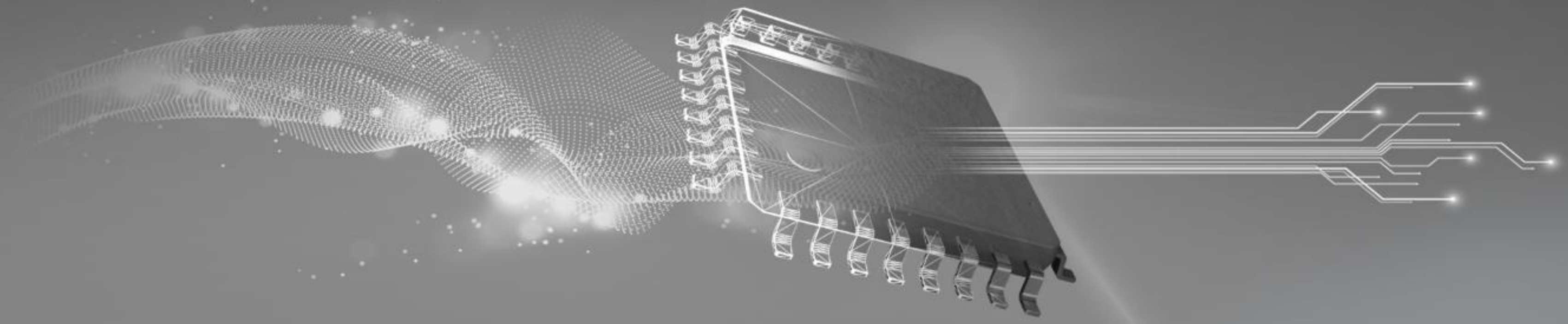
TI TECH DAYS



Solving the Key Design Challenges of Automotive Cameras

Gerard Copeland

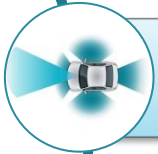
APP-BMC-IPM

Agenda

- Key Design Challenges of Automotive Cameras
  - How the TPS65033x-Q1 Camera PMIC family addresses these challenges
  - Solution Size
  - Scalability
  - System Efficiency
  - Noise Performance
    - Evaluating Power Supply Noise Performance for Camera Applications
- Recap
- Questions

Key Design Challenges of Automotive Cameras

Solution Size



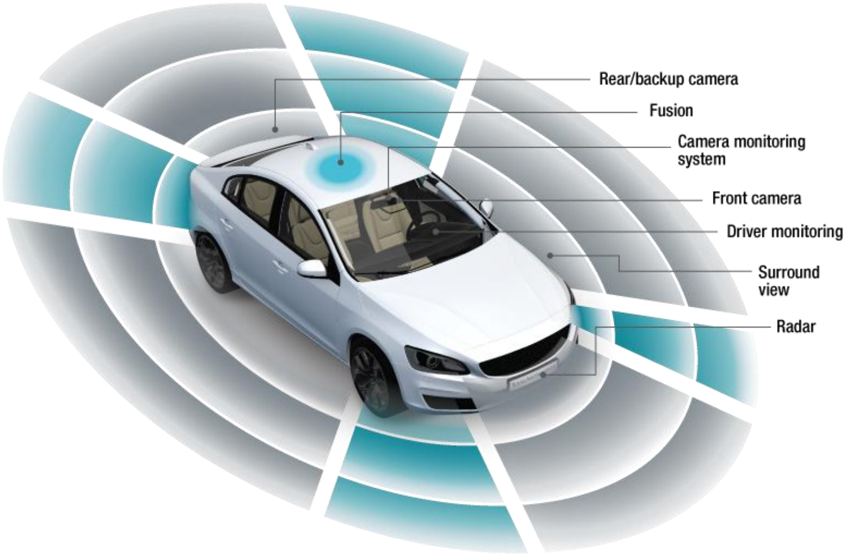
Scalability

System Efficiency

Noise Performance

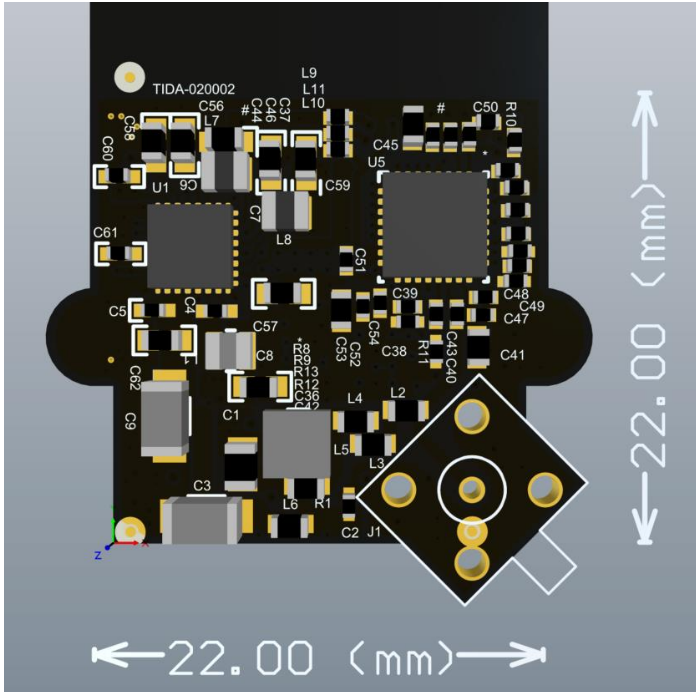
Solution Size

- Camera modules must be small to fit in remote regions of the vehicle
  - Common PCB area constraints are 20 mm x 20 mm or smaller on a single PCB

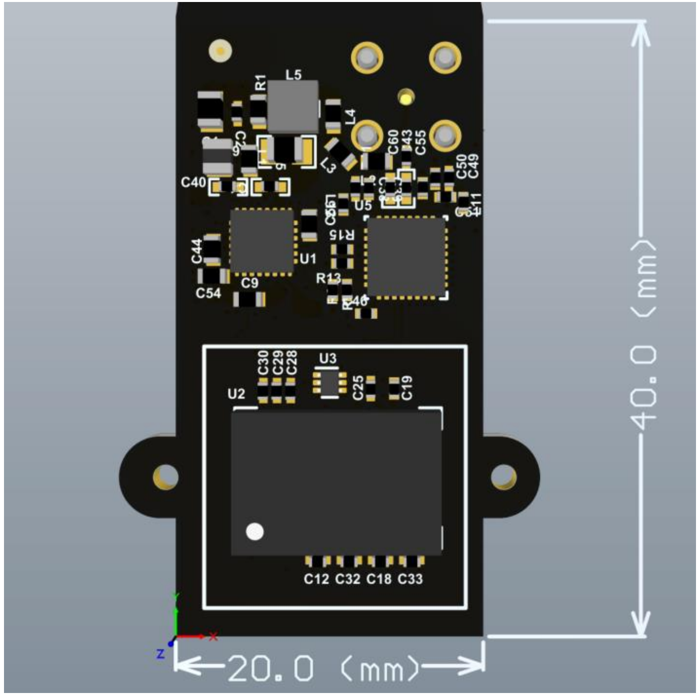


- Integrated PMICs reduce solution size
  - No external resistors
  - No power sequencers
  - No additional routing of Power Good signals
  - No external supervisors or monitors
- Designed for use with small inductors
  - 2.0 mm x 1.6 mm Q100 grade inductors
- Cascaded operation can reduce decoupling capacitor requirements

Reference Designs



TIDA-020003



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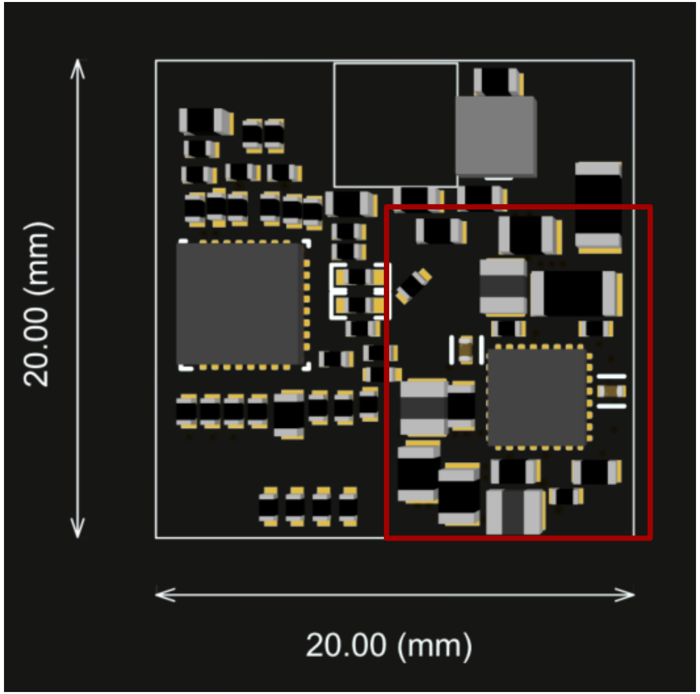
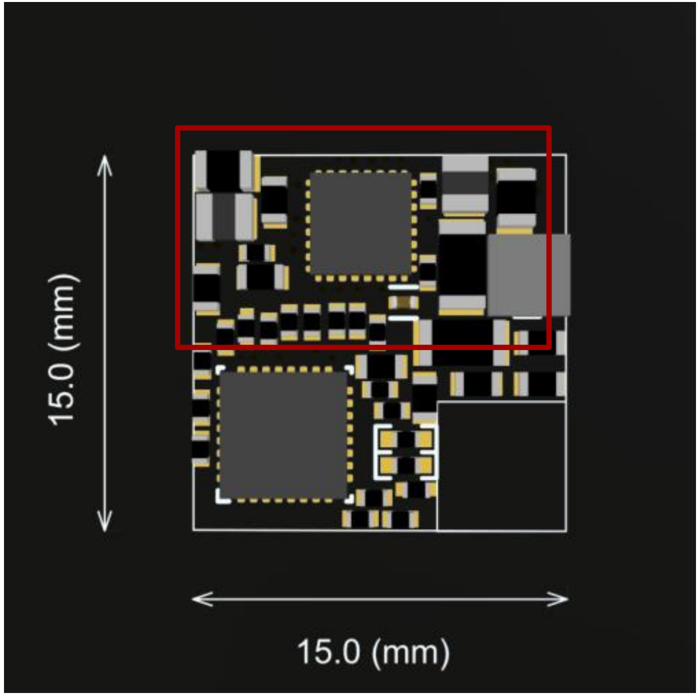
Example Layouts



20 mm x 20 mm Example Layout



15 mm x 15 mm Example Layout

Scalability

Core Applications

Surround View Camera
Satellite View Camera

Smart Rear View Camera
Smart Camera with or without Functional Safety

360 View L5 Autonomous
Camera with Functional Safety

Remote Front Camera
Front Camera over Serializer & Dash Cam DVR

Emerging Applications

Blind Spot Viewing
High Performance with Functional Safety

Driver Monitoring
High Performance with or without Functional Safety

eMirror
High Performance with Functional Safety

Cabin Monitor
Scalable Performance

Programmable Family Approach

TPS650320

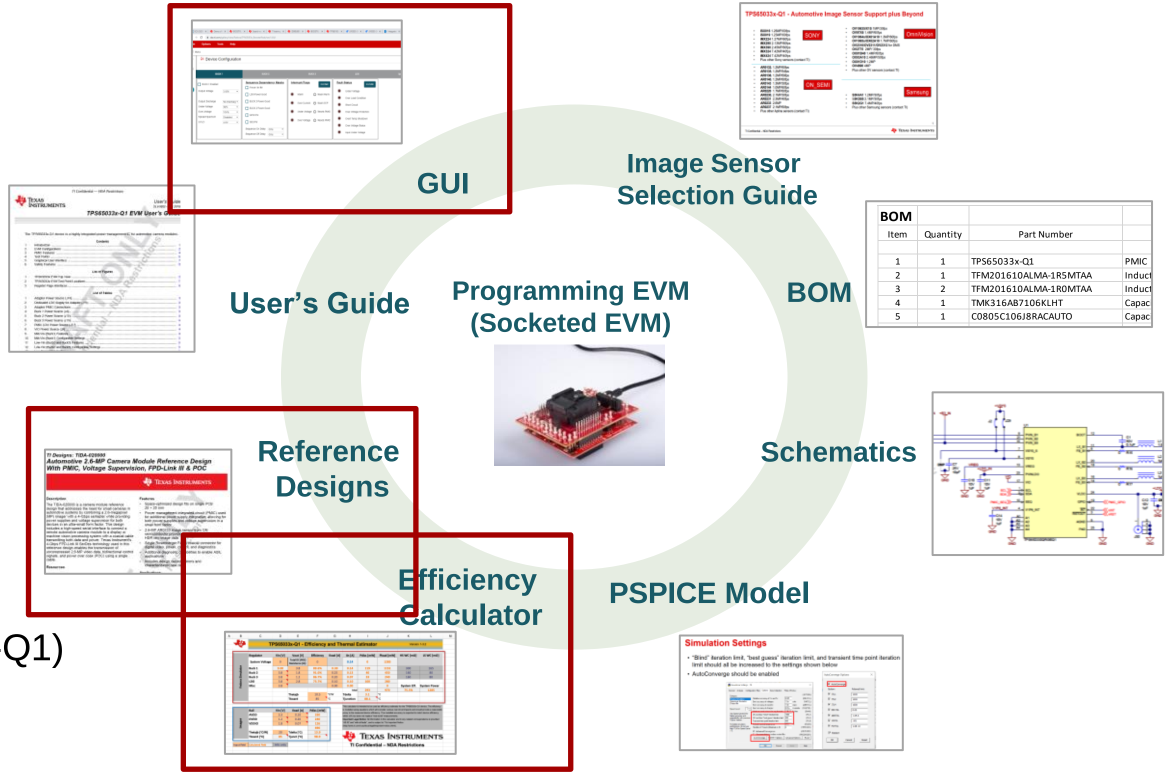
- Lower Output Power
- Low Cost
- No Functional Safety

TPS650330

- High Output Power
- No Functional Safety

TPS650331+

- High Output Power
- Functional Safety
- Watchdog (TPS650333-Q1)



Automotive Vision Applications

Core Applications

Surround View Camera
Satellite View Camera

Smart Rear View Camera
Smart Camera with or without Functional Safety

360 View L5 Autonomous
Camera with Functional Safety

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Cabin Monitor
Scalable Performance

Automotive Vision Applications

Core Applications

Surround View Camera
Satellite View Camera
- TPS650320
- TPS650330

Smart Rear View Camera
Smart Camera with or without Functional Safety
- TPS650330
- TPS650331+

360 View L5 Autonomous
Camera with Functional Safety
- TPS650331+

Remote Front Camera
Front Camera over Serializer & Dash Cam DVR
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Emerging Applications

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High Performance with Functional Safety
- TPS650331+

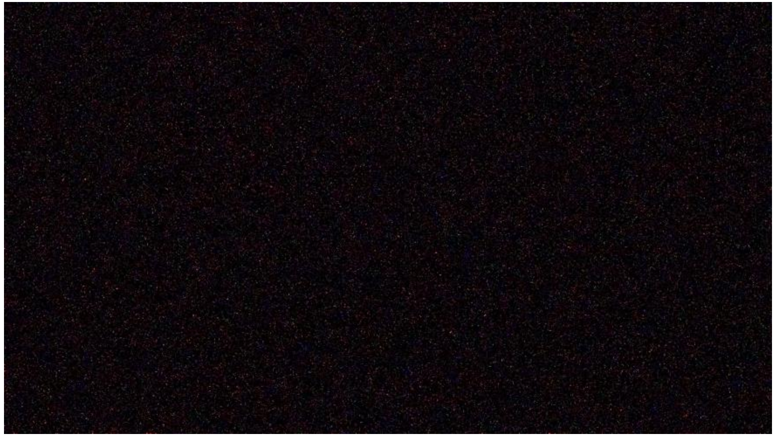
Driver Monitoring
High Performance with or without Functional Safety
- TPS650330
- TPS650331+

eMirror
High Performance with Functional Safety
- TPS650331+

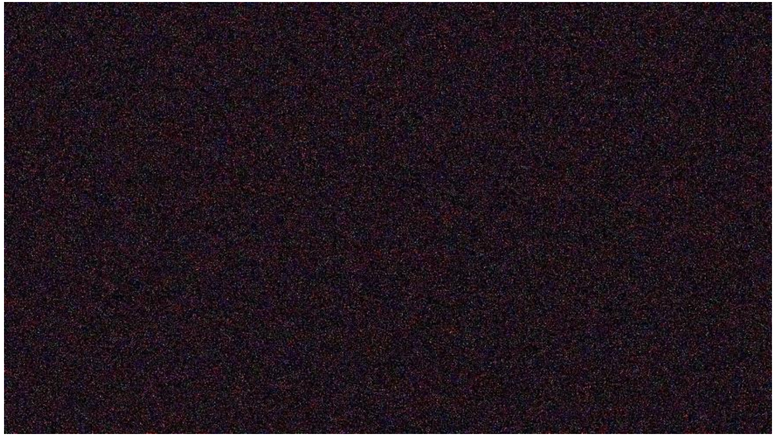
Cabin Monitor
Scalable Performance
- TPS650330
- TPS650331+

System Efficiency

- An efficient power supply reduces power dissipation
- Image quality degrades at higher temperatures due to increases in
  1. Shot noise: current fluctuations, especially in the pixel (dark current)
  2. Thermal noise: random movement of electrons



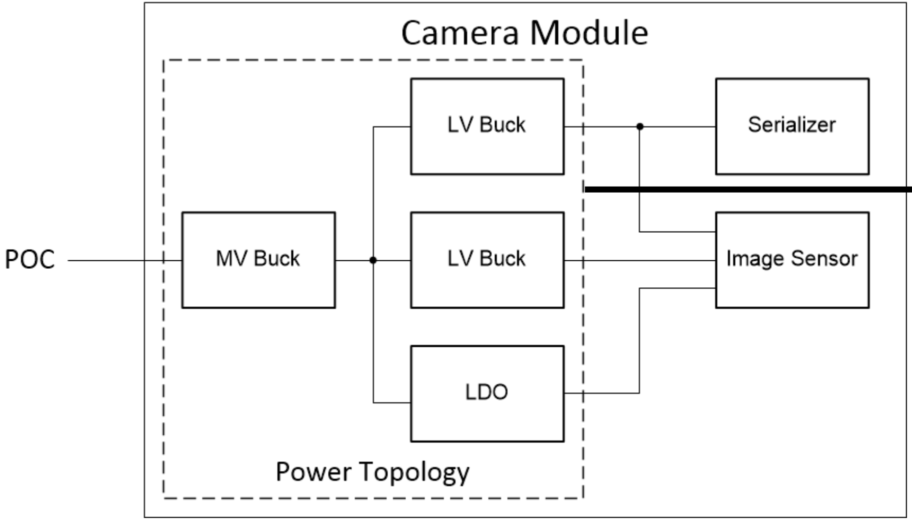
Camera Module Dark Image at 25ºC Ambient

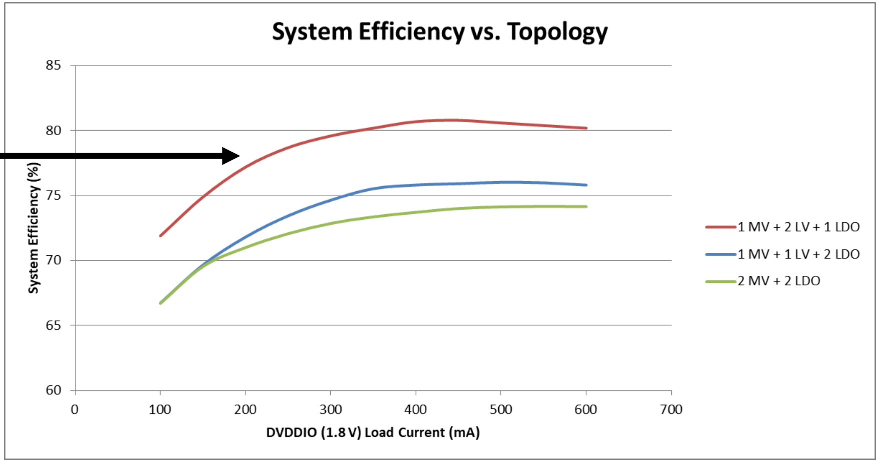


Camera Module Dark Image at 85ºC Ambient

Industry Leading Efficiency

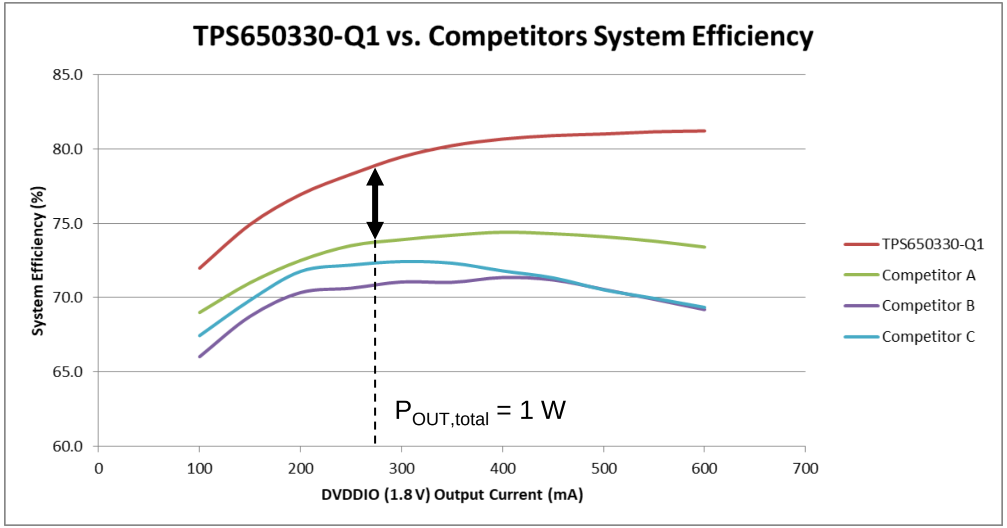
1. Most efficient power topology





Industry Leading Efficiency

2. Advanced TI 130 nm analog process
   – Small Figure-Of-Merit (FOM) for power transistors = $R_{DS,on} * Q_G$

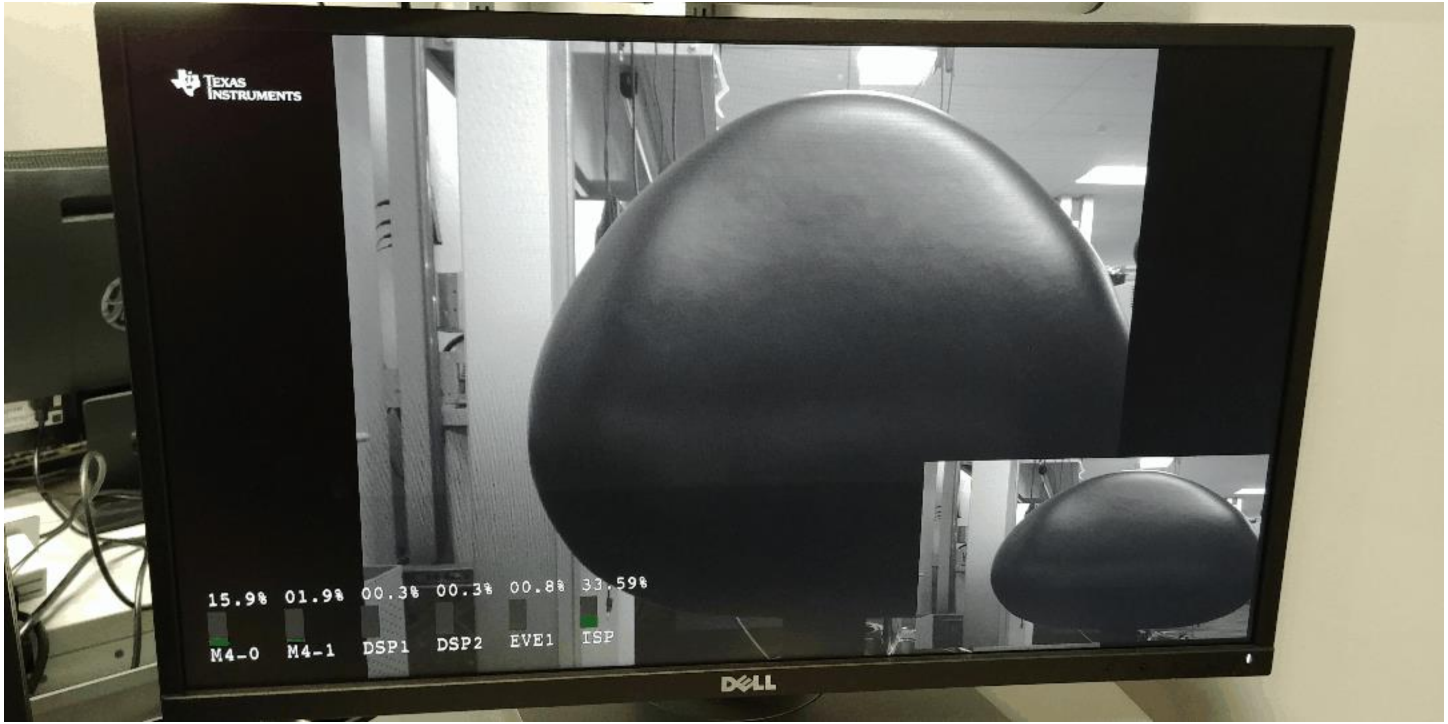


- I_{AVDD} = 50 mA
- I_{CORE} = 100 mA

→ P_D = 280 mW → ΔT_B = 5°C
→ P_D = 370 mW → ΔT_B = 10°C
→ P_D = 410 mW → ΔT_B = 15°C

$$\Delta T_B \cong P_D(\theta_{JA} - \Psi_{JB})$$

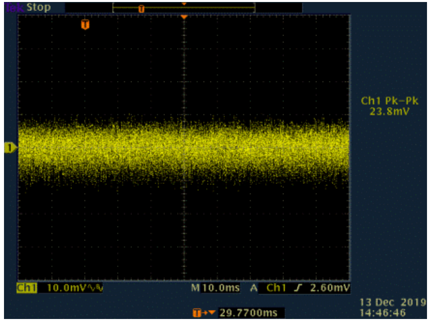
Noise Performance

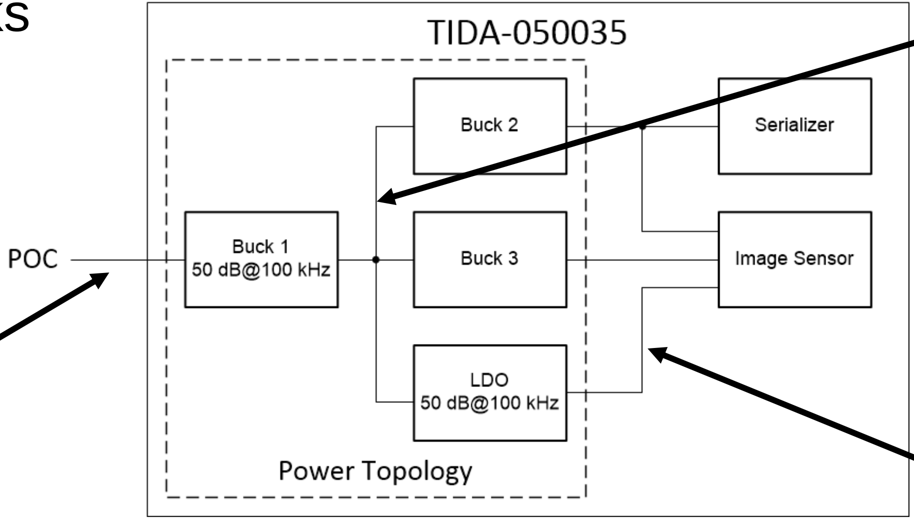


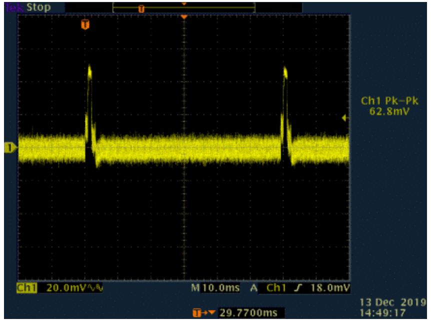
Camera Module Row Noise with 200 mVpp @ 42 kHz Injected on AVDD

System Level Noise Performance

- Good transient response
- Low ripple Bucks
- Low noise LDO
- High PSRR







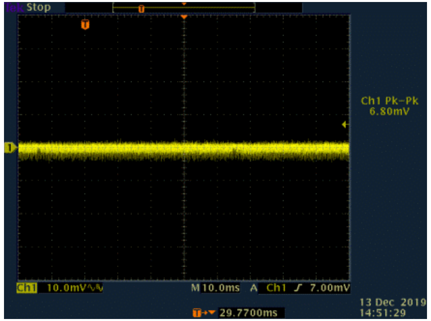
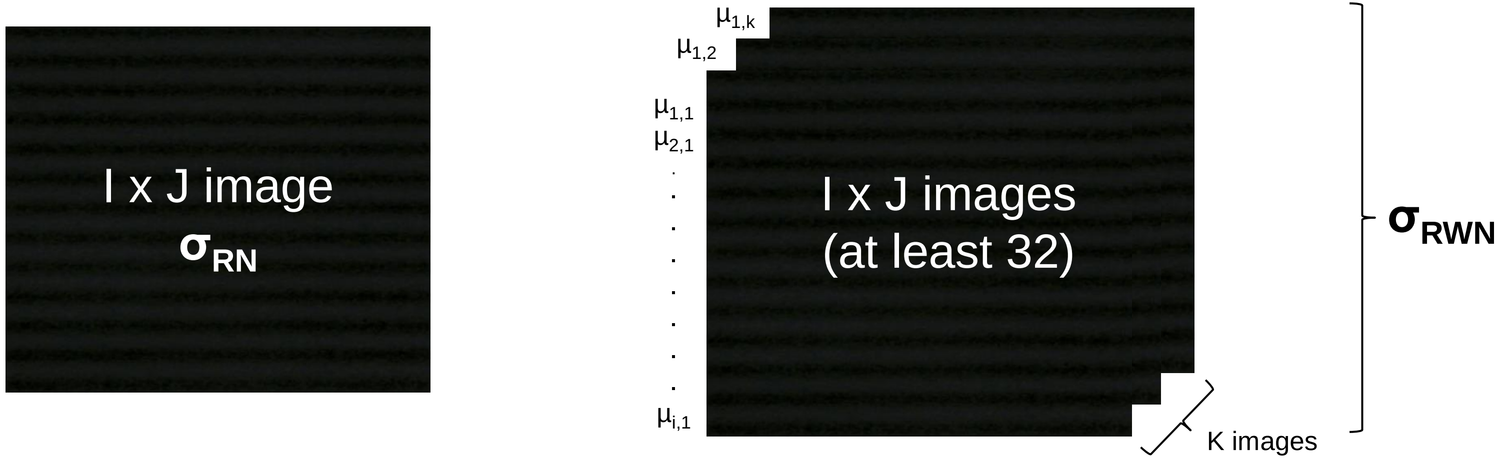


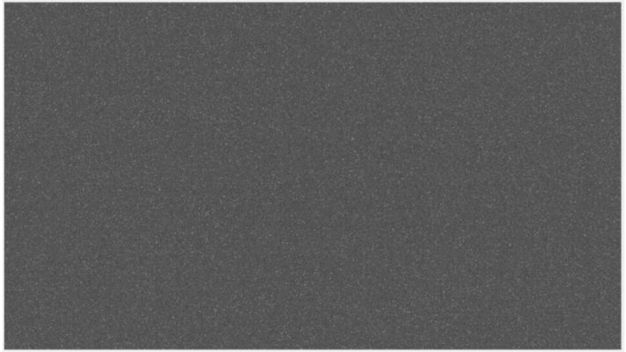
Image Sensor Noise Metrics

- Supply performance can be evaluated with output image noise metrics
  - Image data collected in no light conditions with sensor set to high analog gain
  - Random Noise: standard deviation of all pixels in a given frame
  - Row-wise Noise: standard deviation of pixel row-averages
- Typical requirement: Row-wise Noise over many frames << Random Noise



Example

- Reference design: TIDA-050035
- Sensor operation: 1920 x 1080 resolution @ 30 fps
- RAW12 sensor data collected in no-light conditions
- Analog gain = 30 dB



Example image with 16x digital gain for visibility
No visible structural noise

$\sigma_{RWN} = 2.07$

$\sigma_{RN} = 109$

Recap

- Key design challenges of automotive cameras:
- How does the TPS65033x-Q1 address these challenges?
  1. Solution Size
     - Design around full integration and minimizing external components
  2. Scalability
     - Programmable device family approach to support core and emerging applications
  3. Efficiency
     - Maximized efficiency in terms of power topology and technology
  4. Noise Performance
     - Low noise, high PSRR regulators with good transient performance
     - Image noise metrics for automotive camera applications

Questions?

Thank you for joining the session!

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