Welcome!
Texas Instruments New Product Update

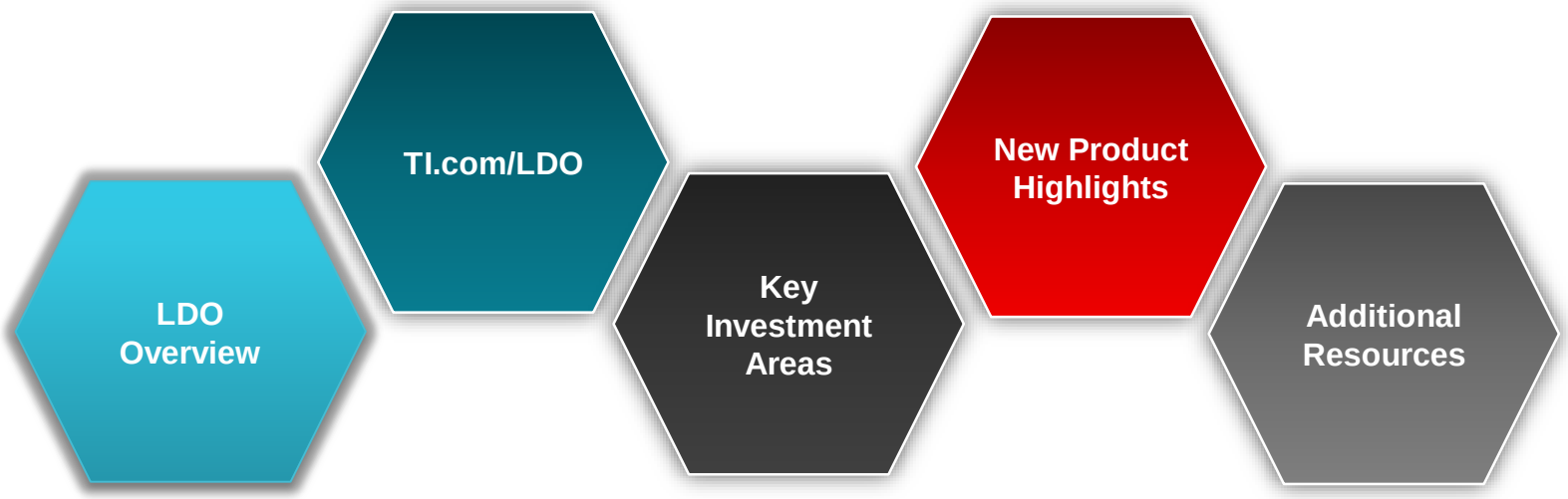
- This webinar will be recorded and available at www.ti.com/npu
- Phone lines will be muted
- Please post questions in the chat or contact your sales person or field applications engineer

New Product Update

Linear Power

Linear & Low-Dropout Regulators

Agenda


LDO Overview
TI.com/LDO
Key Investment Areas
New Product Highlights
Additional Resources

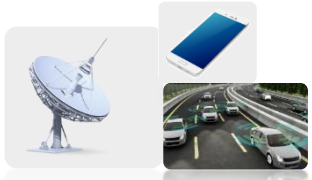
TI LDO – Linear and Low Dropout Regulators

500+ Devices, Best-in-class Performance, Covering wide range of applications, Largest market share in the industry

Low V_{IN} (≤7.5V)

Products
- Low Noise
- Low I_Q
- Standard LDO

Sectors/EEs
- Wireless Infrastructure
- Mobile phones
- Infotainment/Cluster
- ADAS



Mid V_{IN} (>7.5V and ≤30V)

Products
- Low Noise
- Low I_Q
- Standard LDO
- Lin Reg

Sectors/EEs
- Appliances
- Grid Infrastructure
- HEV
- Building Automation

Wide V_{IN} (>30V)

Products
- Low I_Q
- Standard LDO
- Lin Reg

Sectors/EEs
- Infotainment/Cluster
- HEV
- Body electronics
- Appliances/Power Delivery

TI.com/LDO

Improve your system performance with our LDO linear regulators

With the largest portfolio of LDOs, we have the right one for you

Low-dropout (LDO) linear regulators are a simple, inexpensive way to regulate an output voltage that is powered from a higher voltage input in a variety of applications. Browse our portfolio of over 500 devices with features such as low noise, wide input voltage (V_{IN}), small package size, low quiescent current (I_Q), processor attach and the industry's first smart AC/DC linear regulator. We also help you meet nearly any regulator design challenge, from powering sensitive analog systems to extending battery life.

Products | What's new | Power trends

Product portfolio

Our high-performance linear power regulators and low-voltage regulators feature low noise, low I_Q and wide V_{IN} ranges. Our LDO regulators are available in small package sizes and for automotive applications.

Low-VIN (≤7 V)

Design for low-voltage applications with our broad portfolio of low-VIN LDOs.

- Automotive LDOs
- Space-grade LDOs

Find all low-VIN LDOs

Mid-VIN (7 V to 30 V)

Design for multicell battery or other mid-voltage applications with our regulators.

- Automotive LDOs
- Negative LDOs
- Space-grade LDOs

Find all mid-VIN LDOs

Wide-VIN (>30 V)

Enhance system reliability with our robust LDOs featuring input ranges above 30 V.

- Automotive LDOs
- Negative LDOs
- Space-grade LDOs

Find all wide-VIN LDOs

Find all linear regulators >

What's new

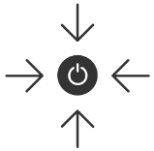
The industry's lowest quiescent current (25-nA), ultra-small LDO regulator

This ultra-small LDO combines low I_Q with fast transient response to improve system lifetime and performance. The TPS7A02 helps reduce solution size by 70%, increase application run times and extend the battery life of your electronics.

Start your design now with the TPS7A02 >

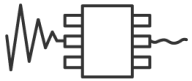
TI POWER

Power density



Low quiescent current (I_Q)

Low noise & precision



Texas Instruments

Key Investment Areas

Automotive

Technology Highlights
- Wide V_{IN} operation
- Highest accuracy across temperature
- Functional Safety compliant

Industrial

Technology Highlights
- Lowest quiescent current
- Smallest form factor
- Lowest output noise

Wide V_{IN}	Increase reliability with the highest working voltage
Low I_Q	Extend battery and shelf life without compromising system performance
Low-Noise	Enhance power and signal integrity to improve system-level performance
Small Size	Achieve higher performance in smaller spaces, enhancing system functionality

TPS7A52/3/4:

Ultra Low-Noise, High-PSRR 2A/3A/4A Robust LDO Family

Features

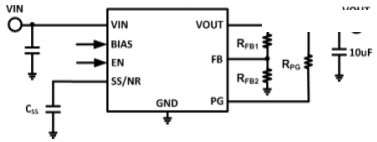
- Maximum Dropout = 100mV @ 2A
- **Vin = 1.4V – 6.5V, no BIAS rail required**
- **Vin = 1.1V – 1.4V, with 3V-6V BIAS rail**
- Very Low Output Noise: **4.4uV$_{RMS}$ (10Hz-100kHz)**
- **0.75% Accuracy over Line/Load/Temp**
- FB adjustable: V_{OUT} = 0.8V-5.2V
- **PSRR: 45dB @ 1MHz**
- Programmable Soft-Start
- Power Good Output
- Available in 2.2x2.5mm SON-12 packages
- **Temperature Range: -40°C to 125°C**

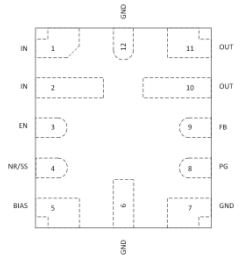
Applications

- High-Speed Analog Circuits: VCOs, ADCs, DACs, LVDS
- Imaging: CMOS Sensors, Video ASICs
- Test & Measurement
- Instrumentation, Medical & Audio
- Digital Loads: Serdes, FPGA, DSP

Benefits

- Supports 1.8V → 1.5V; 1.5 → 1.2V; 1.2V → 0.8V
- Fixed performance with adjustable flexibility
- Remote sensing maximizes Clock/ADC/DAC performance
- Low jitter / low phase-noise of Clock/ADC/DAC
- Less filter required for power-line ripple
- Reduces in-rush current
- Ease to use with multiple rails supplying In, Bias and Enable



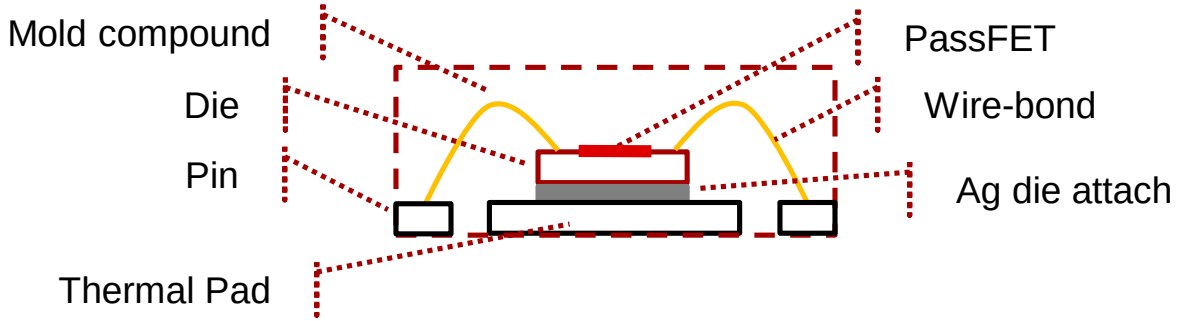


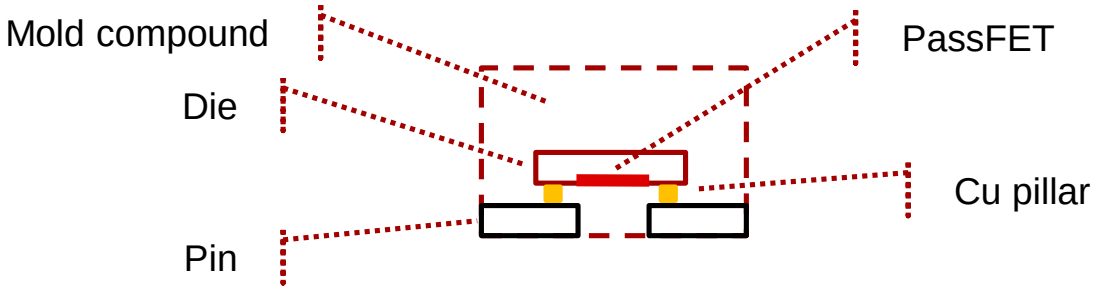
Device	V_{IN}	I_{OUT}	V_{DO}	Package
TPS7A52/3/4	1.1V-6.5V	2A/3A/4A	100mV@2A	SON-12 2.2 x 2.5 mm

Latest High Current + Low-Noise LDOs

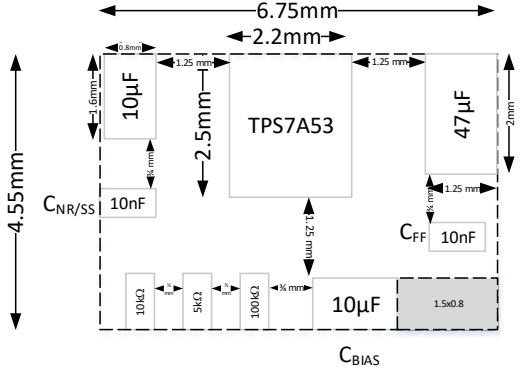
Advantages	2A	3A	4A
-40°C to 150°C	TPS7A52-Q1	TPS7A53-Q1	TPS7A54-Q1
Smallest Solution Size Improved V_{DO} Improved PSRR	TPS7A52	TPS7A53	TPS7A54
ANY-OUT Programming	TPS7A83A	TPS7A84A	TPS7A85A

Traditional vs HotRod package





Solution Size comparison

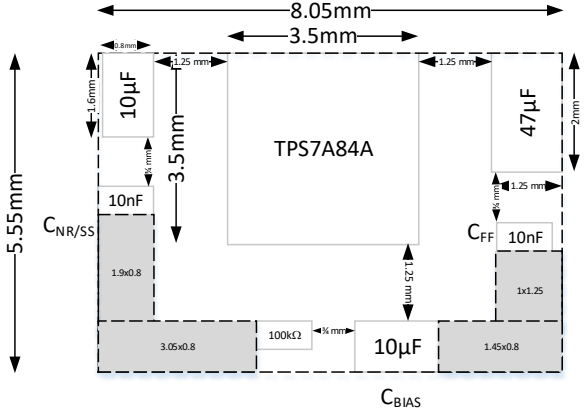


TPS7A53
Total footprint
29.5 mm²

47µF X5R (0805,6.3V_{DC}, ±20%, Murata)
GXM31CE70J476ME10#

10µF X7R (0603,10V_{DC}, ±10%, Murata)
GRM188Z71A106KA73#

10nF X7R (0402,16V_{DC}, ±10%, Murata)
GRM033R71C103KE14#



TPS7A84A
Total footprint
40.6 mm²

47µF X5R (0805,6.3V_{DC}, ±20%, Murata)
GXM31CE70J476ME10#

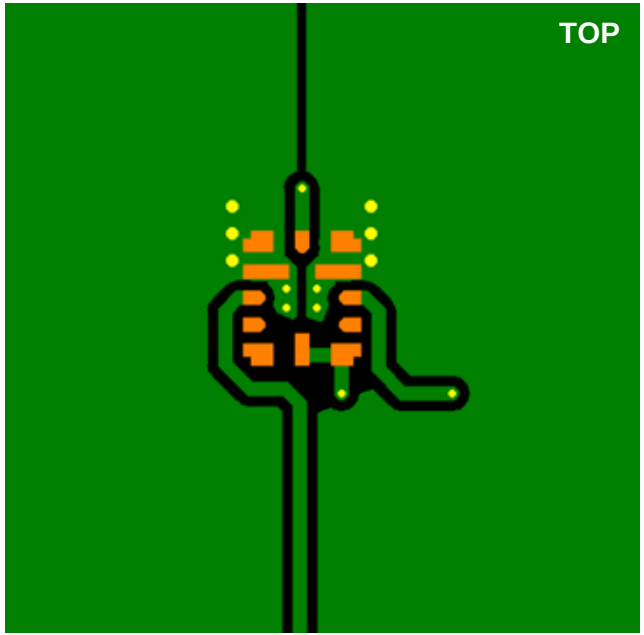
10µF X7R (0603,10V_{DC}, ±10%, Murata)
GRM188Z71A106KA73#

10nF X7R (0402,16V_{DC}, ±10%, Murata)
GRM033R71C103KE14#

EVM Comparison (reduced # of vias)

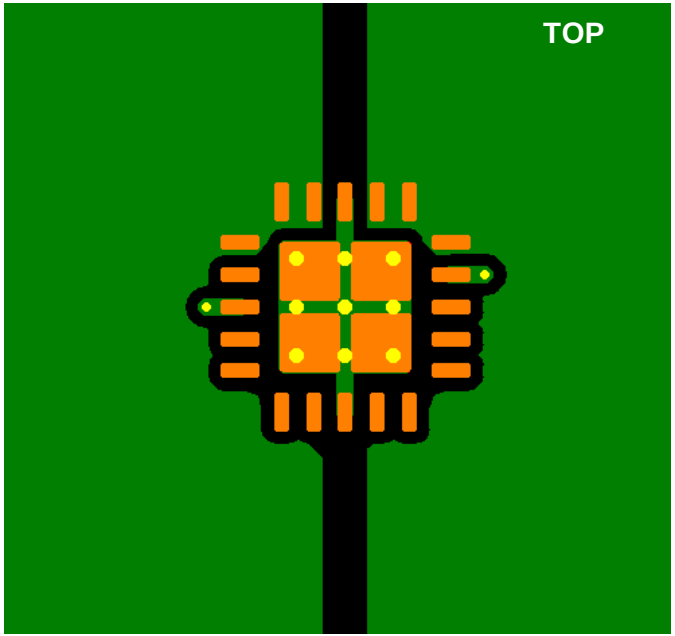
TPS7A5xRPS

- PCB Size: 114.3 x 76.2 x 1.6 mm
- 4 Layers: 8 mil vias
  5 mil vias under device



TPS7A84ARGR

- PCB Size: 114.3 x 76.2 x 1.6 mm
- 4 Layers: 8 mil vias for thermal pad



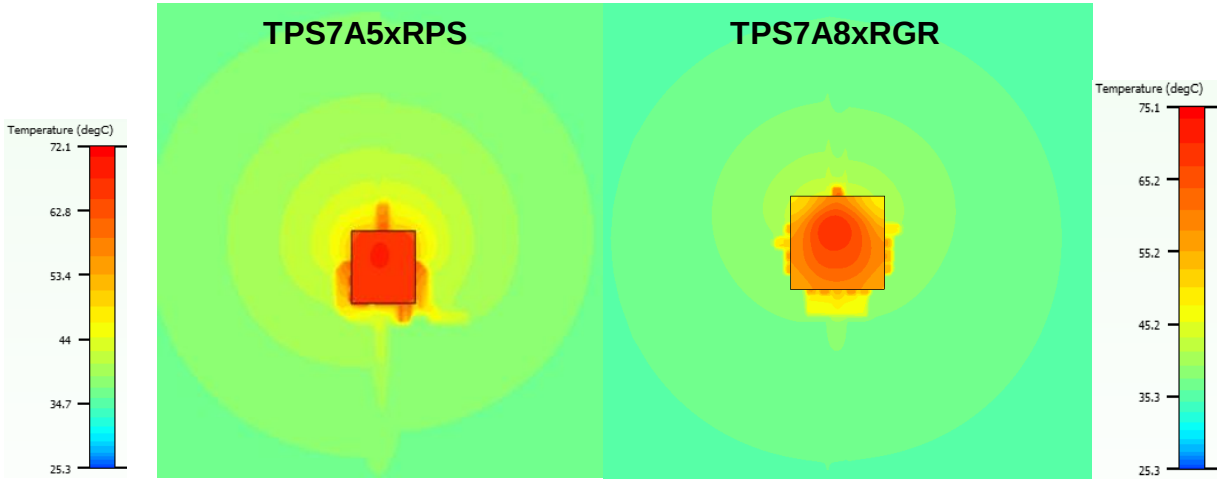
Board level Temperature Map

Conditions:

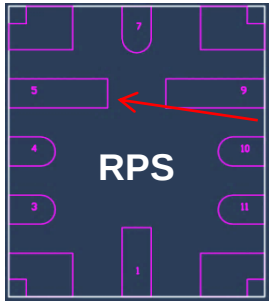
- Assumed 1 W power dissipation evenly distributed on Pass FET area
- 25 °C Ambient

Results:

- The HotRod packaging allows heat to **spread more evenly** which results in more heat transfer out of the package reducing the max die temp
  - **55% smaller** than original RGR
  - **2.8°C Cooler** under same operating conditions



Parameter	TPS7A5xRPS	TPS7A8xARGR
Max Die Temperature	72.3 °C	75.1 °C
Theta-JA	47.3 °C/W	50.1 °C/W



*“Case temp” monitored here

TPS7A20

300 mA Ultra Low I_Q, Low Noise, Small Size LDO

Features

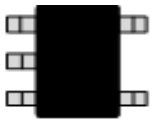
- **Very low noise: 7 μV_{RMS} (10-100kHz)**
- **Low I_Q: 6.5 µA (typ)/10µA(max) 0.5µA disabled**
- **No external noise reduction capacitor**
- **High PSRR: 85 dB at 1 kHz**
- Low dropout: 140 mV max @ 3.3V
- ±1.5% Total output voltage tolerance
- Small size 0.65mm x 0.65mm WCSP, 1mm x 1mm DQN, SOT23-5

Applications

- Mobile Phones, Tablets
- Digital/IP Cameras and Audio Devices
- Portable Medical Equipments
- RF, PLL, VCO, and Clock Power supplies
- Motor Drives
- Smart Meters and Field Transmitters

Benefits

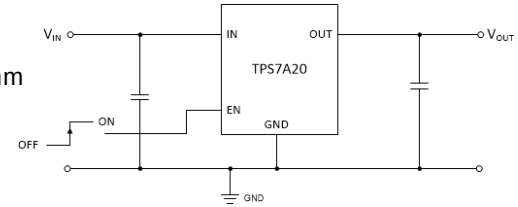
- **Lowers the noise floor to help comply with RF standards**
- Minimal battery drain to improve operating life
- Saves PCB area
- Filters input ripple from upstream converters
- Can support low V_{IN}-V_{OUT} (i.e. 2.8->2.5V)



SOT-23

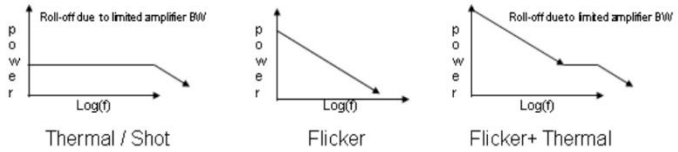
X2SON
1mm x 1mm

DSBGA



Device	V_{IN}	V_{OUT}	I_{OUT}	V_{DO}	I_Q	Package
TPS7A20	1.6 to 6.0V	0.8 to 5.5V	300 mA	140 mV	6.5µA	Ultra thin DSBGA-4, X2SON, SOT-23

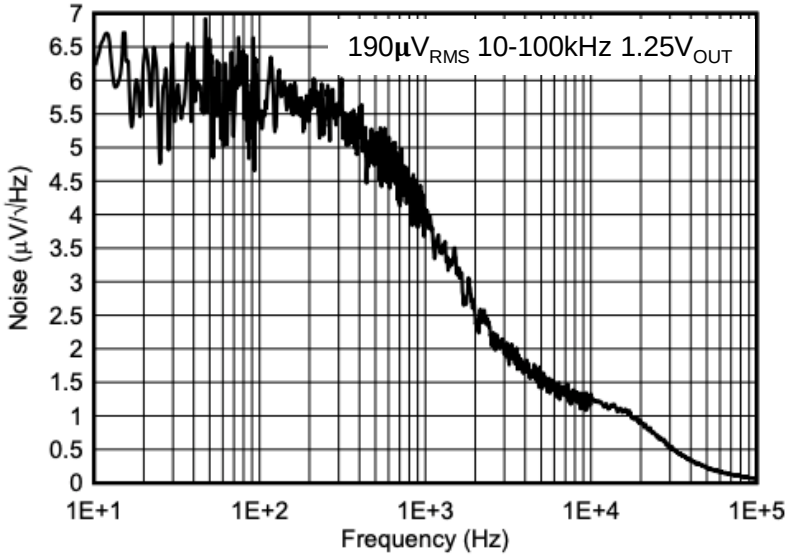
Low I_Q vs Noise



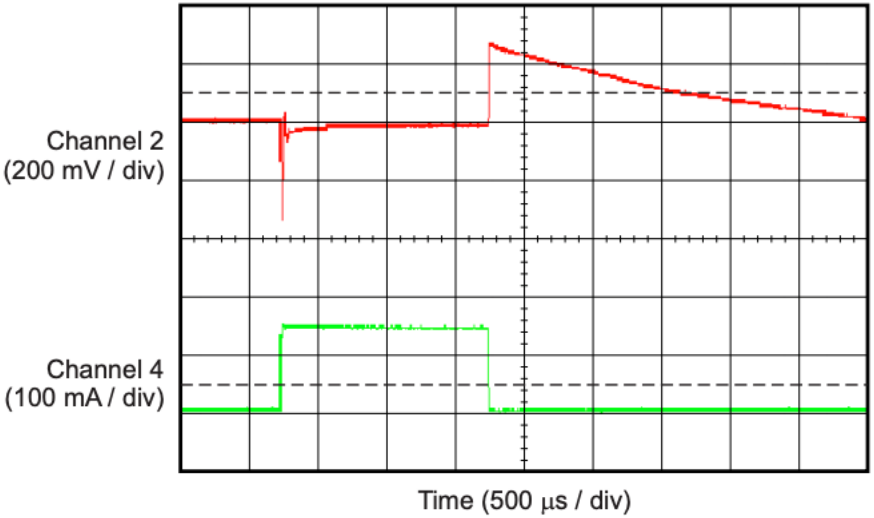
- Semiconductor Noise has two primary sources
  - Thermal/Shot
  - Flicker
- The primary source of noise in an LDO is the bandgap reference
  - This Noise is gained up as a function of V_{OUT}
- Some common techniques to reduce noise internally are
  - Lower the bandwidth of the error amp
    - This slows transient response
  - Increase the bias currents
    - This reduces the size of the resistors which reduces the Thermal noise or Johnson-Nyquist noise ($v_n = \sqrt{4k_B T R \boldsymbol{\Delta} F}$)
    - This also increases the I_Q

Transient and Noise Plots

- Here is an older Low I_Q LDO
  - The TPS706 is a 1µA I_Q Regulator



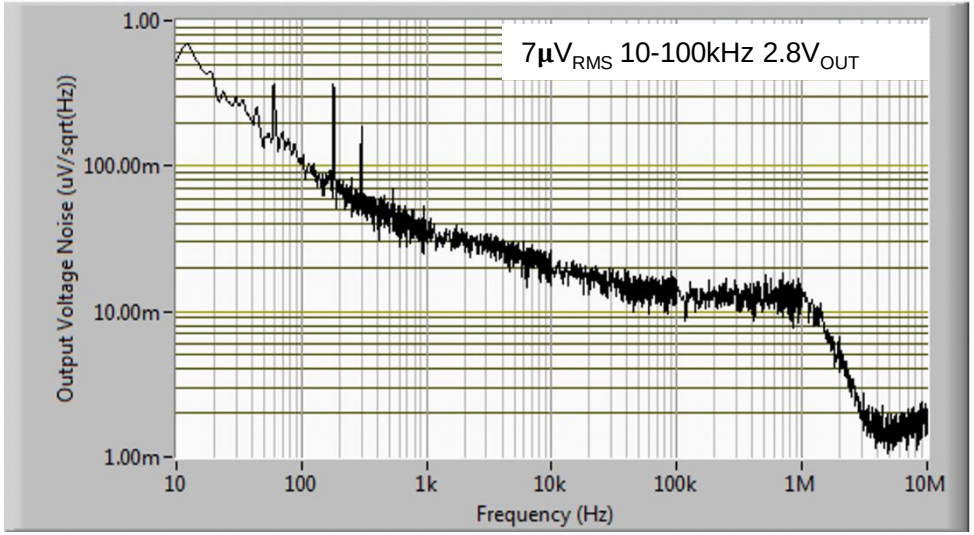
V_{OUT} = 2.8 V

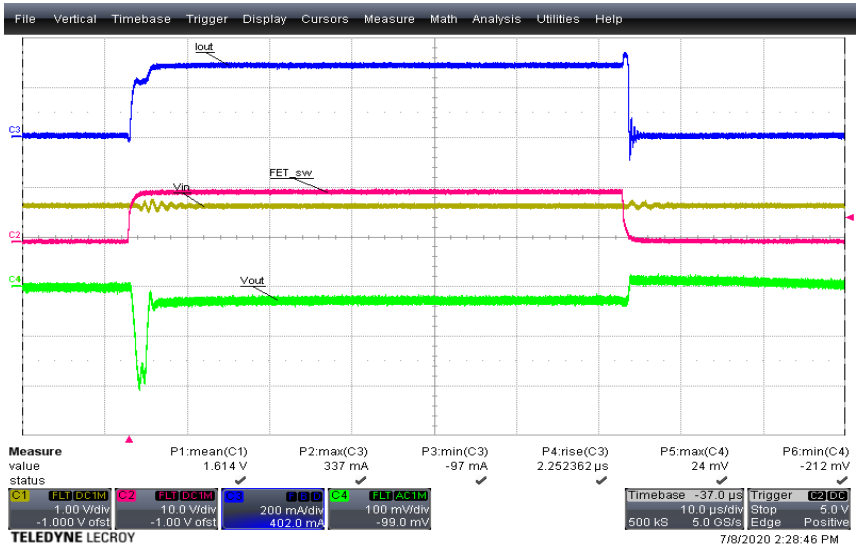


Channel 2 = V_{OUT}, channel 4 = I_{OUT}, V_{IN} = 2.7 V

TPS7A20 Noise and Transient Plots

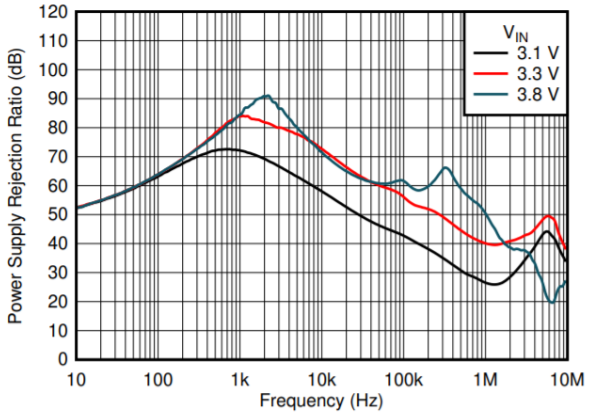
- The I_Q of the TPS7A20 is 6.5µA
  - Noise reduction is >30x of the TPS706
  - Load transient response is 100x faster than the TPS706



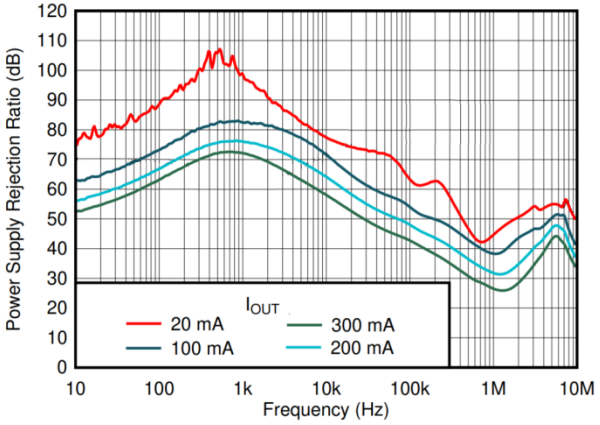


PSRR and V_{DO} (Drop-Out)

- PSRR is an indication of how well the LDO can filter input ripple
- An LDO needs some headroom
  - When in drop-out the LDO loses its ability to filter the input ripple since V_{OUT} will track V_{IN}
- At 2.8V the TPS7A20 has a maximum V_{DO} of 140mV
  - This helps to improve PSRR performance with lower V_{IN}-V_{OUT} differentials



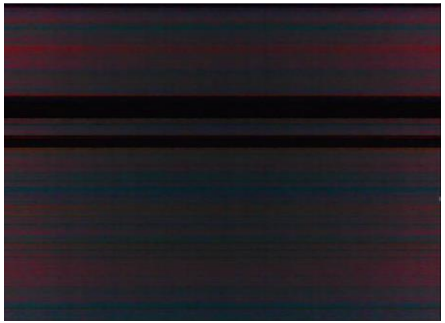
Vout=2.8V Iout=300mA



Vout=2.8V Vin=3.1V

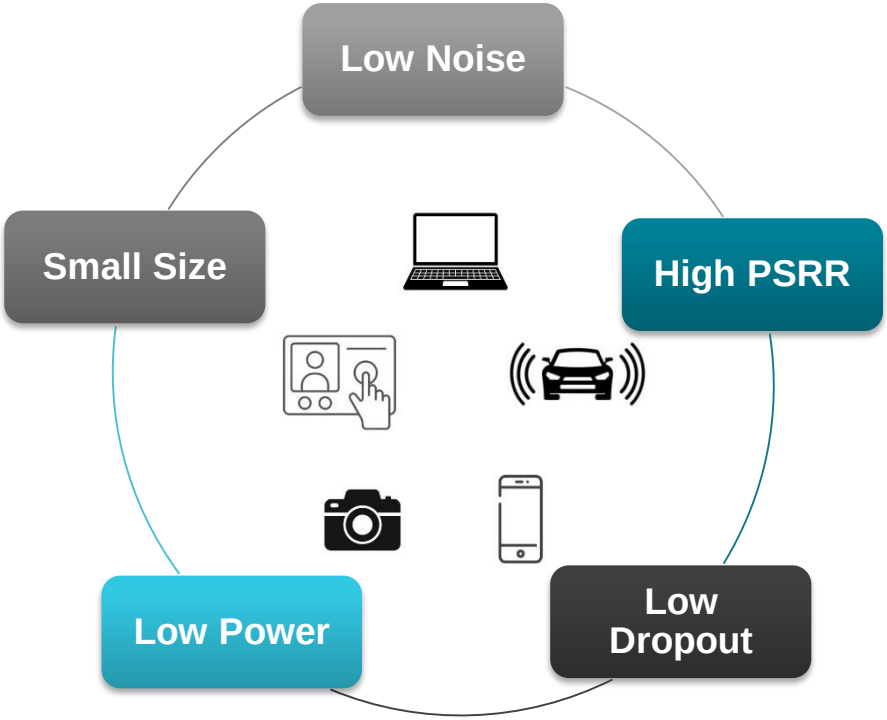
Why Low Noise + High-PSRR Matters

- Camera applications require sufficient PSRR & low-noise in order to attenuate voltage ripple generated by upstream supplies
  - Critical Frequency Range: **1kHz to 1MHz+**
  - Insufficient PSRR / low-noise of the power supply will result in pixelated images

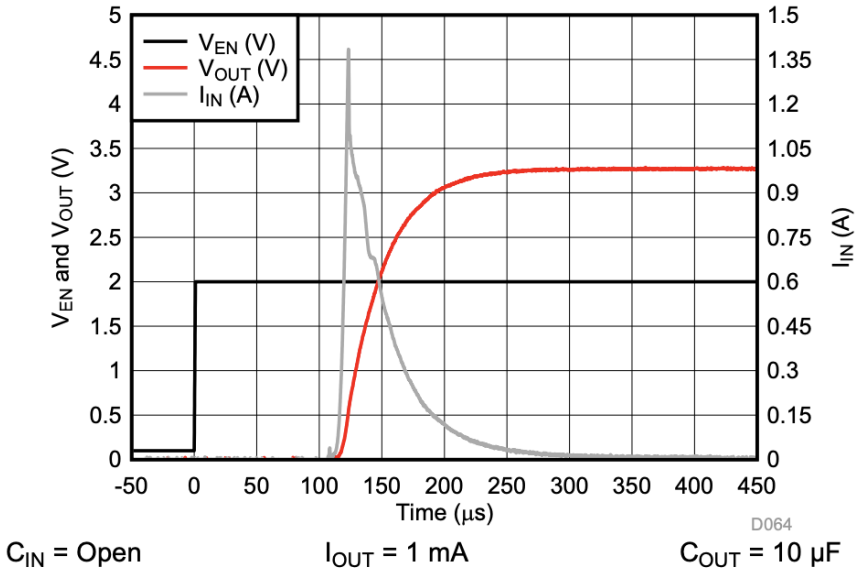


High Noise LDO

Low Noise LDO



Why Inrush Control is Important

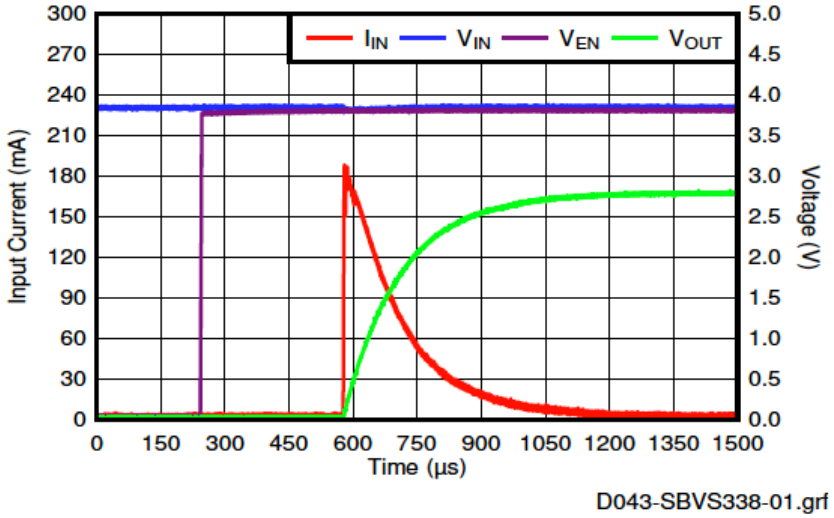


C_{IN} = Open I_{OUT} = 1 mA C_{OUT} = 10 µF

- Inrush can result in the input voltage dropping
  - To minimize this C_{IN} needs to be increased to help supply the load current
  - The Upstream supply may also go into current limit if the inrush current is too high
  - This can add size and extra area
- This also limits the maximum amount of capacitance you can put out the output
- This plot shows a 500mA LDO that does not have proper inrush control
  - The spike in current is going up to 1.35A!

TPS7A20 Inrush Control

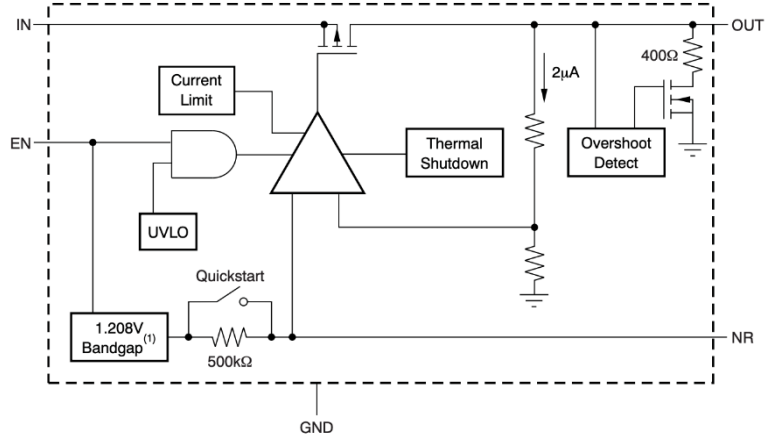
- The TPS7A20 does not even hit its own current limit under similar conditions
- This minimizes the need for input capacitance
  - In some cases it may eliminate it altogether!
- The TPS7A20 can handle up to 200µF at V_{OUT}
  - This helps maintain regulation during extreme load transients

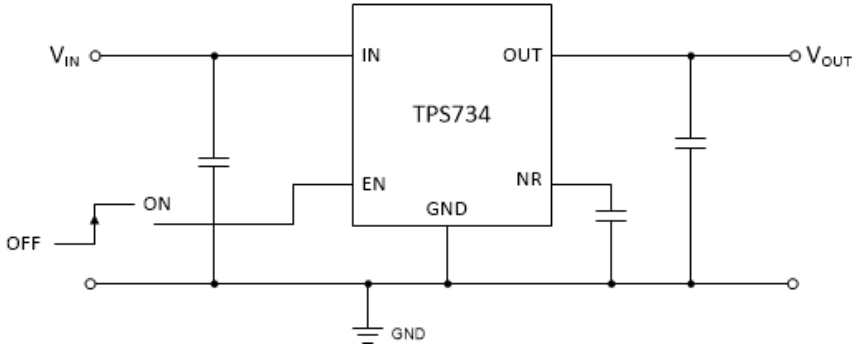


V_{IN} = 3.8 V, V_{EN} = 0 V -> 3.8 V, V_{EN} slew rate = 1 V/µs, Cout = 10 µF

PCB Area vs Performance

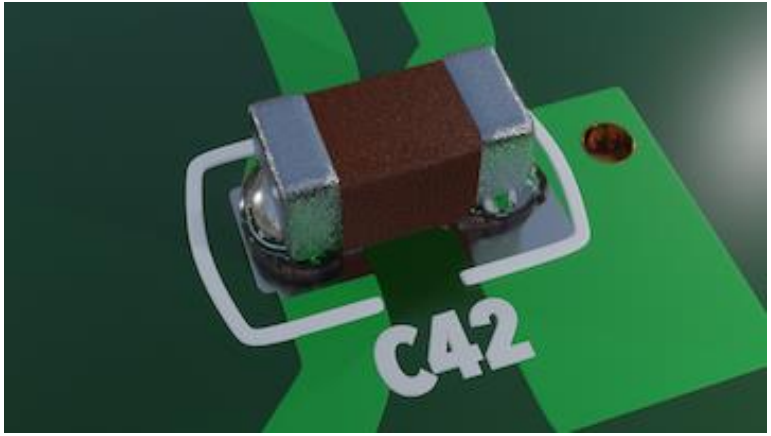
- Low Noise LDO's commonly use an external capacitor to filter the bandgap noise
  - Originally this filtered the bandgap directly as shown with our TPS734
  - Since the bandgap is gained up, noise will increase as V_{OUT} increases
- An external capacitor is required to optimize low noise performance

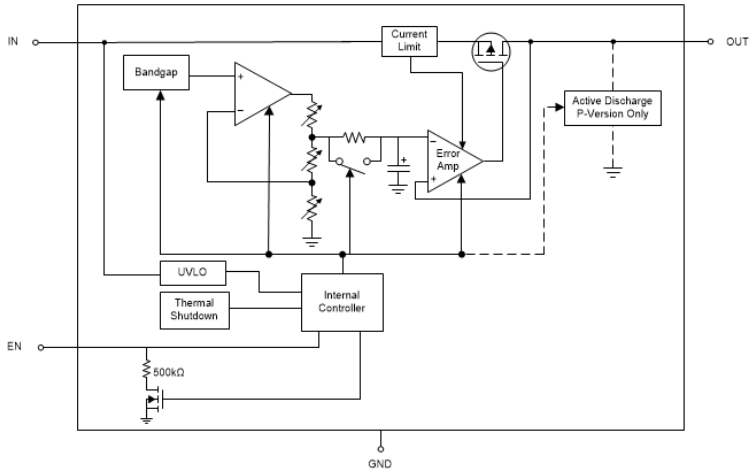


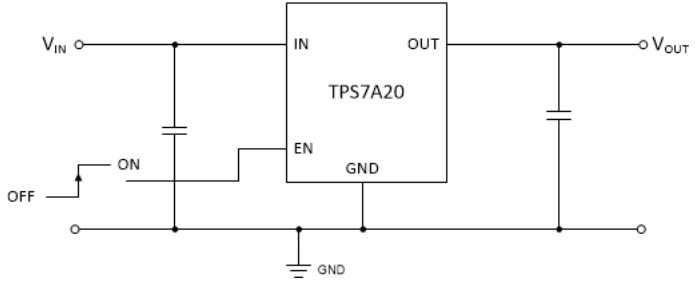


TPS7A20 PCB Advantage

- The TPS7A20 uses an RC filter
  - Instead of filtering the bandgap directly we are now filtering after the band gap reference is gained-up
  - The impact of V_{OUT} on noise is minimized





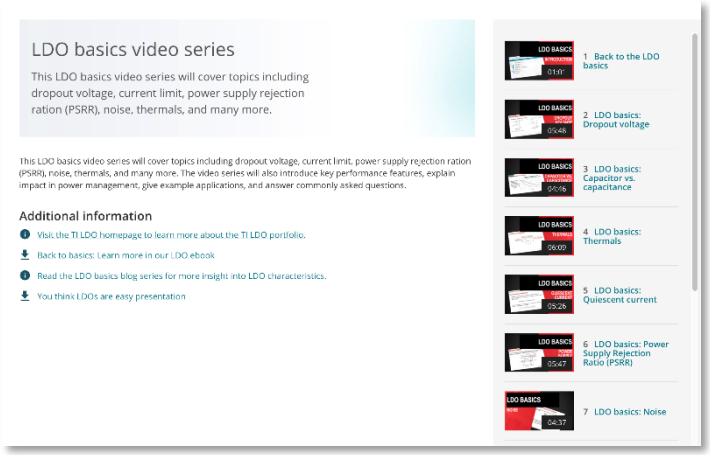


LDOs to Leverage in 2020/2021

LDO Quick Reference Guide

LDO Type		Existing Solutions	Newer Solutions	Upcoming/Recently Released Solutions	Features/Benefits
Low V_{IN} (<= 7.5V)	Low I_Q	TPS782, TPS706	TPS7A05	TPS7A02/3	- Nano-power I_Q: 25nA / 200nA - Excellent Transient Response - P2P in DSBGA, SOT-23, X2SON
	Low Noise (> 1A)	TPS7A83/4/5A	TPS7A91/92	TPS7A52/3/4	- High Current Capability (2A / 3A / 4A) - Small Package: 2.2 x 2.5mm - 0.5% Accuracy
	Low Noise (< 1A)	LP5907	TPS7A90	TPS7A20	- Low Noise (6uVrms) - Ultra-low I_Q (6.5uA) - High PSRR
	Cost Effective	TLV741/2/3	TLV755/7 TLV758/9	TLV751/2 TLV740	- Dual Channel, 500mA / 1A Capability - Small 2x2 mm package - Lowest cost LDO
Mid V_{IN} (7.5 – 30V)	Low I_Q	TPS709	TPS7A25/6	TPS7A24	- Ultra-low I_Q (2 uA) - Low Dropout Voltage - Industry standard SOT-23 package/pinout
	Cost Effective	TLV1117	TLV767	TLV767-MSOP	- Cost Effective 1A capable device - Improved performance vs traditional -1117 - Leaded Package with improved thermals
	Smart AC/DC LDO	Discrete Cap Drop power supply	NA	TPS7A78	- Magnetic Free AC/DC Power Architecture - Lower Standby Power - Ideal for <600mW AC/DC Power Supplies
Wide V_{IN} (> 30V)	Low Iq	TPS7A16	NA	TPS7B81	- Ultra-low I_Q (3uA) - Wide VIN (up to 40V)
	Low Noise	TPS7A47 TPS7A33	TPS7A39	-	- Dual Channel (+/-) - Monotonic Start-up Tracking

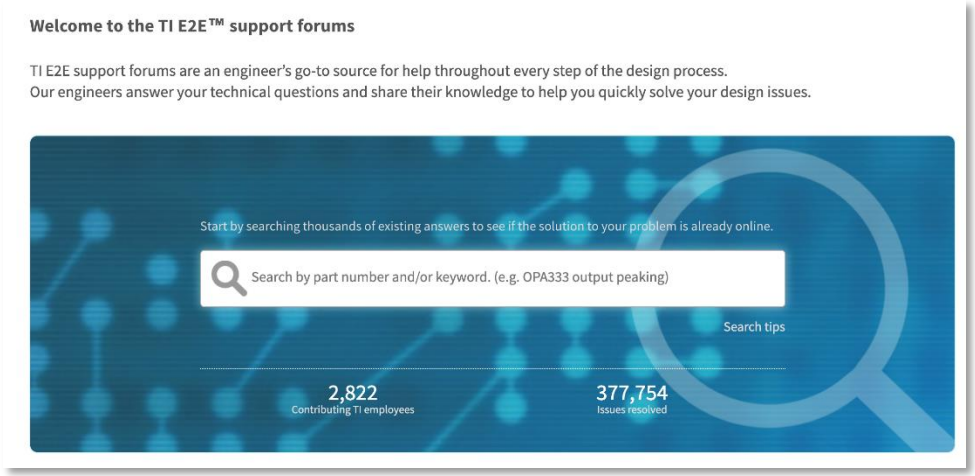
Additional Resources



LDO Basics Videos

LDO Basics E-Book

E2E



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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265