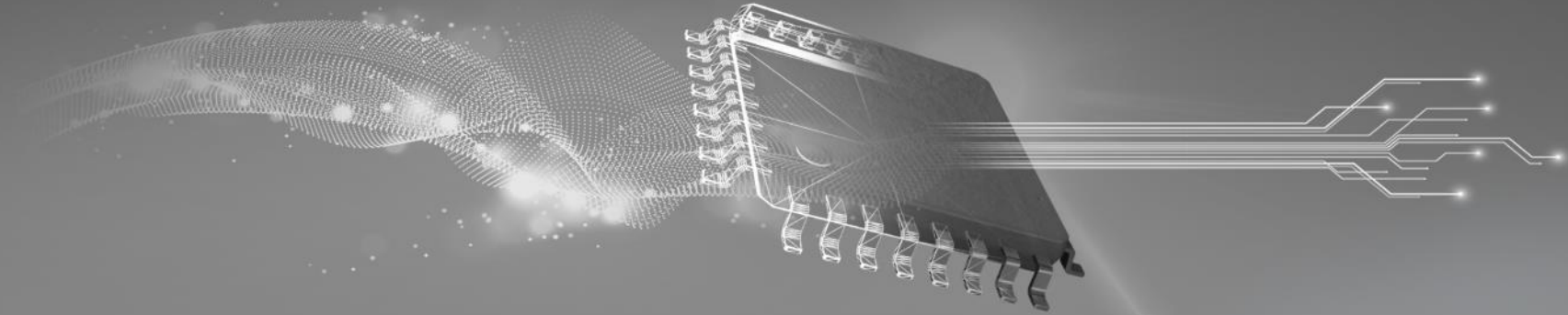


TI TECH DAYS



Solving the Key Design Challenges of Automotive Cameras

Gerard Copeland

APP-BMC-IPM

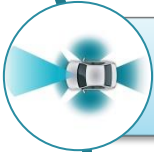
Agenda

- 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

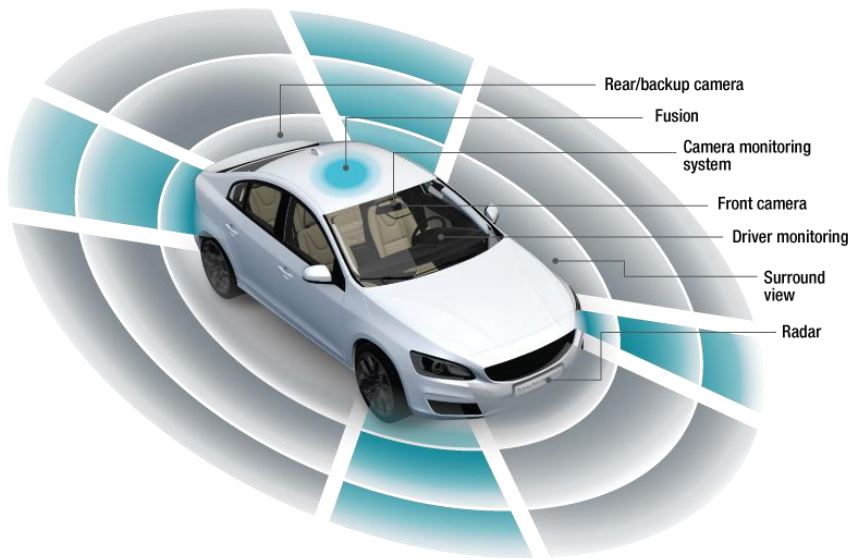


Noise Performance



Solution Size

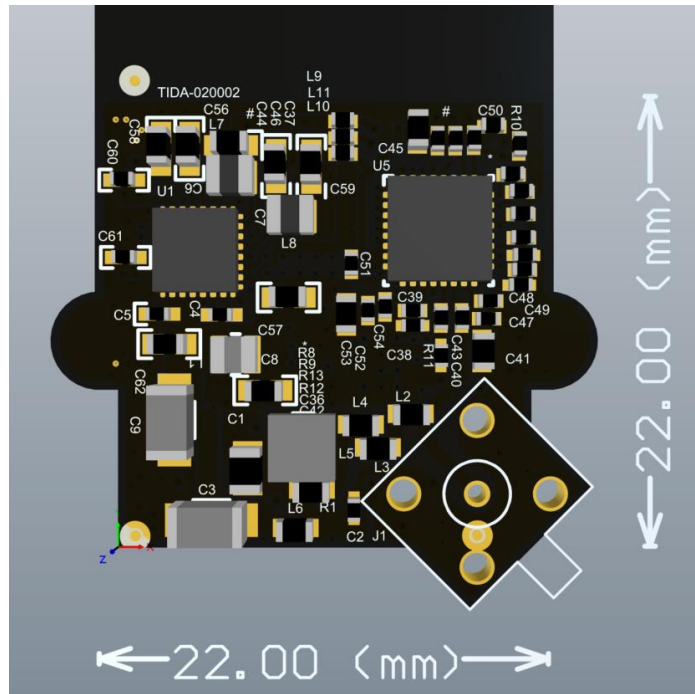
- Camera modules must be small to fit in remote regions of the vehicle
 - Common PCB area constraints are 20 mm x 20 mm or smaller on a single PCB



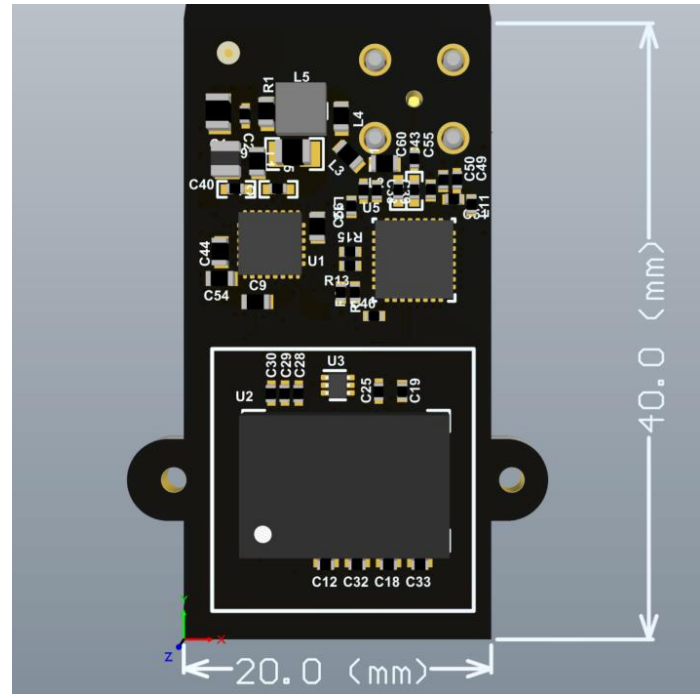
- Integrated PMICs reduce solution size
 - No external resistors
 - No power sequencers
 - No additional routing of Power Good signals
 - No external supervisors or monitors
- Designed for use with small inductors
 - 2.0 mm x 1.6 mm Q100 grade inductors
- Cascaded operation can reduce decoupling capacitor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



Reference Designs



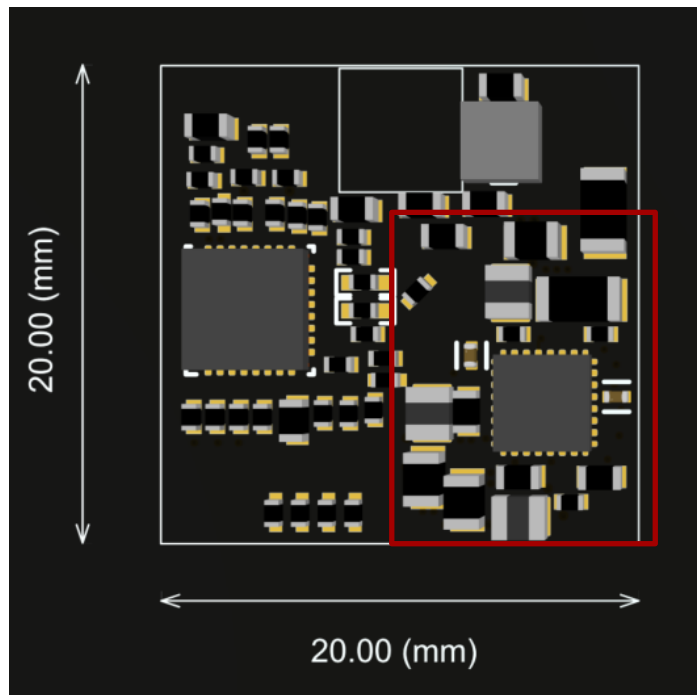
TIDA-020003



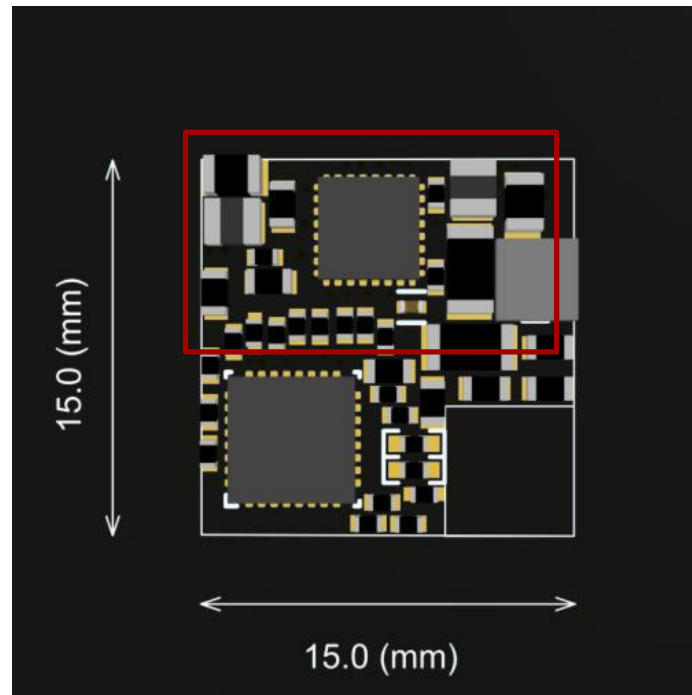
TIDA-020006



Example Layouts

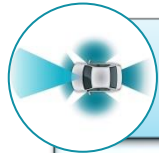


20 mm x 20 mm Example Layout



15 mm x 15 mm Example Layout





Scalability

Core Applications

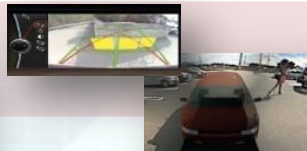
Surround View Camera

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

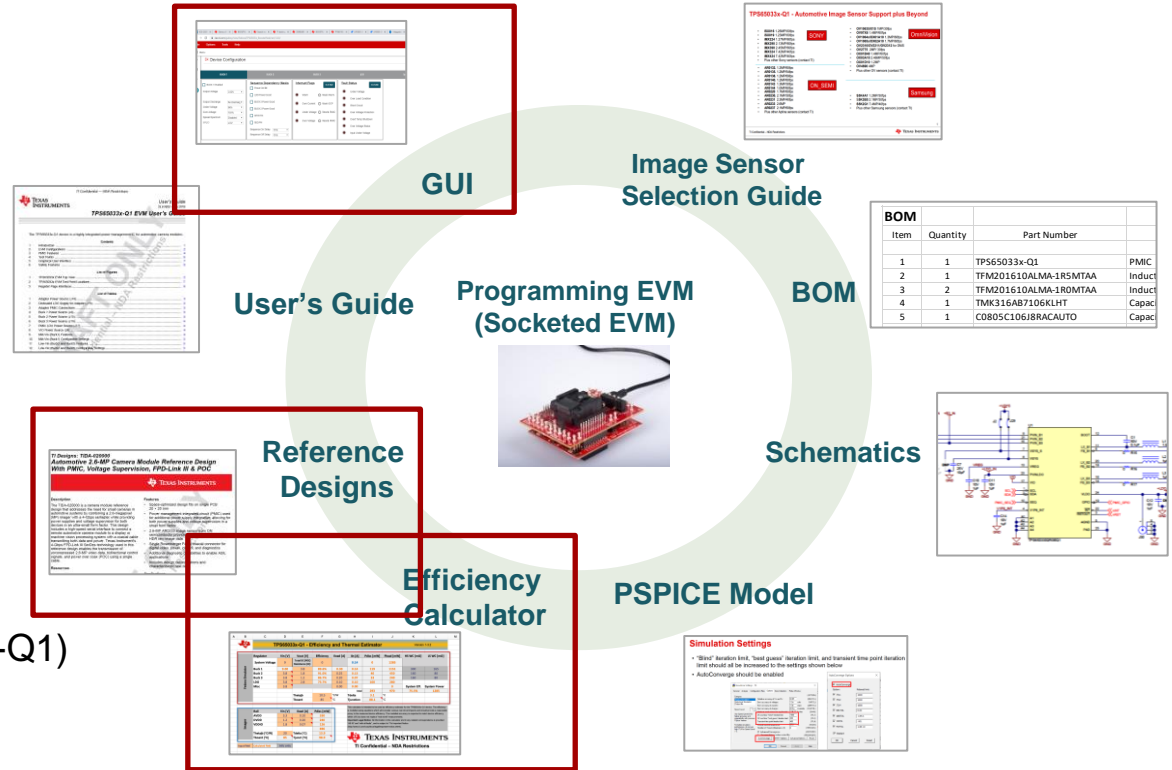
- Lower Output Power
- Low Cost
- No Functional Safety

TPS650330

- High Output Power
- No Functional Safety

TPS650331+

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



Automotive Vision Applications

Core Applications

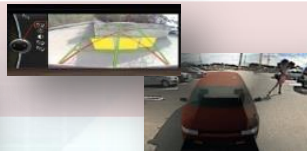
Surround View Camera

Satellite View Camera



Smart Rear View Camera

Smart Camera with or without Functional Safety



360 View L5 Autonomous

Camera with Functional Safety



Remote Front Camera

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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

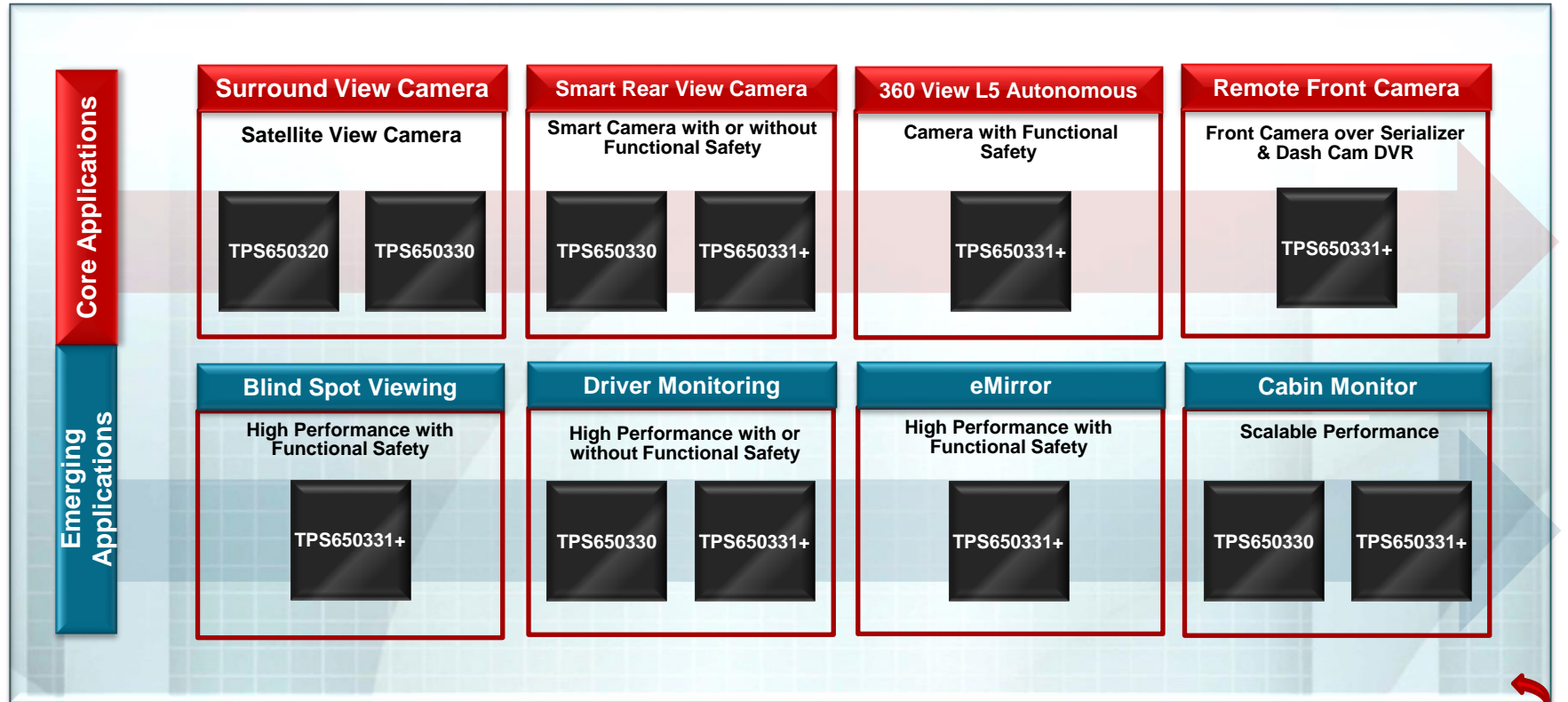


Cabin Monitor

Scalable Performance



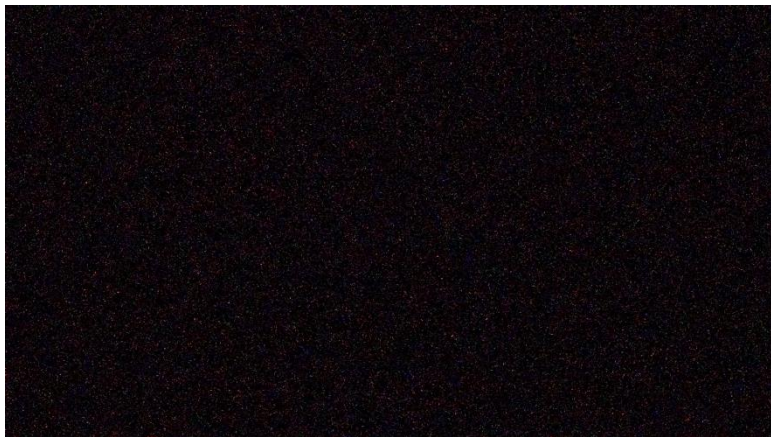
Automotive Vision Applications



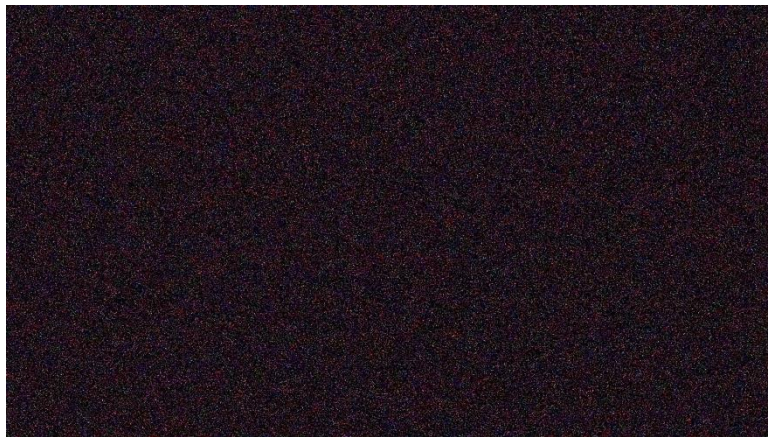


System Efficiency

- 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



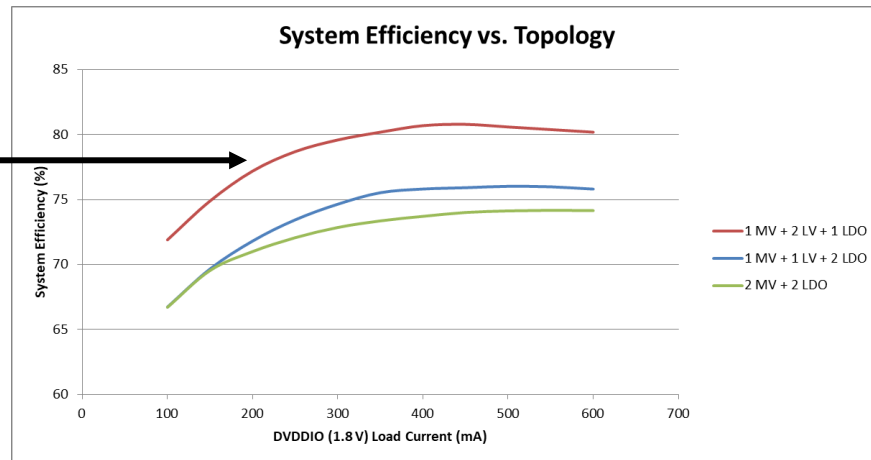
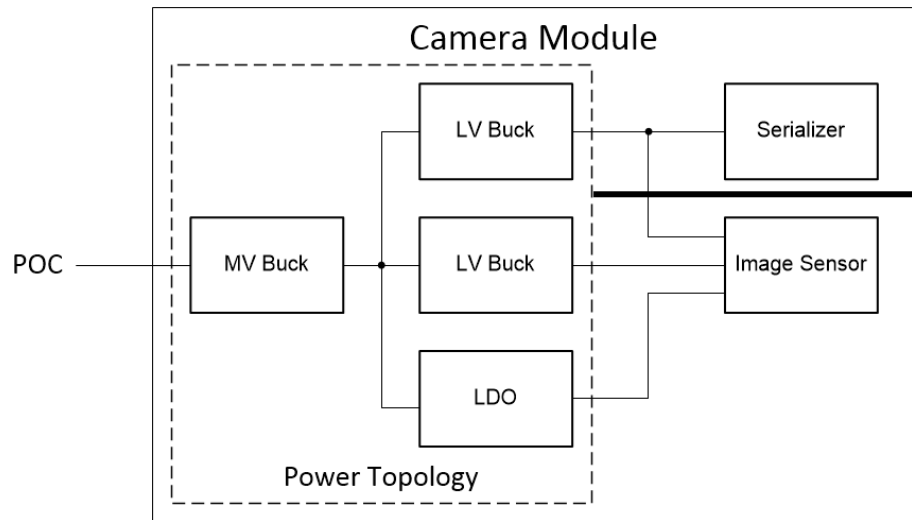
Camera Module Dark Image at 25°C Ambient



Camera Module Dark Image at 85°C Ambient

Industry Leading Efficiency

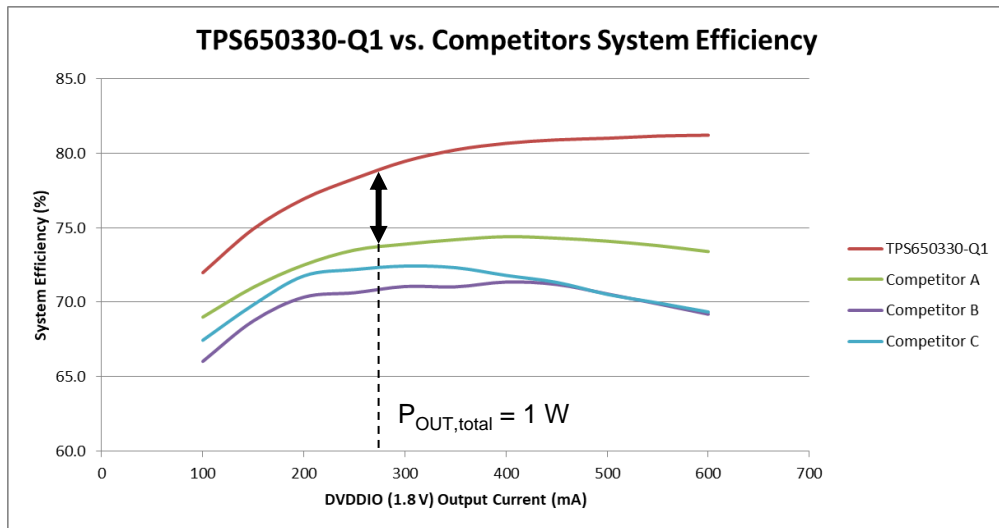
1. Most efficient power topology



Industry Leading Efficiency

2. Advanced TI 130 nm analog process

- Small Figure-Of-Merit (FOM) for power transistors = $R_{DS,on} * Q_G$



- $I_{AVDD} = 50 \text{ mA}$
- $I_{CORE} = 100 \text{ mA}$

- $P_D = 280 \text{ mW}$ → $\Delta T_B = 5^\circ\text{C}$
- $P_D = 370 \text{ mW}$ → $\Delta T_B = 10^\circ\text{C}$
- $P_D = 410 \text{ mW}$ → $\Delta T_B = 15^\circ\text{C}$

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





Noise Performance

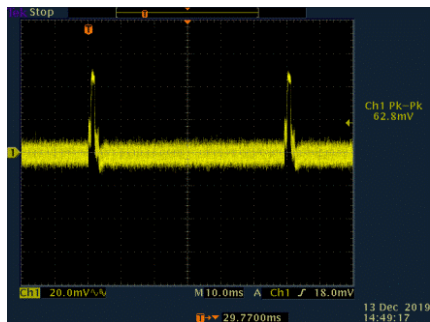


Camera Module Row Noise with 200 mVpp @ 42 kHz Injected on AVDD



System Level Noise Performance

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



POC

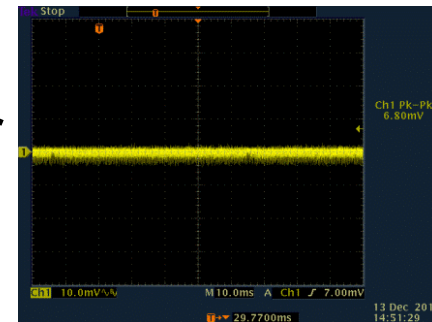
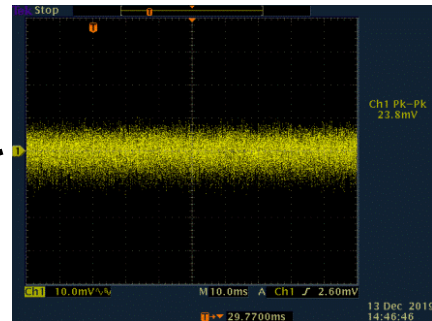
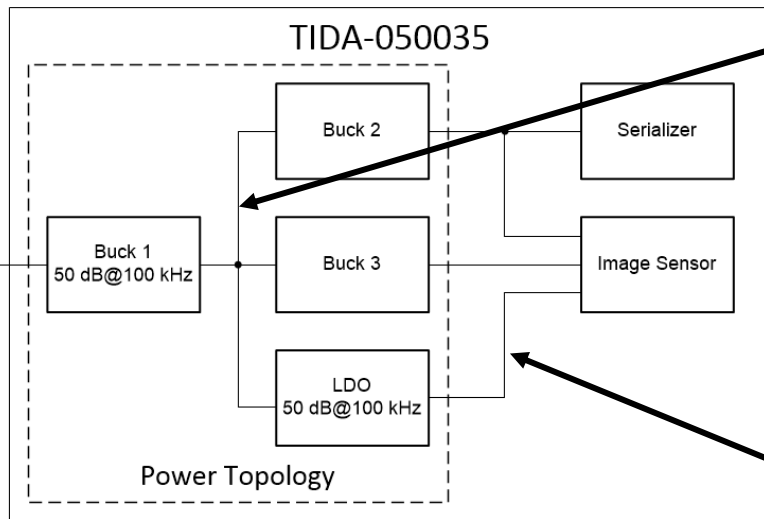
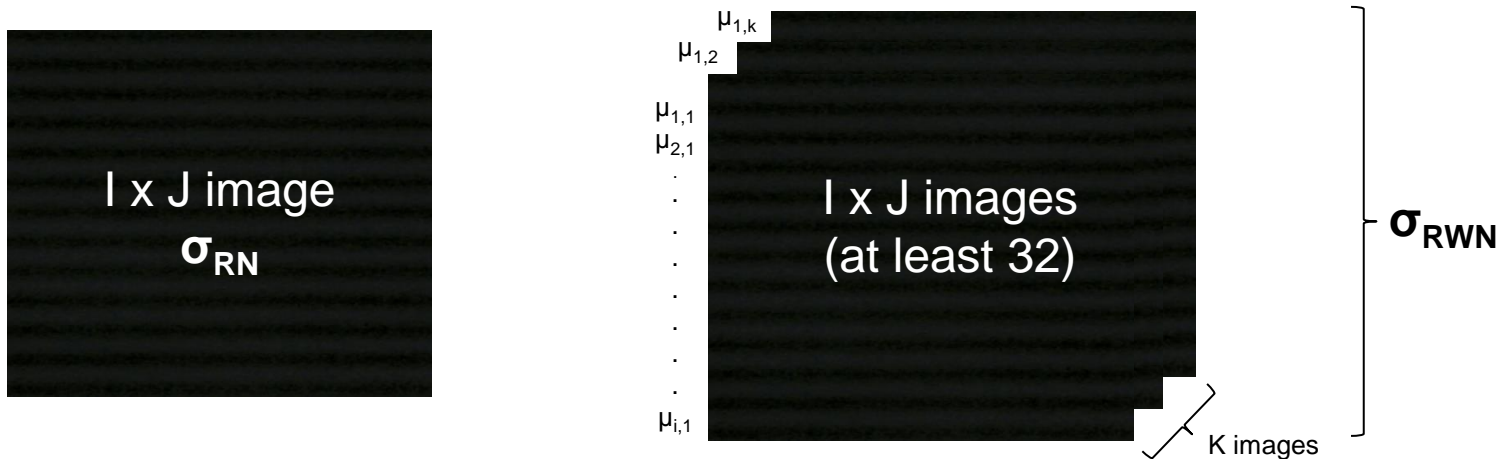


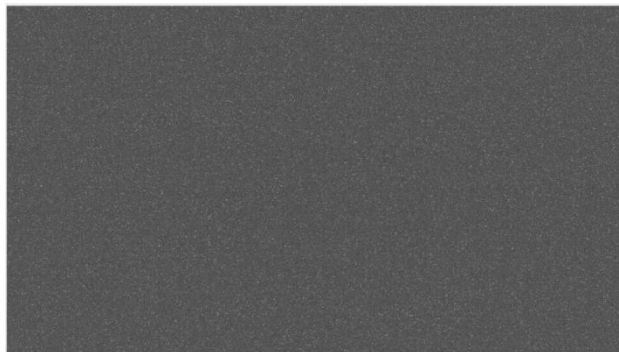
Image Sensor Noise Metrics

- 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 \ll 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



$$\sigma_{\text{RWN}} = 2.07$$

$$\sigma_{\text{RN}} = 109$$

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



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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