Texas Instruments

Power Management Solutions for Defense and Aerospace

Rich Nowakowski
Marketing Manager // Power Management

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Most Popular Power Links:

- Power portal www.ti.com/power
- DC/DC portal www.ti.com/dcdc
- LDO portal www.ti.com/ldo

Broad power management portfolio

LDO Regulators

- Single Channel LDO
- Multi-Channel LDO
- LDO Controller (External FET)

DC/DC Regulators

- Converter (Integrated Switch)
- Controller (External Switch)
- Charge Pump

Power Modules

- Non-isolated module
  - Step-down (buck)
  - Step-up (boost)
  - Buck/boost & negative output module
- Isolated module

Power MOSFETs

- N-Channel MOSFET Transistor
- P-Channel MOSFET Transistor
- Power MOSFET Module

IGBT, MOSFET Gate Drives

- Low-side Driver
- Half-bridge Driver
- Isolated Gate Driver

Offline and Isolated DC/DC

- PWM and Resonant Controller
- Flyback Controller
- Offline Converter
- Isolated DC/DC
- Synchronous Rectifier

AC/DC Solutions

- Power Factor Correction
- Digital power

Battery Management

- Battery chargers
- Wireless power
- Fuel gauges, monitors
- Protection & authentication
- Energy harvesting

Power Special Functions

- NVSRAM (Non-Volatile SRAM)
- Schottky Diode Array
- DDR Memory Power
- LED lighting
- Interface Controlled Pre-FET Drivers

Other

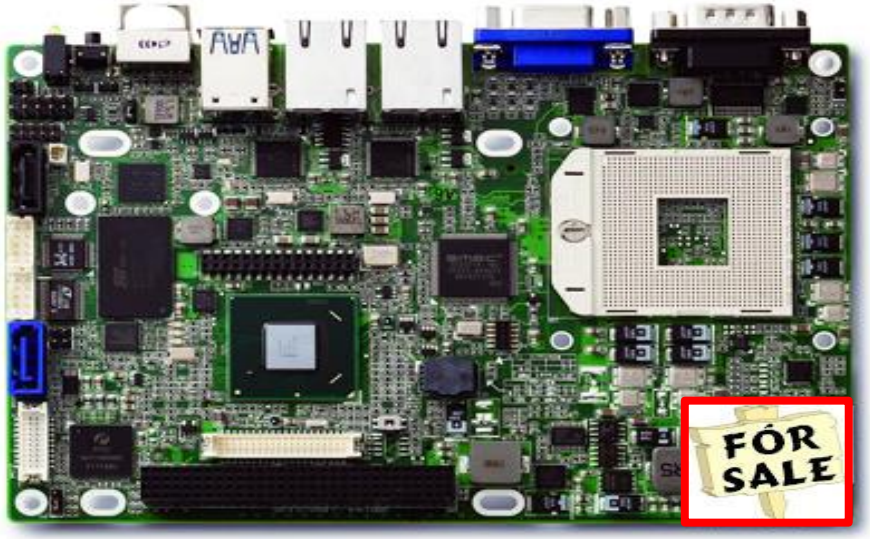
- Power Protection, Distribution, Monitoring
- USB Power
- Supervisor and Reset
- PMICs
- Power Multiplexer (MUX)

WEBENCH® design tools available http://webench.ti.com

6 Design Challenges for Defense / Aerospace

1. Easy to Use / Small Solution Size for POL
2. Low Noise Power for Signal Chain Power
3. Voltage Regulation Accuracy for FPGA Power
4. Achieving High Power Density with GaN
5. Enhanced Products for Environmental Extremes
6. Simulating your Power Design

Challenge #1:
Designing High Power Density that's Easy to Use!



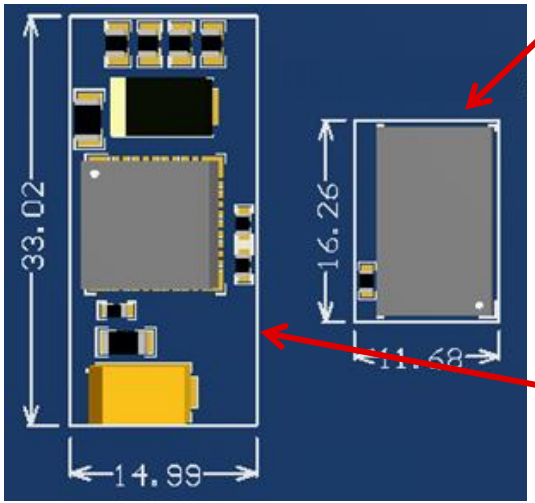
- Product value is in IP developed to improve functionality, not always the power management solution
- An experienced power designer is needed to match board space of today's over-molded power modules
- If discrete designs are not routed and optimized properly, they can have noise & EMI problems

How much is your board space worth?

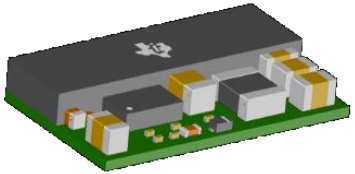
Solution:

Smallest 10A Power Module

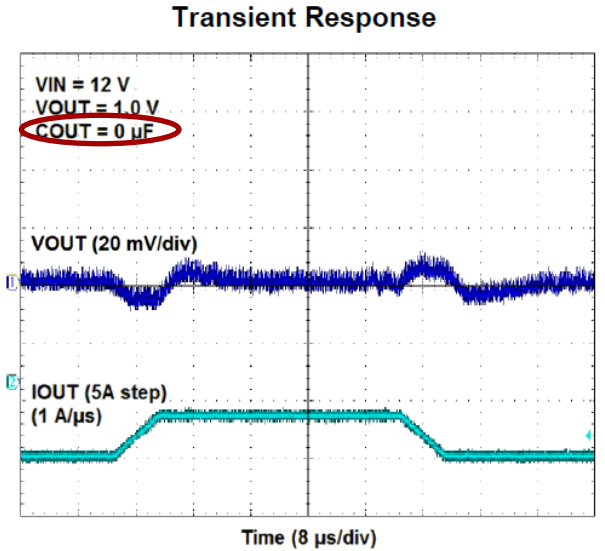
TPSM84A21: 12Vin, 10A, 4MHz Step Down Power Module Integrates Cin & Cout



Total solution using TPSM84A21

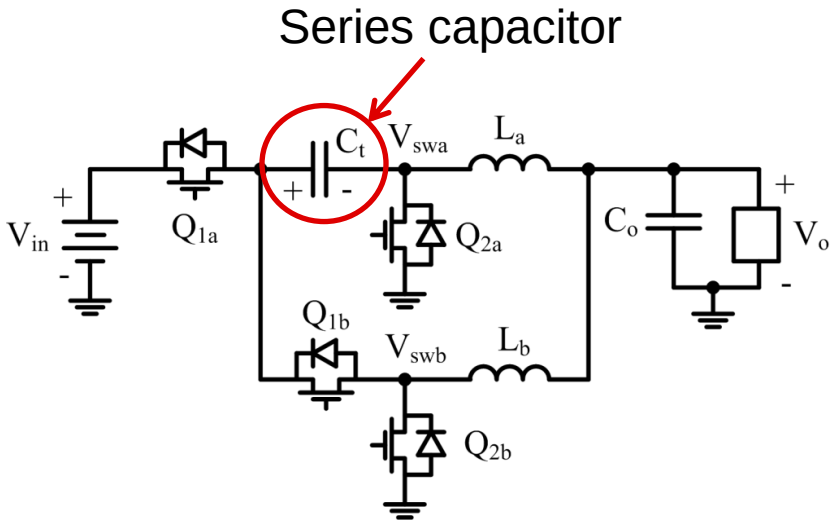


Total solution using traditional 10A module



Integrated input and output capacitors make the total solution size **over 60% smaller** than similar competitive 10A modules. Only one resistor required.

High Density: Series Capacitor Buck Topology



Two-phase, series cap buck converter:

- TPS54A20 Converter & TPSM84A21 Module
- Series Capacitor App Note: http://www.ti.com/lit/pdf/slva750
- Development Boards: http://www.ti.com/tool/tps54a20evm-770
- http://www.ti.com/tool/tpsm84a21evm-808
- Spice Model: http://www.ti.com/product/TPS54A20/toolssoftware

- ✓ Benefits
  - ✓ Single conversion stage
  - ✓ Switching at reduced V_{ds}
  - ✓ Series cap soft charge/discharge
  - ✓ Automatic current balancing
  - ✓ Duty ratio doubled
- Drawbacks
  - 50% duty cycle limitation
    - Theoretical: $V_{IN,MIN} = 4 \times V_{OUT}$
    - Practical: $V_{IN,MIN} = 5 \times V_{OUT}$
  - No phase shedding

TI's Power Module Portfolio

Advanced Info

Extended Temp Range

Output Current >4A

- PTH04040W — 3.3V/5V, 60A
- PTH05T210W — 5.5V, 30A
- PTH08T250W — 4.5-14V, 50A
- TPSM846C23 — 15V, 35A, PMBus
- LMZ31520/30 — 3-15V, 20A/30
- TPSM84A21/2 — 8-14V, 10A — NEW!
- LMZ31707/10 — 2.95-17V, 7A/10A
- LMZ12008/10 — 6-20V, 8A/10A
- LMZ22008/10 — 20V, 8A/10A
- LMZ13608/10 — 6-36V, 8A/10A
- LMZ23608/10 — 6-36V, 8A/10A
- TPSM82480 — 2.4-5.5V, 6A
- LMZ30604/6 — 6V, 4A/6A
- LMZ31506/H — 4.5-15V, 6A
- TPSM84824 — 4.5-17V, 8A
- LMZ22003/5 — 4.5-20V, 3A/5A

Output Current <4A

- LMZ20501/02 — 5.5V, 1A / 2A
- LMZ10501 — 5.5V, 1A
- TPS82697/98 — 4.8V, 800mA
- TPS81256 — Boost, 400mA*
- TPS8267X — 4.8V, 600mA*
- TPS82695 — 4.35V, 500mA
- TPS82085 — 6V, 3A
- TPS82084 — 6V, 2A
- LMZ30602 — 6V, 2A
- TPS8268090/105/150 — 5.5V, 1.6A
- LMZ10500 — 5.5V, 0.65A
- TPS82740 — 5.5V, 0.2A
- TPS82130 — 3-17V, 3A
- TPS82140 — 3-17V, 2A — NEW!
- TPS82150 — 3-17V, 1A — NEW!
- LMZ21701/00 — 3-17V, 650mA / 1A
- LMZ31704 — 2.95-17V, 4A
- LMZ12003 — 4.5-20V, 3A
- LMZ23603/5 — 6-36V, 3A/4A
- LMZM33602/3 — 36V, 2/3A
- LMZ12001/2 — 4.5-20V, 1A/2A
- LMZ34002 — 40V, 2A (Neg)
- TPSM842xx — 28V, 1.5A. T0220 — NEW!
- LMZ14203/H — 6-42V, 3A
- LMZ35003 — 7-50V, 2.5A
- LMZ34202 — 4.5-42V, 2A — NEW!
- LMZ36002 — 4.5-60V, 2A
- LMZ14201/2/H — 6-42V, 1/2A

6V 17V 36V 60V

Visit: www.ti.com/powermodule

Challenge #2:
Power Supply Noise Affecting Data Converters

The most important aspect of communication systems is their ability to transfer large amounts of data quickly and is measured by the system's data capacity which is determined by the fidelity of data signals (SNR).

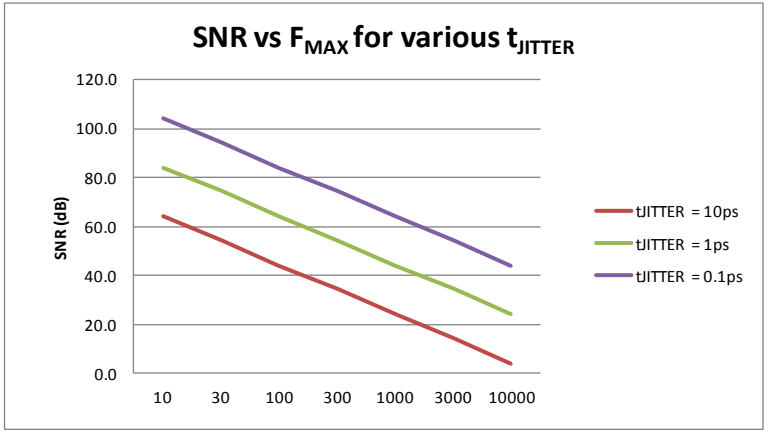
A system's data capacity is set by:

- $C = B \bullet \text{Log } 2(1 + SNR)$ - Shannon's equation

For ADC and DAC in communication systems:

- $SNR = 20\log[1/ 2\pi \times f_{MAX} \times t_{JITTER}]$

Typical values for PSR for data converters are 40-60dB in the 100kHz to 1MHz range. This means **40mV of ripple could reduce a 14 bit converter to 12 bit performance**.



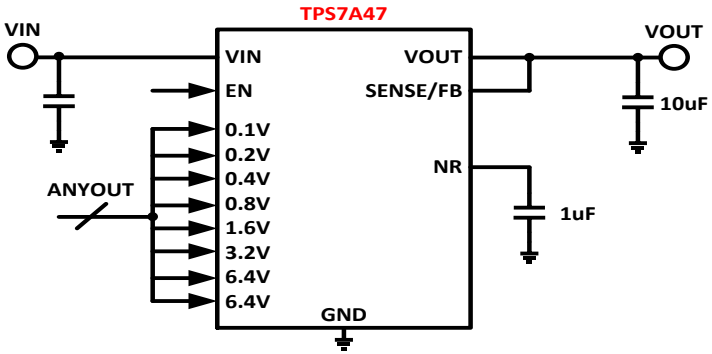
Jitter and SNR Calculator for ADCs
http://www.ti.com/tool/jitter-snr-calc

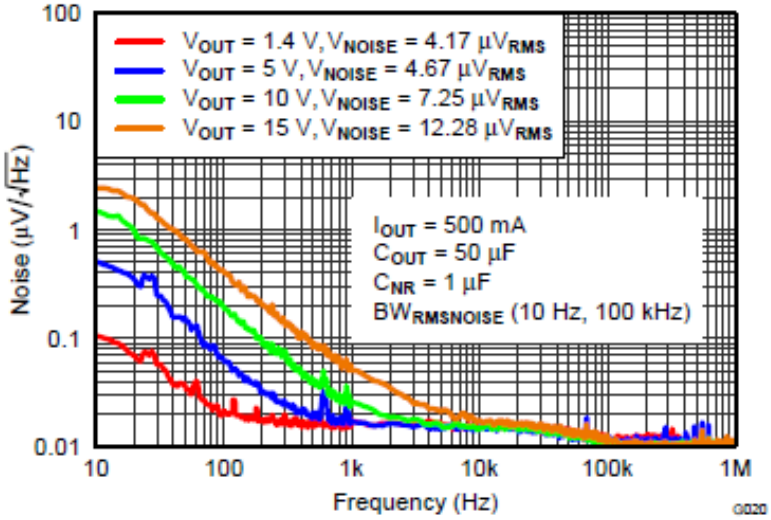
Solution:

TI Low Noise LDOs for Signal Chain Power

TPS7A4700: 36V/1A RF Ultra Low Noise LDO

- **4.17μV_{RMS}** 10 to 100kHz
- **PSRR:** 82dB @10kHz; 82dB @ 100kHz; 55db @ 1MHz; ***PSRR peak of almost 80dB at 2 MHz***
- Stable with ≥10μF ceramic output cap
- **ANYOUT** adjustable from 1.4V - 20.5V
- FB pin adjustable: 1.4V – 34V (TPS7A4701)
- **TPS7A4701-EP version available**





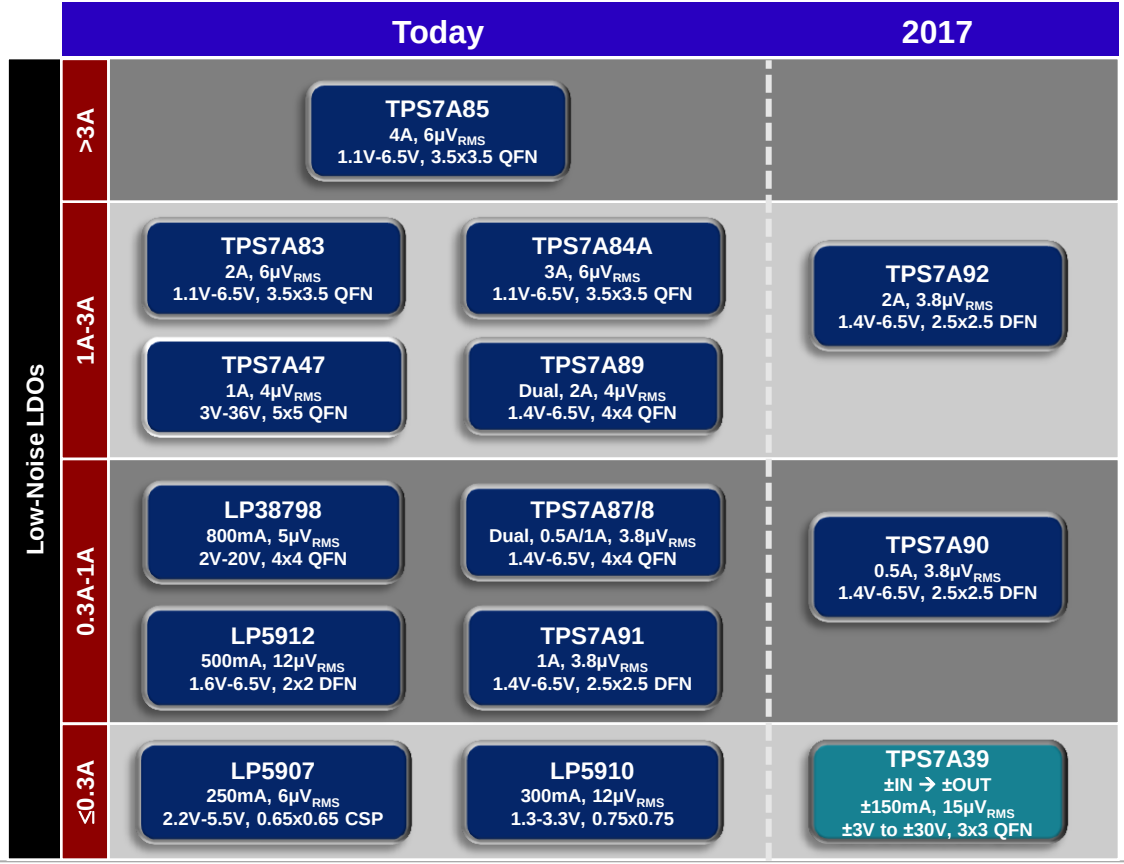
TIDesigns

PMP8372: 40V Dual 1A Power Module w/Low Noise LDOs Split-Rail (±5V) Output Voltages Reference Design

Device	V_{IN}	I_{OUT}	V_{DO}	Package
TPS7A4700/1	3.0V-36V	1A	307mV@1A	5x5mm 20 QFN

TI LDOs: Low-Noise LDOs (≤15μV_{RMS})

Status: Production | Development



TI Designs

TIDA-00388: Low noise linear regulator + DC/DC reference design with excellent transient response

PMP8372: 40V Dual 1A Power Module w/Low Noise LDOs Split-Rail (±5V) Output Voltages Reference Design

TIDA-00270 : Current-Sharing Dual LDOs – 6A

Visit: www.ti.com/ldo

Challenge #3:
Voltage Regulation Accuracy

As process technology advances, processor voltage requirements are lower and require high accuracy

1. Choose DC/DC with Vref <= 1% accuracy

TPS54020 ELECTRICAL CHARACTERISTICS: TJ = –40°C to 150°C, VIN = 4.5V to 17V, PVIN = 4.5V to 17V (unless otherwise noted)					
Parameter	Conditions	Min	Typ	Max	Unit
Voltage Reference	0 A ≤ IOUT ≤ 10 A, –40°C ≤ TA ≤ 150°C	0.594	0.6	0.606	V

Recommended Operating Conditions

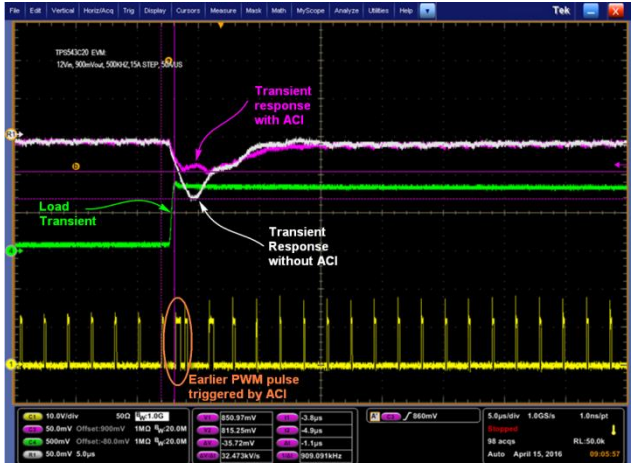
Symbol	Min	Typ	Max	Units
FPGA Logic				
V_{CCINT}(3)	0.97	1.00	1.03	V
	0.87	0.90	0.93	V
V_{CCBRAM}(3)	0.97	1.00	1.03	V
	0.87	0.90	1.03	V

2. Choose tighter tolerance **resistor dividers**
   - 0.1% or 0.5% resistors cost more than 1% resistors
   - High accuracy for lower voltages is not difficult, since low divider ratios are inherently accurate
   - Search “Kollman Power Tip #18” to learn more about voltage dividers and accuracy

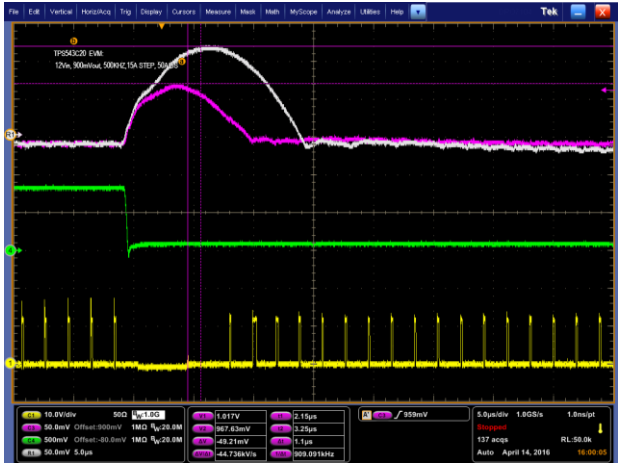
3. A **remote sense** feature in the POL DC/DC converter will compensate for I*R drops and maintain accuracy

Solution:
Over / Undershoot Improvement

TPS543C20: 4Vin to 16Vin, 40A Fixed-Frequency, Stackable Synchronous Step-Down SWIFT™ Converter with Remote Sense, API, and Body Braking for FPGA power



Transient response with and without Asynchronous Pulse Injection (API)

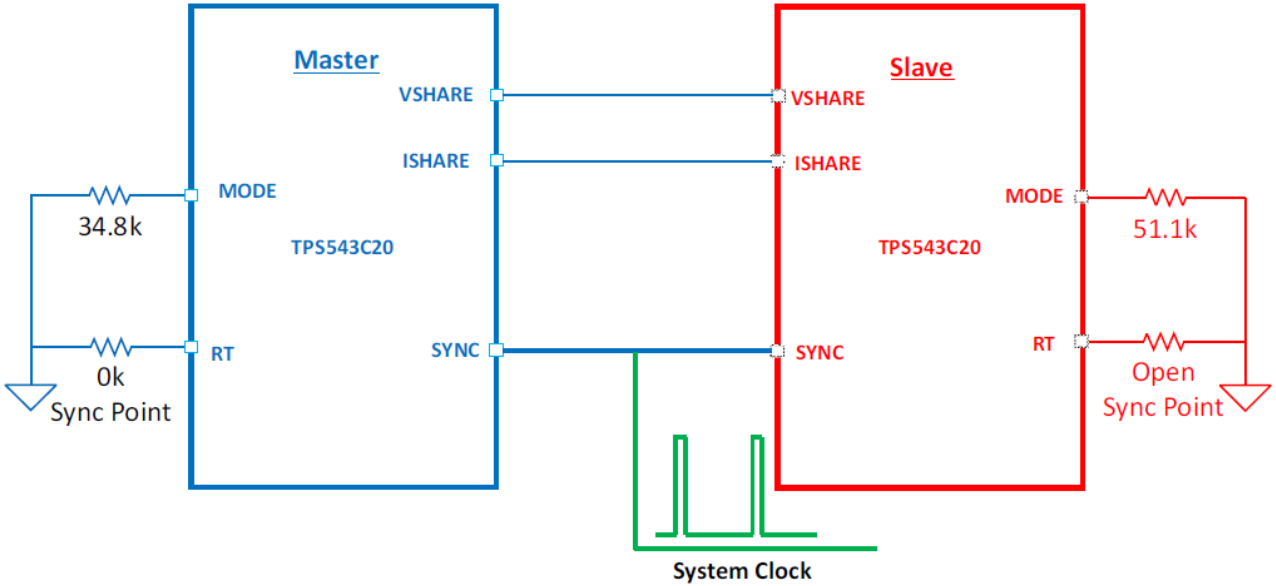


With and without Body Breaking

Meet voltage over / undershoot requirements during transient with less capacitance!

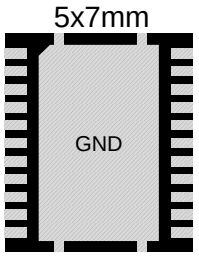
Solution:

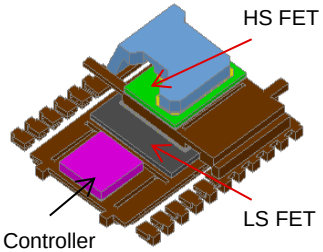
Up to 80A with Stack-ability



QFN Package

- 3D for highest power density & lowest Rds(on)
- Highest current capability
- Reduced parasitics
- Large single GND pad versus competition





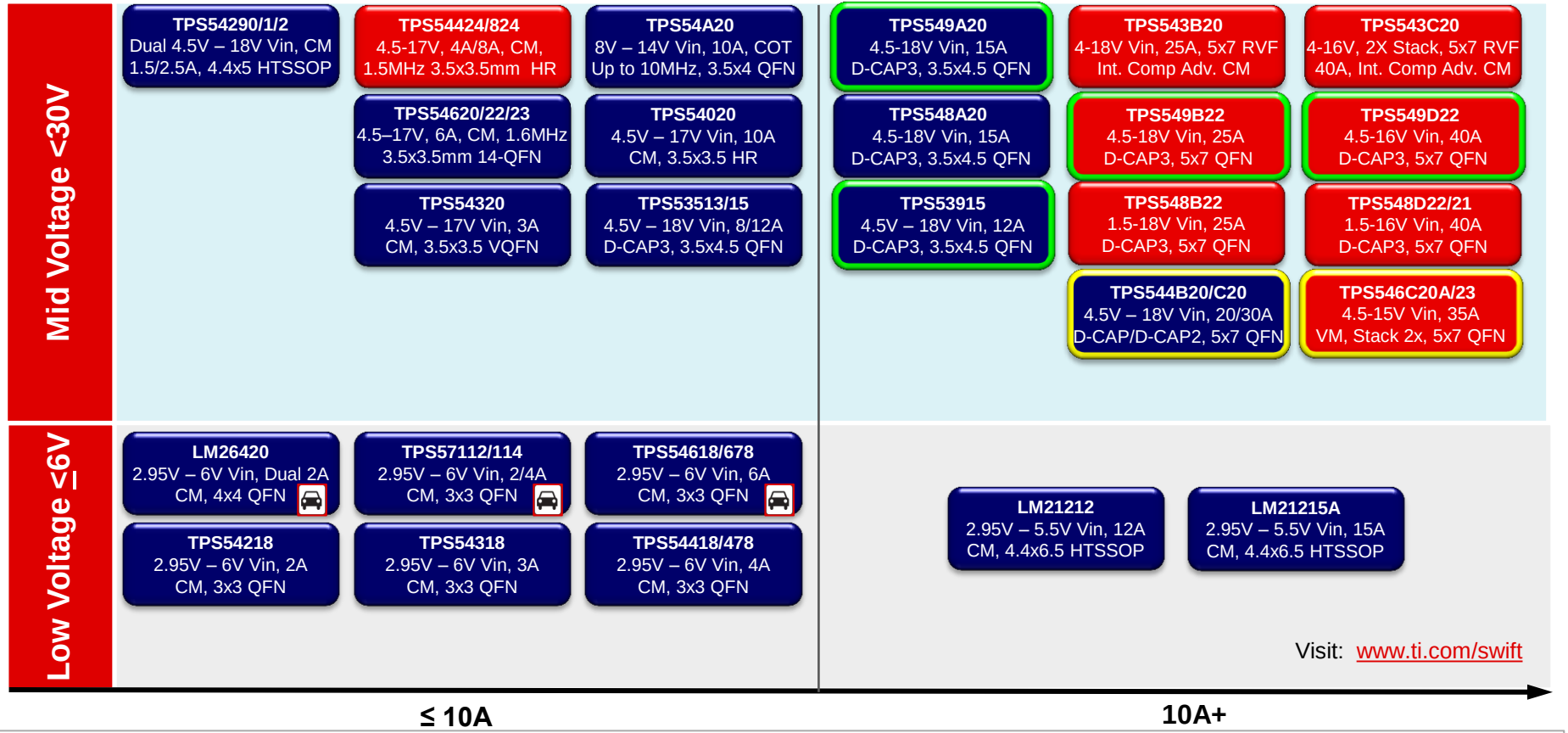
Evaluation Modules:

- TPS543B20 25A EVM
- TPS543C20 40A EVM
- TPS543C20 80A EVM

See also the pin-to-pin compatible 25A TPS543B20

SWIFT™ Synchronous Buck Converters Portfolio

PMBus w/o Telemetry
PMBus w/Telemetry
Automotive
Released
Newly Released

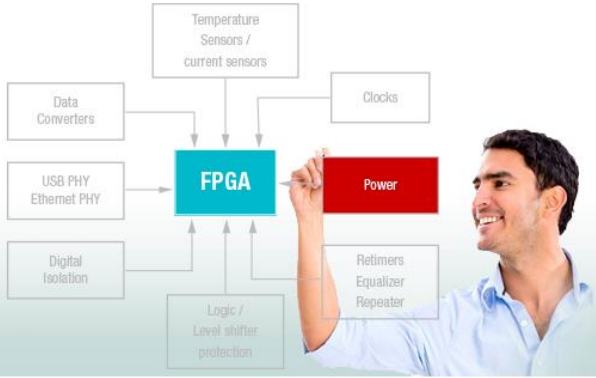


Solution:
Power for FPGAs

Overview | Reference Designs | Power | Clocks | Data Converter | Analog Building Blocks | JESD204B Interface | Xilinx Boards | Videos

Power for FPGA, processors, and ASICS

With a robust portfolio of LDOs, power modules, DC/DC switchers, and PMICs, TI's easy- to-use solutions - combined with system expertise - support a range of voltages, currents, performance levels, and sizes to form a perfect match with your FPGA.



Overview | Xilinx | Altera

Find the right TI devices for your Xilinx solution

Family: Artix-7 | Part Number: XC7A200T | Nominal Input Voltage: 12.0V | Design Reference: Highest Efficiency | ☐ Automotive only

Power	Sequence #*	Loads** (Max)	% Loads	Solutions			
				LDO	Module	DC/DC Converter	Controller
Power Supply: #1 Output Voltage: 1V Max Load: 8.670A		VCCINT (8.000A) VCCBRAM (0.080A) MGTAVCC (0.590A)	Low (2.601A)		LMZ31704, 4A LMZ31707, 7A LMZ31506, 6A	TPS54824, 8A TPS53313, 6A TPS53318, 8A	TPS40170, 25A LM3150, 15A LM27403, 40A
			Med (5.202A)		LMZ31707, 7A	TPS53318, 8A	TPS53219A, 25A

Visit:
www.ti.com/powerfpga

Solution:
FPGA Power Reference Designs

Tool Number	Tool Title
PMP8251	Power Solution for Xilinx FPGA Zynq 7
PMP10520	Xilinx Virtex UltraScale FPGA Multi-Gigabit Transceiver (MGT) Power Solution
PMP10555	Xilinx Ultrascale 16nm Power Solution with PMBus
PMP6776	Xilinx Kintex FPGA Power Solution
PMP9407	Xilinx Virtex Ultrascale FPGA Multi-Gigabit Transceiver (MGT) Power Reference Design with PMBus
TIDA-00432	Synchronization of JESD204B Giga-Sample ADCs w/Xilinx for Phased Array Radar Systems
PMP11328	30A PMBus Reference Design for Xilinx Zynq Ultrascale+ ZU9EG MPSoC Core Rail
PMP9357	Altera Arria V FPGA Power Supply Reference Design
PMP5006	20V Input Sync Buck Designs to Power Altera Arria GXII
PMP2543	Altera Cyclone III FPGA Power Management Reference Design
PMP8824	7 to 12Vin 1.2Vout 8A Step-down Conv for Powering Rails in Altera Arria V FPGA Reference Design

- Test report, BOM, schematic, design files, and test report. Search Tool Number
- Visit www.ti.com/tidesigns to see a complete searchable design list

Challenge #4:
High Power Density with GaN

Advantages of TI GaN over Discrete GaN

- **Easy System Design**
  - Optimized Integrated driver with zero common-source inductance enables high-speed low loss switching
  - Regulated gate drive bias provides reliable GaN switching
  - Low inductance package reduces power loop ringing
  - Ease of board layout
- **Higher Efficiency**
  - ZERO reverse-recovery losses in hard-switched, half-bridge converters
  - Low output capacitance, Coss
  - Low switch ringing
- **Ecosystem**
  - Complete range of digital and analog controllers, and complementary analog and power solutions
- **Reliability**
  - Over 3 million device hour of application reliability testing beyond JEDEC

Simplify the Design

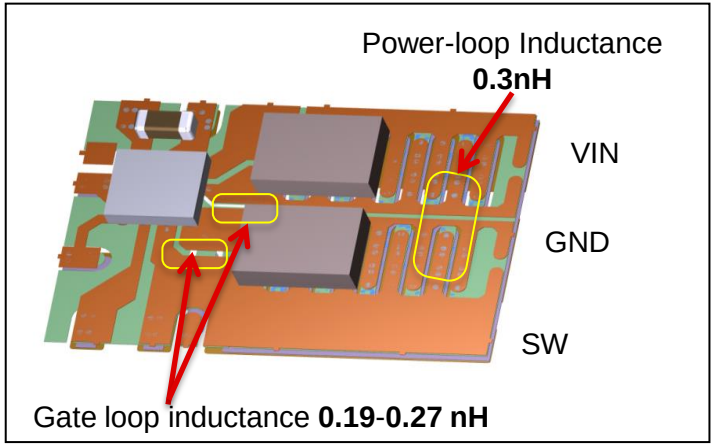
Save Time and Resources

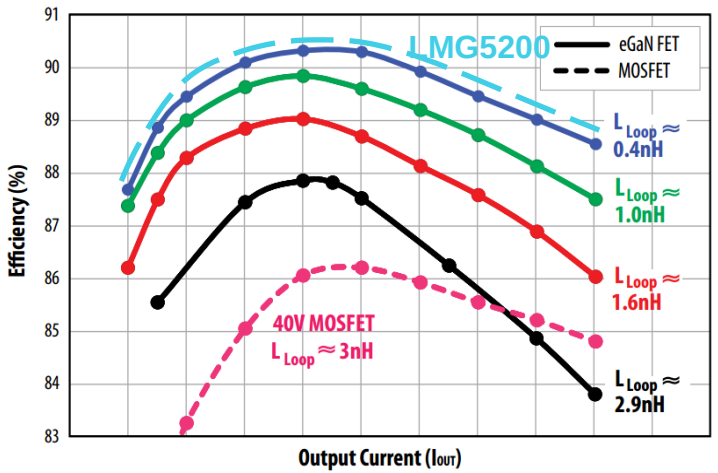
Improve system performance

Find out more at www.ti.com\GaN

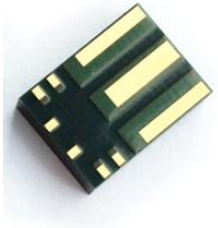
LMG5200: 80V/10A GaN Power Stage

- Although MV GaN has been in production for a number of years, the LMG5200 Power Stage removes barriers to GaN design:
  - Removed driver design complexity – We can call it *Digital-GaN*
  - Minimal drive and power loop inductance – Get the *real performance* of the GaN
  - Robust QFN package – Something power designers *know and trust*.





6x8mm QFN



EVMs and SPICE Models Available

Find out more at www.ti.com\GaN

PMP4497 GaN Module 48V to 1V 40A Converter

TIDesigns

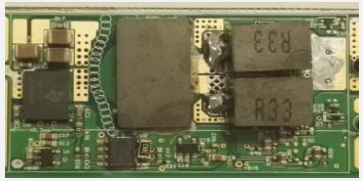
Features

- Extra high Efficiency up to 89.9% @1.0V/40A
- 600kHz ~ 1MHz operation frequency
- LMG5200 GaN FET module
- DCAP+ Controlling with the TPS53632G
- Half-Bridge Isolated with Current-Doubler topology
- One stage to replace the traditional two-stage solution

Benefits

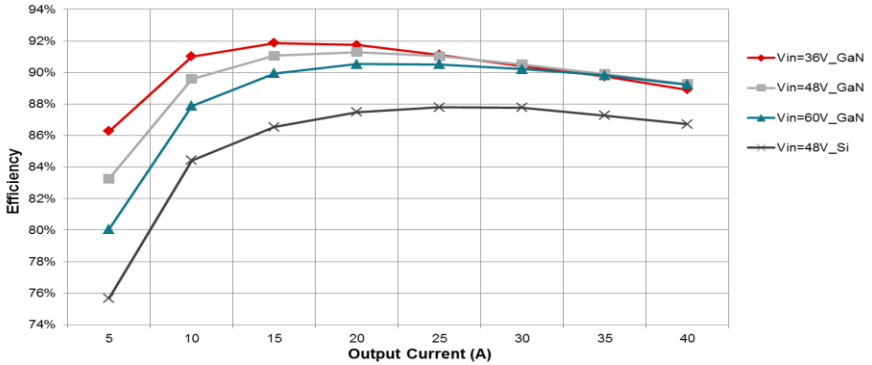
- Extra higher efficiency comparing with two stage solution
- High power density with up to 1/3 foot print reduced
- Less components
- Isolated design

Tools & Resources



- PMP4497 Tools Folder
- **Design Files: Schematics, testing report, BOM, Gerber and more**
- **Device Datasheets:**
  - LMG5200
  - TPS53632G
  - ISO7420FEDR
  - TLV70450DBVR
  - TLV70433DBVR
  - UCC27512DRSR

Efficiency Curve With Driver Loss vs. Vin @600kHz



Find out more at www.ti.com\GaN

New GaN Devices and Solutions

- LMG5200: 80V GaN Power Stage Solution
- LMG3410: 600V GaN Power Stage with Smart Direct-Drive
- LM5113: Half-Bridge 100V GaN Gate Driver
- LMG1205: 100-V, 1.2-A, 5-A, Half-Bridge Gate Driver
- PMP4497:TI Design: 48V to 1V/40A Converter
- PMP20289:TI Design: 400Vin, 12V/500W LLC
- TIDA-00909:TI Design: 48V/10A High Frequency 3-Phase Motor Drive

Find out more at www.ti.com\GaN

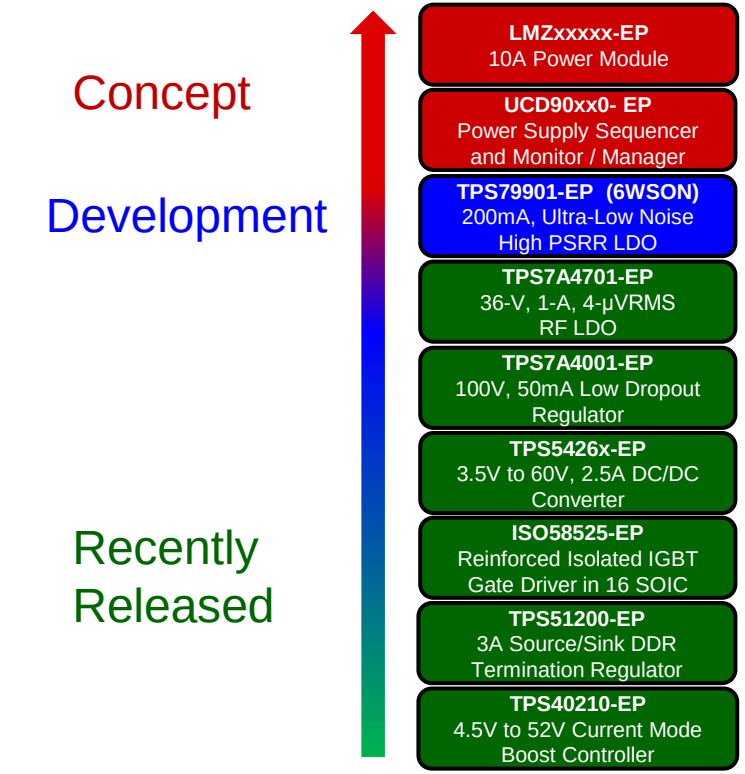
Challenge #5:
Finding Enhanced Products

Enhanced Products offer:

- Controlled Baseline
- Extended Temp range (i.e. -55C to +125C)
- No pure Sn bond pads or Cu bond wires
- Extended PCN notifications
- Qualification & Reliability reports
- Product traceability

Power Products & Links:

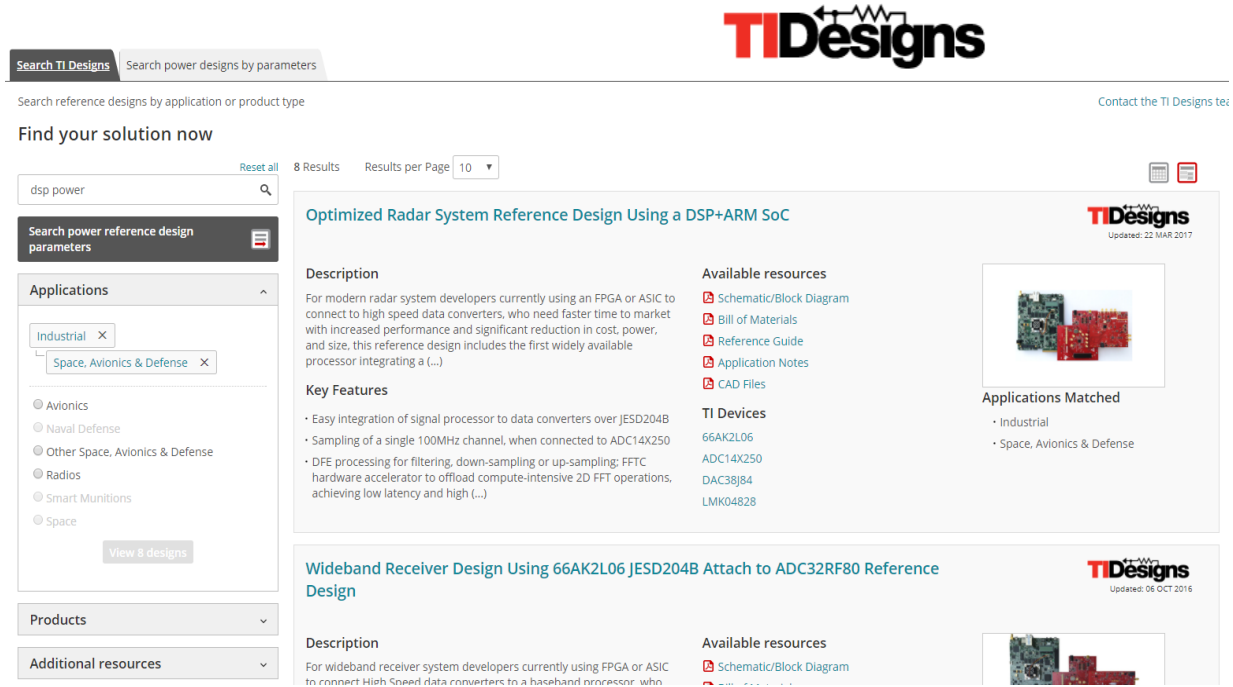
- Enhanced Products Web Page
- Enhanced Products (EP) Guide
- Enhanced Products (EP) Listing



Challenge #6:
Simulating your power design

- Search for a performance power device or solution
- Simulation design tools
- Reference designs, samples & evaluation modules
- Support

Solution:
Download TI Designs



TI Designs Contain

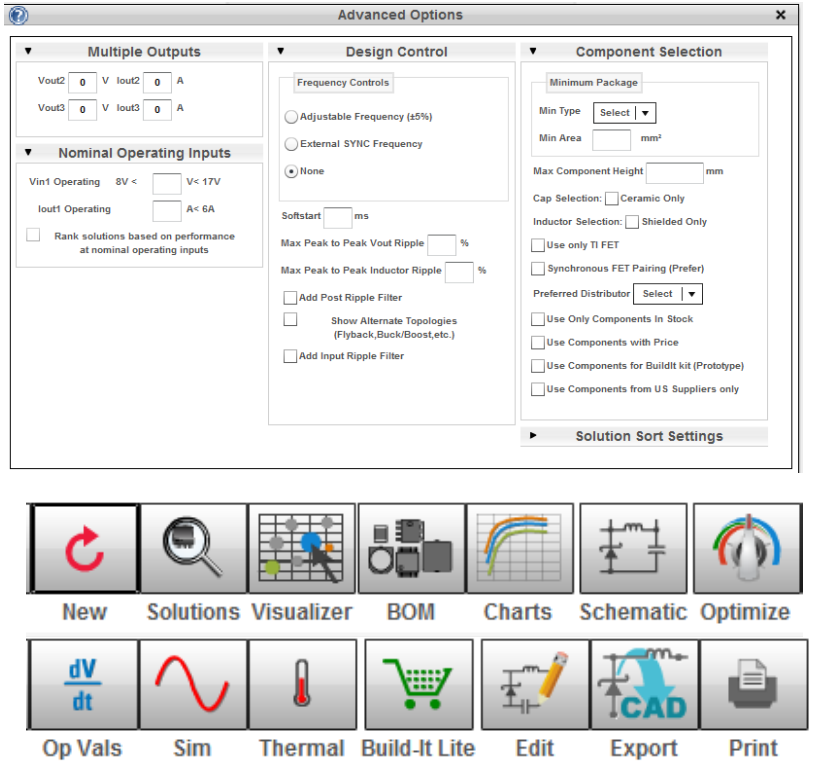
- Schematic
- Bill of Materials
- Test Report
- Design Files

Search by Power Supply Parameters, Application, or by Product

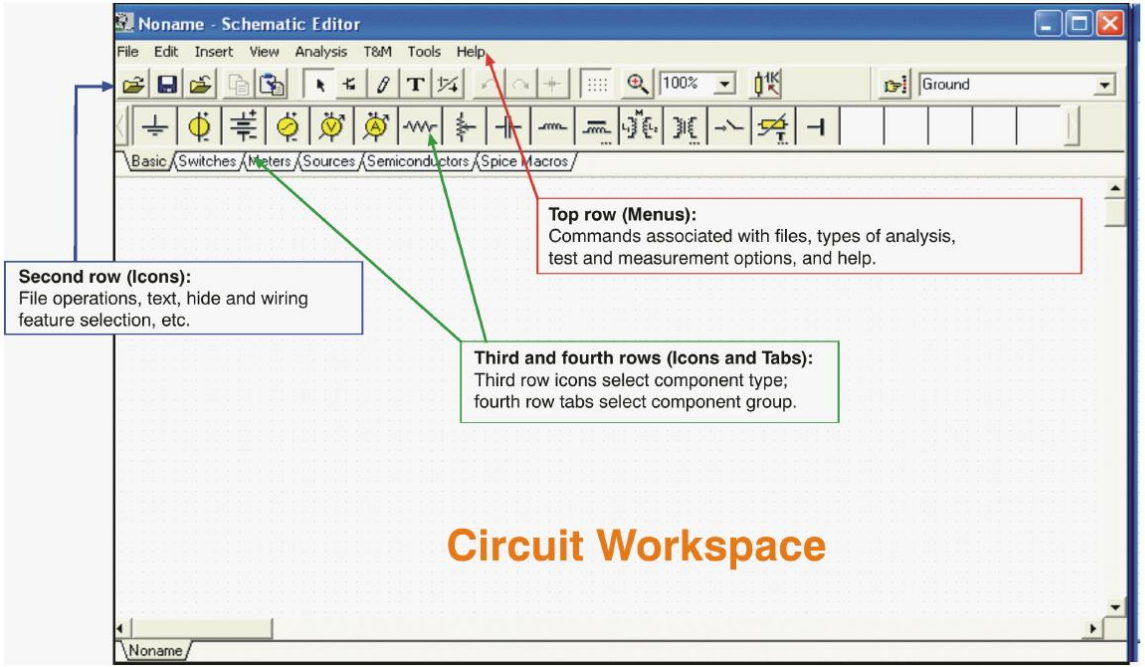
www.ti.com/tidesigns

Solution:
Webench® Power Architect

- Helps select the best part and completes the design by selecting components based on design criteria
- Start design by entering Vin/Vout/Iout and other criteria in advances options
- Allows the design to be optimized, edited, exported, simulated, and more
- If unencrypted PSPICE models are needed, please contact TI



Solution:
TI TINA



- Spice-based analog simulation program
- Develop, test, and simulate circuit ideas
- Supports Analog and SMPS circuits
- Simple and intuitive graphics-based interface
- Quick Start Guide available here: http://www.ti.com/lit/pdf/sbou052

Download TI-TINA: http://www.ti.com/tool/tina-ti

New App Notes and Other Technical Literature

- A Topical Index of TI LDO Application Notes - SBVA026
  - http://www.ti.com/general/docs/lit/getliterature.tsp?baseLiteratureNumber=sbva026
- LDO Noise Demystified – SLAA412A
  - http://www.ti.com/general/docs/lit/getliterature.tsp?baseLiteratureNumber=slaa412&fileType=pdf
- Control mode quick reference guide – SLYT710A
  - http://www.ti.com/general/docs/lit/getliterature.tsp?baseLiteratureNumber=slyt710
- Innovative DC/DC Power Modules Guide – SLYT685
  - http://www.ti.com/general/docs/lit/getliterature.tsp?baseLiteratureNumber=slyt685
- A comprehensive methodology to qualify the reliability of GaN products – SLYY070
  - http://www.ti.com/general/docs/lit/getliterature.tsp?baseLiteratureNumber=slyy070

Conclusion

- Power for Defense and Aerospace applications is challenging and TI has the power solutions!
- TI power converters provide a high density, high performance power solution ideal for processors
- TI low noise LDOs provide clean power for data converters
- TI has tools and resources to simplify your power designs

Thank you!