

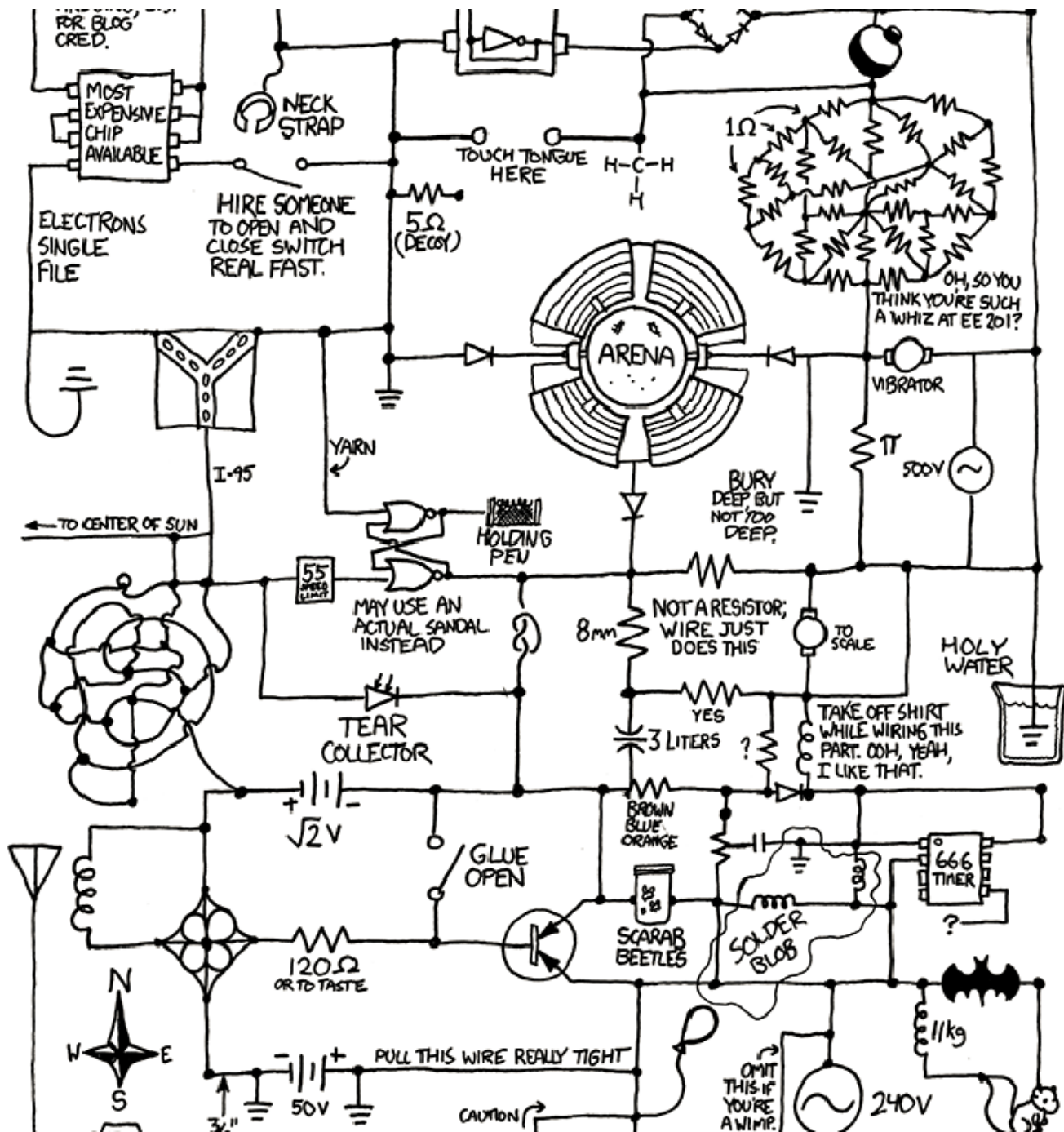


MICROCHIP

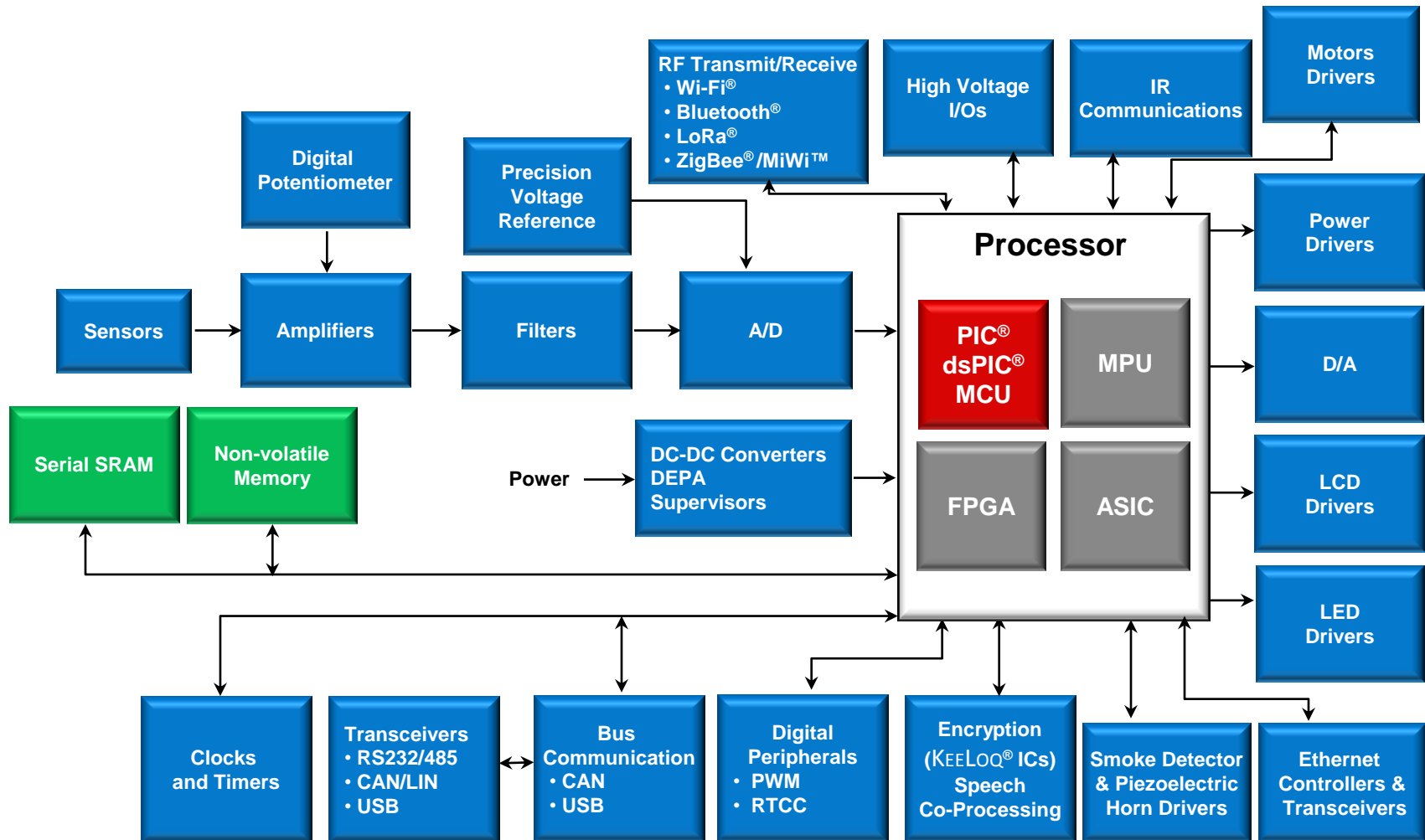
**Microchip Analog
Power**

Октябрь 2016

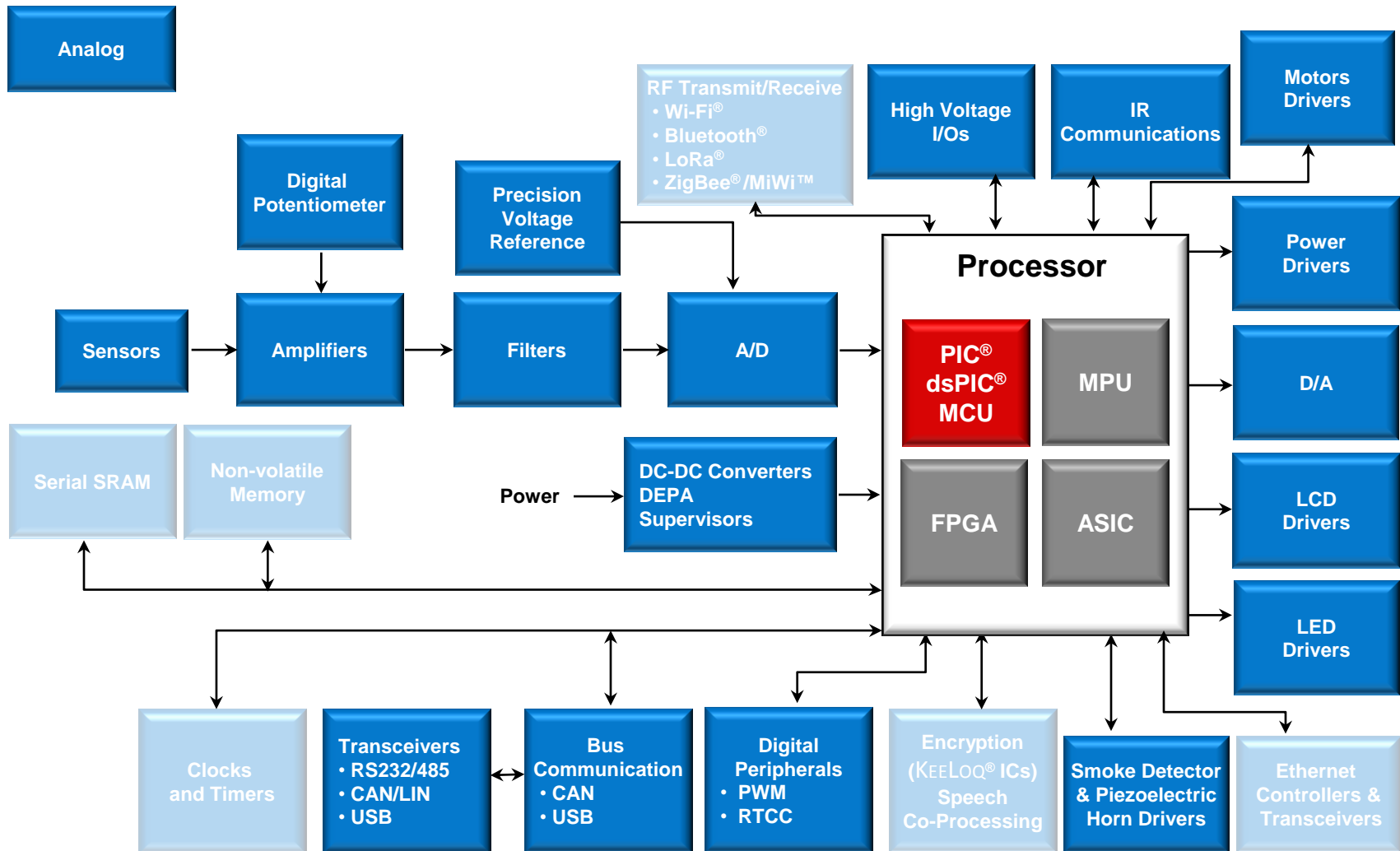
Гамма – Санкт-Петербург



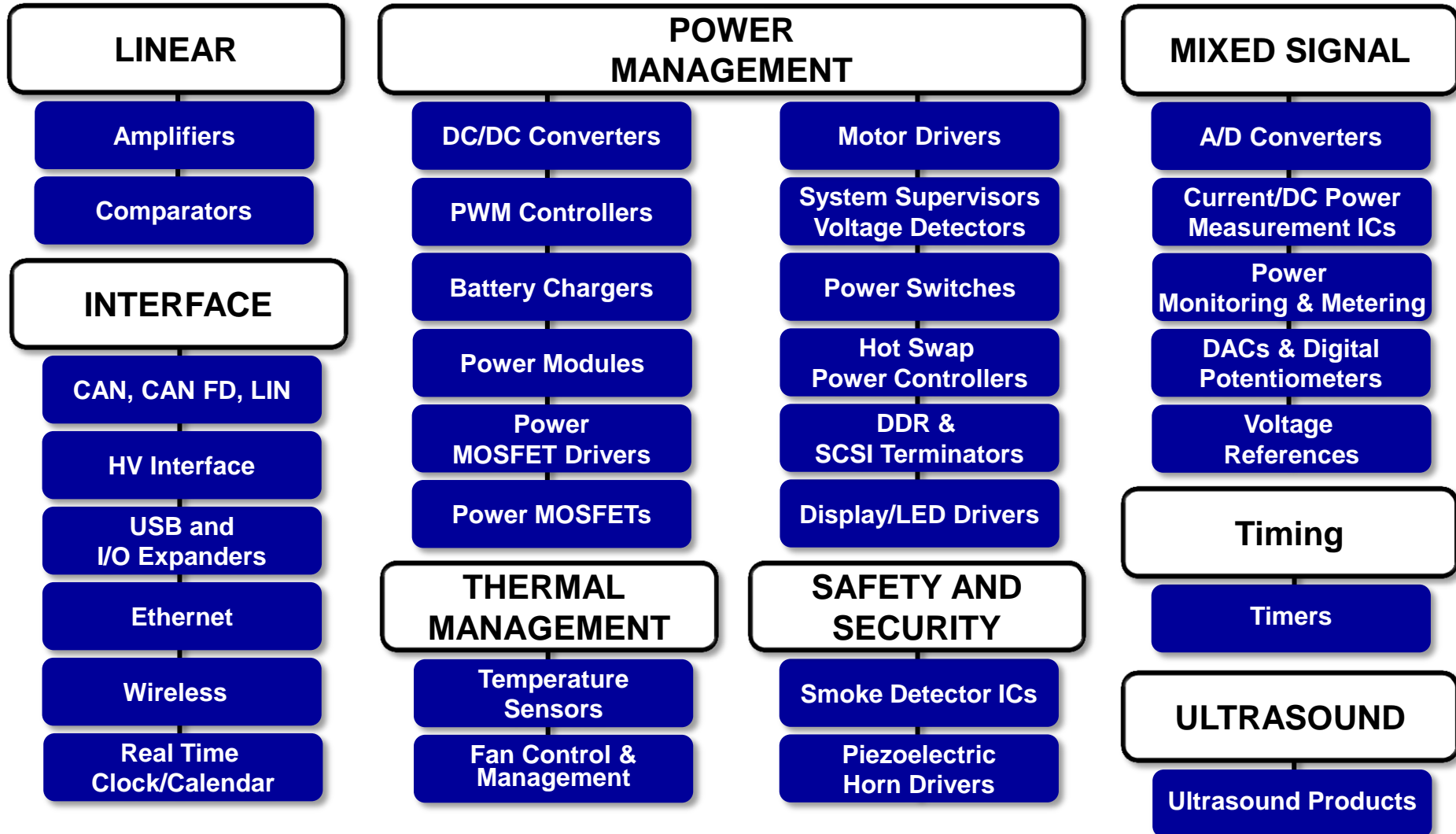
Providing Complete Solutions



Analog Offering

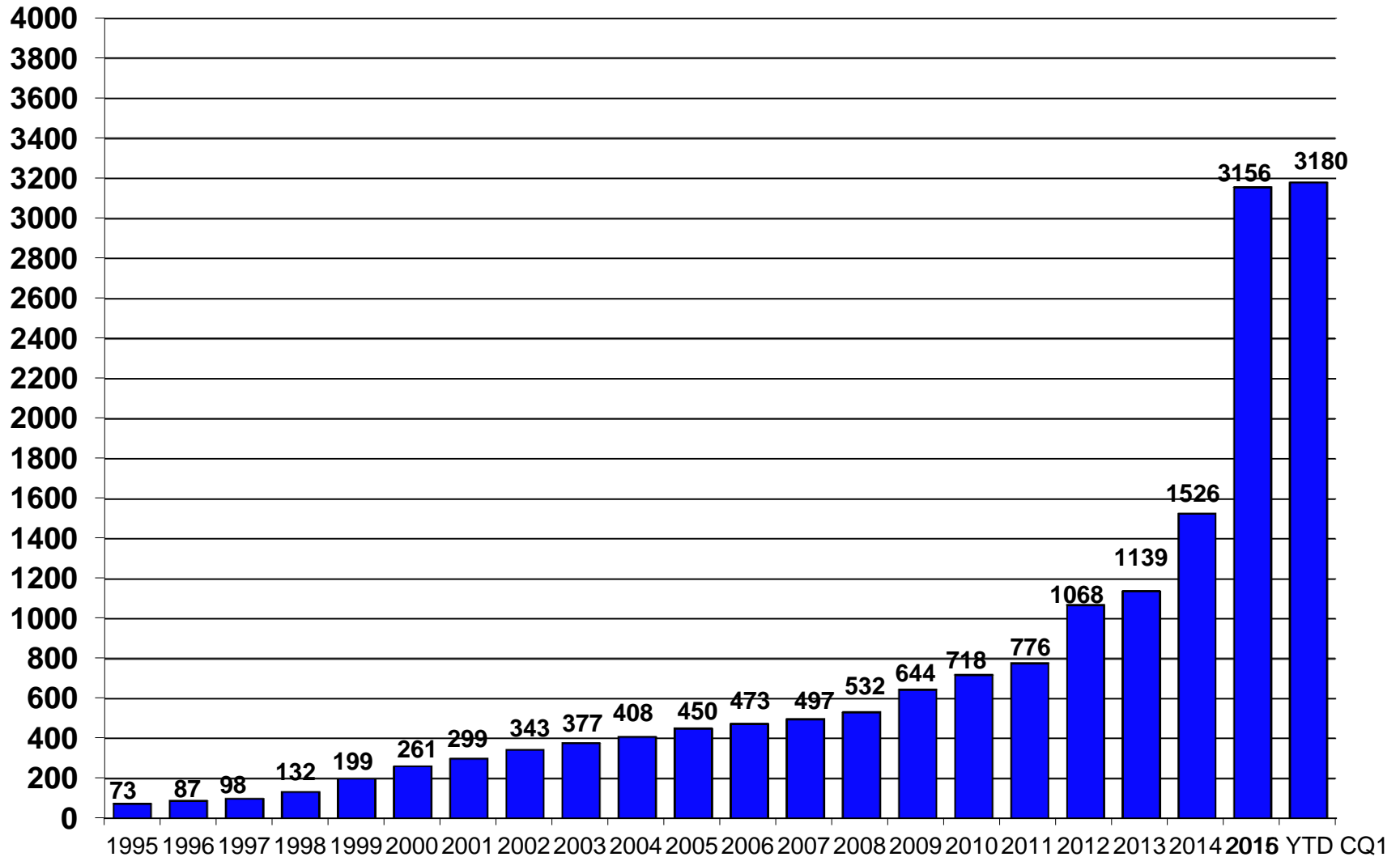


Analog & Interface Products




















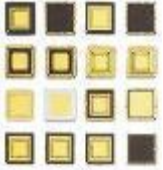






Microchip Analog Product Portfolio Growth



Broadening Microchip Solutions Through Acquisitions

 	 <p>CLICK HERE for Horn Driver ICs and Smoke Detector ICs from R&E International, Inc.</p>  	 	 	 	  
Hampshire	R&E	HI-TECH	ZeroG	SST	Adv Silicon Products
Oct '08	Apr '09	Mar '09	Jan '10	Apr '10	Oct '10
Touch Screen Controllers	Security/ Life-Safety ASICs	Development Tools/ Compiler	Low-Power Embedded Wi-Fi®	High-Density Flash/IP	Motor Drive Products

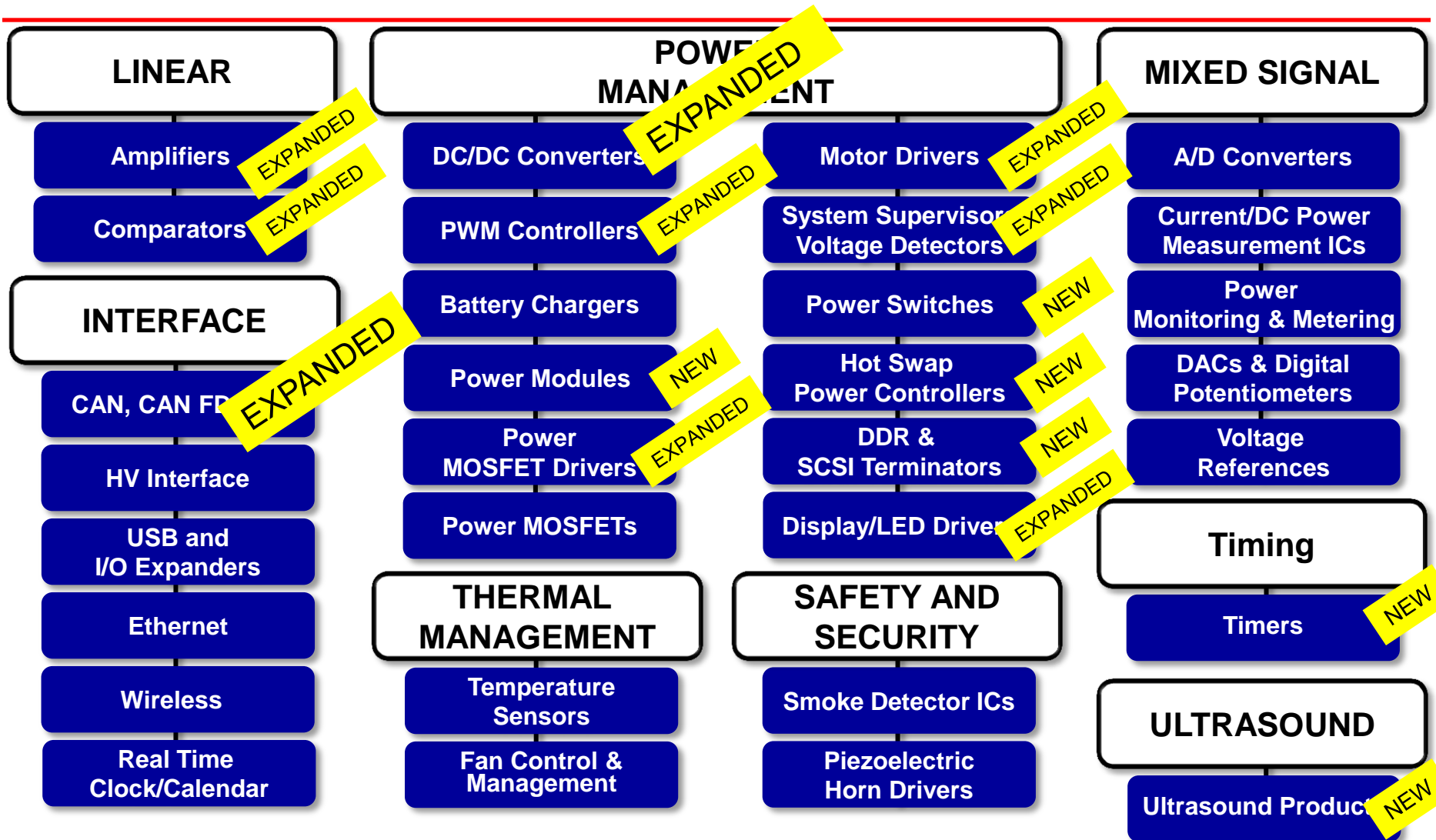
Broadening Microchip Solutions Through Acquisitions

 	<p>LSS</p> <p>ANALOG</p>	 	 	  <p>ANALOG</p>
<p>MMT</p>	<p>LSS</p>	<p>Ident</p>	<p>Roving Networks</p>	<p>SMSC</p>
<p>Feb '11</p>	<p>Oct '11</p>	<p>Feb '12</p>	<p>Apr '12</p>	<p>Aug '12</p>
<p>Assembly & Test Capacity Expansion</p>	<p>High-Speed ADC</p>	<p>Gesture Recognition and Proximity</p>	<p>Bluetooth® and Wi-Fi® Solutions</p>	<p>MOST®, USB, Ethernet, Wireless Audio, PC Controllers</p>

Broadening Microchip Solutions Through Acquisitions

	 	 		 
<p>Novocell</p>	<p>EqcoLogic</p>	<p>Supertex, Inc.</p>	<p>ISSC</p>	<p>Micrel</p>
<p>Jun '13</p>	<p>Nov '13</p>	<p>April '14</p>	<p>July '14</p>	<p>August '15</p>
<p>Non-Volatile-Memory IP</p>	<p>Equalizer and Coaxial Transceiver Products</p>	<p>High-Voltage Analog and Mixed Signal</p>	<p>Low-Power Bluetooth® and Advanced Wireless Solutions</p>	<p>Power, LAN, MEMS, Timing and Clock Solutions</p>

Analog & Interface Products





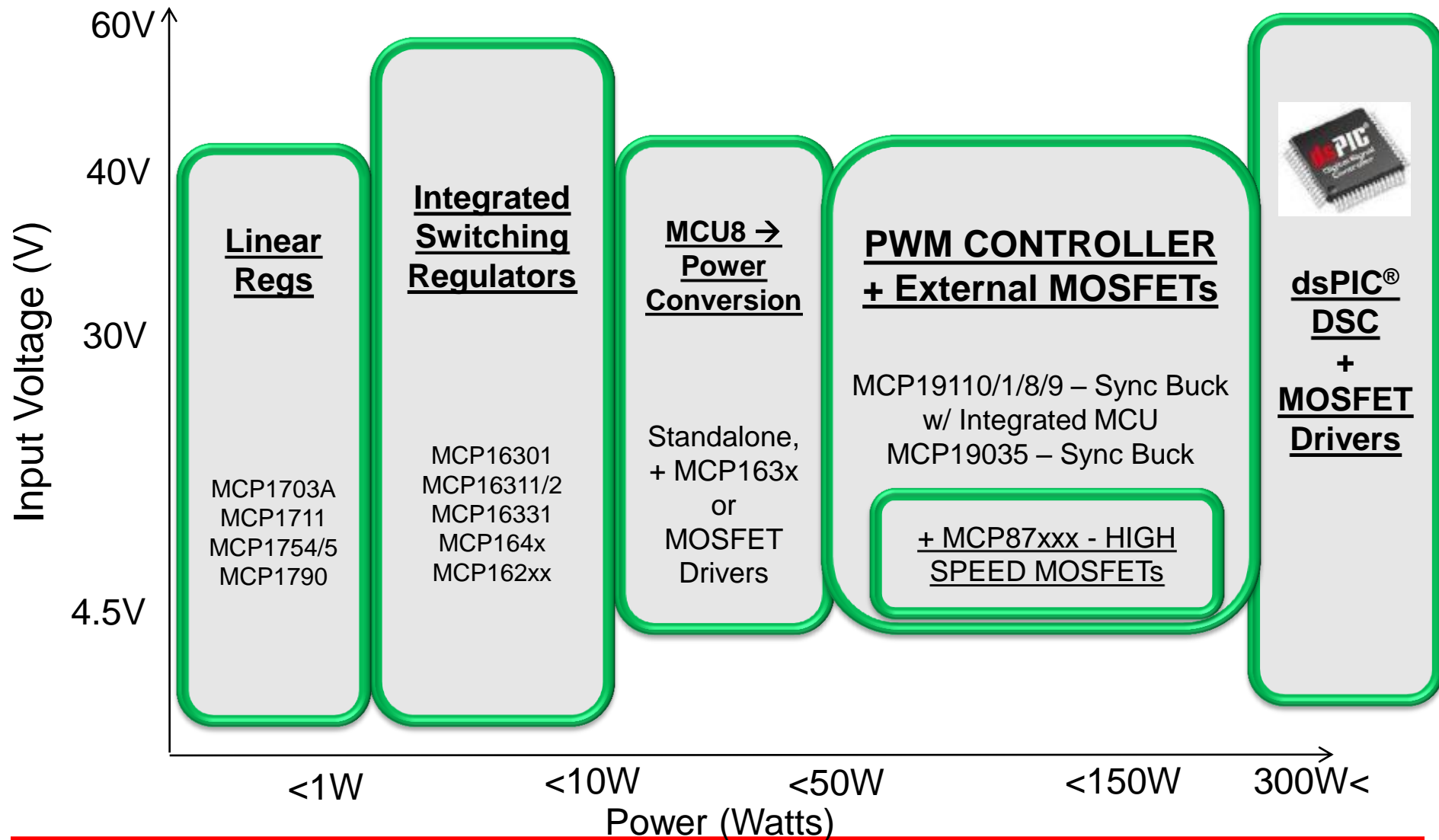
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Компоненты питания

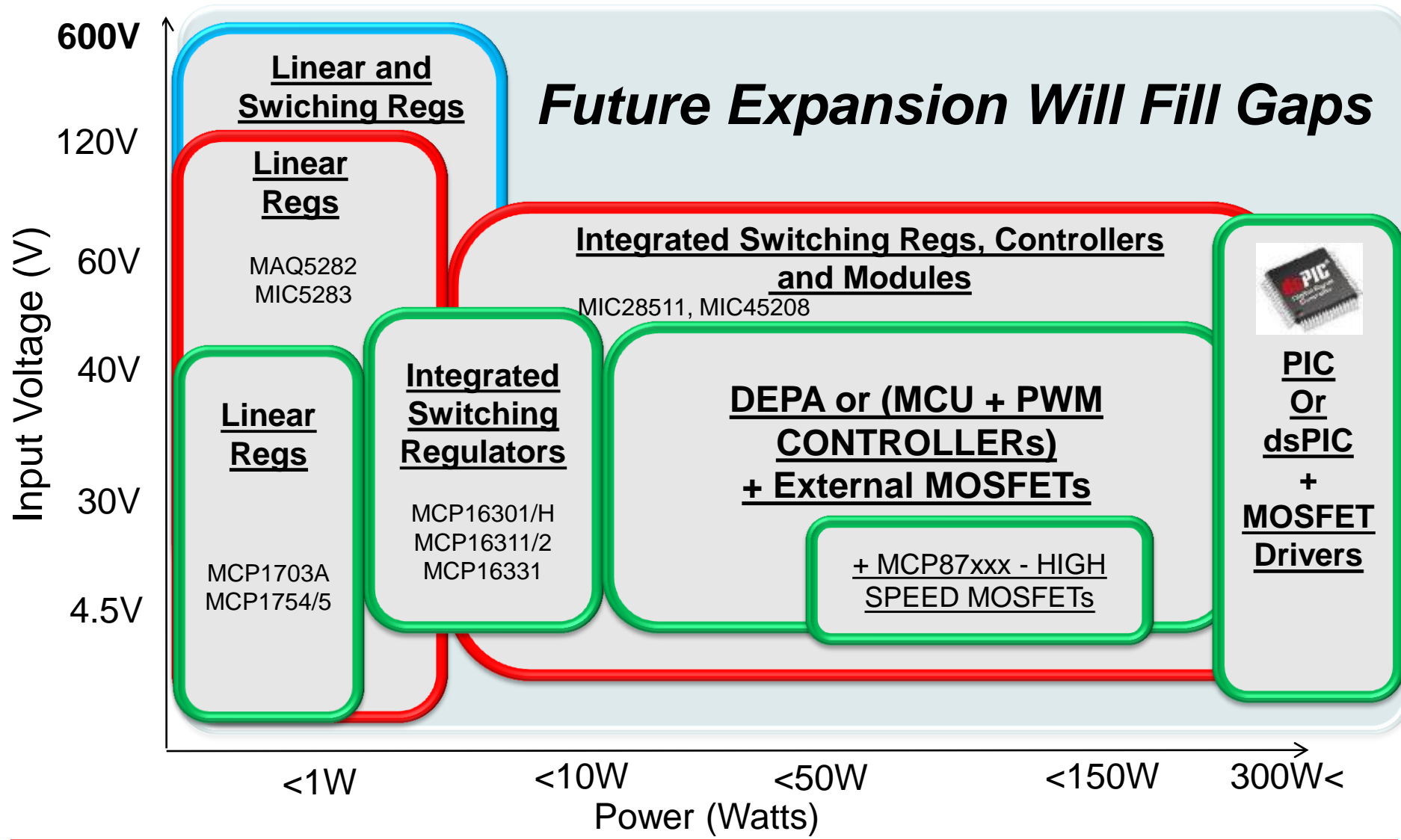
Октябрь 2016

- **Общий обзор**
- **Обзор LDO стабилизаторов**
- **Обзор импульсных стабилизаторов**
- **Обзор модулей импульсных преобразователей**

Power Management



Microchip Power Conversion Portfolio



What is a Low-Dropout Regulator?

- A **Low-DropOut (LDO)** regulator
 - LDO can regulate the output voltage even when the supply voltage is very close to the output voltage
 - Simple DC to DC regulator (buck conversion only)
 - Pros and Cons compared to switching regulator

Linear vs Switching

	Linear	Switching
Function	Only steps down (buck) so input voltage must be greater than output voltage	Step up (boost), step down (buck), inverts
Efficiency	Low to medium, but actual battery life depends on load current and battery voltage over time. Efficiency is high if difference between input and output voltages is small	High, except at very low load currents (μA), where switch-mode quiescent current (I_Q) is usually higher
Waste heat	High, if average load and/or input to output voltage difference are high	Low, as components usually run cool for power levels below 10 W
Complexity	Low, usually requiring only the regulator and low-value bypass capacitors	Medium to high, usually requiring inductor, diode, and filter caps in addition to the IC; for high-power circuits, external FETs are needed
Size	Small to medium in portable designs, but may be larger if heatsinking is needed	Larger than linear at low power, but smaller at power levels for which linear requires a heat sink
Total cost	Low	Medium to high, largely due to external components
Ripple/Noise	Low; no ripple, low noise, better noise rejection	Medium to high, due to ripple at switching rate

LDO Performance Strategy

- **Better Efficiency**

- Lower Iq
- Lower Dropout

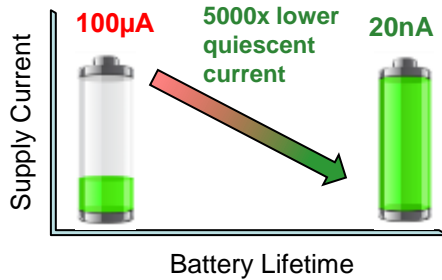
- **Smaller Solution Size**

- Capless
- Dual/Multi Output

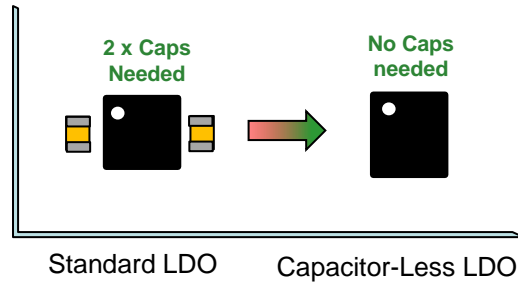
- **Noise Performance**

- Higher PSRR
- Lower Output Noise

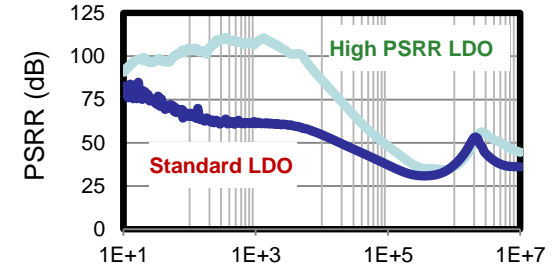
Ultra-Low Iq (<1uA)



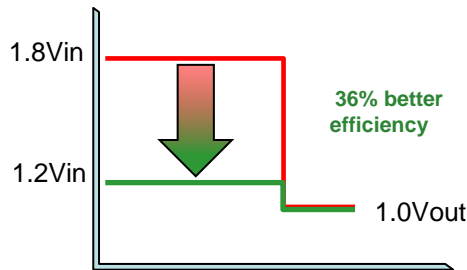
Capless Operation



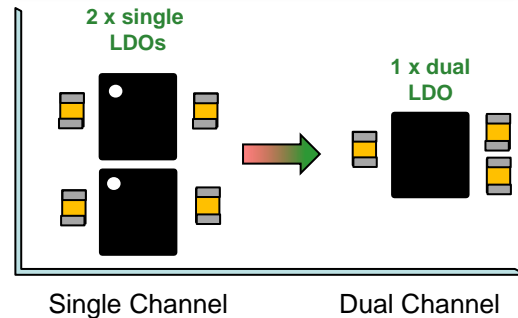
Ultra-High Ripple Rejection (<90dB)



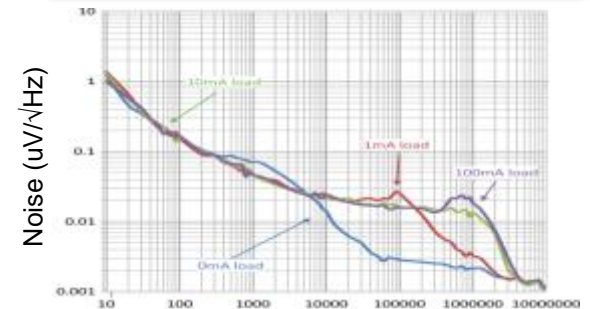
Ultra-Low Drop Out (<50mV)



Multi-Channel LDO Regulators



Ultra-Low Noise Output



LDO Offering

- **Over 300+ LDOs from MCHP + Micrel**
 - **High Vin LDOs**
 - Up to 120V
 - **High Current Output**
 - Up to 7.5A
 - **High Performance**
 - Ultra-Low Iq: 20 nA typ
 - Small package: 1x1mm DFN
 - High PSRR: Ripple Blocker Family
 - Multiple Output LDO: 4 Channel Output LDOs
-



Overview of Combined LDOs

Type	Max Input Voltage	Output Current													
		< 100 mA Single	~ 150 mA		~ 200 mA		~ 300 mA		~ 400 mA	~ 500 mA		~ 1.0 A	~ 1.5 A	~ 3.0 A	> 3.0 A
		Single	Dual	Single	Dual	Single	Dual	Single		Dual	Single				
Standard Type	5.5 V	MIC5253	MIC536x MIC5301	MIC5310 MIC532x	MIC5367	MIC538x	MIC5504 MIC5303	MIC531x	MIC5325	MIC5524 MIC5319	MIC5355 MIC5356	MIC37120 MIC37122	MIC69151 MIC69153	MIC69301 MIC69302	MIC68400 MIC69502
	6.0 V	TC1070 TC2054	MIC5252 MIC525x TC1186 TC2185	MIC5254	~ 300mA		MIC5249 MIC5318 MCP1824S TC1107		~ 500mA	MIC5353 TC1262 MCP1725		MI3710x MCP1726 MCP1826	MIC35152 MIC3715x MCP1727 MCP1827	MIC3730x MIC47300	MIC3750x MIC49500
	7.0/8.0V	MIC5232													MIC29311
High performance															
Low Iq (<2uA)	-	MIC5231	MCP1711		MCP1810 MCP1703				~ 500mA	MIC47050					
High PSRR (>80dB)	-	MIC5281 MCP1790	MIC5308		MIC94310		MIC5309 MCP1755		~ 500mA	MIC94325		MIC47100			
Small Package	-		MIC536x MCP1711	MIC538x	MIC536x		MIC550x MIC5399		~ 500mA	MIC5524					
Med Input	12V - 22V	MIC5231 MIC5203	MIC5205 MIC5225 MCP1754		MCP1702		MCP1755			MIC5219 MIC5209		MIC3910x	MIC3915x	MIC2931x MIC3930x	MIC2951x MIC3950x
High Input	>24V	MIC528x MIC5233 MCP1790	MIC528x ** MIC295x MCP1804		MIC2954				MIC2920x	MIC5239		MIC294xA	MIC2915x	MIC2930x	MIC2950x MIC2975x



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High Input Voltage LDOs

Октябрь 2016

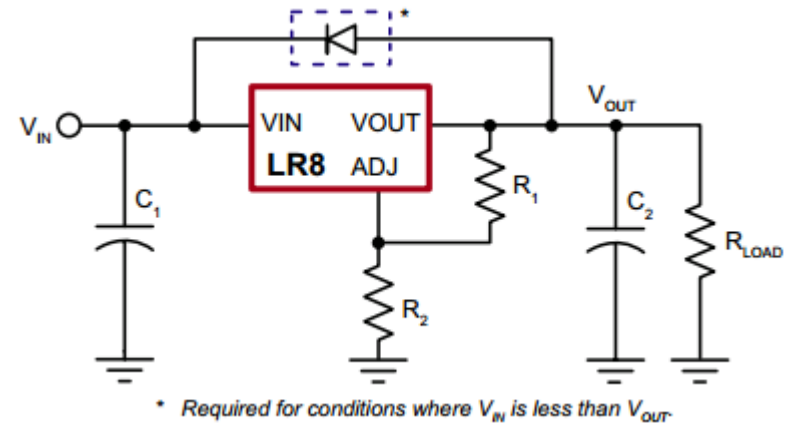
LR8, LR12

LR8:

- 13.2V - 450V input voltage range
- Adjustable 1.2V - 440V output regulation
- Output current limiting
- Internal junction temperature limiting

LR12:

- 13.2V to 100V input voltage range
- Adjustable 1.2V to 88V output regulation
- Output current limiting, 50mA min.
- Over temperature protection



Свойства:

- 5% reference voltage tolerance
- Output current limiting
- 10 μ A typical ADJ current
- Over temperature protection
- Operating Temperature Range: -55°C to +150°C
- Package Options: TO-252 (DPAK), TO-92, SOIC-8



High Input Voltage

Part Number	Vin Range	Iout Max	Iq	Dropout Voltage	Key Features	Package
MIC5280*	4.5 - 120V	25 mA	31 uA	1100 mV	Fast line regulation, load dump, reverse protection, ADJ output	SOIC-8 EP
MIC5281*	6.0 - 120V	25 mA	6 uA	2000 mV	Low Iq, fast line regulation, load dump	3x3mm DFN10
MIC5282*	6.0 - 120V	50 mA	6 uA	2000 mV	Low Iq, fast line regulation, load dump	MSOP-8 EP
MIC5283*	6.0 - 120V	150 mA	8 uA	1800 mV	Low Iq with High Vin	SOIC-8 EP 3x3mm DFN
MIC5233	2.3 - 36V	100 mA	18 uA	270 mV	Low Iq	SOT-23
MIC5234	2.3 - 30V	150 mA	20 uA	320 mV	Low Iq	SOIC-8 EP
MCP1804	2.0 - 28V	150 mA	50 uA	1300 mV	Current foldback	SOT-23 SOT-89 SOT-223
MCP1703*	2.7 - 16V	250 mA	2 uA	625 mV	Low Iq in small package	2x3mm DFN SOT-23 SOT-89 SOT-223

* AEC-Q100 qualified (MAQ prefix is used for MIC devices)

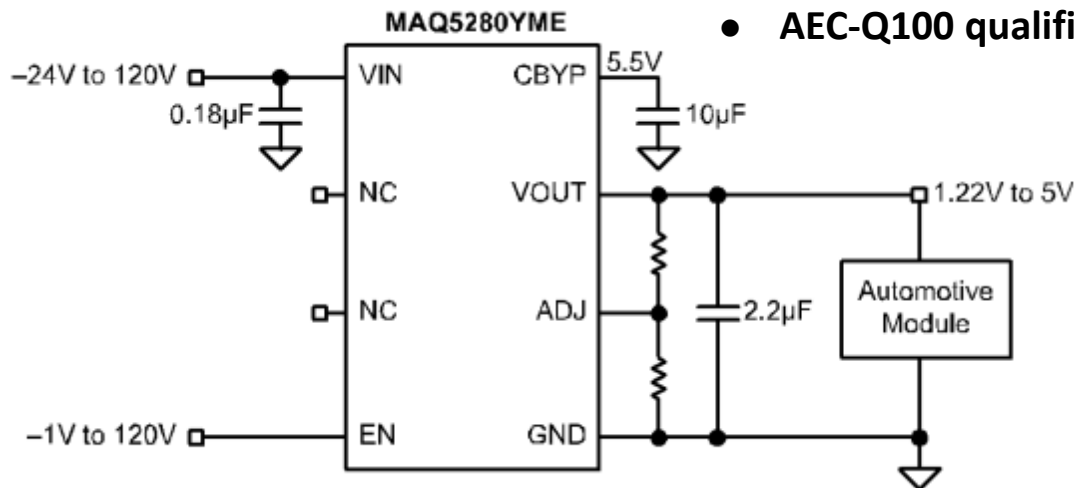
MIC5280 – 120Vin LDO

Features:

- 4.5V to 120V DC Input voltage range
- 25mA Guaranteed output current
- **Automotive load dump protection**
 - -24V to 120V Maximum input voltage range
 - Surge protection for automotive load dump
- Reverse voltage protection
- -40°C - 125°C T_J rating

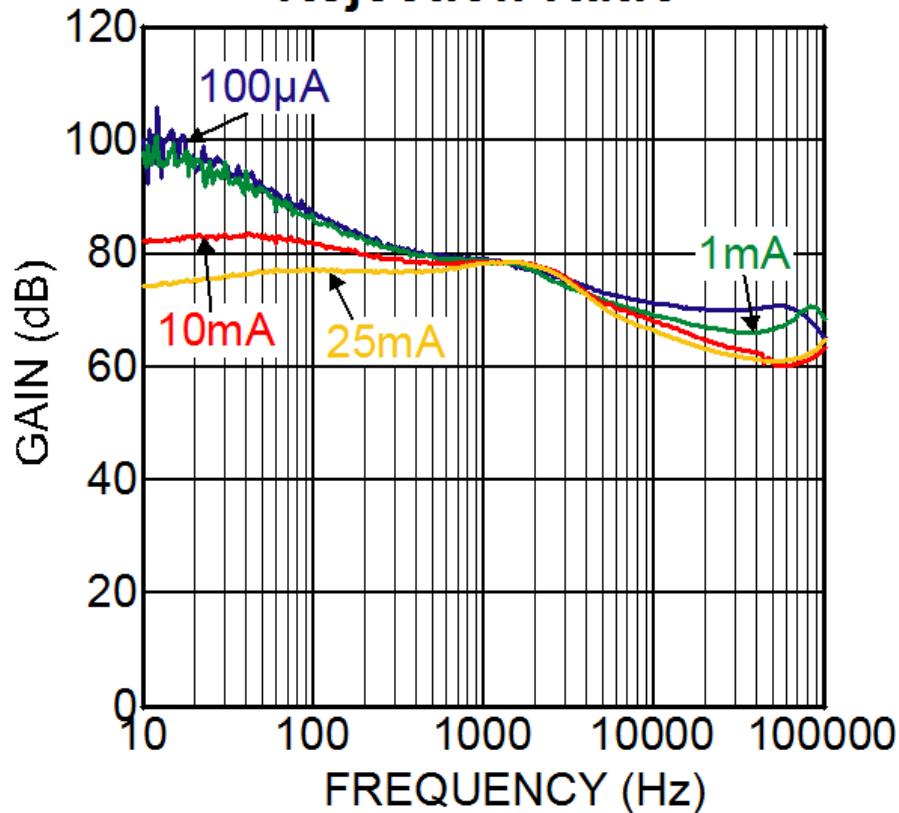
Highlights:

- **Very low quiescent current**
 - Ideal for stand-by power supply in automotive applications
- **Thermal shutdown and over current protection**
- **Ultra High >80dB PSRR**
 - Ideal for RF Power Supplies in Noisy Automotive Environments
- **Thermally efficient SOIC-8 EP package**
- **AEC-Q100 qualified, up to Grade 2**

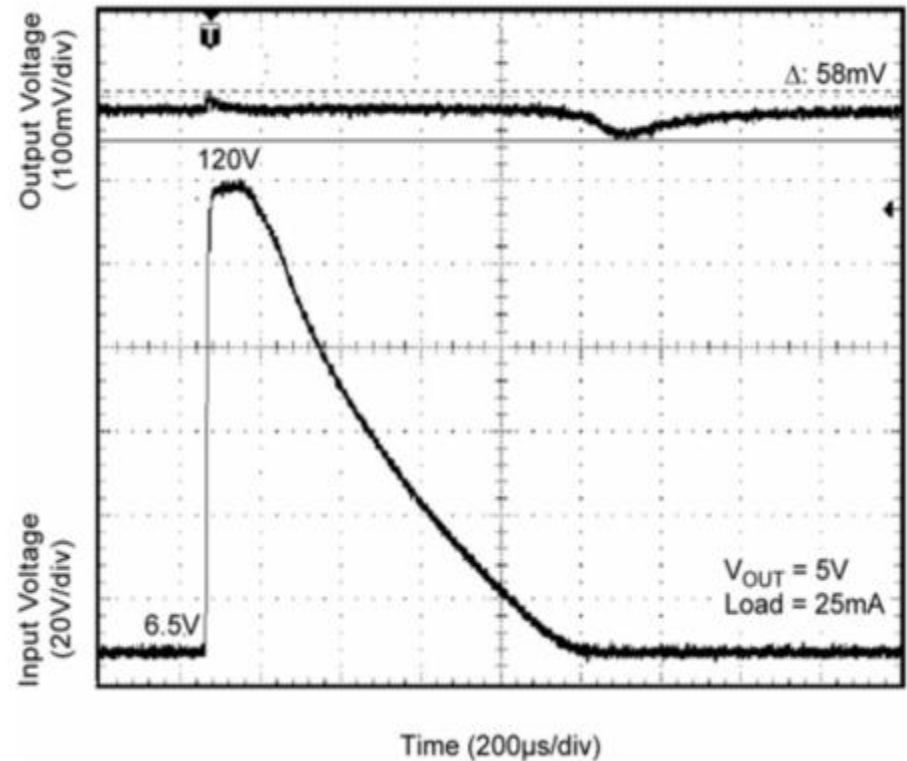


MIC5280 – High PSRR and Load Dump

Power Supply Rejection Ratio



Load Dump





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High Current LDOs

Октябрь 2016



High Current Output LDO 1

Part Number	Iout Max	Vin Range	Enable	Dropout Voltage	Key Features	Package
MCP1727	1.5 A	2.3 - 6.0V	Y	330 mV	Low dropout, Adjustable Delay on PWR Good Output	SOIC8 3x3 DFN8
MCP1827/S	1.5 A	2.3 - 6.0V	Y	330 mV	Fixed and ADJ output	DDPAK TO-220
MIC47150	1.5 A	1.4 - 6.5V	Y	280 mV	Low dropout, High Speed	TO-252
MIC61150	1.5 A	1.1 - 3.6V	Y	75 mV	Ultra low dropout, Low input voltage	MSOP-10 3x3mm DFN10
MIC69151	1.5 A	1.65 - 5.5V	Y	250 mV	Low input voltage, power good	SOIC-8 3x3mm DFN10
MIC68200	2.0 A	1.65 - 5.5V	Y	300 mV	Low noise, high speed	3x3mm DFN10
MIC68220	2 x 2A	1.65 - 5.5V	Y	300 mV	Dual output, high speed	4x5mm DFN20



High Current Output LDO 2

Part Number	I _{out} Max	V _{in} Range	Enable	Dropout Voltage	Key Features	Package
MIC47300	1.5 A	1.4 - 6.5V	Y	230 mV	Low dropout, Adjustable Delay on PWR Good Output	SOIC8 3x3 DFN8
MIC59300	1.5 A	1.0 - 3.8V	Y	205 mV	Ultra low V _{in}	SOIC-8 TO-263
MIC61300	1.5 A	1.1 - 3.6V	Y	150 mV	Ultra low dropout	3x3mm DFN10
MIC68400/1	4.0 A	1.65 - 5.5V	Y	360 mV	High speed, low I _q	4x4mm DFN16
MIC69502	5.0 A	1.65 - 5.5V	Y	250 mV	Low V _{out} of 0.5V	SPAK-7
MIC29751	7.5 A	2.5 - 26V	Y	700 mV	High speed, low I _q	TO-247
MIC29710	7.5 A	2.3 - 16V	Y	425 mV	High current output	TO-220

Dual Input (Vbias) LDOs

- **Dual Input LDOs are ideal for applications which require**
 - A fast transient response
 - Capability of converting very low input voltage
 - High output current
 - Low dropout voltage
 - Low noise and high PSRR
- **Ideal for FPGAs and ASICs**

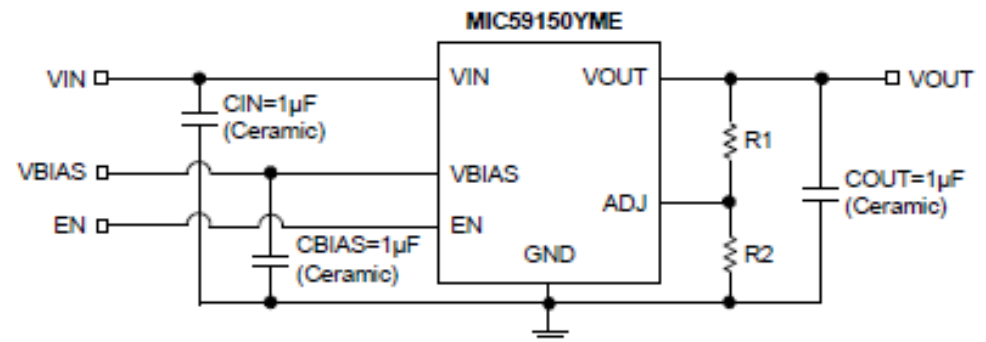
MIC59150

Features:

- Ultra Fast Transient Response
- 1.5A Output
- Low Input and output voltage conversions
- VIN: 1.0V to 3.8V
- Maximum dropout (VIN – VOUT) of 250mV over temperature
- Adjustable output voltage down to 0.5V
- Excellent line and load regulation specifications
- Logic controlled shutdown
- Thermal shutdown and current limit protection
- Exposed Pad SO-8 package
- $T_J = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$

Applications:

- Telecommunications processors
- Graphics Processors
- MCU power
- Digital TVs and Set Top Boxes
- DSP and FPGA Power





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Low Iq LDOs

Октябрь 2016

Что такое I_q ?

- **I_q = Quiescent Current**
 - I_q это необходимый ток для работы LDO
 - I_q это ток, текущий в GND без нагрузки
 - При полной нагрузке (150мА, 300мА, 1А, 5А, т.д.), I_q не имеет значения, так как это лишь часть общего тока. Тем не менее, для малой нагрузки или без нагрузки, I_q становится критическим параметром
 - На рынке присутствуют LDO с I_q ~1мкА до 500нА



Low Iq LDO

Part Number	Iout Max	Vin Range	Iq typ	Dropout Voltage	Key Features	Package
MCP1711	150 mA	1.4 – 6.0V	0.6uA	500 mV	Ultra Low Iq, Capless where applicable	1x1mm DFN SOT-23
MCP1700	200 mA	2.3 – 6.0V	1.6uA	178 mV	Ultra Low Iq, Low Dropout	SOT-23 SOT-89 TO-92 2x2mm DFN6
MCP1703A	250 mA	2.7 – 16V	2.0uA	625 mV	Ultra Low Iq, High Input Voltage	SOT-23 SOT-89 TO-92 2x3mm DFN8
MCP1810	150 mA	2.3 – 6.0V	0.02 uA	450 mV	Lowest Iq in the Market	2x2mm DFN8
MIC5281/2	25/50 mA	6.0 – 120V	6.0uA	2000 mV	Ultra High Input Voltage, Low Iq	MSOP8
MIC5232	10 mA	2.7 - 7V	1.8uA	100 mV	7V Input, Low Iq	TSOT-5 VDFN6

MCP1711

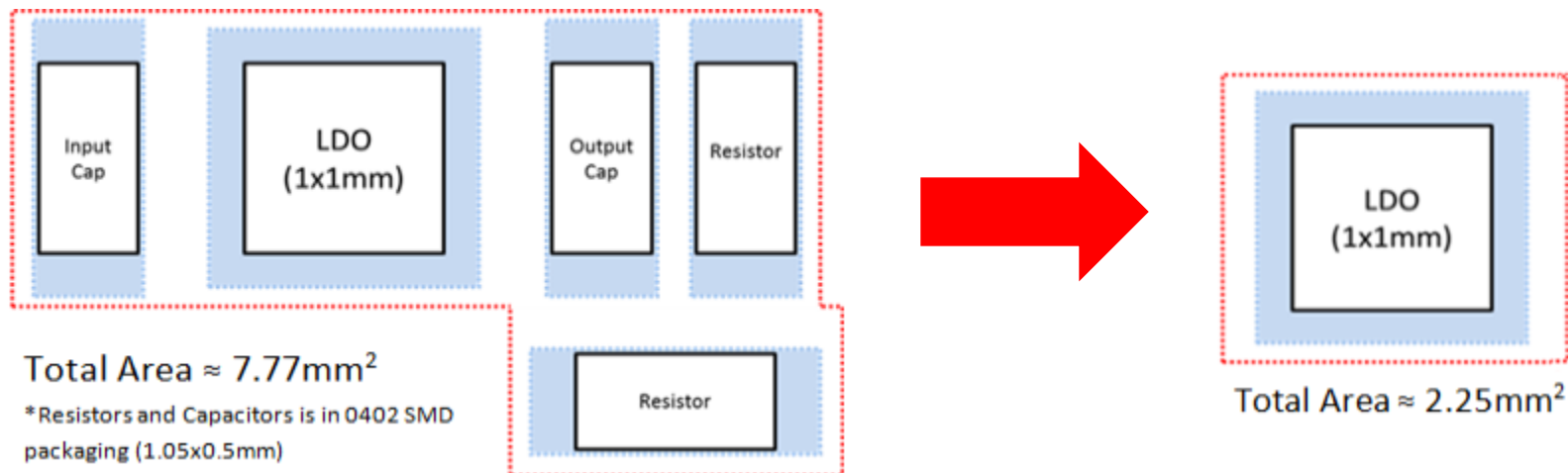
Ultra Low Iq, Capless LDO

Features:

- Ultra Low Iq of 0.6uA typ
- Very Accurate Output of 20mV Offset for Output of 1.2 to 1.8V
- Vin: 1.4V to 6.0V
- Stable Without Output Capacitor
- Available Package
 - 1x1mm DFN
 - SOT-23

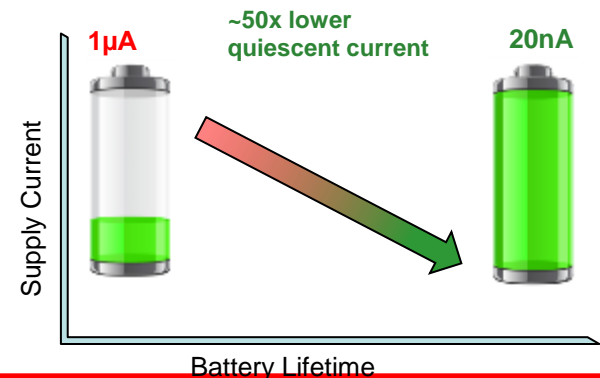
Applications:

- Energy Harvesting
- Long-Life, Battery-Powered Applications
- Portable Electronics
- Ultra-Low Consumption Products



- **(Super) Ultra Low Iq – увеличивает срок службы от батарей**
 - Потребляет лишь 0.02мкА (20нА) (типичное значение)
 - Для приборов с питанием от батарей
 - Потребление меньше в 50 раз чем ближайшиe конкуренты

MCP1810 Iq Performance





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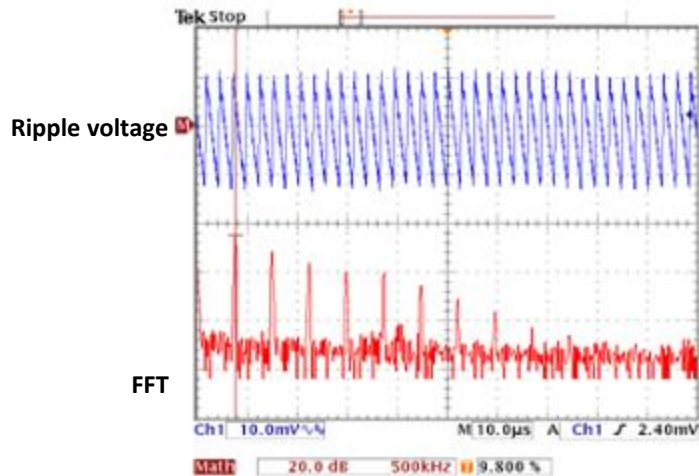
RippleBlocker™

Октябрь 2016

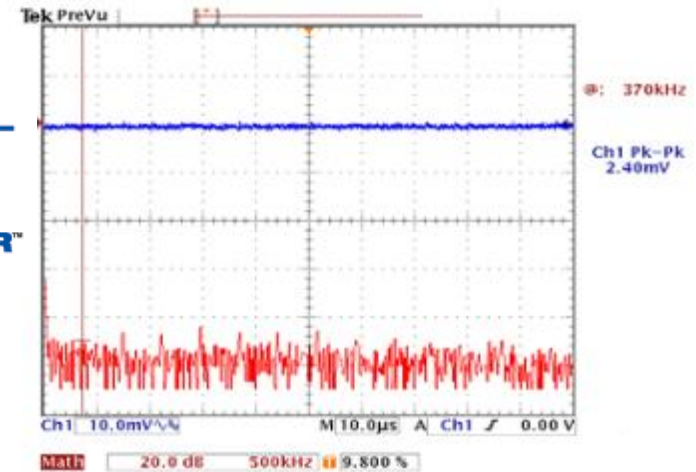
RippleBlocker™

- **What is RippleBlocker™?**
 - Ultra High PSRR to filter ripple voltage from the source

DC/DC Ripple Output



No Ripple Out to POL



Ripple-Blocker™ Response at DC/DC Switching Frequency 370kHz

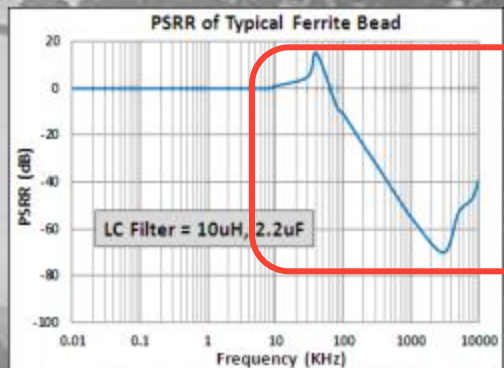
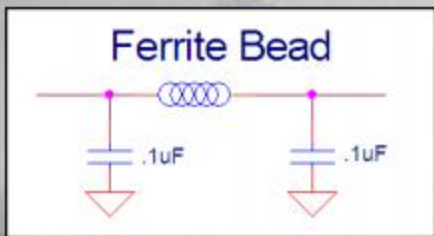
POL=Point of Load



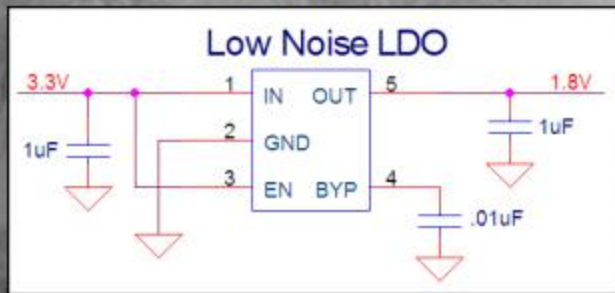
RippleBlocker™

Part Number	Iout Max	Vin Range	Vout	Dropout Voltage	Key Features	Package
MIC94300	200mA	1.8 - 3.6V	Vin - 170mV typ	190 mV	Input follower, Ultra high PSRR	1.2x1.6mm DFN4
MIC94310	200mA	1.8 - 3.6V	Fixed 1.2 - 3.3V	40 mV	Ultra low dropout, Ultra high PSRR	1.2x1.6mm DFN4 SOT-23
MIC94305	500mA	1.8 - 3.6V	Vin - 170mV typ	200 mV	Input follower, Ultra high PSRR	1.6x1.6mm DFN6
MIC94325	500mA	1.8 - 3.6V	Adj 1.2 - 3.4V	100 mV	Low dropout, Ultra high PSRR	1.6x1.6mm DFN6
MIC94345	500mA	1.8 - 3.6V	Fixed 1.2 - 3.3V	90 mV	Low dropout, Ultra high PSRR	1.6x1.6mm DFN6
MIC94355	500mA	1.8 - 3.6V	Fixed 1.2 - 3.3V	90 mV	Low dropout, Ultra high PSRR	1.6x1.6mm DFN6

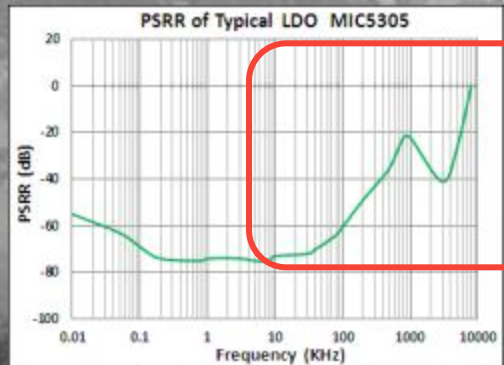
Bad Example to Filter Noise



Resonance Amplifies Noise
Only 2nd Order Filter
Bad filter in high frequencies



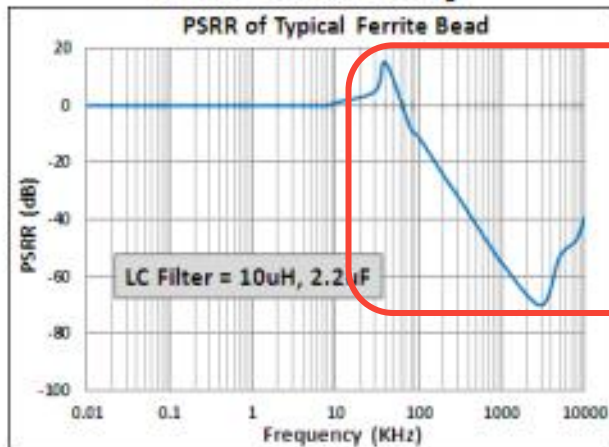
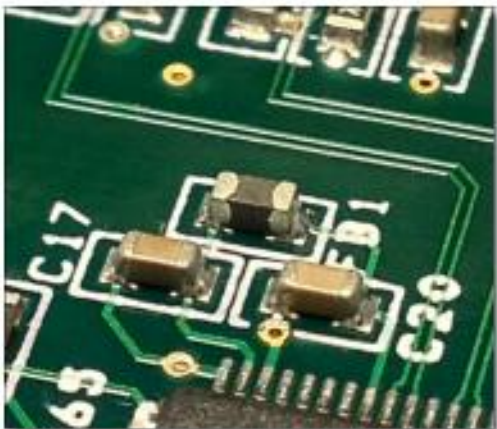
The Old Way



Very Bad Filter in High Frequencies

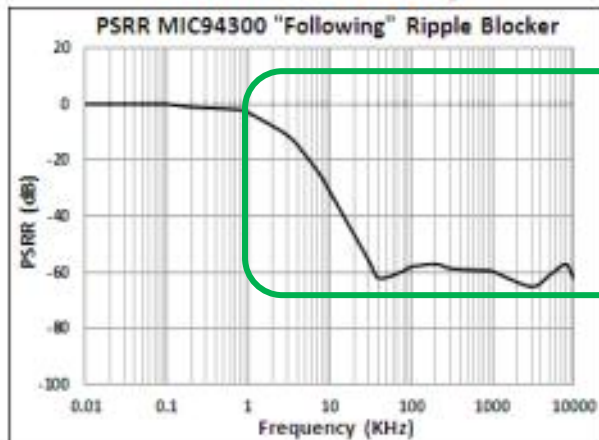
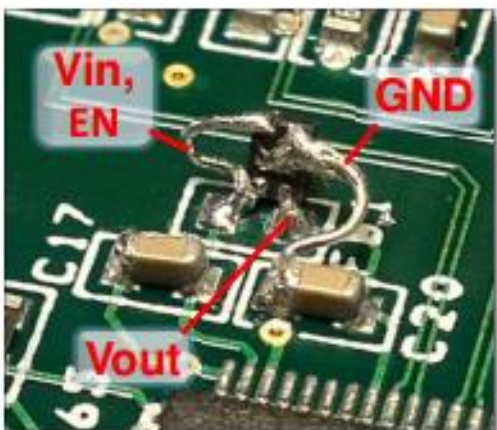
Good Example to Filter Noise

The Old Way



Resonance Amplifies Noise
Only 2nd Order Filter
Bad filter in high frequencies

The Best Way



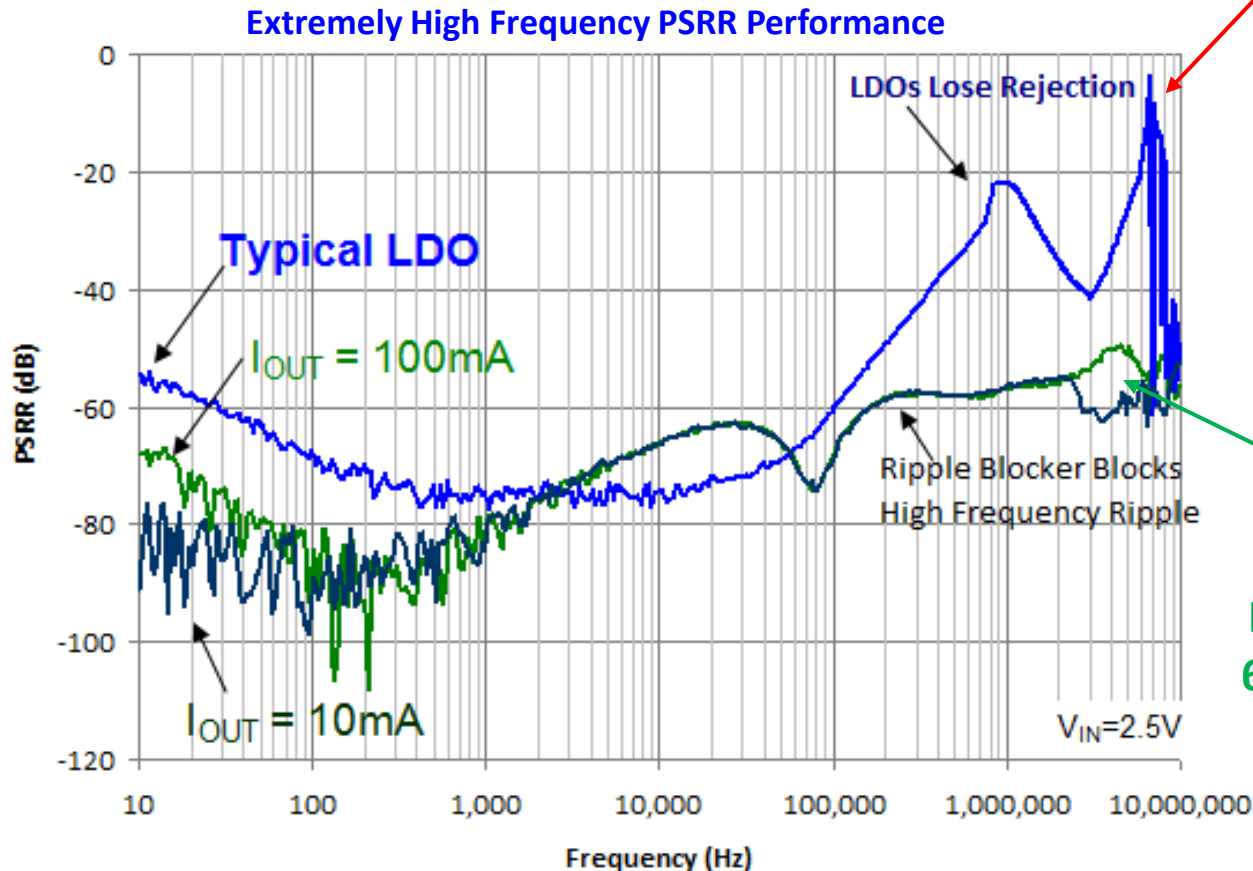
Using Ripple Blocker™
3rd Order Filter Constant Filtering
even in high frequencies



RippleBlocker™ vs. LDO

200mA Fixed Output LDO with Ripple-Blocker™ Technology

94310 PSRR Vs High PSRR Typical LDO



P-Channel LDO
Very Poor PSRR at high Frequency!

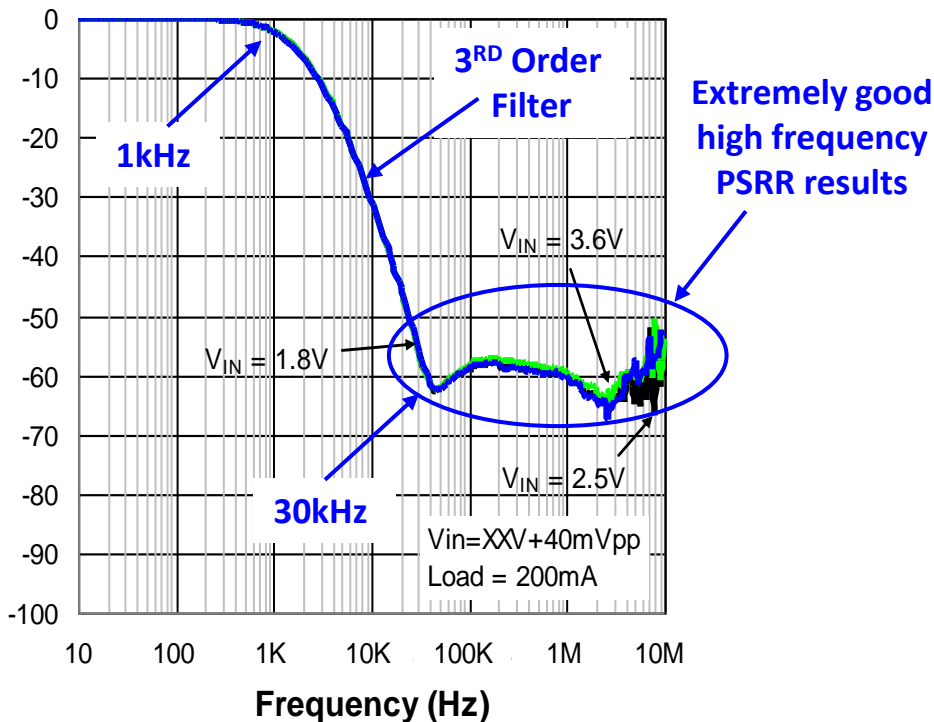
Extremely High PSRR from 60kHz to 10MHz

RippleBlocker™ Performance

10Hz-10MHz Best-In-Class filtering!

MIC94300

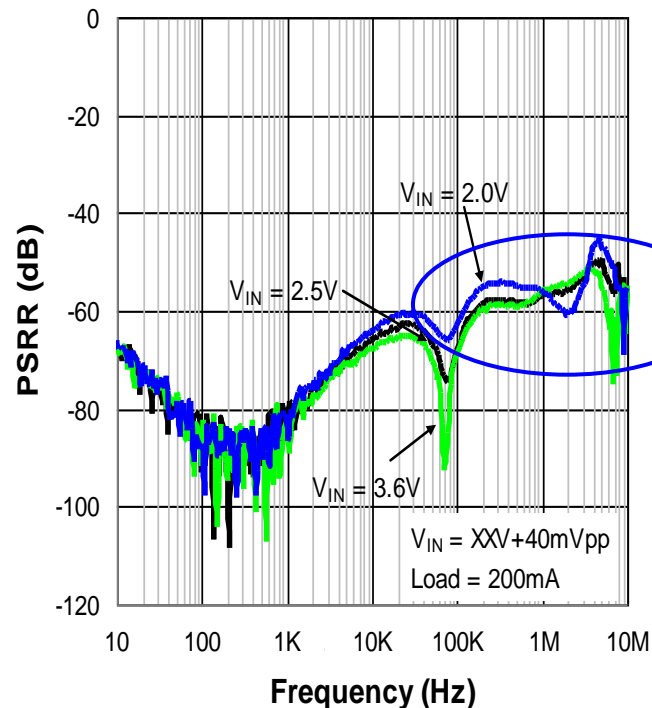
PSRR $C_{OUT} = 1\mu F$



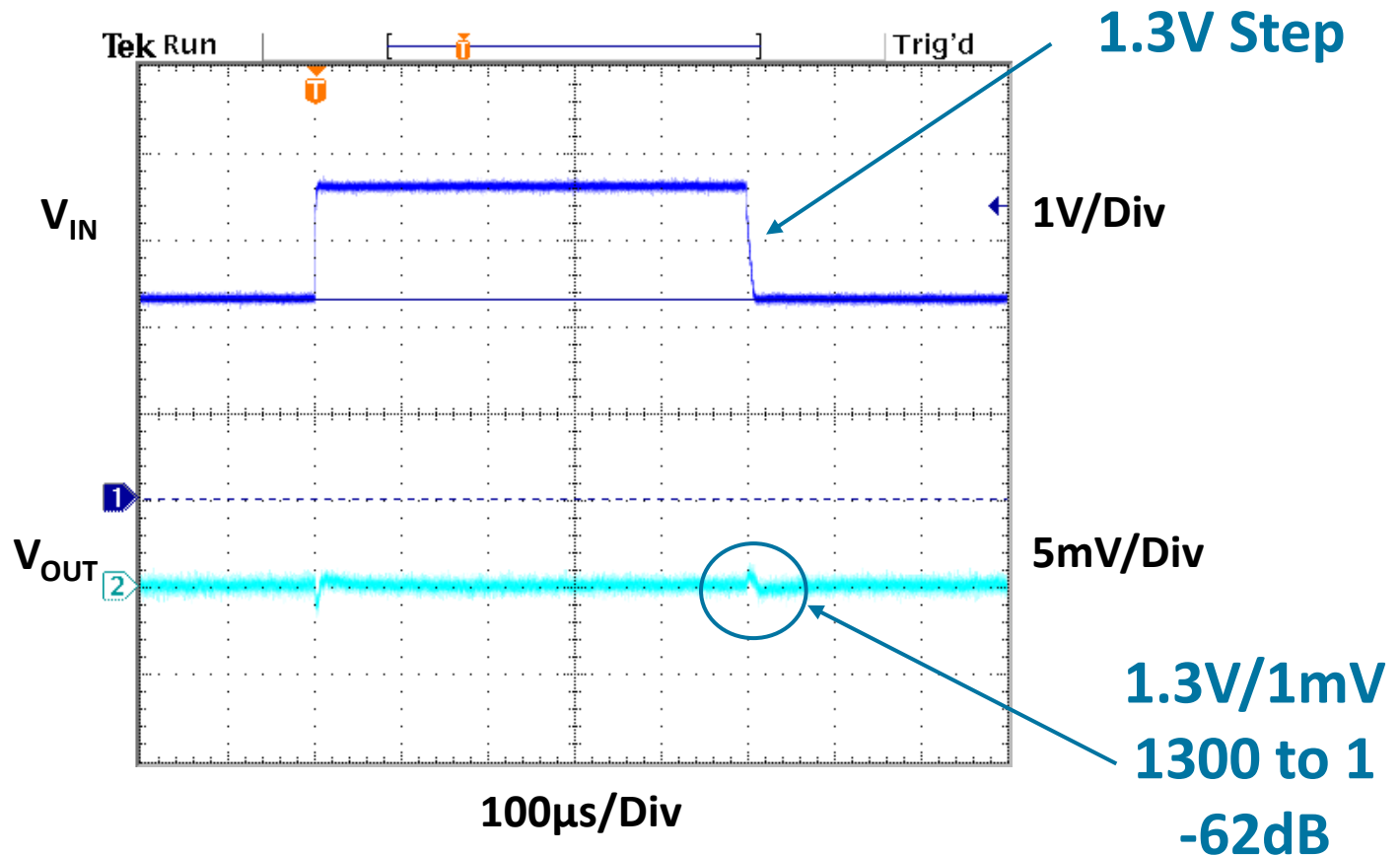
MIC94310

PSRR $C_{OUT} = 1\mu F$

Extremely good high frequency PSRR results



MIC94310 Fast Transient



Line Transient: 2.3V to 3.6V

$$V_{OUT} = 1.8V/100mA$$



RippleBlocker™ Key Take Away

- **Simple**

- 4 pin DFN package in very small package

- **Superior PSRR**

- RippleBlocker™ Constantly provides >60dB from 10Hz to 10MHz

- **Superior Transient Response**

- Load transient will result in ringing for LC filter causing cross-coupling to adjacent circuit
- Ripple blocker provides excellent both load and line transient response



MICROCHIP

Portable Focused LDOs

Октябрь 2016

Focused Products LDO Selection Guide

Part	Vin (V)	Iout (A)	Vout (V)	Outputs	Output Adjust Method	Room Accuracy (%)	I _Q /output (μA)	Dropout at full load (mV)	PSRR at 100Hz (dB)	PSRR at 1 kHz (dB)	Auto Discharge	Enable Pull-down	Package (mm)
	min-max	max	min-max										
MIC5501	2.5–5.5	0.3	1.0-3.3	1	Preset	2	32	160	65	60			1.0 x 1.0 TDFN, SOT23-5L
MIC5502	2.5–5.5	0.3	1.0-3.3	1	Preset	2	32	160	65	60	√		1.0 x 1.0 TDFN, SOT23-5L
MIC5503	2.5–5.5	0.3	1.0-3.3	1	Preset	2	32	160	65	60		√	1.0 x 1.0 TDFN, SOT23-5L
MIC5504	2.5–5.5	0.3	1.0-3.3	1	Preset	2	32	160	65	60	√	√	1.0 x 1.0 TDFN, SOT23-5L
MIC5512	2.5–5.5	0.3	1.0-3.3	1	Preset	2	32	160	70	65	√		1.6 x 1.6 TDFN
MIC5514	2.5–5.5	0.3	1.0-3.3	1	Preset	2	32	160	70	65	√	√	1.6 x 1.6 TDFN
MIC5392	2.5–5.5	0.15	1.0-3.3	2	Preset	2	32	155	65	60			1.2 x 1.2 TDFN, 1.2 x 1.2 XTDFN
MIC5393	2.5–5.5	0.15	1.0-3.3	2	Preset	2	32	155	65	60	√		1.2 x 1.2 TDFN, 1.2 x 1.2 XTDFN
MIC5396	2.5–5.5	0.3	1.0-3.3	2	Preset	2	42	160	65	60			1.2 x 1.6 TDFN, 1.2 x 1.6 XTDFN
MIC5397	2.5–5.5	0.3	1.0-3.3	2	Preset	2	42	160	65	60	√		1.2 x 1.6 TDFN, 1.2 x 1.6 XTDFN
MIC5398	2.5–5.5	0.3	1.0-3.3	2	Preset	2	42	160	65	60		√	1.2 x 1.6 TDFN, 1.2 x 1.6 XTDFN
MIC5399	2.5–5.5	0.3	1.0-3.3	2	Preset	2	42	160	65	60	√	√	1.2 x 1.6 TDFN, 1.2 x 1.6 XTDFN
MIC5524	2.5–5.5	0.5	1.0-3.6	1	Preset	1	38	260	80	65	√	√	1.0 x 1.0 TDFN
MIC5528	2.5–5.5	0.5	1.0-3.6	1	Preset	1	38	260	70	60	√	√	1.2 x 1.2 TDFN, 1.2 x 1.2 XTDFN
MIC5317	2.5–6.0	0.15	1.0-3.6	1	Preset	2	29	155		70			1.0 x 1.0 TDFN, SOT23-5L
MIC94310	1.8–3.6	0.2	1.0-3.3	1	Preset	1	170	40	85	80			0.8 x 0.8 CSP, 1.2 x 1.6 TDFN, SOT23-5
MIC94325	1.8–3.6	0.5	1.0-3.3	1	Resistor	1	170	100	85	85			1.6 x 1.6 TDFN
MIC94345	1.8–3.6	0.5	1.0-3.3	1	Preset	1	170	100	85	85			0.84 x 1.32 CSP, 1.6 x 1.6 TDFN
MIC94355	1.8–3.6	0.5	1.0-3.3	1	Preset	1	170	100	85	85			0.84 x 1.32 CSP, 1.6 x 1.6 TDFN

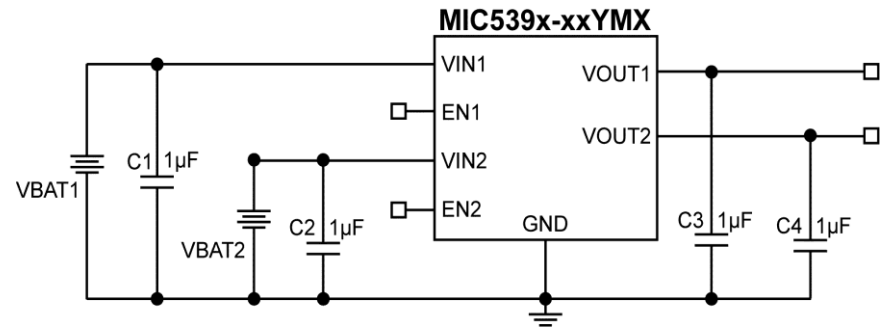
Ultra Small High Performance LDO Solutions

MIC5396/7/8/9

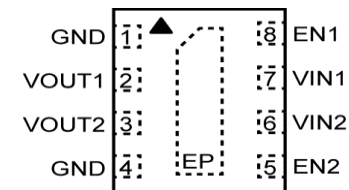
Low Power Dual 300mA Low Dropout Regulators

Key Features

- Input voltage range: 2.5V to 5.5V
- Two independent supply inputs
- Output voltage range from 1V to 3.3V
- Two 300mA outputs
- Room accuracy $\pm 2\%$
- Low quiescent current – 42 μ A/channel
- Stable with 1 μ F ceramic output capacitors
- Low dropout voltage – 160mV @ 300mA
- Independent enable pins
- Internal enable pull-down – MIC5398/99
- Output discharge circuit – MIC5397/99
- Thermal shutdown protection
- Current limit protection



Typical Application



8-Pin 1.2mm x 1.6mm Extra Thin DFN (MX) & (MT)

Applications

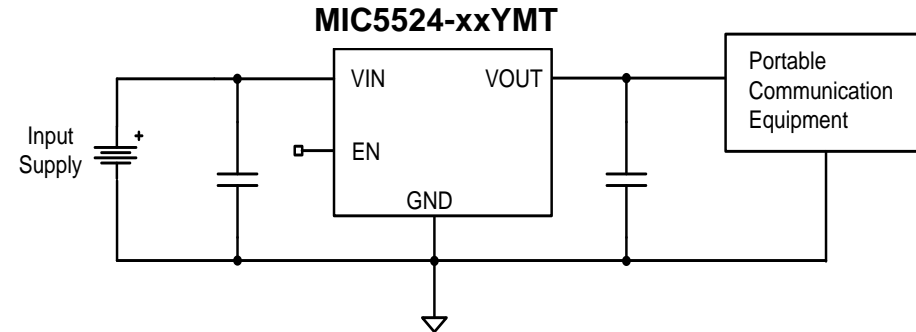
- Desktop
- Handheld instruments
- Battery powered equipment
- Digital still and video cameras
- 5V general purpose

MIC5524

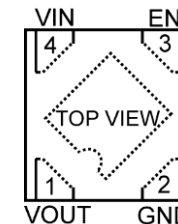
Industry's Smallest Single 500mA Low Dropout Regulator

Key Features

- Input voltage range 2.5V to 5.5V
- Fixed output voltages from 1.0V to 3.6V
- 500mA peak output current
- Output accuracy at room temp ($\pm 1\%$)
- High PSRR – 80dB @ 100Hz
- Low quiescent current – 38 μ A typical
- 2.2 μ F ceramic capacitance stable
- Low dropout voltage – 260mV @ 500mA
- Output discharge circuit
- Internal enable pull down
- Thermal shutdown protection
- Current limit protection



Typical Application



4-lead 1.0mm x 1.0mm Thin DFN (MT)
Top View

Applications

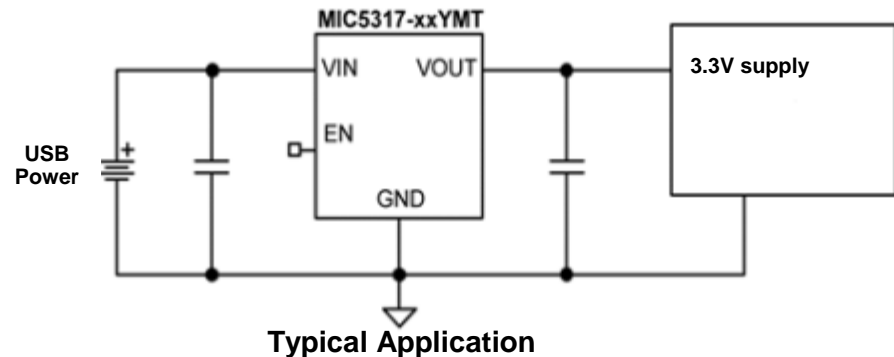
- Tablet PC
- Smart phones
- 5V general purpose
- Consumer electronics
- Low power LED/IR LED driver

MIC5317

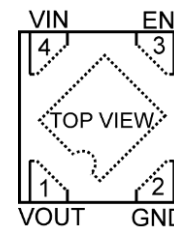
High Performance 6V Single 150mA LDO

Key Features

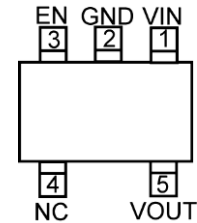
- Wide operating range: 2.5V to 6.0V
- 7V Abs. max. tolerant
- Fixed output voltages from 1.0V to 3.6V
- 150mA guaranteed output current
- High output accuracy ($\pm 2\%$)
- Low quiescent current – 29 μ A
- High PSRR – 70dB
- Stable with 1 μ F ceramic output capacitors
- Low dropout voltage – 155mV @ 300mA
- Thermal-shutdown
- Current-limit protection
- -40°C to 125°C JC Temperature Range



Typical Application



4-Pin 1mm x 1mm Thin DFN (MT)
Top View



5-Pin Thin SOT23-5
& 5-Pin SOT23-5

Applications

- USB port applications
- Handheld instruments
- Battery powered equipment
- Digital still and video cameras
- 5V general purpose



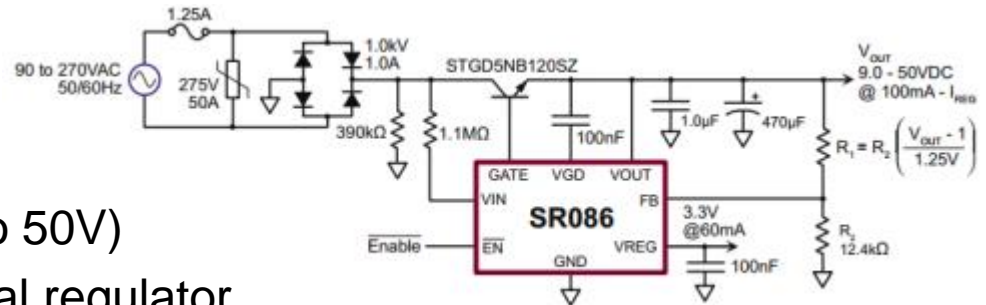
MICROCHIP

**Импульсные
преобразователи**

Октябрь 2016

Features:

- Efficient operation without magnetics
- No high voltage capacitors
- Adjustable main output voltage (9.0 to 50V)
- Additional 3.3V (5V для SR87) internal regulator
- Up to 100mA combined output current
- Single BOM for 120VAC/230VAC
- Built-in soft start
- Less than 200mW standby power
- Operating Temperature Range: -40°C to +125°C
- Package Options: SOIC-8 w/Heat Slug





Switching Regular Product Line Summary

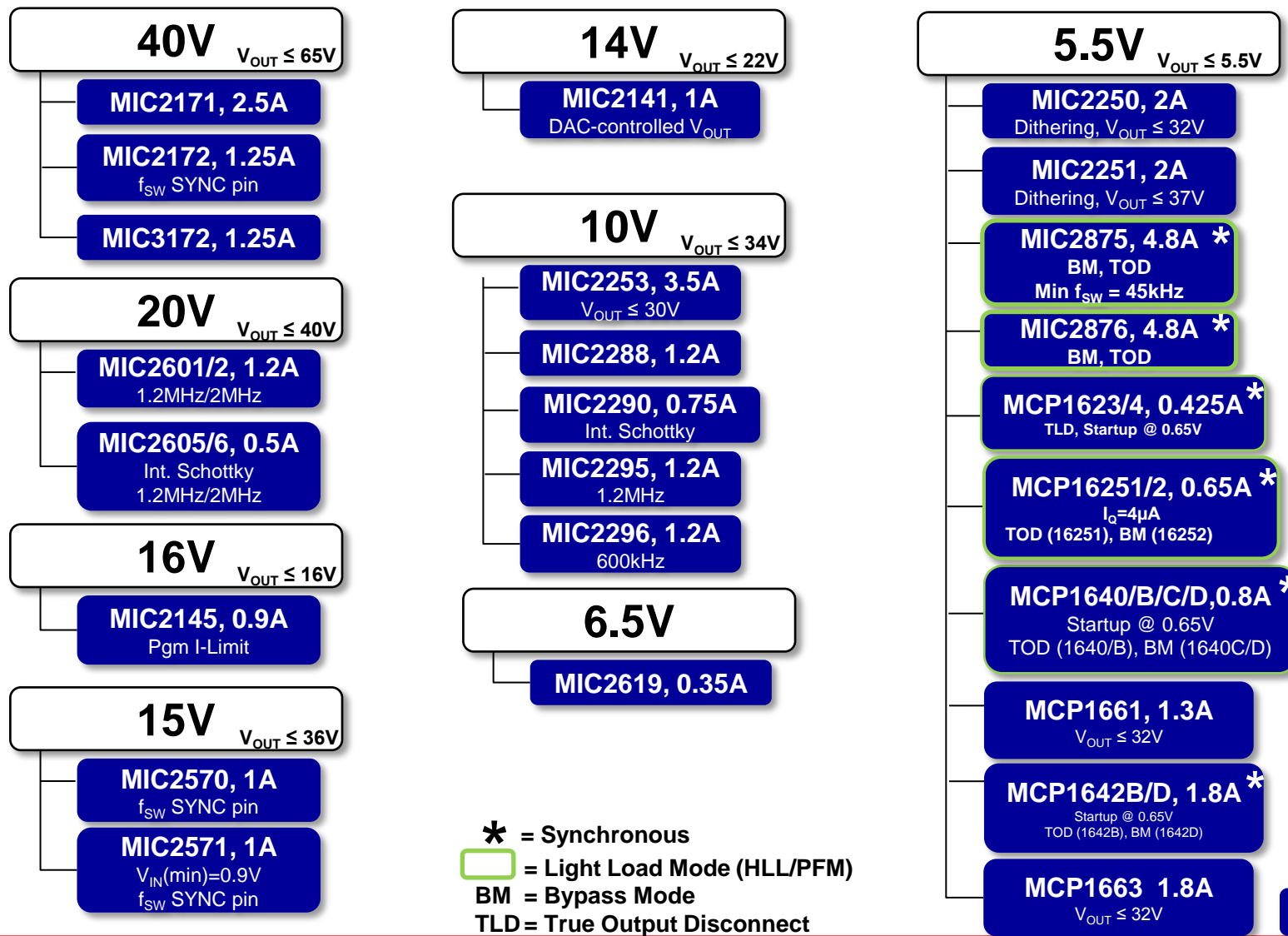
- **Micrel switching regulator strength**

- Higher voltage and current capability
- Higher switching frequency allows small inductor designs
- Multi-phase and Multi-channel switching regulators
- COT architecture

- **Classic APID switching regulator strength**

- Built-in Intelligence
- Optimized, High-efficiency power conversion
- Low power, low startup voltage regulators

Step-Up (Boost) Internal SW





Low Voltage Boost Regulators

	MCP1623/4	MCP16251/2	MCP1640/B/C/D	MCP1643	MCP1642B/D
Mode	PWM or PWM/PFM	PWM/PFM	PWM or PWM/PFM	PWM	PWM
Start-up Voltage (V)	0.65	0.82	0.65	0.65	0.65
Input Voltage (V)	0.35 – 5.5	0.35 – 5.5	0.35 – 5.5	0.35 – 5.5	0.35 – 5.5
Peak Switch Current (mA)	425	650	850	1600	1800
Quiescent Current (µA)	19	4	19	-	400
Switching Frequency (kHz)	370 - 630	425 - 575	425 - 575	850 - 1150	850 - 1150
Shutdown	True Load Disconnect	Input to Output Bypass or True Load Disconnect	Input to Output Bypass or True Load Disconnect	True Load Disconnect	Input to Output Bypass or True Load Disconnect
Packages*	SOT23-6*	SOT23-6* 2x3 TDFN-8**	SOT23-6* 2x3 DFN-8**	MSOP-8 2x3 DFN-8	MSOP-8 2x3 DFN-8
Key Attributes	Lowest Cost	Lowest Quiescent Current	Highest Performance	LED Driver $V_{REF} = 120$	Highest Current Capability

*, ** Packages are pin-to-pin compatible
For Higher output voltages, consider MCP1661/2

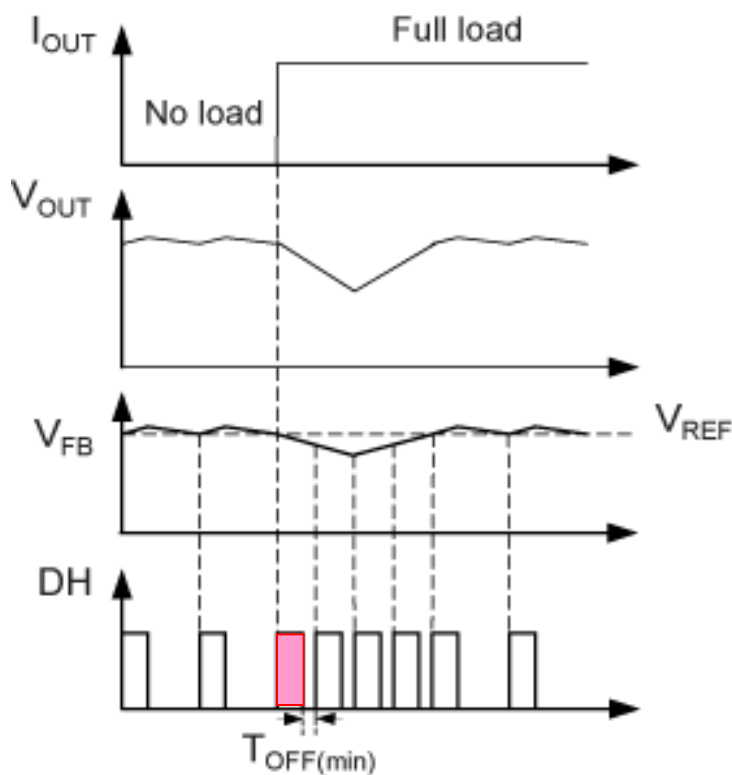


MICROCHIP

Hyper Speed Control™

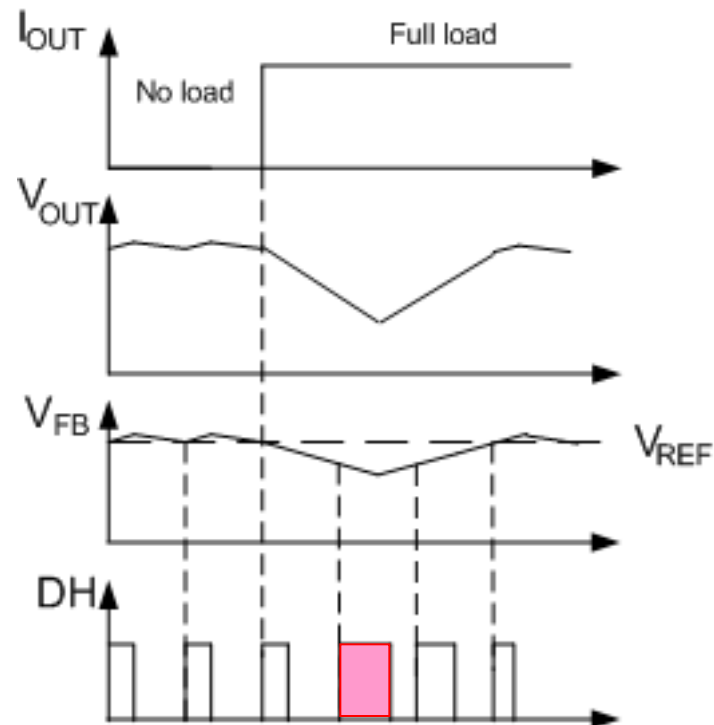
Hyper Speed Control vs. PWM Control

Hyper Speed Control



- Minimum OFF time is applied during the load transient.
- The switching frequency is increased during the load transient.
- Responds in one switching cycle!

PWM Control



- Duty cycle is increased during the load transient.
- The switching frequency is constant during load transient.
- Responds in next switching cycle!



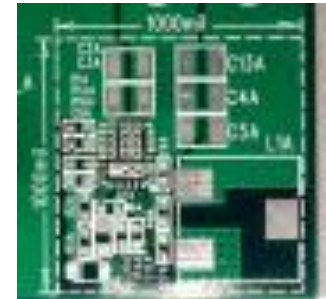
Hyper Speed Control™ - a Great Architecture

MICROCHIP

Hyper Speed Control™	
Key Features	Benefits
ANY CAP STABLE	Stable with Zero ESR output capacitor, no problems with extra distributed board capacitance
V_{OUT} down to 0.6V @ ±1%	Address powering all low voltage applications requiring tight tolerance
Unique Hyper Speed Control™ loop architecture	Ultra fast transient response Smaller value of output cap compared to competitors High V_{IN} /Low V_{OUT} buck capability
Cycle by cycle fold-back current limiting	Ensures protection of external MOSFETs
Up to 25A drive capability	Perfect for high power applications such as telecom/networking equipment
Input voltages to 75V	Great for 12V bus, 24V bus, 40V bus, and 60 V bus.

High Efficiency and High Power Density Switchers

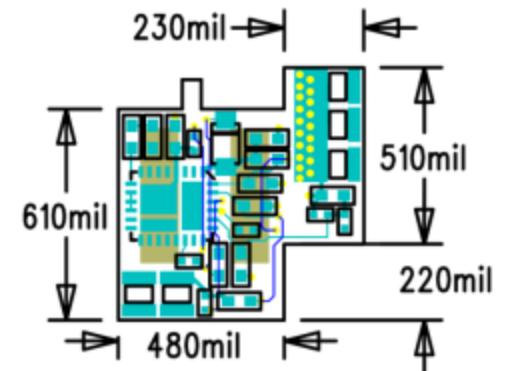
- Support up to 12A in Small Power Package
- Lower System Cost
- Easy Design
- Excellent Thermal Performance
- High Efficiency



1"X1" size on single side PCB



12V to 1V, 12A at 600KHz
Room Temp, No Airflow
MIC24056 raise only 27°C at 12A



0.41 in² size on double side PCB

MIC24046 19V, 5A Switching Reg.

Features:

Ease of use Switching Regulator

- Integrated Controller, MOSFETs and Feedback Resistors
- Pin Programmable: V_{OUT} , F_{SW} , I_{OUT} Limit
- 9 programmable V_{OUT} settings
- 3 Switching Frequency Options
- 3 Current Limit Options
- Reduces external component count
- -40°C to $+125^{\circ}\text{C}$ Junction Temp

Packaging

- QFN- 20 (3x3mm)

Evaluation Board

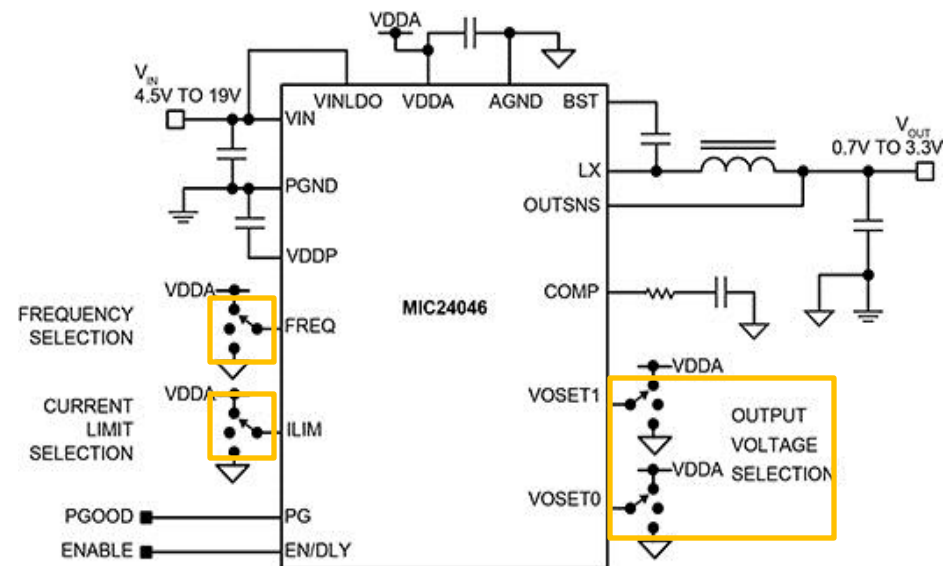
- MIC24046YFL EV

5Ku Pricing

- \$1.26

Applications:

- Telecom
 - Networking Switches & Routers
 - DC – DC Power Distribution
- ### High Power Density Applications!
- FPGAs, Processors, Industrial



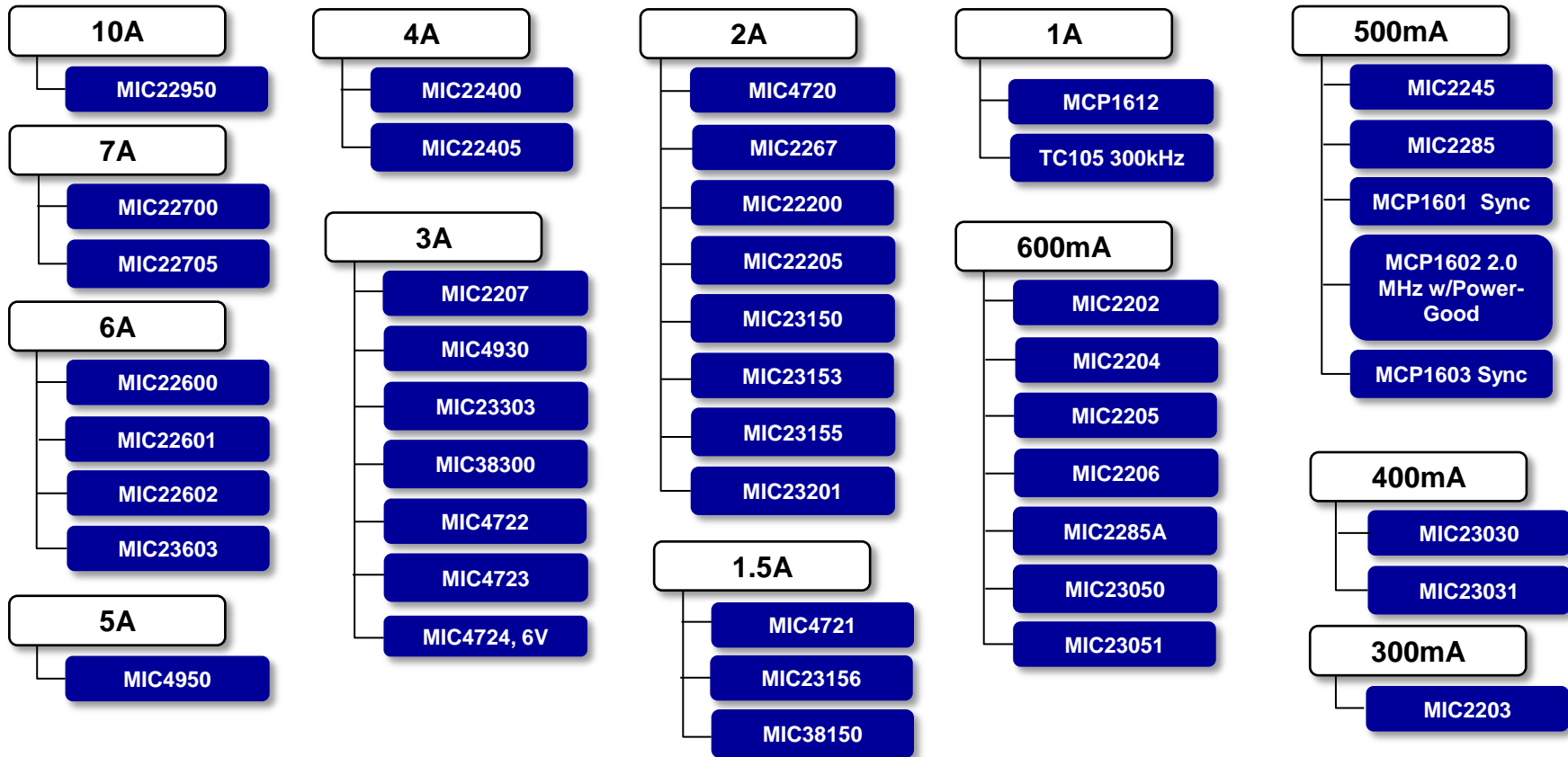
Buck Switching Regulators

- **Input up to 75V**
- **Output from 300 mA up to 12A**
- **Switching frequency up to 8 MHz**
- **Quiescent current down to 10 μ A**
- **Pin or I2C selectable parameters**



Step-Down (Buck) Internal SW 5.5V – 6V

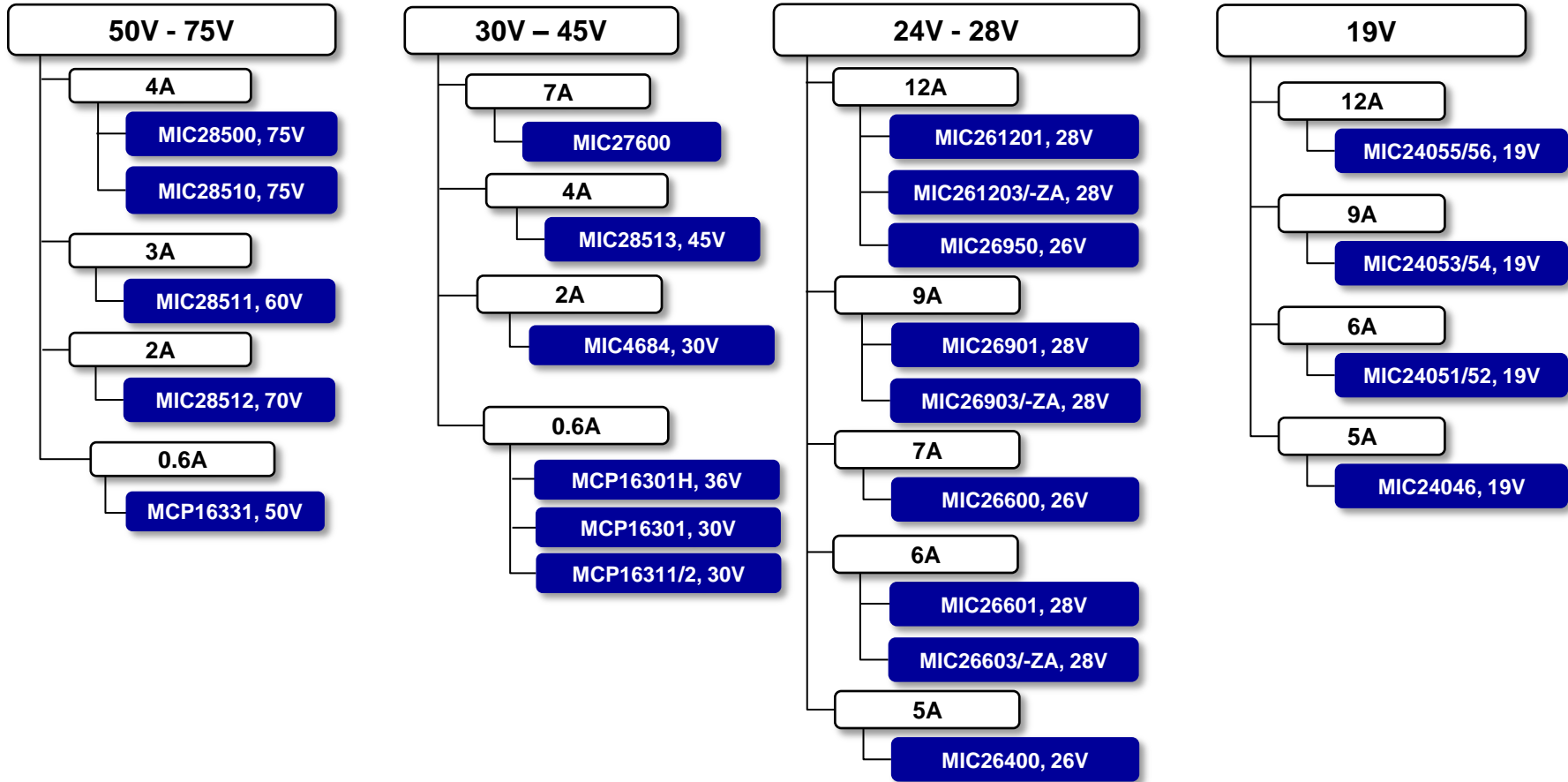
Product Tree





Step-Down (Buck) Internal SW 19V – 75V

Product Tree



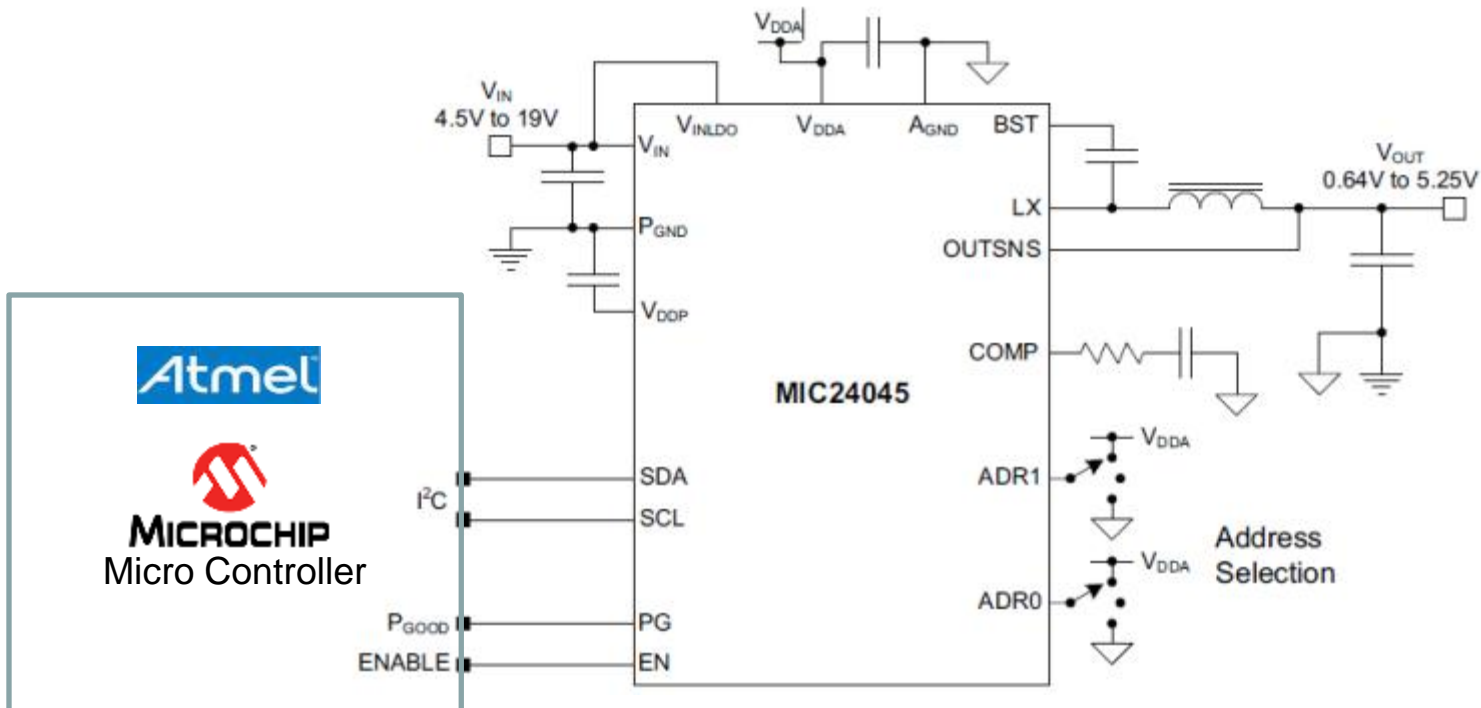
<< BACK



MIC24045: Making (Power) Life Less Complicated

- **Input voltage range: 4.5V to 19V**
- **5A Maximum Output Current**
- **I²C Programmable**
 - **Output voltage:** 0.64V to 5.25V in 5mV, 10mV, 30mV, and 50mV steps
 - **Soft-Start:** 0.16, 0.38, 0.76, and 1.5 V/ms ramp rates
 - **Switching Frequency:** 310kHz, 400kHz, 500kHz, 570kHz, 660kHz, 780kHz, 1MHz, 1.2MHz
 - **Current Limits** for 2A, 3A, 4A and 5A loads
 - **Margining:** -5%, +5%
 - **Start-up delays** (8 values): 0ms to 10ms

- **Pairs Up With Any Micro Controller to Offer Complete Power and Fault Management**



Step-Down (Buck) External SW

75V

- MIC2103/4**
75V, COT, HLL, HS 3X3 QFN
- MIC2176-1/2/3**
75V, COT, HS 100/200/300 KHZ, 10 pin MSOP

40V

- MIC2130/1**
40V, Voltage mode, Low EMI option, 4x4mm QFN

38V

- MIC2101/2**
38V, COT, HLL, HS 3x3 QFN

32V

- MIC2182**
32V, CM/Skip mode, 300KHZ, low IQ, SOP
- MIC2198**
32V, CM, 500 Khz, 4X4 QFN
- MIC2199**
32V, CM, 300 Khz, 4X4 QFN

30V

- MCP19035**
30V, VM, 300/600kHz, 3x3 DFN

28V

- MIC2164/-2/-3/C**, COT, 1% Vref, 270/300/600kHz/1MHz, 10pin MSOP
- MIC2165**, COT, 1% Vref, 600kHz, 10pin MSOP
- MIC2166**, COT, 1% Vref, 600kHz, 10pin MSOP
- MIC2125**, COT, 1% Vref, 600kHz, Int LDO, 10pin MSOP
- MIC2126**, COT, HS/HLL, 200/750kHz, 0.6V vref, 3x3 QFN

18V

- MIC2124**, CM, 1% Vref, 300kHz, 0.8V Vref, 10pin MSOP

16V

- MCP1631HV**, Prog. Charger, 2MHz, 4x4 QFN, 20LTSSOP

15V

- MIC2168/A**, Sych Buck, 1MHz, 10pin MSOP
- MIC2169/A/B**, Sych Buck, 500kHz, 10pin MSOP

14.5V

- 2 Phase**
 - MIC2155/56**
14.5V, 2 phase w/ SYNC 300/500Khz, 25A/Ø, 5X5 QFN
- Dual Output**
 - MIC2150/51**
14.5V, Dual Output 300/500Khz, 20A/Ø, 4X4 QFN

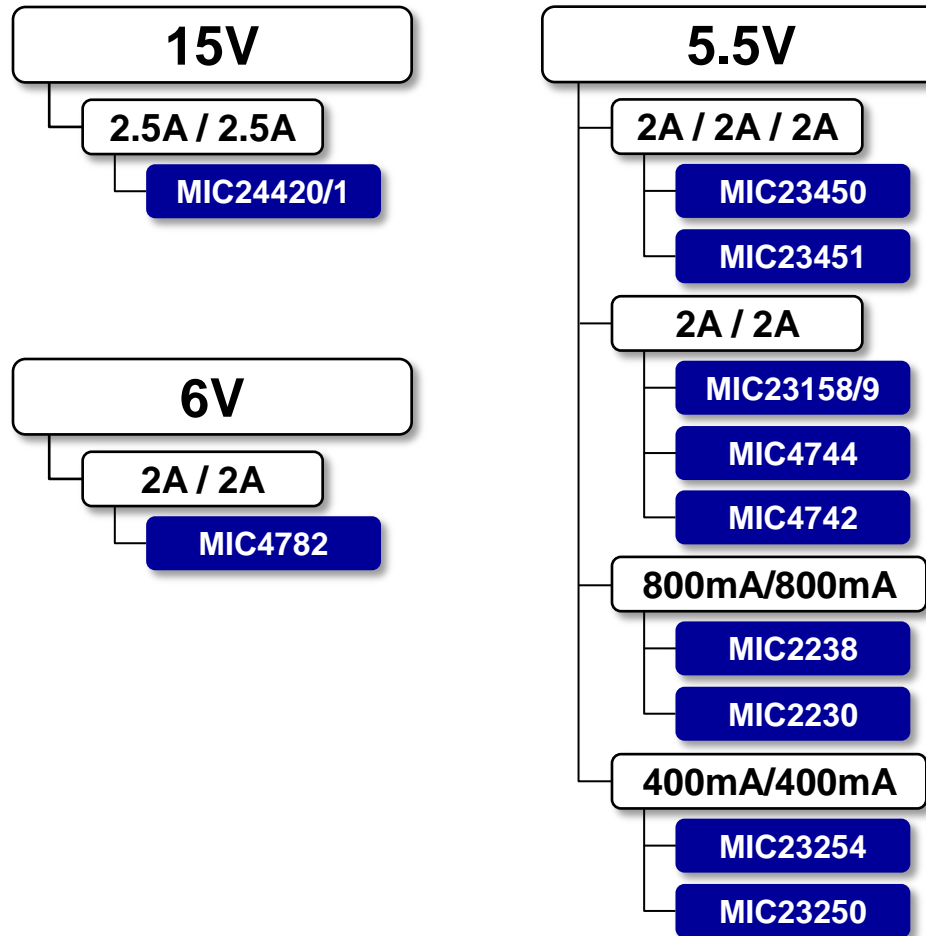
14V

- MIC2183**
2.9V to 14V 400/600Khz, W/Sync 16L SOIC
- MIC2184**
2.9V to 14V non Synch 400/600Khz, W/Sync, 16L SOIC
- MIC2193**
2.9V to 14V 400Khz, 100% Duty cycle, 8L SOIC
- MIC2194**
2.9V to 14V, Non Synch 400Khz, 100% Duty cycle, 8L SOIC

6V

- MIC2111B**
Multi-mode, Driverless 0.6V vref, 200Khz/2Mhz 3x3mm QFN

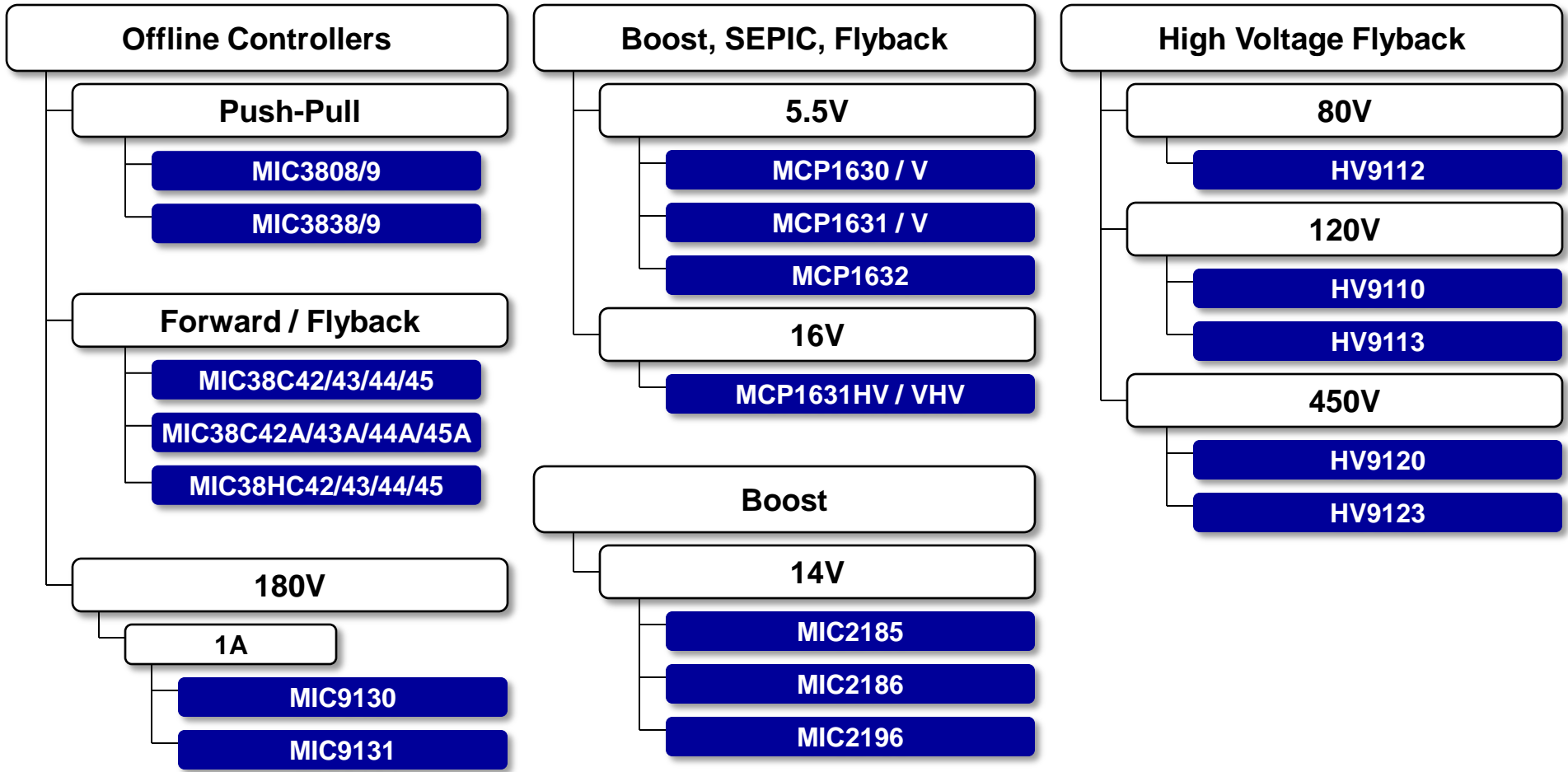
Step-Down (Buck) Multi-Output





Boost/SEPIC/Flyback/Forward & Push-Pull Controllers

Product Tree



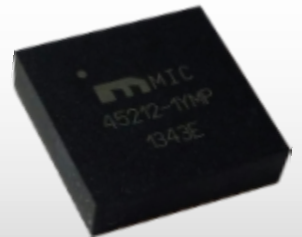
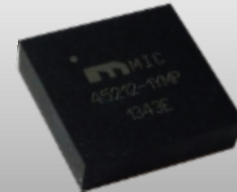
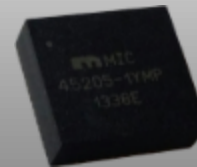
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MICROCHIP

Power Modules

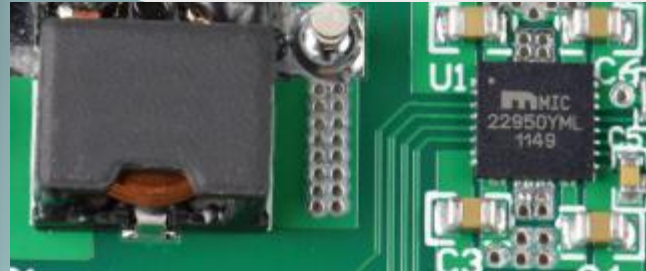
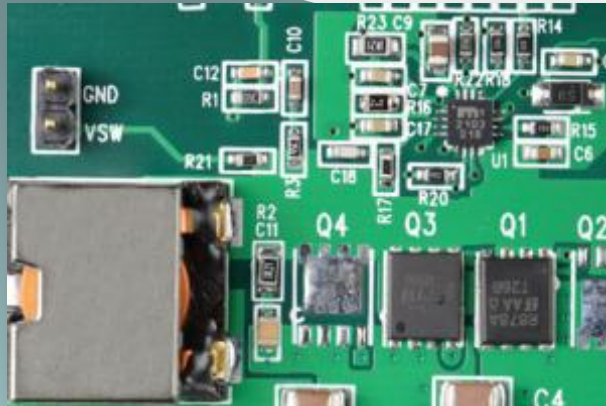
May 2016



What is different?

- ✓ **Enhanced Thermal performance**
- ✓ **Higher Power Density**
- ✓ **Better EMI Performance**
- ✓ **Ease of rework and manufacturability**

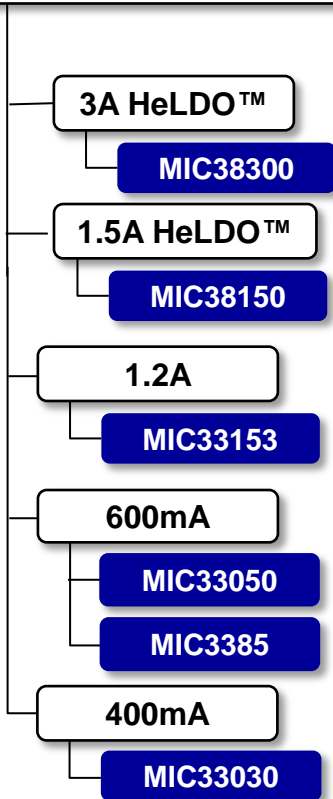
Why Module?



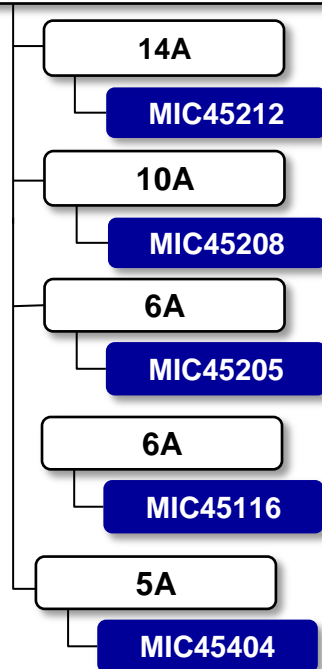
- ✓ Reduction Overall Solution Size
- ✓ Simplifies DC/DC Buck Design
- ✓ Time to Market
- ✓ Pre-characterized electrical, Thermal and EMI Performance

Power Modules

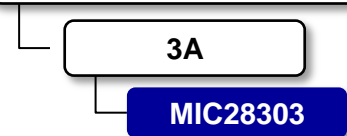
Low Voltage
 $V_{IN} = 2.7V$ to $5.5V$



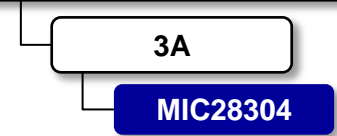
Medium Voltage
 $V_{IN} = 4.5V$ to $26V$



High Voltage
 $V_{IN} = 4.5V$ to $50V$



High Voltage
 $V_{IN} = 4.5V$ to $70V$



Power Module Family

4.5V to 70V

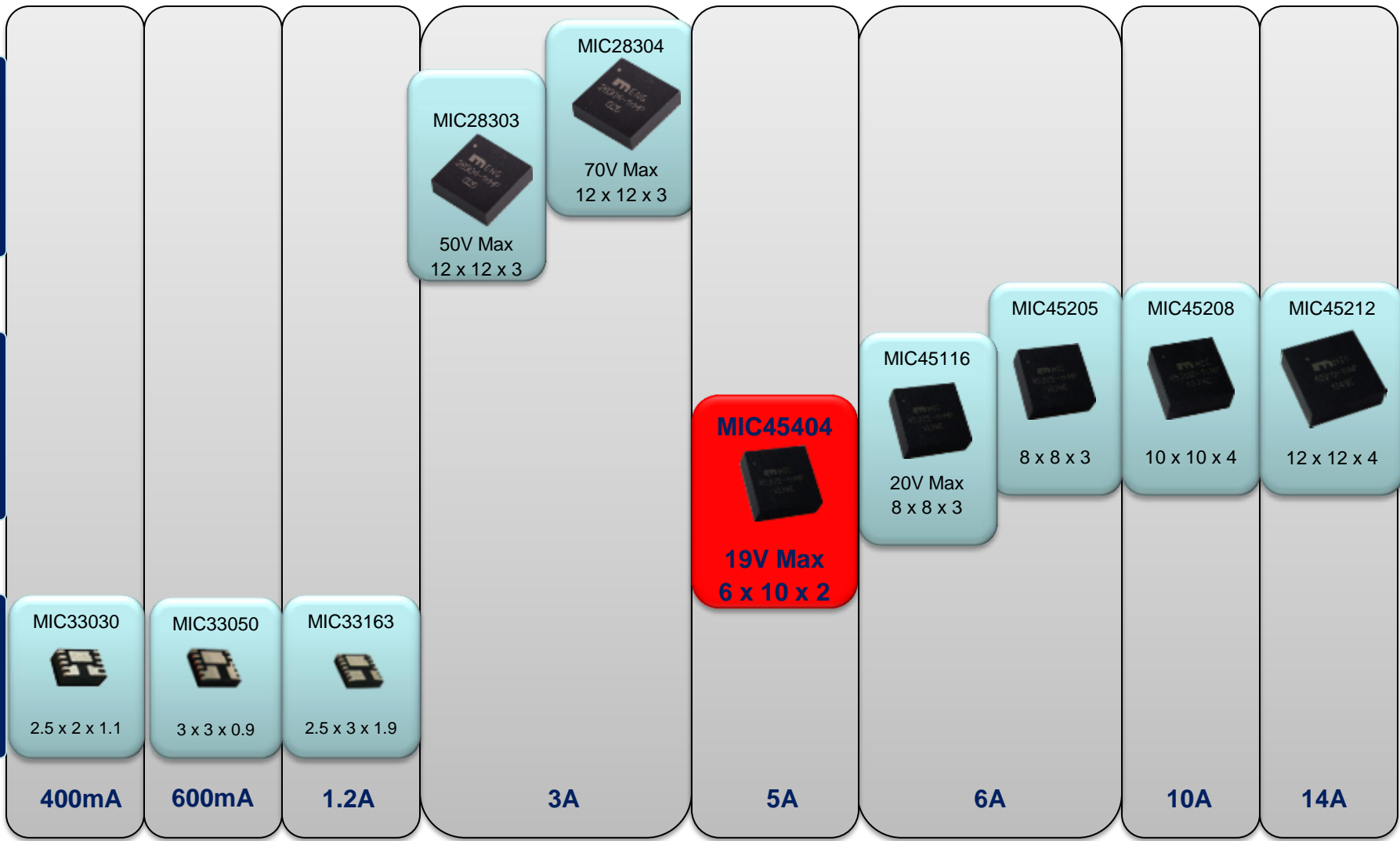
4.5V to 26V

2.7V to 5.5V

High Voltage

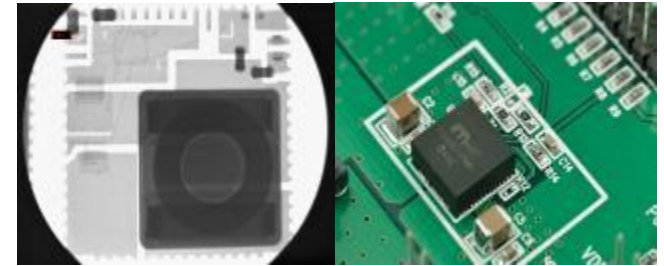
Mid Voltage

Low Voltage

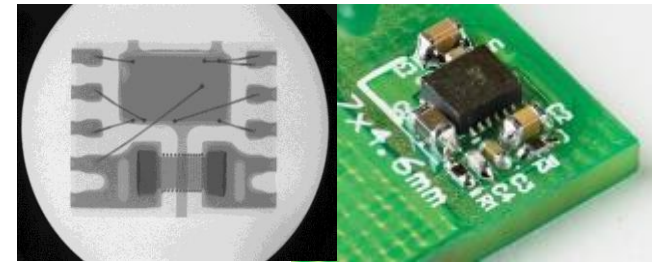


Power Module Packages

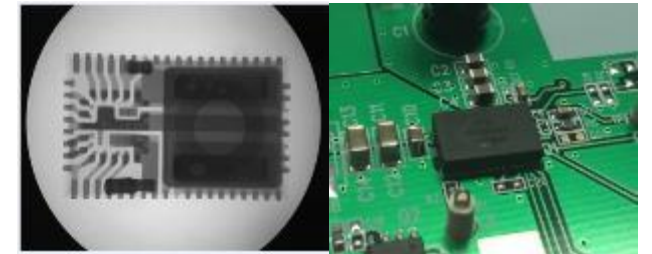
1) MCM, Multi chip – Proven,
Performance, Fast TTM,
MIC45205/MIC45208/MIC45212

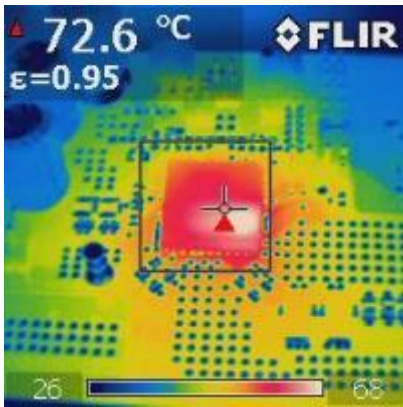


2) High density Monolithic –
Size, Performance,
MIC33030/MIC33050/MIC33153

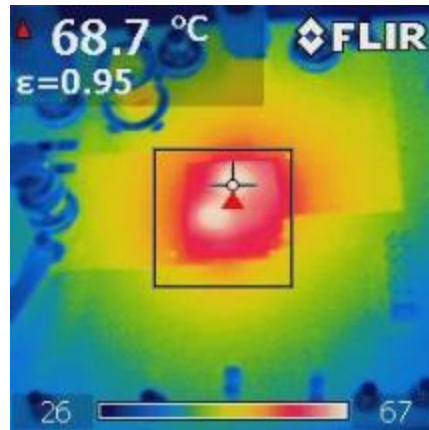


3) Copper Pillar – Density,
Thermal performance,
MIC45404/MIC45405





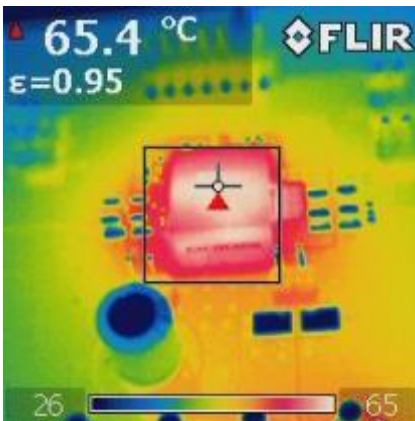
Competitor 1



Competitor 2



Competitor 3



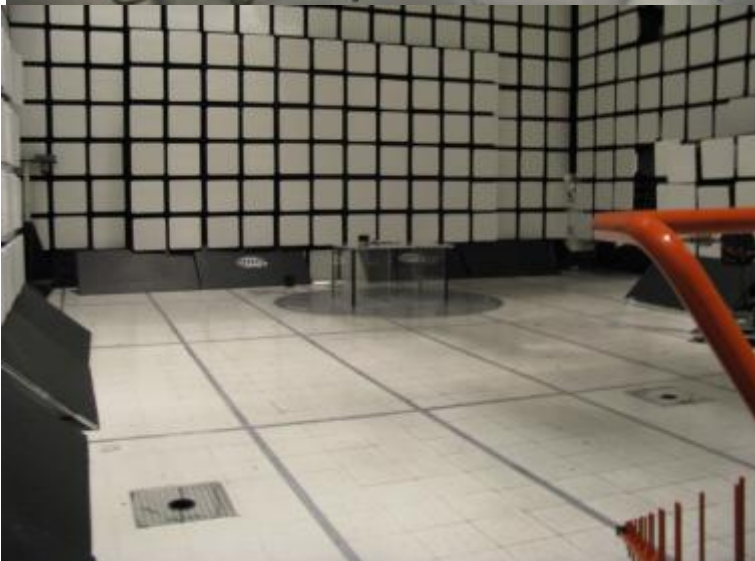
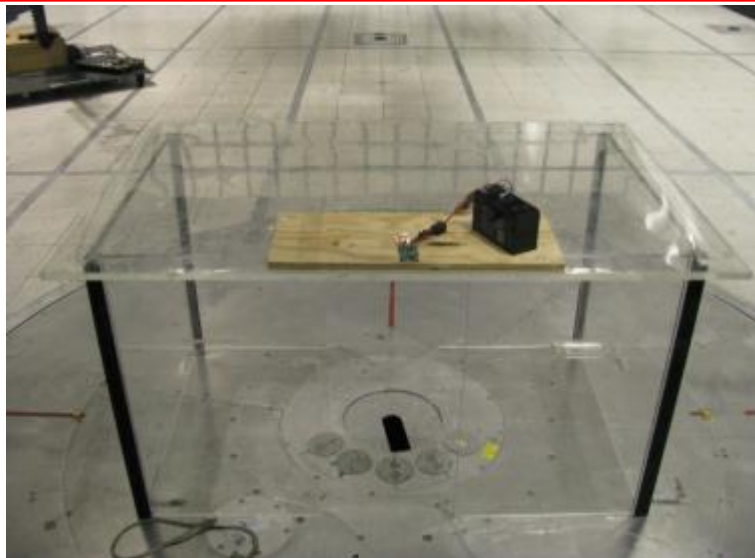
MIC45212

Operating Conditions:

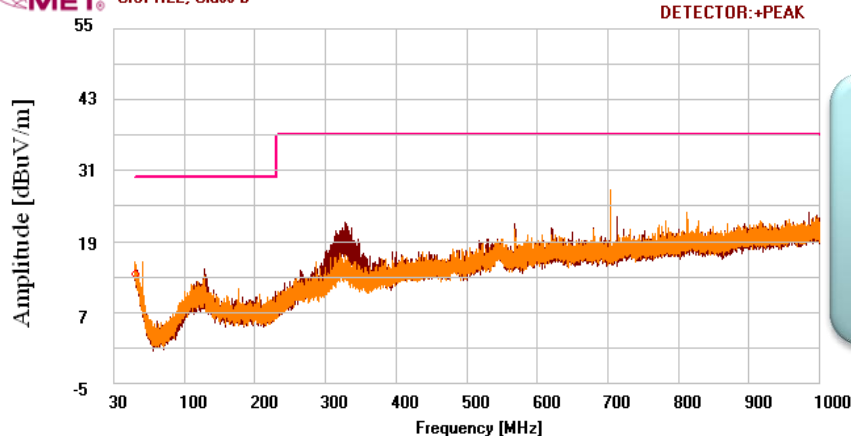
$V_{in}=12V$, $V_{out}=1.2V$, $f=600kHz$, $I_{out}=10A$, $T_a = 25C$,
Based on standard evaluation board by each vendor
(size varies)



Radiated Emissions (CISPR 22, CLASS B)



Job# 40114 <> Customer: Micrel (Austin)
CISPR22, Class B



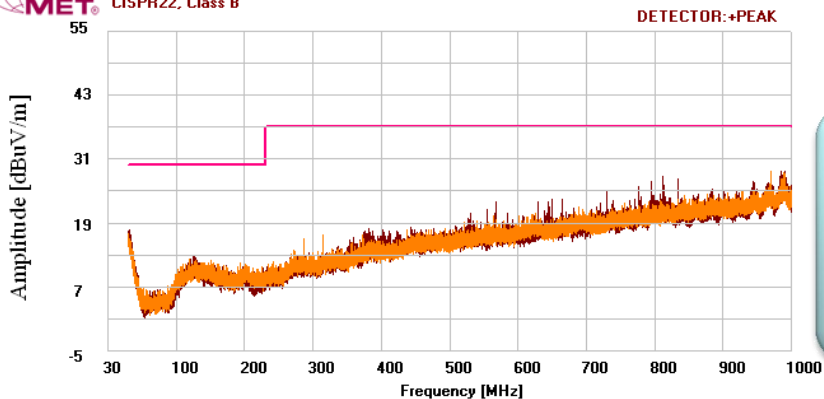
MIC45212

12 x 12 x 4

MIC45212_12V_3.3V_3A



Job# <> Customer:
CISPR22, Class B



MIC28304

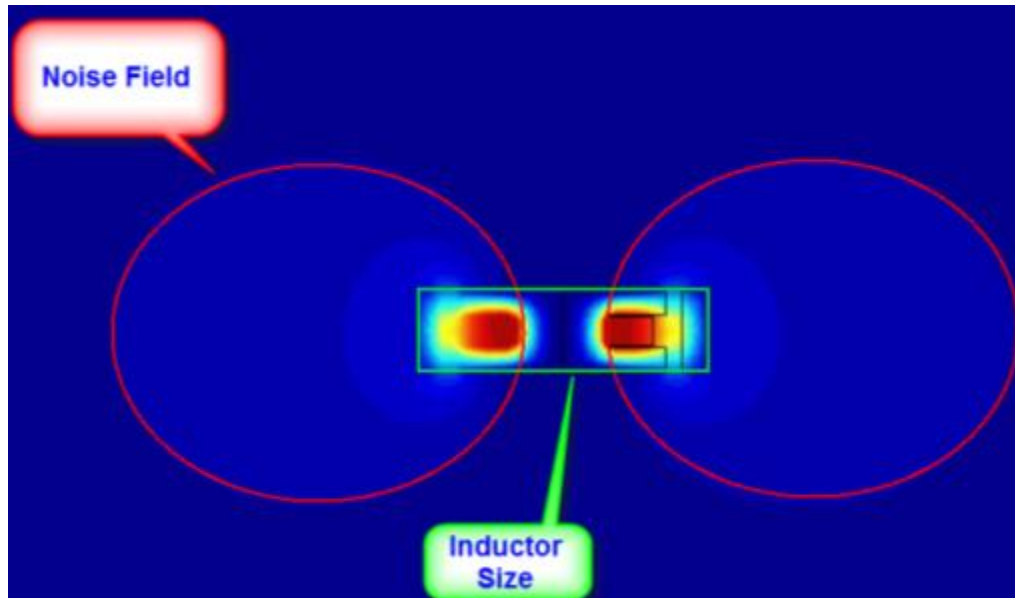
12 x 12 x 3

Plot 4: MIC28304_12V_5V_3A

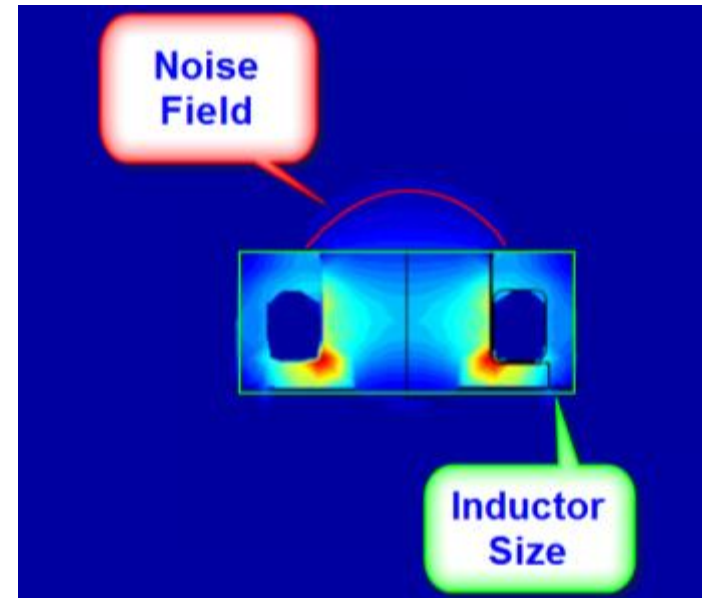


MIC45205 Low EMI Signature – Molded Inductor Fringing Field is the LOWEST!

Shielded Assembled Type (Ferrite)



Molded Type (Composite)



- The molded inductor replaces the core with a soft magnetic material molded into the windings, eliminating the empty space and reducing fringing field



MICROCHIP

MIC45404

19V/5A Ultra-Low Profile DC to DC Power Module

Features:

- Wide Input Supply Voltage: 4.5V-19V ★
- Output Current: Up to 5A
- Pin-Selectable Output Voltages: 0.7V-3.3V
- Supports Pre-Biased Start-up ★
- 82% Peak Efficiency at 12Vin, 0.9Vout ★
- Internal Soft Start
- Thermal Shutdown
- -40C to 125C Junction Temperature ★

Packaging

- 54L QFN (6x10mm)

5Ku Pricing

- \$4.20

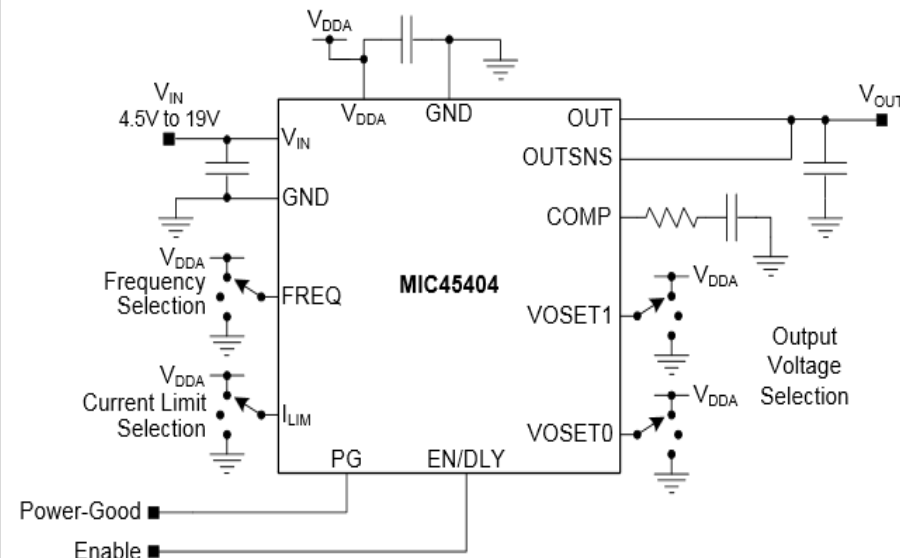
Development Kit

- MIC45404YMP-EV; US\$55



Applications:

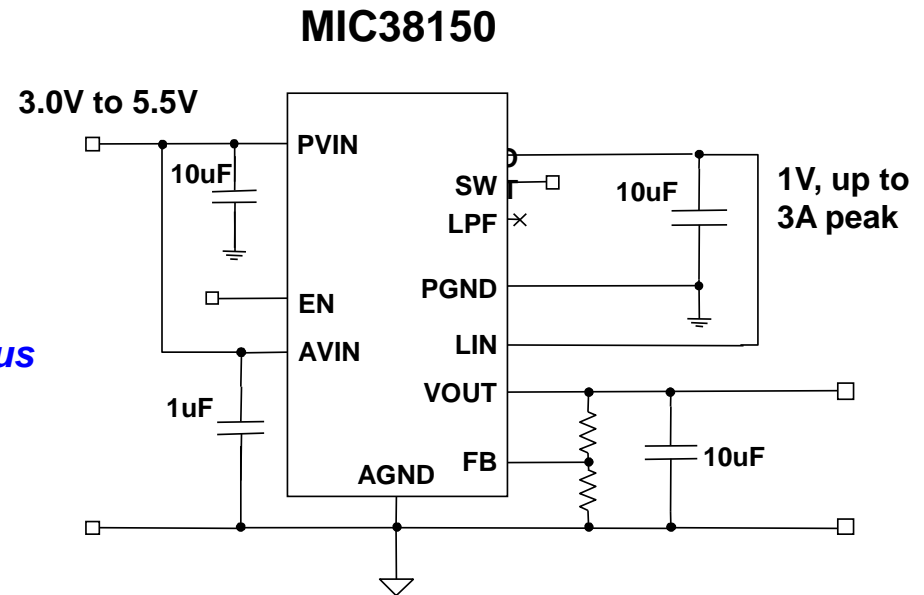
- FPGAs, Low-Voltage ASIC Power
- Telecom
- Network Switchers and Routers
- Server Storage
- DC Power Distribution
- Solid State Drives



MIC45404 12V 5A DC-to-DC Converter

Features

- V_{IN} range = 3.0V to 5.5V
- Output Current
 - MIC38150: $I_{OUT} = 1.5A$ continuous*
 - MIC38300: $I_{OUT} = 3A$ peak; 2.2A continuous*
- V_{OUT} : Adjustable down to 1.0V
- Low Output noise
 - less than 5mV, 2.5mV typical
- Ultra fast transient performance
- Micro-power shutdown
- 70dB PSRR at 1kHz
- Protection features:
 - Thermal shutdown
 - Current limit
- Tiny 4mm × 6mm MLF® package



**Extremely Easy to use:
Integrated Switches + Inductor**

Space saver on the board



MICROCHIP

DEPA
Digitally-Enhanced Power
Analog

The Analog – Digital Power Spectrum



**Digitally
Enhanced Power
Analog**

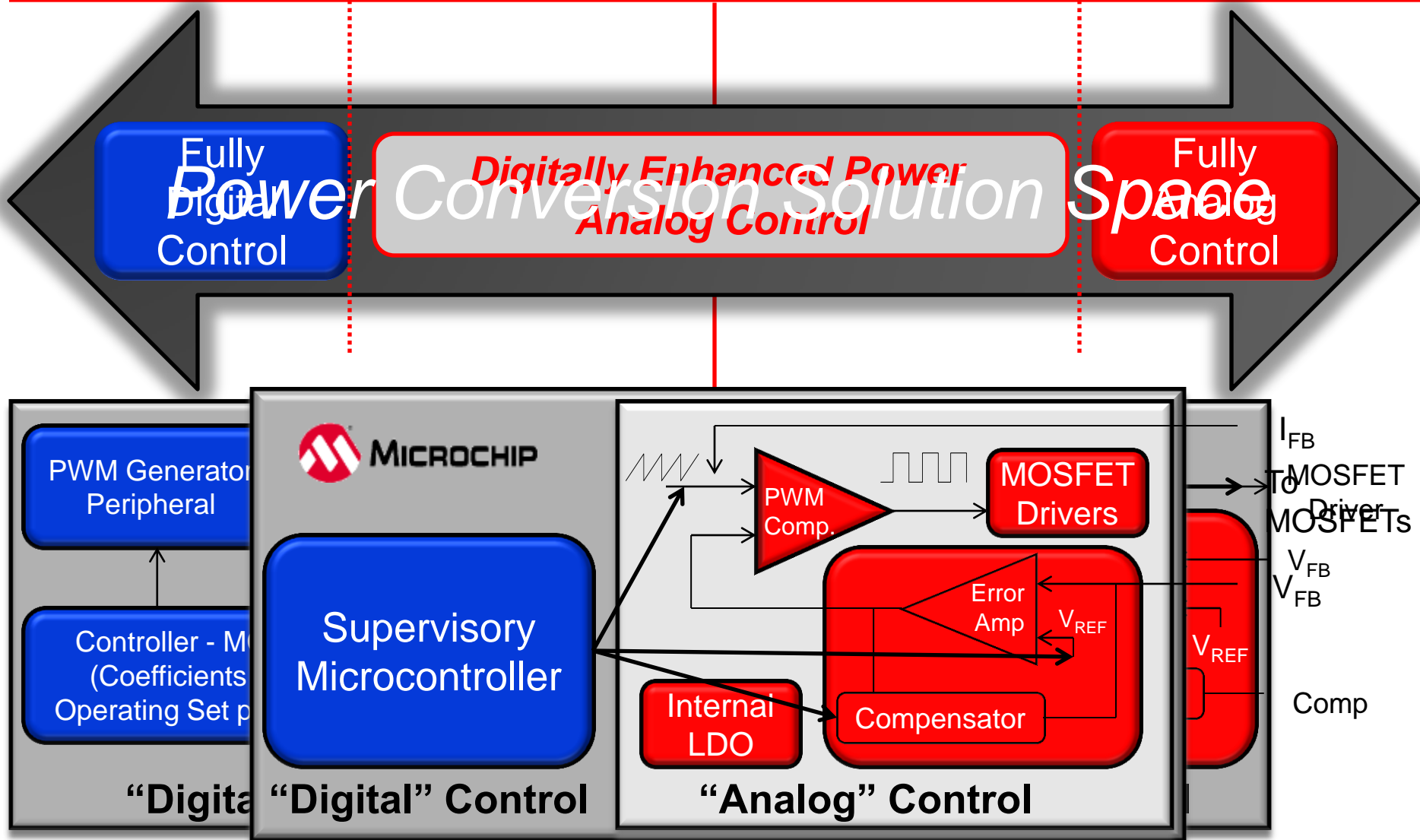


All Digital

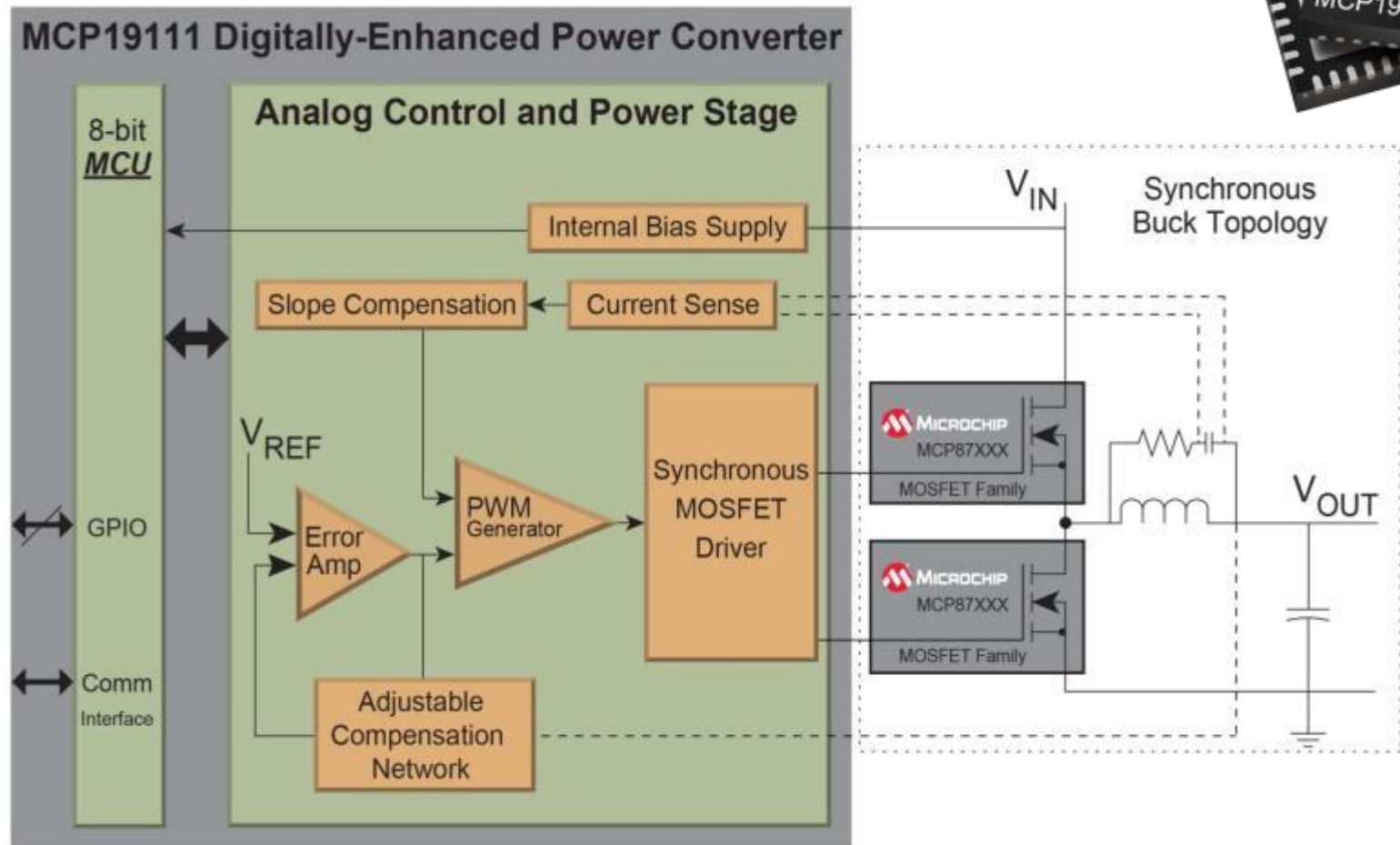
Everything Between

All Analog

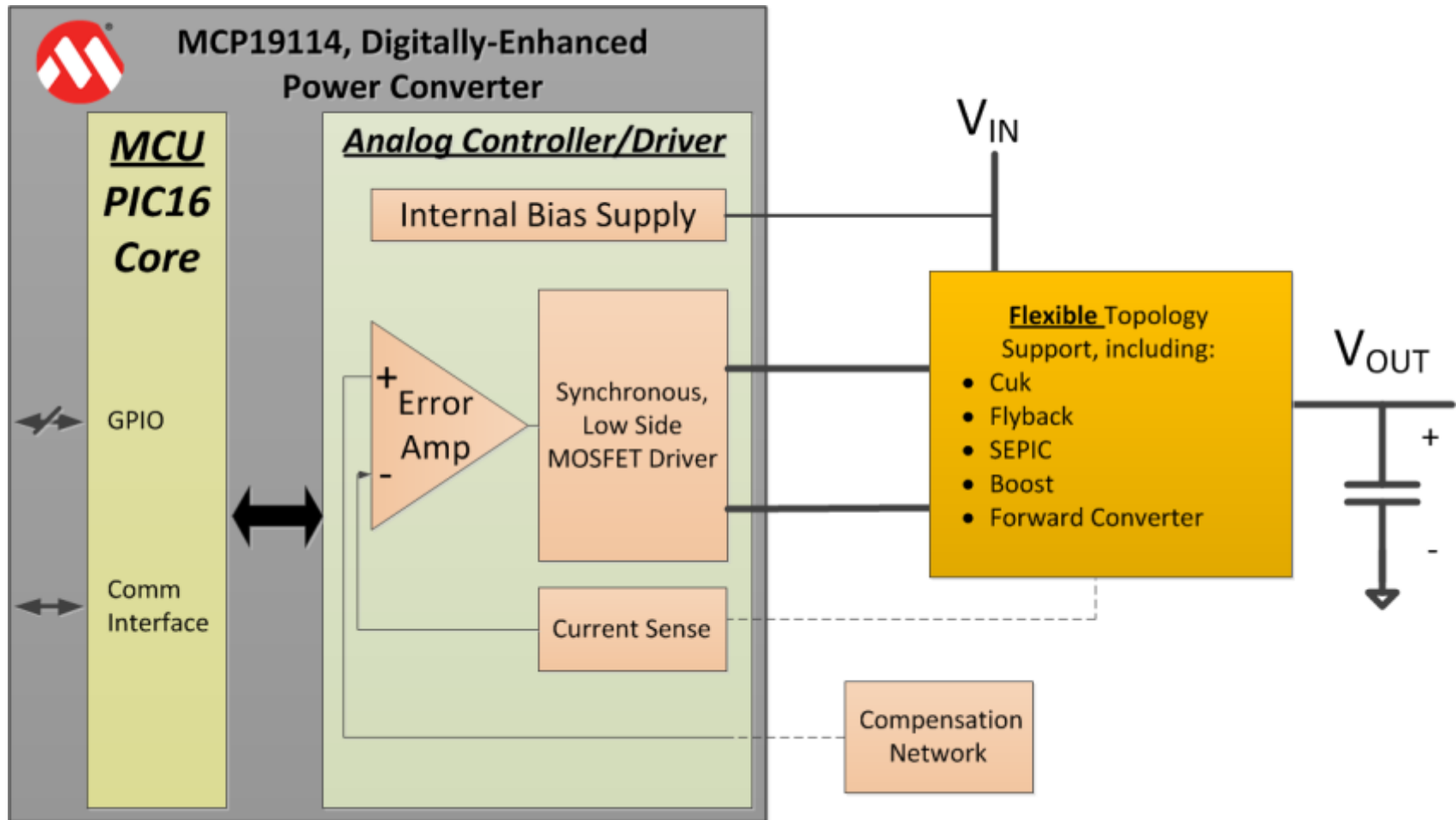
What is Digitally-Enhanced Power Analog?



Simplified Block Diagram MCP19110/1

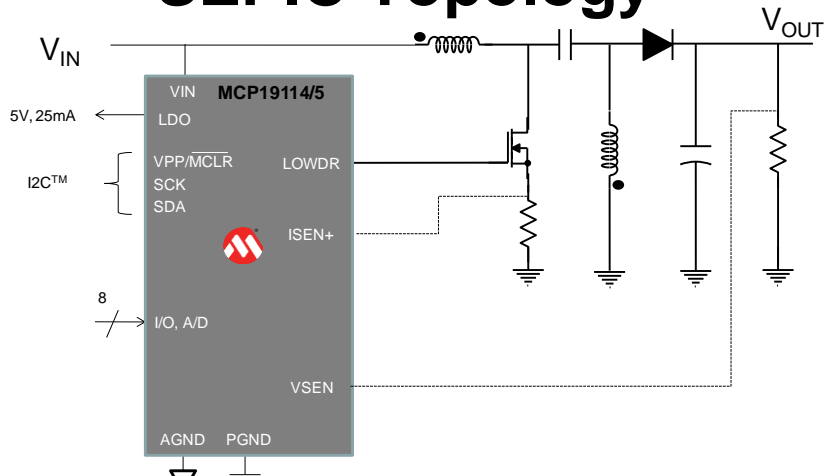


Digitally-Enhanced Power Converter MCP19114/5, Low-Side Boost Controller

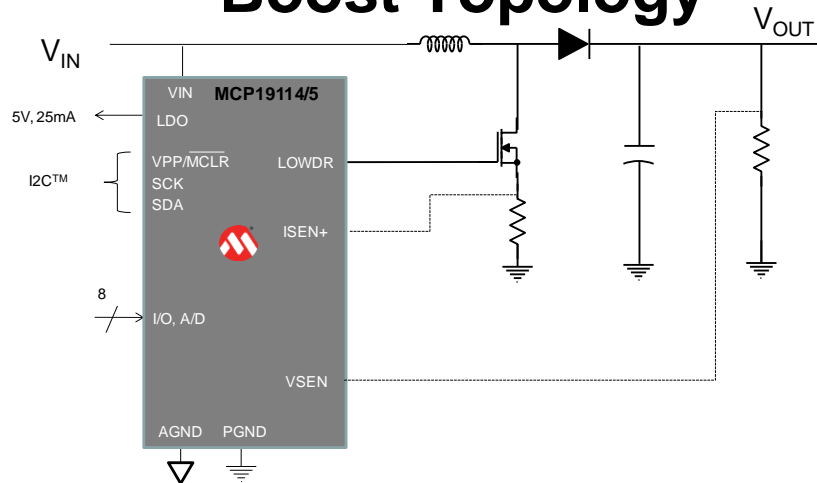


Broad Topology Support

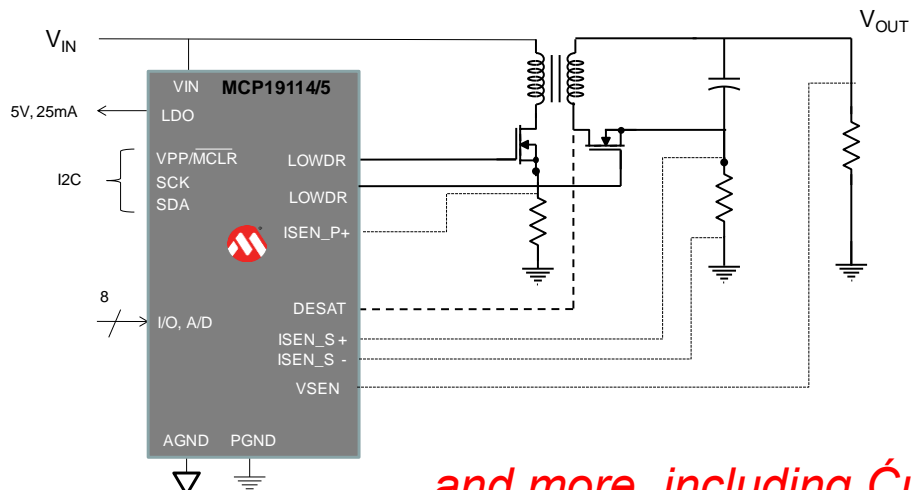
SEPIC Topology



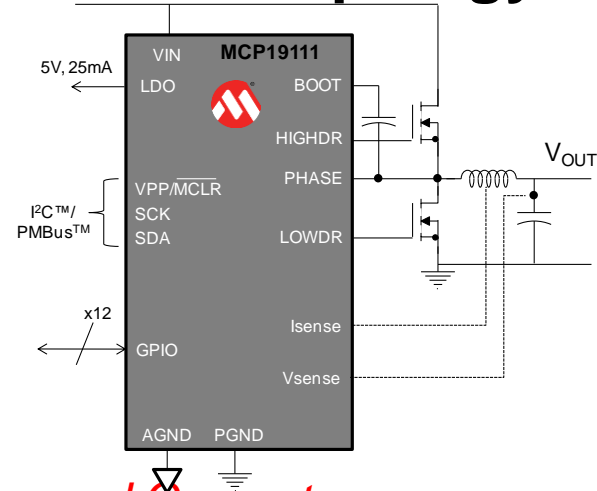
Boost Topology



Flyback Topology



Buck Topology



...and more, including Ćuk and Forward Converters



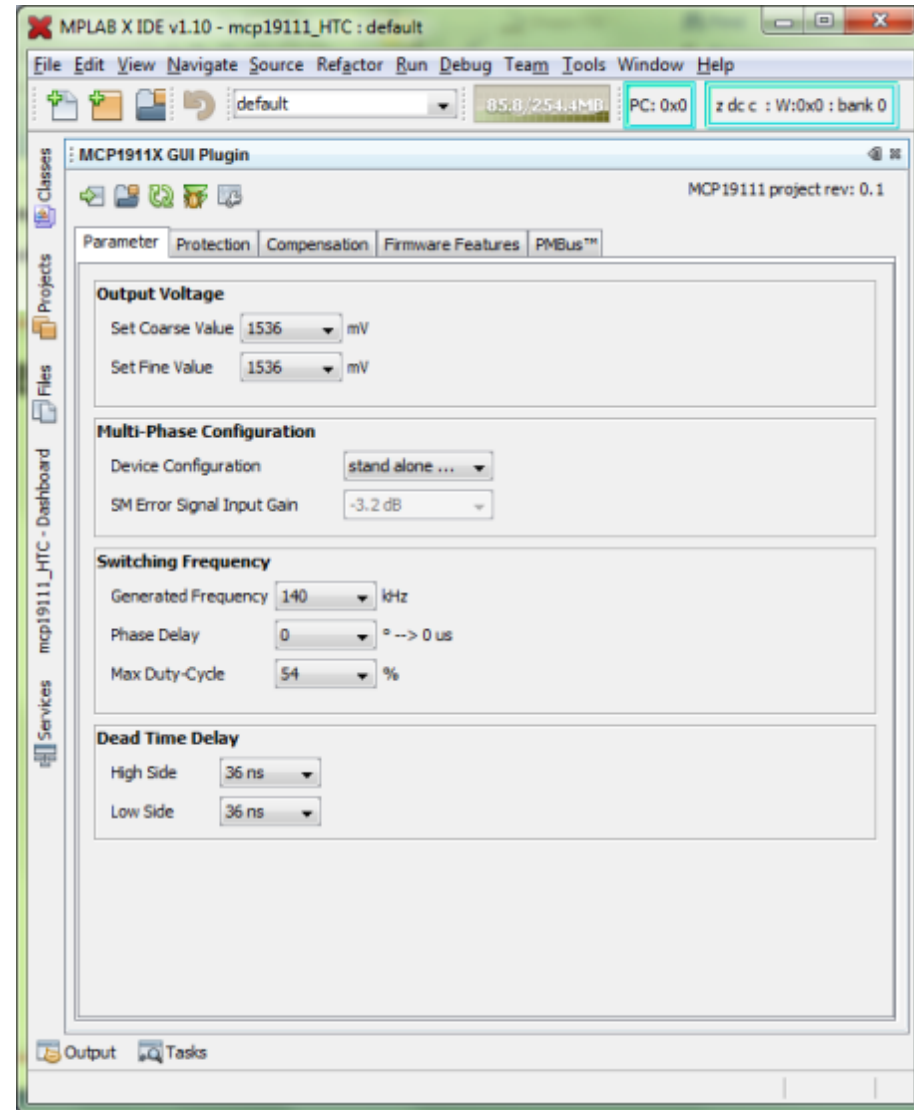
Digitally Enhanced Power Analog Portfolio

	MCP19114/5	MCP19116/7	MCP19110/1	MCP19118/9
Integrated PIC™ MCU	Yes	Yes	Yes	Yes
Power Topologies Supported	Boost, SEPIC, Ćuk, Sync Flyback	Boost, SEPIC, Ćuk, Sync Flyback	Sync Buck	Sync Buck
Input Operating Voltage	4.5 – 42V	4.5 – 42V	4.5 - 32V	4.5-40V
Output Voltage	1V – 200V*	1V – 200V*	0.6V – 90%*V _{IN}	0.6V – 90%*V _{IN}
Compensation Network	External	External	Internal	Internal
Switching Freq	32kHz – 2MHz, Quasi-Resonant Mode	32kHz – 2MHz, Quasi-Resonant Mode	100kHz – 1.6MHz	100kHz – 1.6MHz
Flash Memory	4kW	8kW	4kW	4kW
Communication Interface	I ² C, Optionally PMBus™ Capable	I ² C, USART , Optionally PMBus™ Capable	I ² C, Optionally PMBus™ Capable	I ² C, Optionally PMBus™ Capable
GPIO Available	Yes (10 / 12)	Yes (10 / 12)	Yes (10 / 14)	Yes (10 / 14)

* With resistive divider network for feedback signals

Power Supply Evaluation

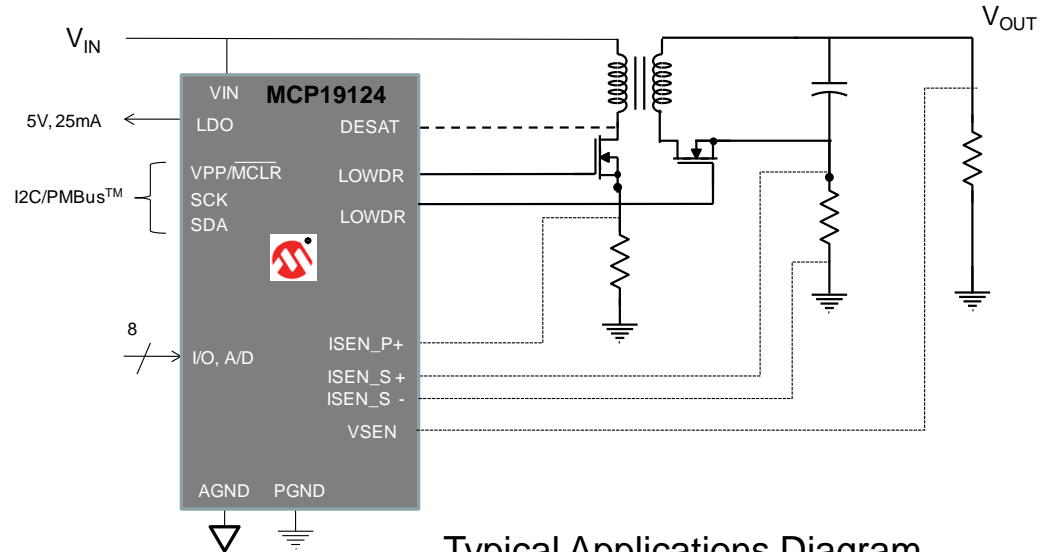
- **GUI available to simplify programming for a standard power supply applications**
 - GUI resides in MPLABX (plugin)
 - Supports PICKIT3 and ICE3 Program/ Debug
- **Standard Firmware for Power Supply application**



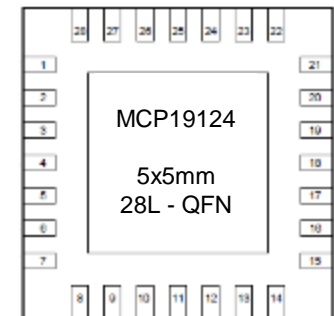
MCP19124/5

Digitally-Enhanced, Synchronous Low-Side PWM Controller with Integrated MCU and MOSFET Driver

- Single Channel
- V_{IN} Range: 4.5V to 42.0V
 - 48V Load Dump Capability
- Switching Freq: 32kHz to 2MHz
- Integrated MOSFET Drivers
- External Compensation
- **Two Independent Control Loops**
 - Voltage control loop with V_{ref}
 - Current control loop with I_{ref}
- **Fully Programmable**
 - Integrated mid-range PIC core
 - MPLABX Support, GUI-Configurable
 - 4k word Flash, 256B RAM
 - Adjustable Current limit/ULVO/OVLO/...
 - Up to 13 General Purpose I/O
 - I²C™ Communication Interface
- Operating Temperature: -40°C to +125°C
- Package(s):
 - QFN 4x4mm – 24L, QFN 5x5mm – 28L



Typical Applications Diagram



• **Development Status: In production, samples available**

Typical Applications

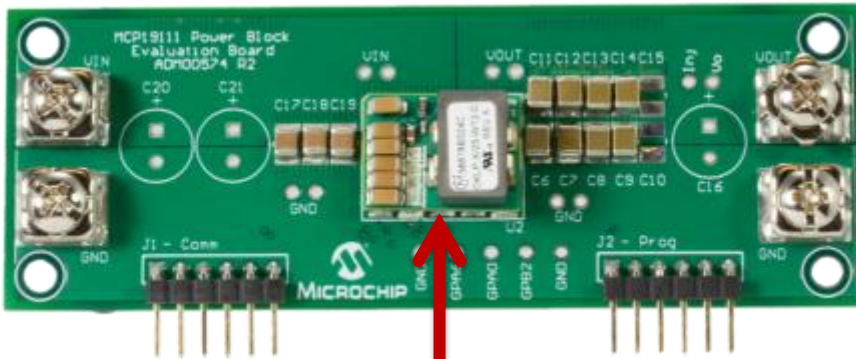
- **Power Supplies, Point-of-Load**
 - **Power Supply Modules**
 - **USB Power**
 - **Battery Chargers**
 - **LED Drivers**
-
- **Applications where intelligent and flexible power control is needed.**



MCP19111 Evaluation Board
(Part # ADM00397)

Point of Load / Power Block Solution

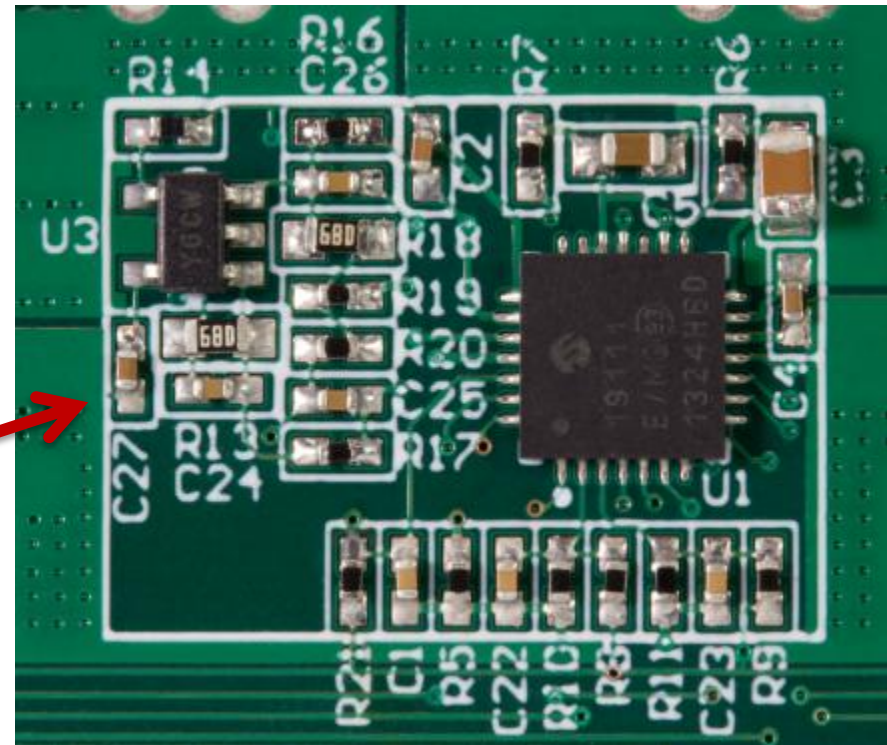
Top Power Block



**Very Dense:
Approximately
0.7" x 0.5"**



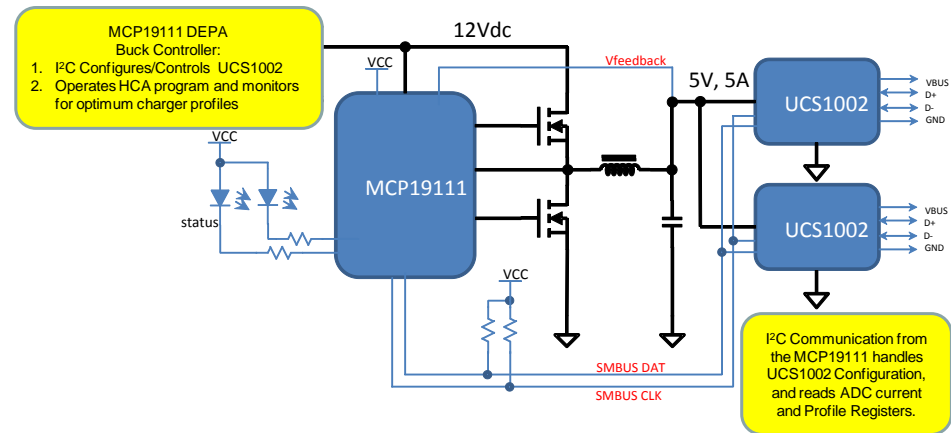
Bottom MCP19111 Circuit



USB Power Port

• USB Power → MCP19119 + UCS2112

- $V_{IN} = 12V_{DC}$
- $V_{OUT} = 5V @ \sim 5A$

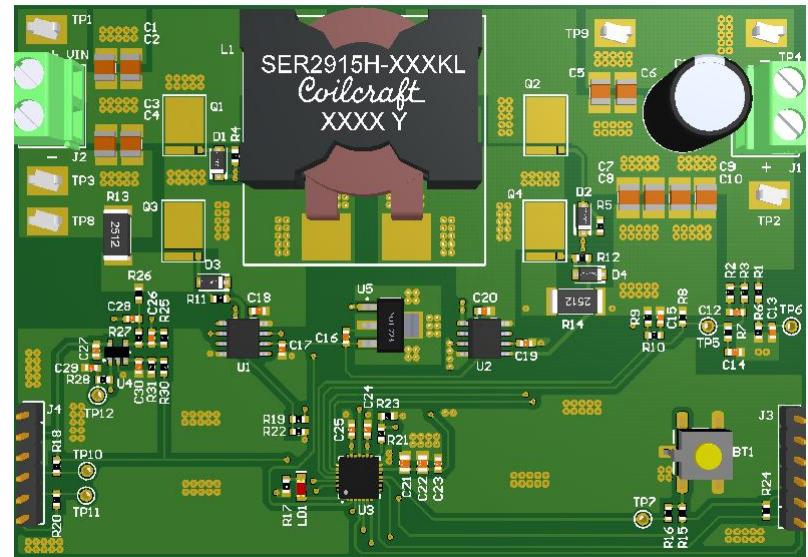


- Core Value:
 - UCS81003 offers USB Charger Emulation
 - UCS2112 offers dual port USB load switching
 - MCP19119 can offer a variable output voltage for cable drop compensation, intelligence for status reporting (LED), timeout and monitoring, fault responses, and a variable output
 - MCP19119 can support BC1.2 and other protocols directly

USB Power

- **USB Power**

- Type C & USB-PD
- Topology:
 - 4 switch buck/boost
 - flyback
- $V_{OUT} = 5V-20V @ 3A - 5A$

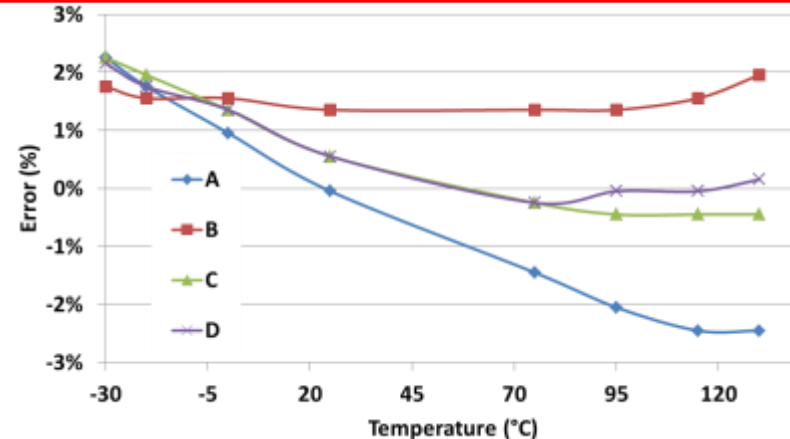


- Core Value:
 - MCP19119 configures system output based upon connected load
 - High efficiency buck or boost conversion

LED Lighting

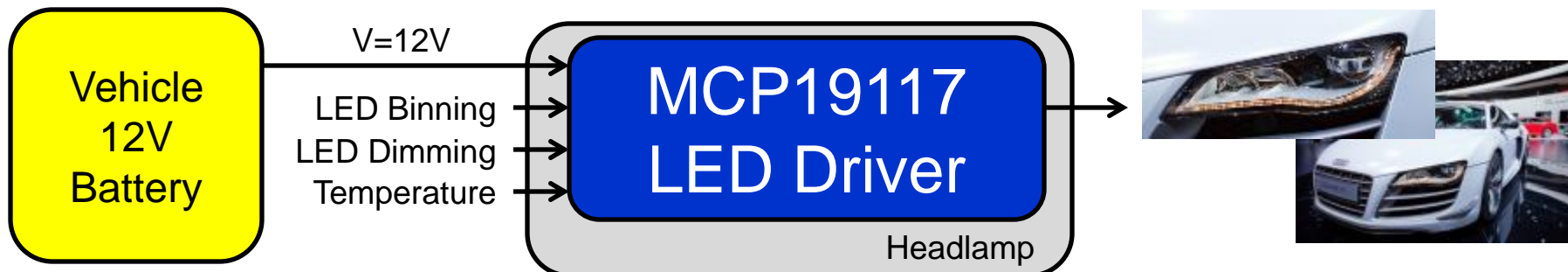
● LED Lighting

- $V_{IN} = 12V_{DC}$ (from Battery)
- $V_{OUT} = \text{up to } 60 V_{DC}$
- $I_{OUT} = \text{Adj., } 350\text{mA}-1.5\text{A}$ (or more)



• Core Value:

- Current regulation accuracy (<3% typical over *all* operating conditions)
- LED loads are complex; accurate light output requires PWM dimming, LED binning capability, intelligent fault response, and temperature compensation
- Creates a platform, customizable for different loads and circuits



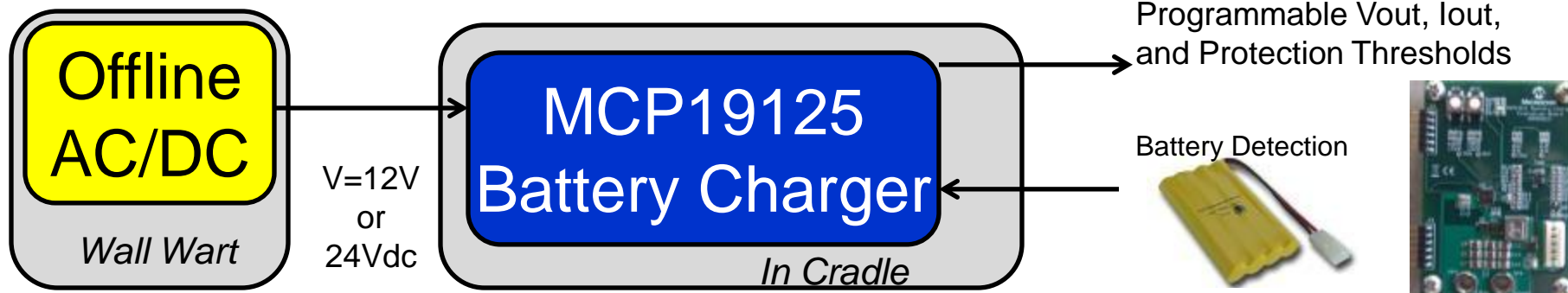
Battery Charging

● Battery Charging

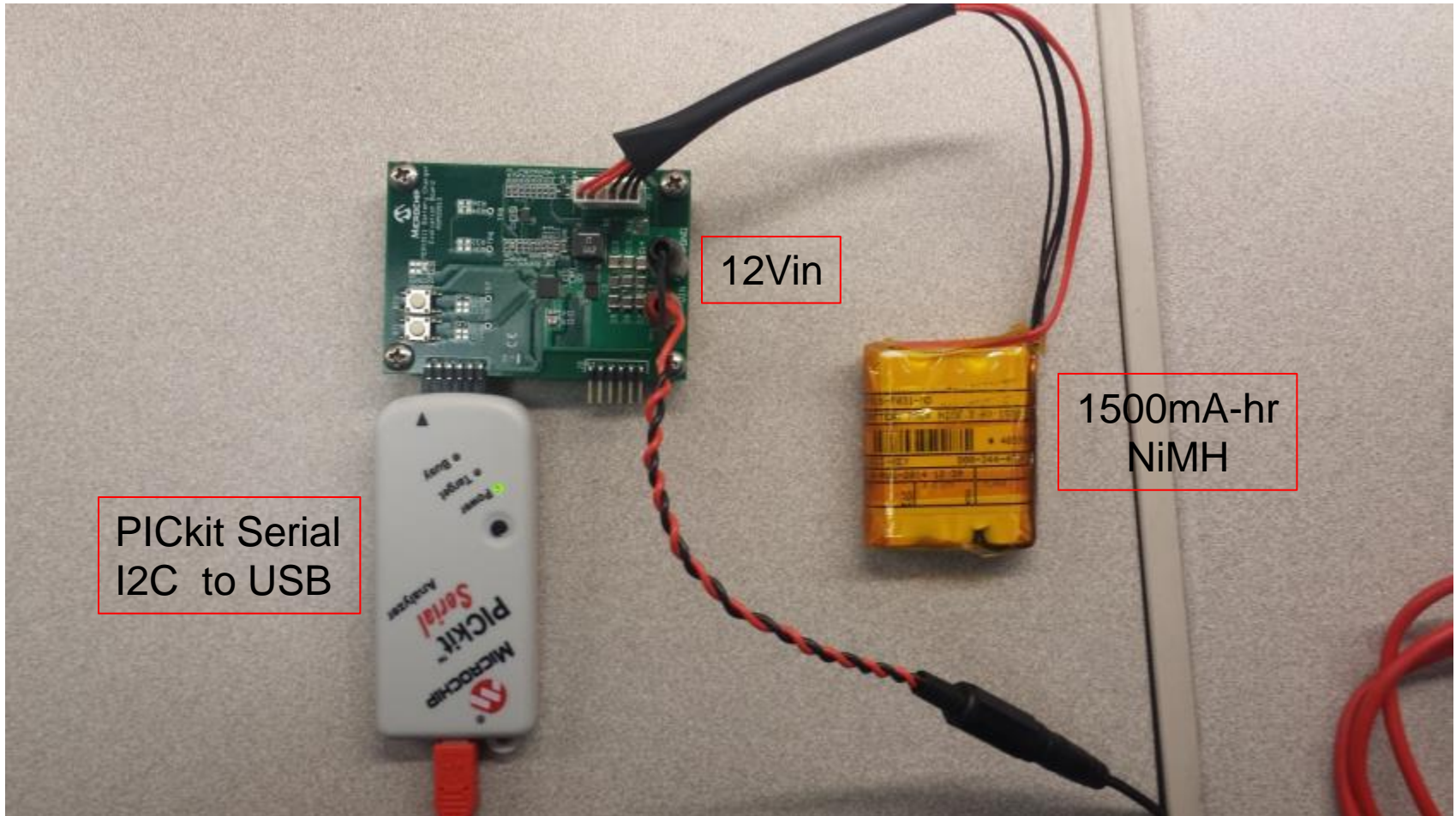
- Chemistry: Any, with firmware adjustment
- $V_{IN} = 12$ or $24V_{DC}$
- $V_{OUT} = 8 - 12V_{DC}$ (8 Cells), adjustable (I, V)

Typical Operating Range	
V_{IN}	12-24V
V_{OUT}	3 – 20V
I_{OUT}	Adj.
Chem	NiMH, Li-Ion

- Core Value:
 - High efficiency switching battery charger platform
 - Fully adjustable: protection limits, trickle charge, precondition levels, time outs, fault responses
 - Can charge virtually any battery pack with appropriate firmware



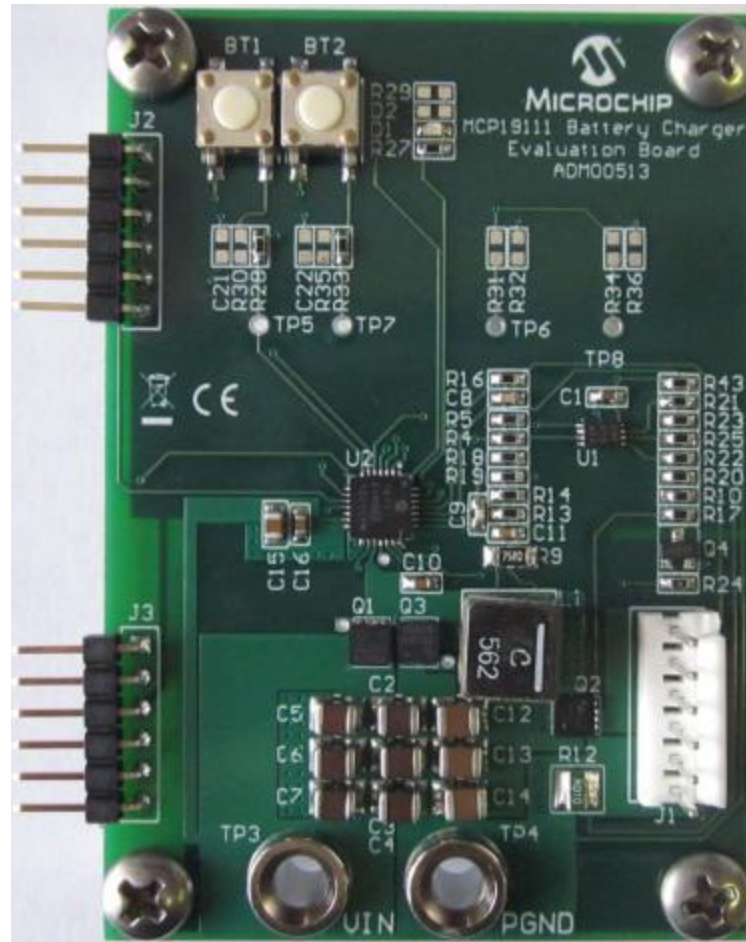
Battery Charger Evaluation Board



Battery Charger Evaluation Board

PICkit Serial Connector (GUI)

PICkit3 Connector (ICD use)

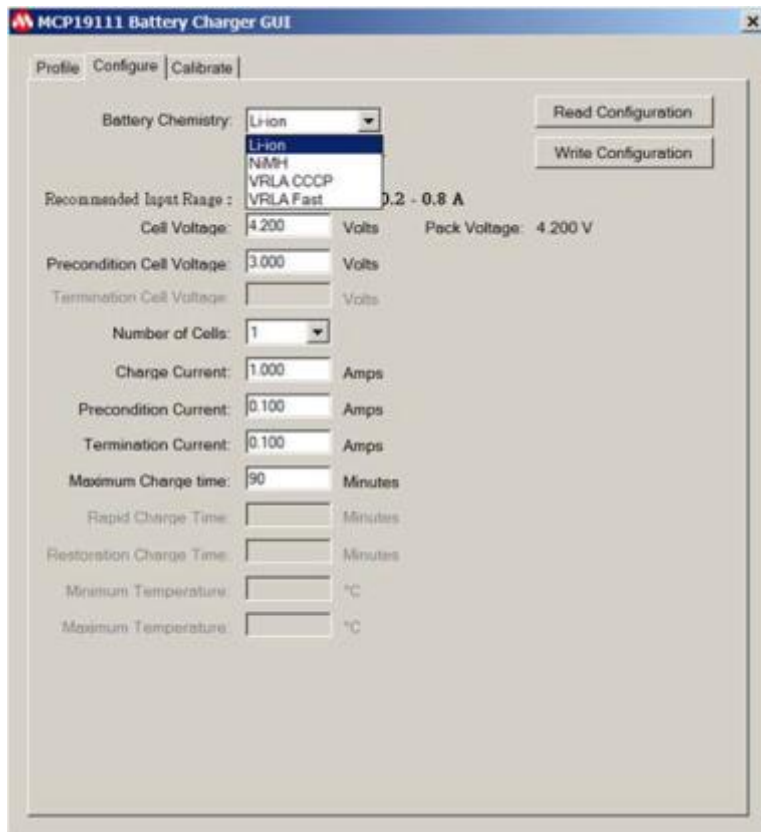


Battery Pack Connection

Vsupply: $V_{in} > V_{bat} + 2V$
Typically 12V

Battery Charger GUI

Control Panel

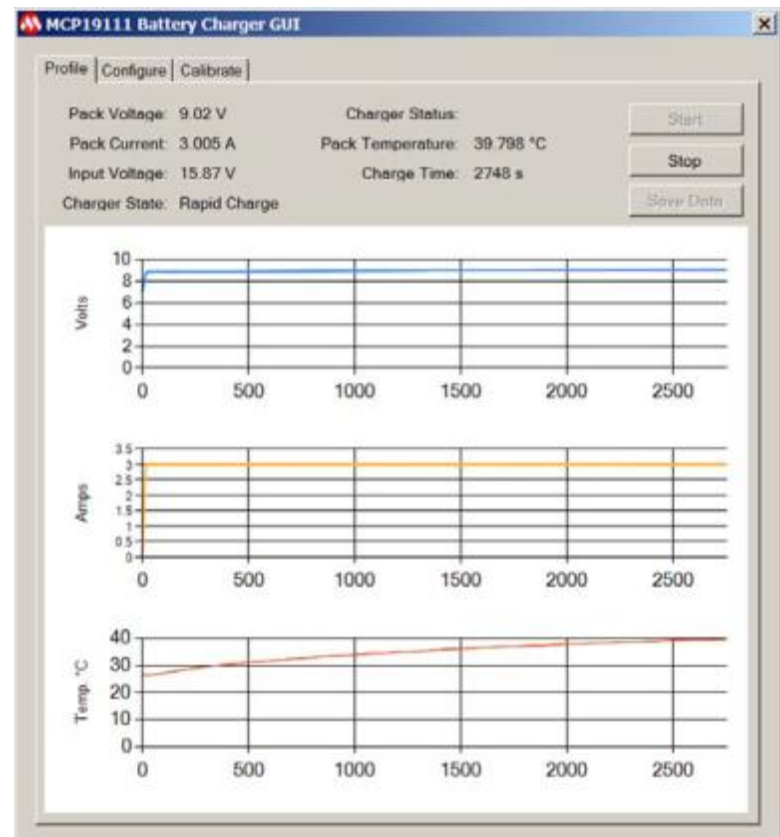


The screenshot shows the 'Control Panel' of the MCP19111 Battery Charger GUI. It features a 'Profile' tab and a 'Configure' sub-tab. The 'Battery Chemistry' dropdown menu is open, showing options: Li-ion (selected), NiMH, VRLA CCCC, and VRLA Fast. Below this, various configuration parameters are listed with input fields and units:

- Recommended Input Range: 0.2 - 0.8 A
- Cell Voltage: 4.200 Volts
- Pack Voltage: 4.200 V
- Precondition Cell Voltage: 3.000 Volts
- Termination Cell Voltage: [] Volts
- Number of Cells: 1
- Charge Current: 1.000 Amps
- Precondition Current: 0.100 Amps
- Termination Current: 0.100 Amps
- Maximum Charge time: 90 Minutes
- Rapid Charge Time: [] Minutes
- Restoration Charge Time: [] Minutes
- Minimum Temperature: [] °C
- Maximum Temperature: [] °C

Buttons for 'Read Configuration' and 'Write Configuration' are located on the right side of the panel.

Output Display Panel





MICROCHIP

**MPLAB® Mindi™
Analog Circuit Simulator**



What is MPLAB[®] Mindi[™] ?

MPLAB[®] Mindi[™] is an integrated, fast, powerful, and reliable electrical simulation tool for Microchip's analog and power management products.

Features:

- ✓ The same elements as the full release of **SIMetrix/SIMPLIS** with a limitation on the number of the components of the circuits.
- ✓ Loaded with Library of Microchip Models.
- ✓ Loaded with application example circuits for many of Microchip Analog and Power Management Products.
- ✓ Downloadable from www.Microchip.com/mindi and **Free of Charge**.
- ✓ Continuously Maintained and Expanded.



Key Features and Benefits

- **MPLAB® Mindi™ Analog Simulator features:**
 - Easy to use simulation interface
 - Proprietary files to model Microchip analog devices
 - SIMPLIS simulation environment that performs both domain (SPICE) and closed loop (SIMPLIS) simulations
 - A library of over 160 individual application schematics and 80 Microchip device models (and growing)
 - The ability to simulate up to 140 nodes worth of circuitry, and the nodes internal to Microchip model files do not count toward the node total
 - Local installation – no internet connection required for use
 - Fast simulation times
- **MPLAB Mindi simulation files and models are also compatible with commercial versions of SIMetrix/SIMPLIS**



Available Models

- **Linear Devices**
 - Operation Amplifiers
 - Instrumentation Amplifiers
 - Comparators

- **Power Management Devices**
 - MOSFET and Motor Drivers
 - PWM and non-PWM Controllers
 - Power Modules
 - LED Drivers
 - Switching Regulators

- **Generic Components (switches, Passives Components etc.)**

Application Schematics are available to download from Microchip's website.

<http://www.microchip.com/mplab/mplab-mindi>

Example Applications

- **Generate BODE responses for active and passive filter systems**
- **Evaluate transient responses to a wide variety of input conditions**
- **Generate closed-loop stability responses for control systems, including switch mode power supplies and motor drive applications**
- **Verify slew rates and drive strengths through power drive or signal conditioning chains**
- **Model noise effects in signal conditioning or control systems**

Operational Amplifiers	PWM and non-PWM Power Controllers
Active Filter Circuits	Power Modules
Instrumentation Amplifiers	LED Drivers
Half-bridge Motor Drivers	Switching Regulators

Work Smarter by Designing with Mindi Analog Simulator!



Availability

Download MPLAB® Mindi™ Analog Circuit Simulator at:

www.microchip.com/Mindi

Download SPICE and SIMPLIS models and application circuits at:

www.microchip.com/analogsimulationlibraries

MPLAB Mindi Analog Circuit Simulator is completely free!

Thank You!

Спасибо