Solving the Key Design Challenges of Automotive Cameras

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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

• Lower Output Power
• Low Cost
• No Functional Safety

• High Output Power
• No Functional Safety

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

BOM

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Efficiency Calculator

PSPICE Model

Schematics

User’s Guide

Programming EVM (Socketed EVM)

Image Sensor Selection Guide

Reference Designs

GUI
Automotive Vision Applications

Core Applications

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Automotive Vision Applications

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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

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**Camera Module**

- MV Buck
- LV Buck
- LDO

**Power Topology**

**System Efficiency vs. Topology**

- Red: 1 MV + 2 LV + 1 LDO
- Blue: 1 MV + 1 LV + 2 LDO
- Green: 2 MV + 2 LDO

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**POC**
Industry Leading Efficiency

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

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

\[ \Delta T_B \cong P_D (\theta_{JA} - \Psi_{JB}) \]
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 $\ll$ Random Noise

$I \times J$ image

$\sigma_{RN}$

$I \times J$ images (at least 32)

$\sigma_{RWN}$

$\mu_{i,1}$

$\mu_{1,k}$

$\mu_{1,2}$

$\mu_{2,1}$

$\cdots$

$\cdots$

$\cdots$

$\cdots$

$\cdots$

$\mu_{i,1}$

$K$ images
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

\[ \sigma_{RWN} = 2.07 \]
\[ \sigma_{RN} = 109 \]

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!

Key Camera PMIC Contacts

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<thead>
<tr>
<th>Name</th>
<th>Role</th>
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</tr>
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