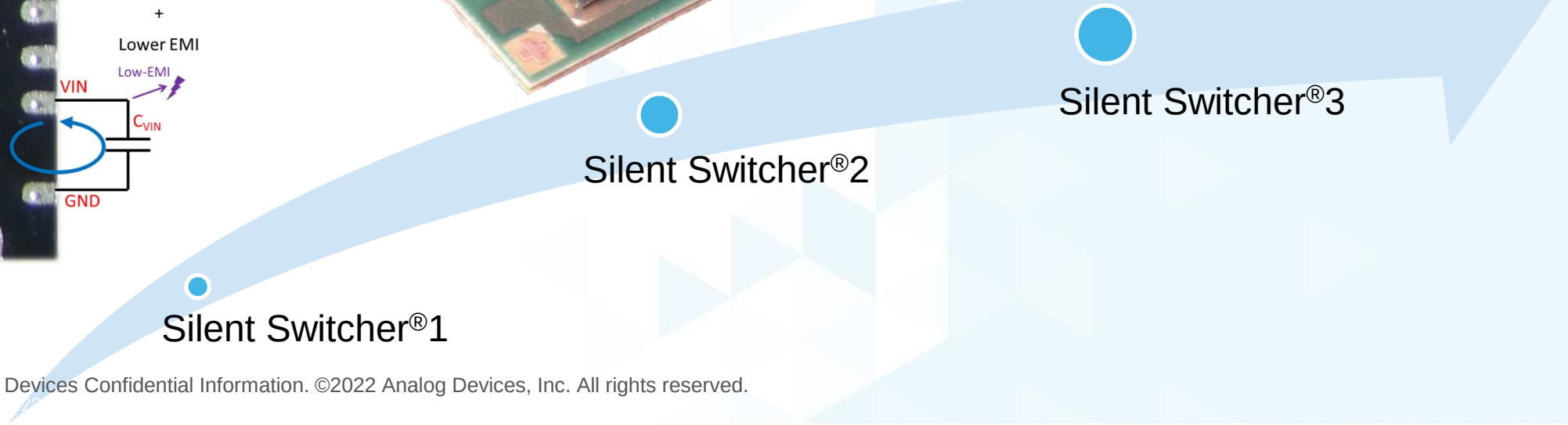
- Exceptional EMI performance
- High Efficiency at High Switching Frequencies
- Easy PCB layout
- **Ultralow LF Noise (10Hz to 100kHz)**
- **Ultrafast Transient Response**







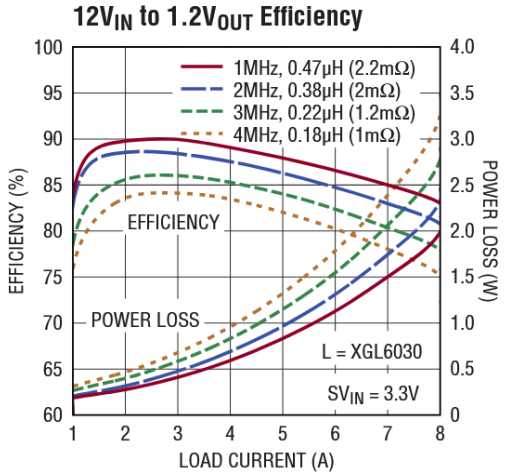


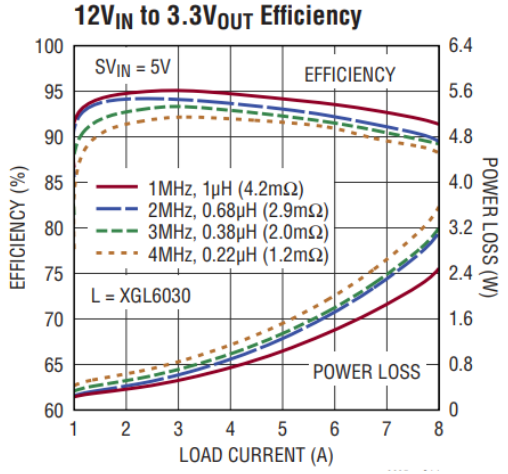


LT8625X Silent Switcher 3 Feature Highlights

High Efficiency at High Frequency

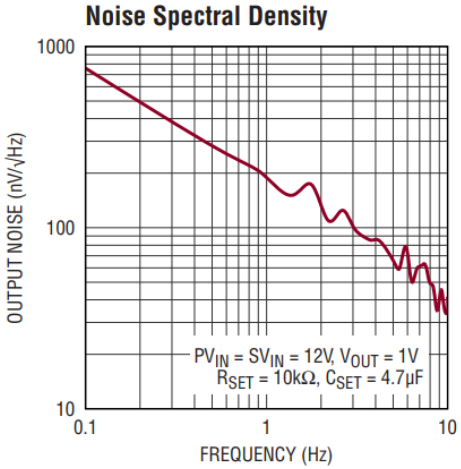
Next Gen Power FETs (Improved LT8642S)

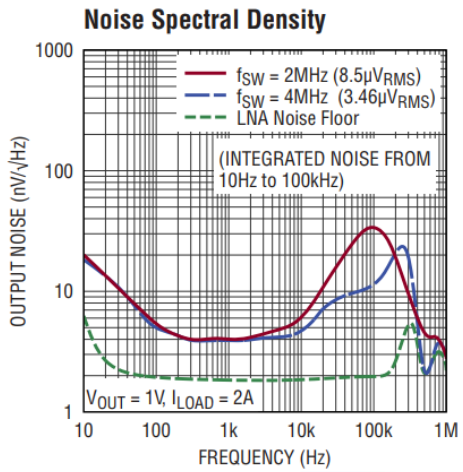




Ultralow LF Noise

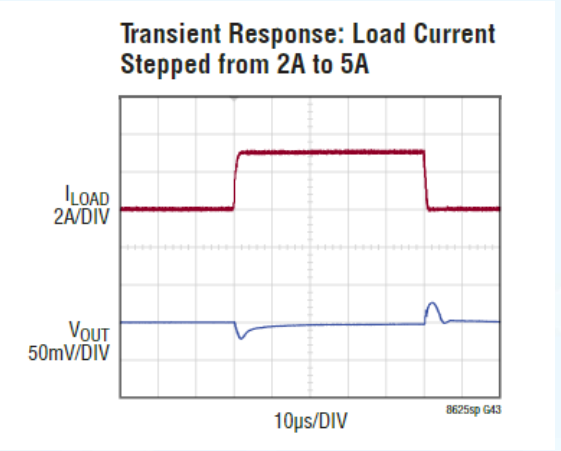
RMS Noise (10Hz to 100kHz): 3.5µV_{RMS}
Spot Noise: 4nV/√Hz at 10kHz

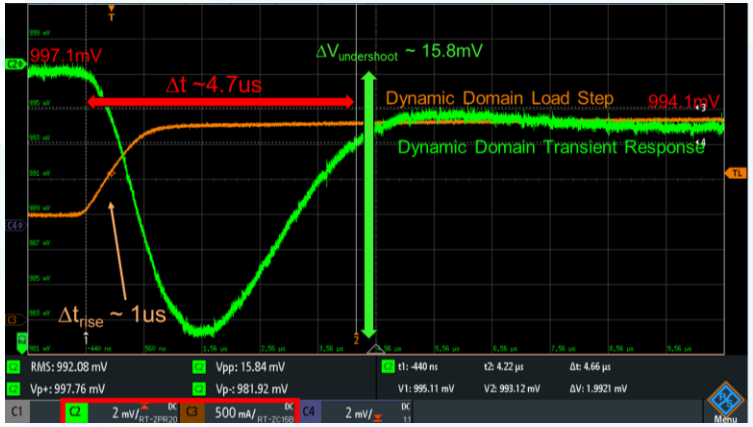




Super Fast Transient Response

High Gain Error Amplifier
Unity Gain Feedback





Q&A

- 是不是所有符合车规AEC-Q100的产品都符合ASIL标准?

Product Development at the Hardware Level ISO 26262 part 5

	ASIL B	ASIL C	ASIL D
Single-point fault metric (SPFM)	≥90%	≥97%	≥99%
Latent fault metric (LFM)	≥60%	≥80%	≥90%

- The above table are target “coverage” values for different ASIL classifications
- It is common practice to target SPFM and LFM for a device that is a System Element out of Context (i.e., ADI’s devices).
- Besides SPFM/LFM, higher ASIL rating also requires higher independency level, more detailed analysis tools(FTA etc), and others.

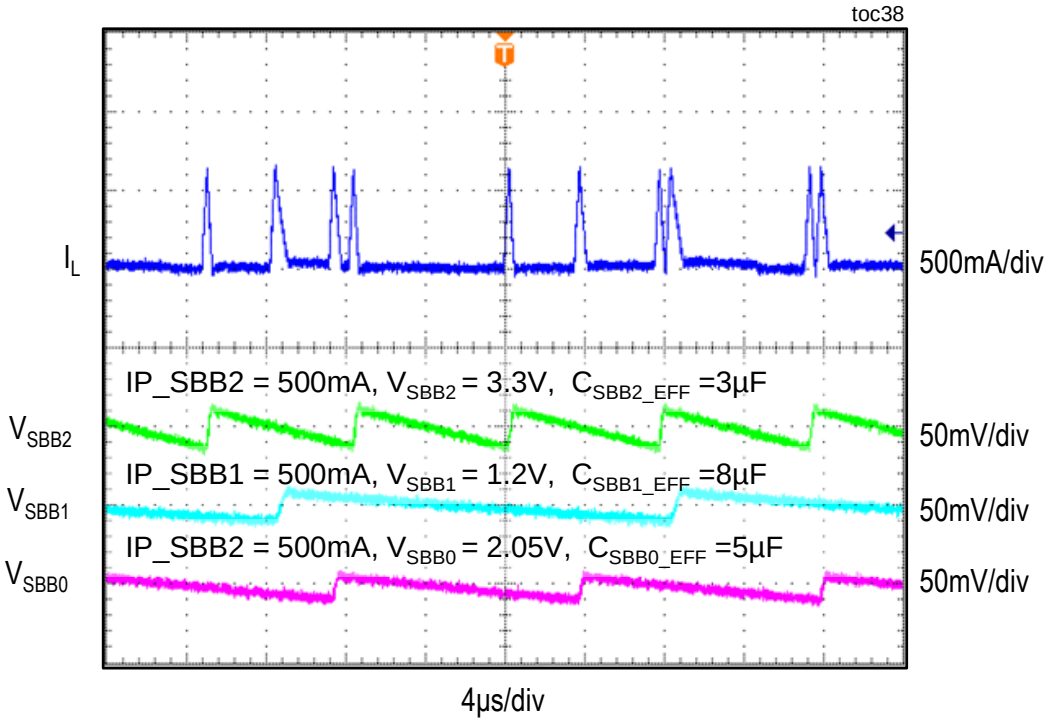
Q&A

- SIMO产品使用单电感多路输出，纹波会不会比较大?

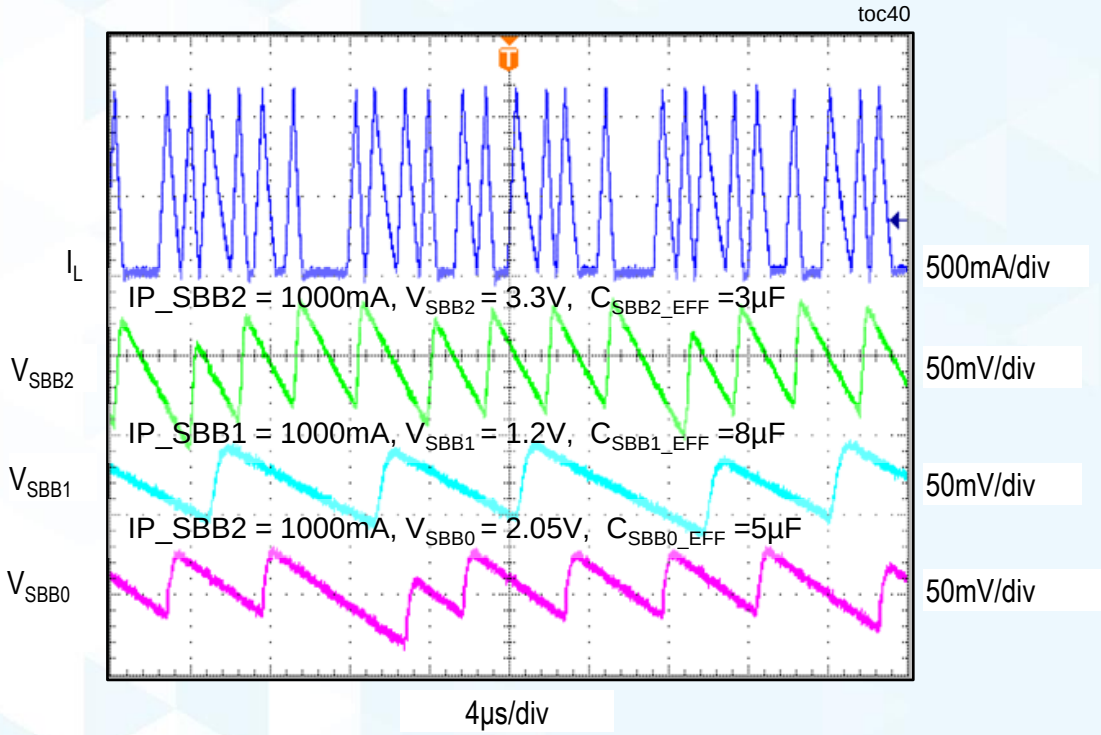
MAX77650: SIMO Typical Operating Characteristics

(3.7V = V_{BATT})

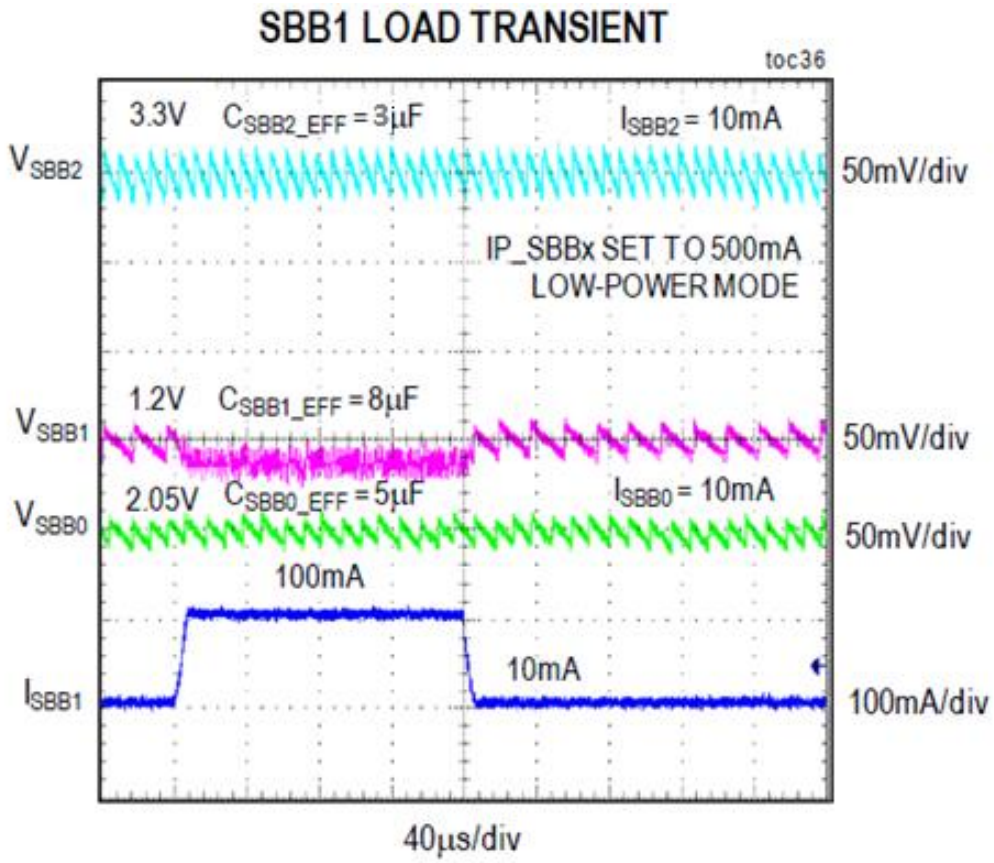
SIMO SWITCHING WAVEFORMS
LIGHT UTILIZATION
10mA PER CHANNEL

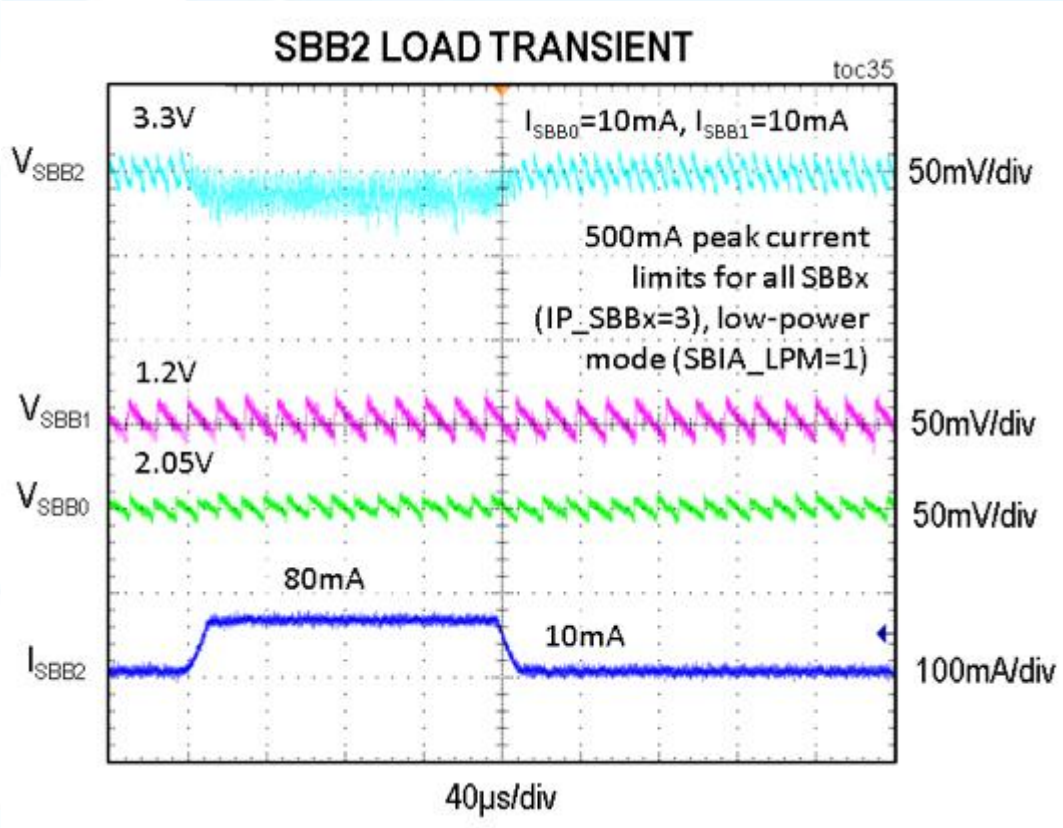


SIMO SWITCHING WAVEFORMS
HEAVY UTILIZATION
75mA PER CHANNEL



MAX77650: SIMO Typical Operating Characteristics





Q&A

- NanoPower比较适合哪些应用场合?

Where Nanopower ?

Function:

- System Backup: Systems using a battery or SuperCap as a backup system
- Power Rails: Energy harvesting (Solar cell), RTC (Real Time Clock), Buzzer, LCD display, Sensors (bio sensor, finger print, gesture, remote), OHRM/green LEDs

End Equipment:

- Medical: Temp patch/tag, insulin delivery system
- Consumer: Watch, band, ear thermometer, wireless headset, speakers, drones
- Industrial: Electric Meters, toxic gas detector, industrial encoder, building automation