



Inside Automotive DMS & OMS

Learn How to Choose the Right LED Driver

Mihai Gireada, Sr. Technical Marketing Engineer

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- Why DMS & OMS
 - Safety Trends
 - Market Adoption
 - Key DMS Camera Features and Capabilities
- DMS & OMS Fundamentals
 - How Infrared Sensing Works
 - Camera Placement
 - Typical System Architecture
- Designing with MPS IR LED Driver

Safety Trends

- **Distraction Alert:** Catches drivers looking at phones or zoning out
- **Fatigue Prevention:** Wakes up drivers showing signs of nodding off
- **Passenger Protection:** Checks seatbelts and monitors children in the backseat

Market Adoption

- **Strict Regulations:** Transitioning from premium luxury cars to a legal requirement
- **Autopilot Handover:** Ensures that the driver is ready to take back control
- **Fleet Demand:** Wanted by delivery and trucking companies to cut down insurance costs

Regulatory Views

- **EU Market Driver**
 - Refer to the [Euro NCAP Compliance Map](#), which shows how Europe mandates driver monitoring for vehicle sales
 - **July 2024:** Already mandatory in the EU for all brand-new vehicle designs introduced to the market
 - **July 2026:** Expanded in the EU to be mandatory for every **single new car sold off dealership lots**

- **US Market Driver:** Refer to the [US Distracted Driving Overview](#), which outlines how US safety bodies are targeting phone usage in cars.



Driver State and Focus Monitoring

Engagement and Attention:

- Detects if the driver is looking away (visual distraction) or zoned out (cognitive distraction)

Impairment and Fatigue:

- Tracks drowsiness levels, micro-sleeping, and actual sleeping episodes

Emotional State:

- Classifies the driver's mood and basic facial expressions

Eye and Face Tracking (Biometrics)

Gaze and Eyelid Dynamics:

- Measures blink rates, eye-opening speeds, and exact gaze direction to see precisely where the driver is looking

Head Tracking and Occlusion:

- Maps facial landmarks and detects if the face is blocked by sunglasses, masks, or hands

Identity and Spoofing Verification:

- Verifies user identity for security, automatically adjusts settings when drivers switch, and prevents spoofing tricks

In-Cabin and Passenger Activities

Mouth Activity:

- Recognizes speaking, yawning, sneezing, coughing, laughing, and smoking

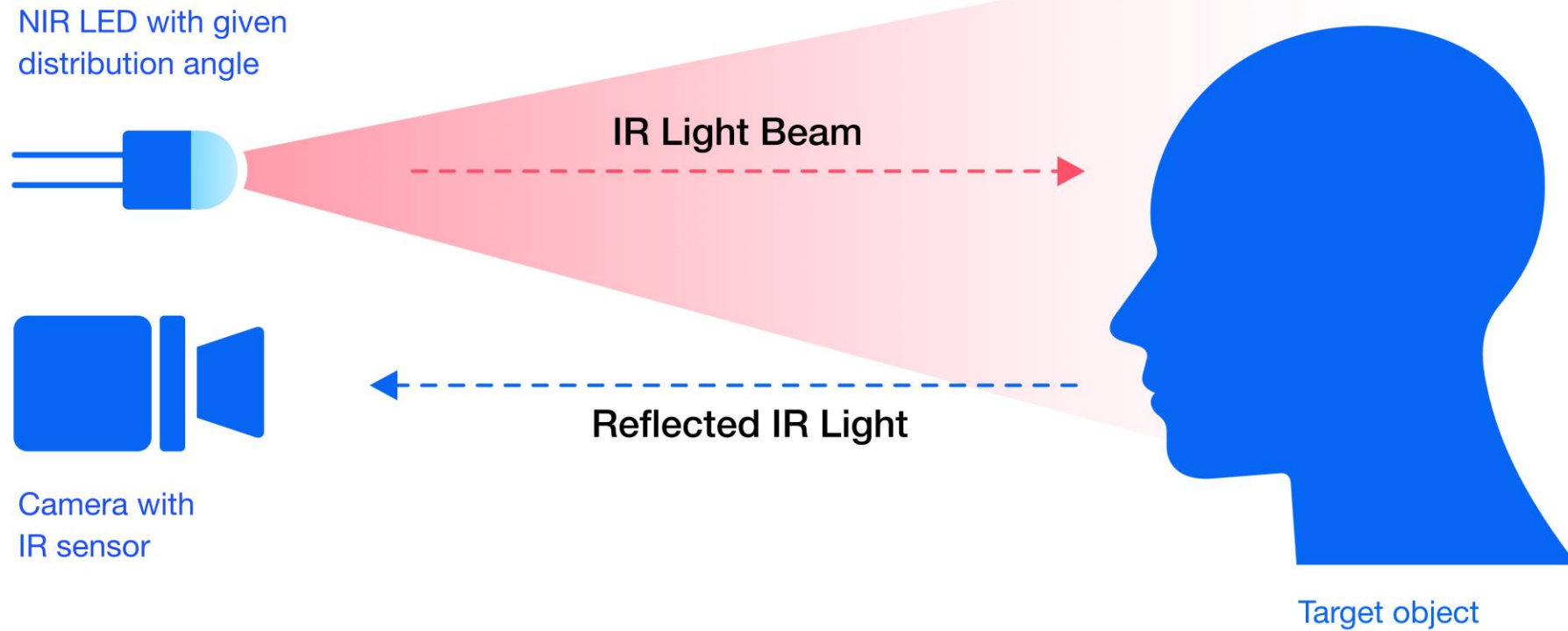
Body and Object Handling:

- Monitors hand placement and detects dangerous habits, such as holding objects or handling a phone

Seat Occupancy Detection:

- Detects passenger presence, checks seatbelt statuses, and automatically estimates occupant sizes (e.g. distinguishing an adult from a child)

How Infrared Sensing Works



1. A-Pillar

- **Now:** Renault, Stellantis
- **Future:** Volvo
- **Pros:** Low packaging impact, and avoids steering wheel blockage
- **Cons:** Poor tracking due to side angle, difficult styling integration, and **no occupant monitoring (OMS)**

2. Interior Rearview Mirror

- **Now:** Volkswagen
- **Future:** Toyota, Stellantis, Volkswagen, and Renault (*major industry shift*)
- **Pros:** Fits all driver heights, clear cluster view, and **ideal for full-cabin/OMS combo systems**
- **Cons:** Movable location requires software auto-calibration, and is easily blocked by hats or caps

3. Overhead Console

- **Now:** US electric car company
- **Future:** US electric car company
- **Pros:** Unobstructed, top-down view; excellent for seat safety and passenger depth sensing
- **Cons:** Steep angle makes precision eye-gaze and microsleep detection very difficult



4. Below Rearview Mirror

- **Now:** Mercedes-Benz, BMW
- **Future:** Mercedes-Benz, Hyundai
- **Pros:** Straight-on view of the driver's face, and shielded from sunlight glare
- **Cons:** Easily blocked by the driver's hands or the steering wheel rim

5. Steering Wheel Hub/Column

- **Now:** Toyota, GM, Ford, Audi, and Volvo (*market dominant*)
- **Future:** GM, Ford, and Audi (*kept for hands-free highway driving*)
- **Pros:** Gold standard for direct eye-gaze tracking and drowsiness performance
- **Cons:** Blocks cluster view, shifts with wheel adjustments, misses some driver heights, and **no OMS capability**

6. Center Dashboard Top

- **Now:** Subaru
- **Future:** Subaru
- **Pros:** Central spot bridges driver safety tracking with passenger gesture controls
- **Cons:** Off-center, asymmetrical angle reduces absolute driver tracking precision

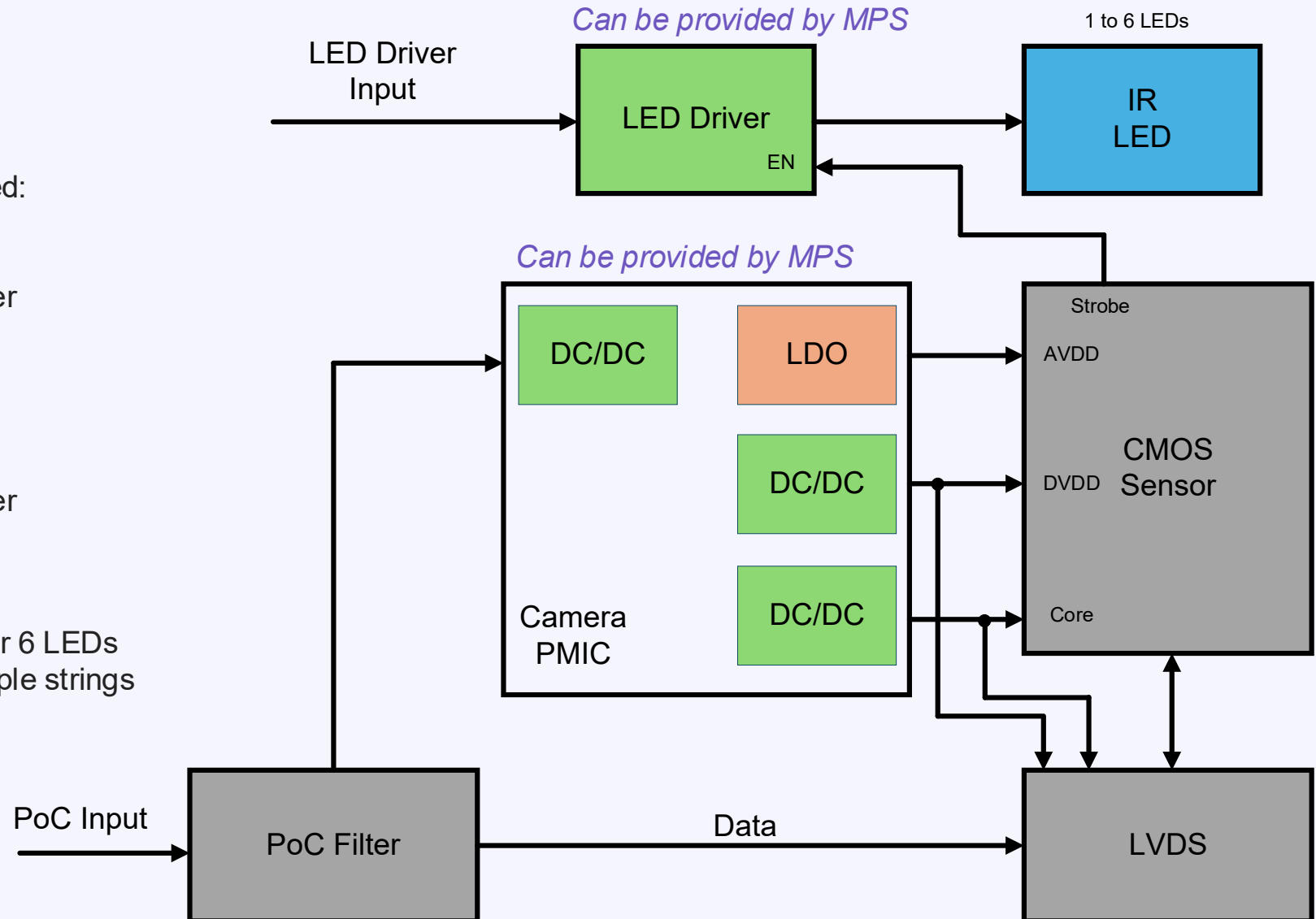
7. Upper Windshield Trim

- **Now:** Minimal use
- **Future:** BMW
- **Pros:** The high perspective completely eliminates hand or steering wheel blockage
- **Cons:** Increased distance from the face requires more powerful infrared (IR) illumination



Typical System Architecture

- An IR LED driver can be supplied:
 - Power over coax (PoC)
 - KL30 switched
 - Buck-boost/boost converter
- The PMIC can be supplied:
 - Power over coax (PoC)
 - KL30 switched
 - Buck-boost/boost converter
- Infrared LED can be:
 - IR LEDs or VCSEL
 - 1 LED, 2 LEDs, 4 LEDs, or 6 LEDs
 - Configured in one or multiple strings



Power over Coax (PoC) (18V)

MPQ70240FS ASIL-B

3 Bucks, 1 LDO

- **2x 0.6A MV Buck + 1A LV Buck + 200mA LDO**
- Optimized for Efficiency + EMI on a 200mm² PCB
- Minimized BOM
- UVLO, OCP, OVP, and Thermal Shutdown
- 2.2MHz Switching Frequency
- [Frequency Spread Spectrum](#)
- I²C and OTP
- QFN-15 (2.5mmx3.5mm) **WF**

Versions:

- **MPQ70244FS** – Enhanced digital interface logic. For systems using an MPQ70244FS output as a pull-up for its own I²C interface

MPQ70241FS ASIL-B

3 Bucks, 1 LDO

- **1A MV Buck + 0.6A MV Buck + 1.5A LV Buck + 200mA LDO**
- Optimized for Efficiency + EMI on a 200mm² PCB
- Minimized BOM
- UVLO, OCP, OVP, and Thermal Shutdown
- 2.2MHz Switching Frequency
- [Frequency Spread Spectrum](#)
- I²C and OTP
- QFN-15 (2.5mmx3.5mm) **WF**

Versions:

- **MPQ70245FS** – Enhanced digital interface logic. For systems using an MPQ70245FS output as a pull-up for its own I²C interface

MPQ7928

3 Bucks, 1 LDO

- **2x 0.6A MV Buck + 1A LV Buck + 200mA LDO**
- Optimized for Efficiency + EMI on a 200mm² PCB
- Minimized BOM
- UVLO, OCP, OVP, and Thermal Shutdown
- 2.2MHz Switching Frequency
- [Frequency Spread Spectrum](#)
- I²C and OTP
- QFN-15 (2.5mmx3.5mm) **WF**

Versions:

- **MPQ7928A** – Enhanced digital interface logic. For systems using an MPQ7928A output as a pull-up for its own I²C interface

MPQ7929

3 Bucks, 1 LDO

- **1A MV Buck + 0.6A MV Buck + 1.5A LV Buck + 200mA LDO**
- Optimized for Efficiency + EMI on a 200mm² PCB
- Minimized BOM
- UVLO, OCP, OVP, and Thermal Shutdown
- 2.2MHz Switching Frequency
- [Frequency Spread Spectrum](#)
- I²C and OTP
- QFN-15 (2.5mmx3.5mm) **WF**

MPQ70250FS ASIL-B

3 Buck, 1 LDO

- **0.9A MV Buck + 0.6A LV Buck + 1.5A LV Buck + 400mA LDO**
- Optimized for Efficiency + EMI
- Configurable Soft Start on All Rails
- UVLO, OCP, OVP, and Thermal Shutdown
- [Frequency Spread Spectrum](#)
- I²C and 2-Page OTP
- QFN-16 (2.5mmx3.5mm) **WF**

12V Battery (40V)

MPQ70340FS ASIL-B

3 Bucks, 1 LDO, Watchdog Timer

- **2x 0.6A HV Buck + 1A LV Buck + 200mA LDO**
- Optimized for Efficiency + EMI on a 200mm² PCB
- Minimized BOM with 3 External Components
- [Windowed Watchdog Timer](#)
- UVLO, OCP, OVP, and Thermal Shutdown
- 2.2MHz Switching Frequency
- I²C and OTP
- QFN-15 (2.5mmx3.5mm) **WF**

Versions:

- **MPQ70341FS**: Buck 2's current updated to 800mA
- **MPQ7934**: QM

MPQ70350FS ASIL-B

3 Bucks, 1 LDO

- **1.5A HV Buck + 0.6A LV Buck + 2A LV Buck + 400mA LDO**
- Optimized for Efficiency + EMI
- Configurable Soft Start on All Rails
- UVLO, OCP, OVP, and Thermal Shutdown
- [Frequency Spread Spectrum](#)
- I²C and 2-Page OTP
- QFN-16 (2.5mmx3.5mm) **WF**

Production

Sampling

Development



China



Japan



France



S. Korea



Germany



USA

100 Million

Cameras with MPS power shipped since 2020

MPS compact power modules and PMICs can be found in vehicles worldwide across leading OEMs.

Camera applications include:

- Forward
- Rear Backup
- 360° Surround View
- Driver Monitoring
- Occupant Monitoring
- E-Mirrors
- Dashcams

IR LED Drivers for DMS & OMS



Standard

MPQ7230

42V/3A

- **Sync Buck or Buck-Boost Driver**
- 3A Peak Current
- [Separate EN and DIM](#)
- [PWM Dimming: 10Hz to 2kHz \(30/60/120FPS compatible\)](#)
- Low $R_{DS(ON)}$ FETs (44mΩ/40mΩ)
- Integrated Current-Sense Resistor
- Fast Transient Response
- 410kHz Switching Frequency with FSS
- LED Open/Short, OCP, OVP with Latch, TD, and TSD
- QFN-19 (3mmx4mm) [WF](#)

MPQ7232

40V/6A

- **Synchronous Buck Driver**
- [6A Peak Current](#)
- [PWM Dimming: 10Hz to 2kHz](#)
- Low $R_{DS(ON)}$ FETs (45mΩ/30mΩ)
- Fast Transient Response
- [2.2MHz Switching Frequency](#)
- [Frequency Spread Spectrum](#)
- LED Open/Short, OCP, OVP with Latch, TD, and TSD
- QFN-15 (3mmx4mm) [WF](#)

MPQ7235

4V to 36V/3A

- **Value Synchronous Buck LED Driver**
- 3A Peak Current
- [PWM Dimming: 10Hz to 2kHz \(30/60/120FPS compatible\)](#)
- Low $R_{DS(ON)}$ FETs (85mΩ/50mΩ)
- [0.2V Built-In Voltage Reference](#)
- Dedicated Dimming Pin
- LED Open/Short
- OCP with Valley Current Detection
- FCCM
- Internal Soft Start
- QFN-13 (2.5mmx3mm) [WF](#)

MPQ7231

42V/3A

- **Synchronous Buck or Buck-Boost Driver**
- 3A Peak Current
- [Eye-Safety Features:](#)
 - [LED Current Limit](#)
 - [Config. Dimming On-Time Limit](#)
- [PWM Dimming: 10Hz to 2kHz \(30/60/120FPS compatible\)](#)
- Low $R_{DS(ON)}$ FETs (44mΩ/40mΩ)
- Integrated Current-Sense Resistor
- Fast Transient Response
- [2.4MHz Switching Frequency with FSS](#)
- LED Open/Short, OCP, OVP with Latch, TD, and TSD
- QFN-19 (3mmx4mm) [WF](#)

Functional Safety

MPQ76230FS ASIL-C

42V/10A

- **Load Switch + Boost + Buck IR LED Driver**
- [Boost Stage: Supports Multi-LEDs in Series](#)
- 410kHz or 2MHz Switching Frequency
- [Eye-Safety Features](#)
- [LED Current Limit](#)
- [Configurable Dimming On-Time Limit](#)
- [Frame Monitoring](#)
- [Built-In Self-Test \(BIST\)](#)
- LED Open/Short/OTP
- Cycle-by-Cycle OCP
- Output OVP and SCP
- LED Open String Protection
- I²C with PEC
- QFN-21 (4mmx4mm) [WF](#)
- [ASIL-C Compliant](#)

MPQ76233FS ASIL-B

42V/10A

- **Buck IR LED Driver**
- 410kHz or 2MHz Switching Frequency
- [Eye-Safety Features](#)
- [LED Current Limit](#)
- [Configurable Dimming On-Time Limit](#)
- [Frame Monitoring](#)
- [Built-In Self-Test \(BIST\)](#)
- LED Open/Short/OTP
- Cycle-by-Cycle OCP
- Output OVP and SCP
- LED Open String Protection
- I²C with PEC
- QFN-21 (4x4) [WF](#)
- [ASIL-B Compliant](#)

MPQ76200FS ASIL-B

40V/6A

- **Pre-Boost + Buck IR LED Driver**
- [Boost Stage: Supports Multi-LEDs in Series](#)
- [CCM Boost Reduces Tank Capacitor by 4x-6x](#)
- 2MHz Switching Frequency
- [Eye-Safety Features:](#)
 - [LED Current Limit](#)
 - [Config. Dimming On-Time Limit](#)
 - [Frame Monitoring](#)
- [Built-In Self-Test \(BIST\)](#)
- LED Open/Short/OTP
- Cycle-by-Cycle OCP
- Output OVP and SCP
- LED Open String Protection
- I²C with PEC
- TQFN-19 (3mmx4mm) [WF](#)
- [ASIL-B Compliant](#)

Production

Sampling

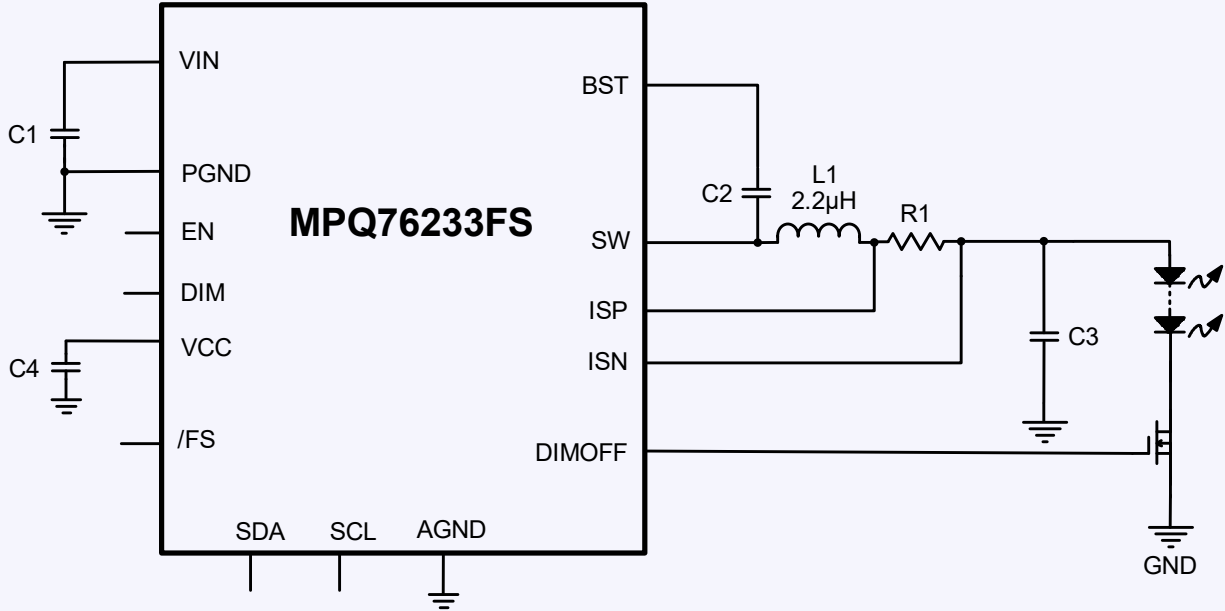
Development

MPQ76233FS-AEC1



MPSafe™, 40V, 10A, IR LED/VCSEL Driver with Eye Safety Features

- **Built to Handle Tough Automotive Transients:**
 - Load Dump Up to 40V, Cold Crank Down to 3.5V
- **Do More With Less:**
 - Integrated, Low $R_{DS(ON)}$ FETs Using Advanced MPS BCD Process
 - Delivers Powerful 10A Output in a Compact Solution
 - Minimal External BOM Overhead
- **Optimized for EMI/EMC:**
 - 2.2MHz Switching Frequency (above AM Band)
 - Frequency Spread Spectrum (FSS)
 - MeshConnect™ Packaging
- **Achieve Functional Safety Goals:**
 - [ISO 26262 Functional Safety Rating: ASIL-B](#)
 - Eye Safety: Current, Dimming On Time, and Dimming Frame Rate Frequency Limit
 - Compatible with Common 30FPS, 60FPS, and 120FPS Dimming Requirements
 - Protections Include LED/VCSEL Short/Open, String, and Thermal Shutdown
- **Enhanced System Oversight:**
 - 8-Bit SAR ADC Monitors for OC, UV/OV, Input Voltage, and Temperature
- **Vast Flexibility through Digital Configurability:**
 - Instantly Adjustable Output Current, Current Slew Rate, Dimming Frequency, Pulse Width, and More
 - I²C with Optional PEC



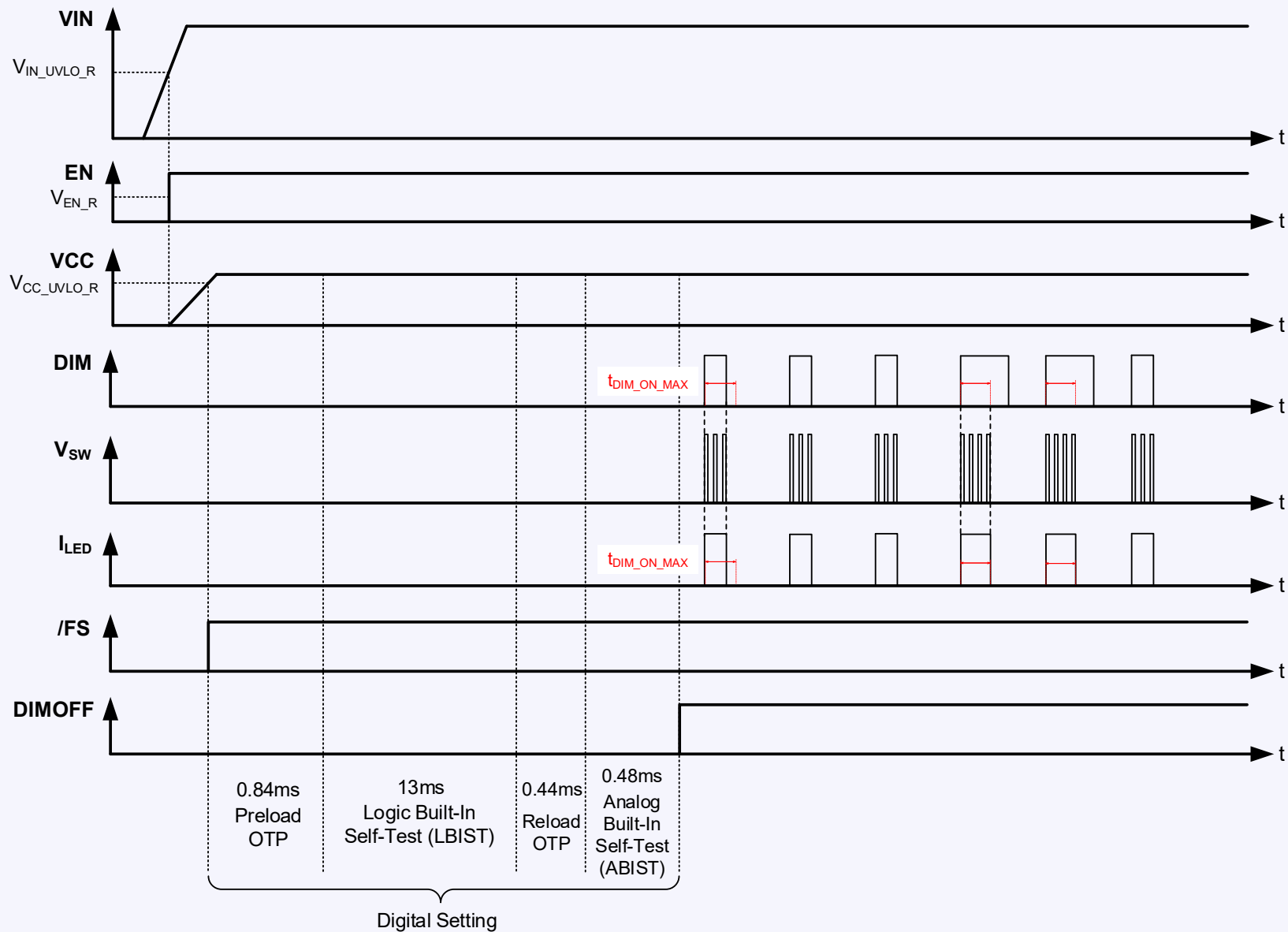
Key Specifications

Input Voltage	Output Current	HS-FET/ LS-FET $R_{DS(ON)}$	Functional Safety	Package
4.5V to 36V	10A	25mΩ/25mΩ	ASIL-B	QFN-21 (4mmx4mm) WF

Applications

- Driver Monitoring Systems

MPQ76233FS-AEC1 Operation



MPQ76233FS-AEC1 Protections



- LED+ Short to Battery: The device triggers over-voltage protection (OVP) during DIM on, and triggers STB during DIM off
- LED+ Short to GND: LED open or LED under-voltage protection (UVP) is triggered
- LED- Short to GND: Can be detected via DIMOFF
- LED+ Short to LED-: LED open

Buck	Fault Item	Description	Action if Fault Is Triggered	Show on /FS Pin	Fault Register	Disable Block
FS_BUCK	OV	Over-voltage condition on buck output	Latch/hiccup	/FS	Yes	Turns buck off
	UV	Under-voltage condition on buck output	Latch/hiccup	/FS	Yes	Turns buck off
	OC	Peak over-current condition on buck converter	Latch/hiccup	/FS	Yes	Turns buck off
	STB	Output short to battery	Latch/hiccup	/FS	Yes	Turns buck off
	LEDOPEN	LED open	Latch/hiccup	/FS	Yes	Turns buck off

Thermal	Fault Item	Description	Action if Fault Is Triggered	Show on /FS Pin	Fault Register	Disable block
FS_THERMAL	TWN	Thermal warning	No action	No	Yes	N/A
	TSD	Thermal shutdown	Latch/hiccup	/FS	Yes	Turns off buck

DIM Pin	Fault Item	Description	Action if Fault Is Triggered	Show on /FS Pin	Fault Register	Disable Block
FS_DIM	DIM_MIN	DIM minimum on time	No action	Register	Yes	N/A
	DIM_MAX	DIM maximum on time	No action	Register	Yes	N/A
	DIM_FREQ	DIM frequency limit	No action	Register	Yes	N/A

PWM Dimming: Maximum Dimming On Time Limit

Test Conditions: $V_{IN} = 34V$, $R_{SENSE} = 40m\Omega$, $C_{OUT_BUCK} = 1\mu F$, $L_{BUCK} = 2.2\mu H$, $f_{SW} = 2.2MHz$

Maximum DIM On Time Limitation

DIM Maximum On Time Enable

Enable[0b1]

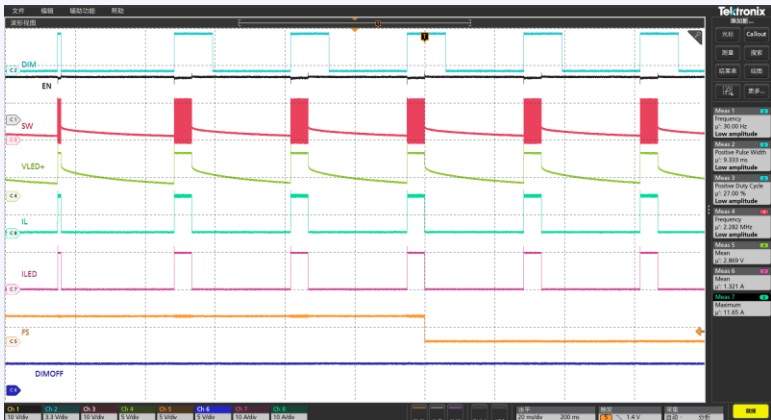
DIM Maximum On Time Limit (ms)

5.02

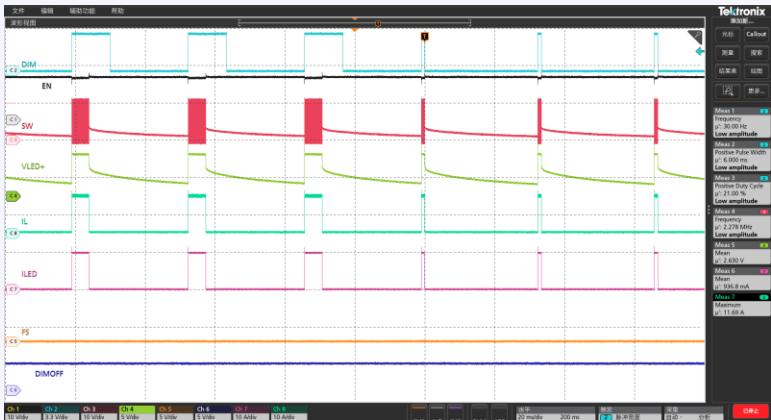
DIM Maximum On Time Error Counter

3[0b001]

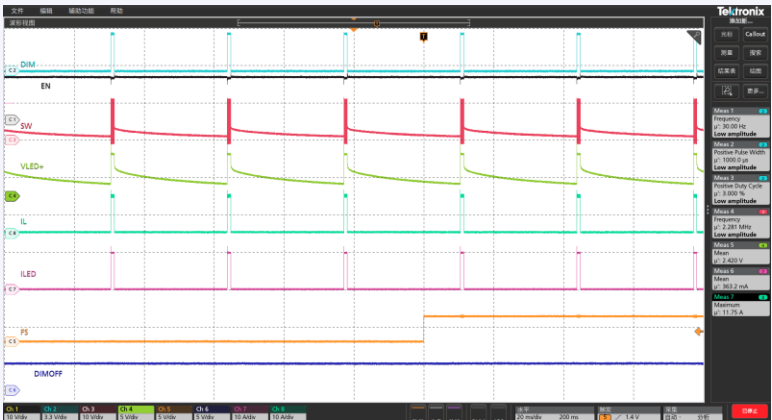
PWM Dimming (30Hz/1ms to 11ms)



PWM Dimming (30Hz/11ms to 1ms)



Clear FS_DIM_MAX_ON_ERR/W1C_ALL_FS



Key

FS_DIM_MAX_ON_ERR

Clear

MAX_ON_ERR_CNT

0d3

PWM Dimming: Maximum Dimming Frequency Limit

Test Conditions: $V_{IN} = 34V$, $R_{SENSE} = 40m\Omega$, $C_{OUT_BUCK} = 1\mu F$, $L_{BUCK} = 2.2\mu H$, $f_{SW} = 2.2MHz$

Dimming Frequency Limitation

DIM Frequency Limit

150Hz[0x1C]

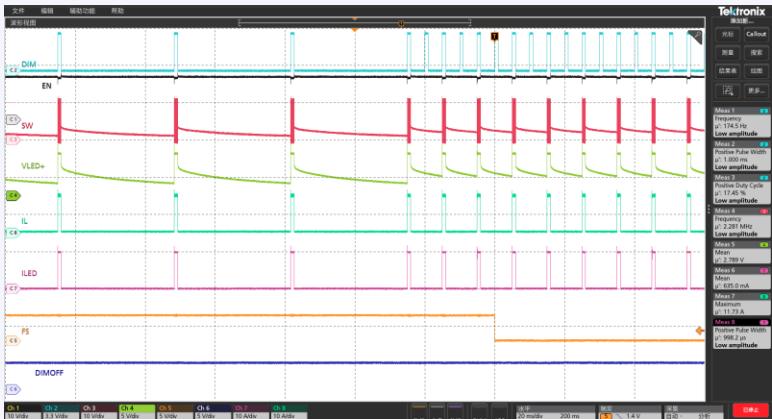
DIM Frequency Limit Enable

Enable[0b1]

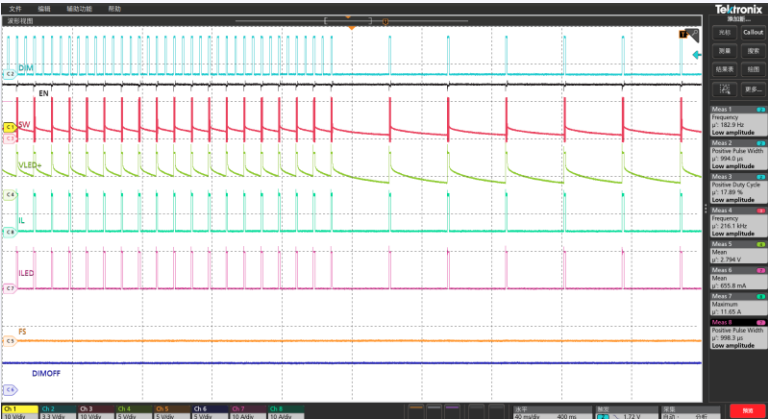
DIM Frequency Error Counter

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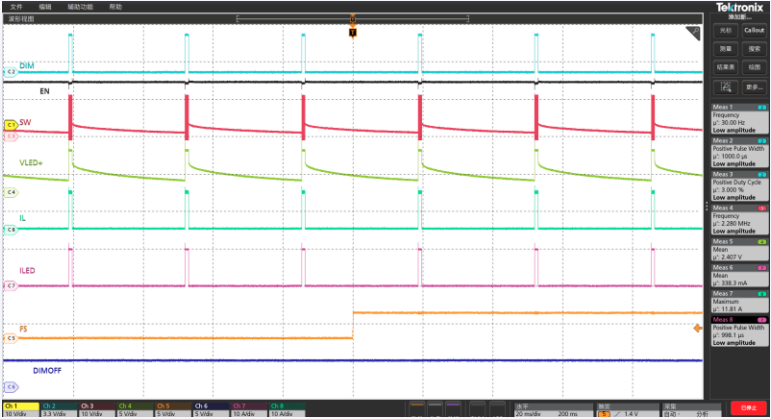
PWM Dimming (30Hz/1ms to 200Hz)



PWM Dimming (200Hz/1ms to 30Hz)



Clear FS_DIM_FREQ_ERR/W1C_ALL_FS



Key

FS_DIM_FREQ_LIMIT_ERR

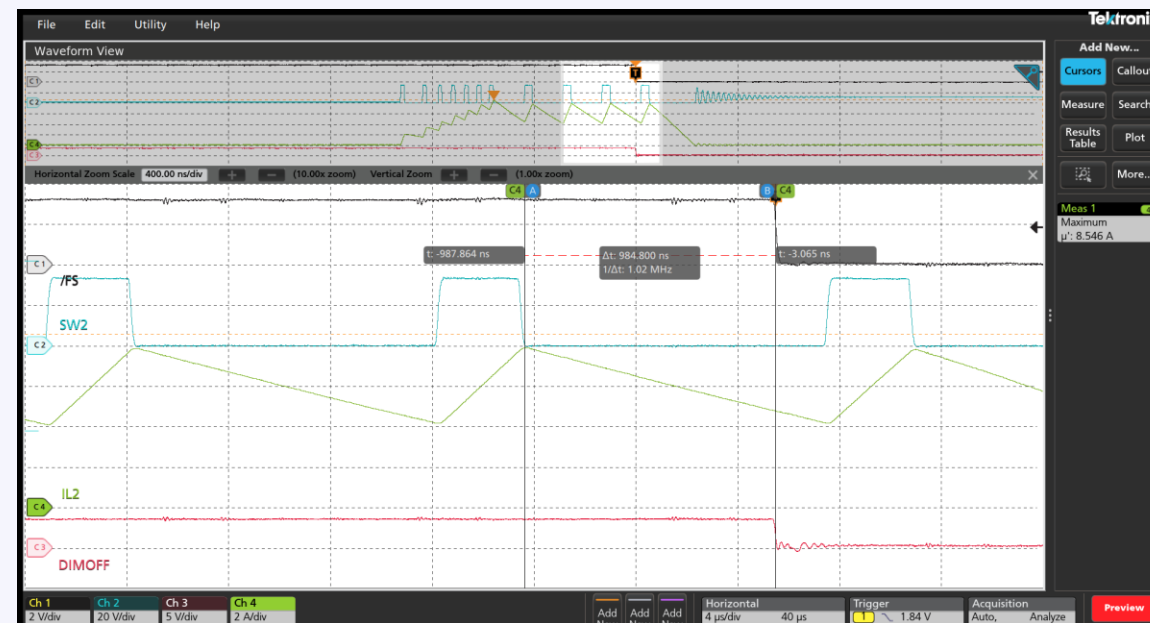
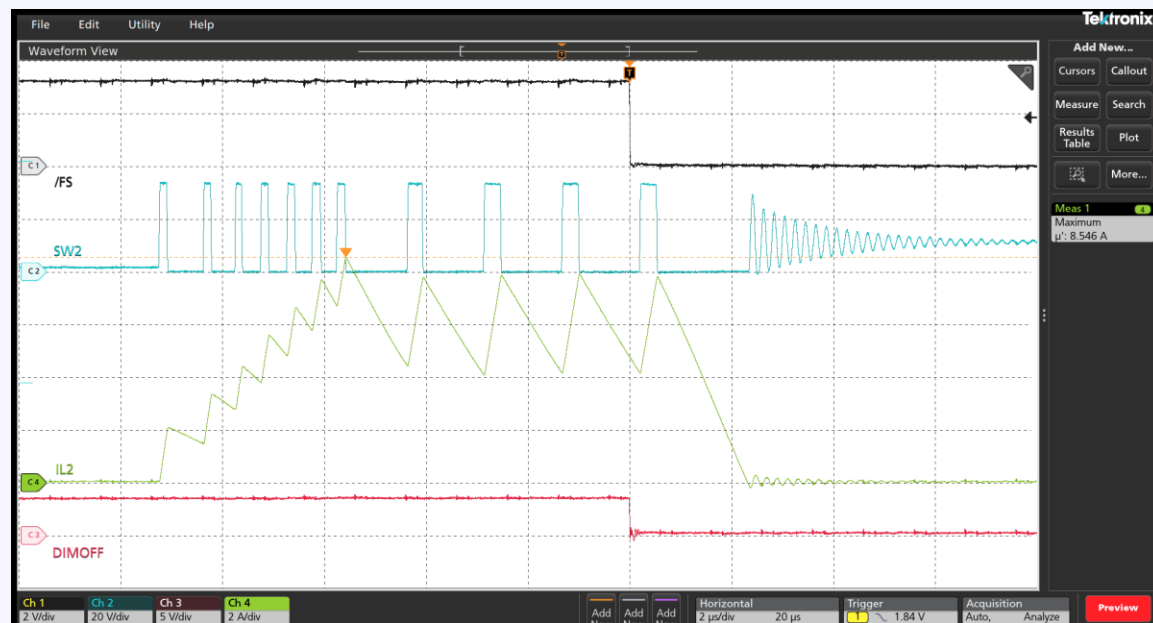
Clear

FREQ_ERR_CNT

0d3

Buck Over-Current (OC)

Test Conditions: $V_{IN} = 34V$, $R_{SENSE} = 40m\Omega$, $C_{OUT_BUCK} = 1\mu F$, $L_{BUCK} = 2.2\mu H$, $f_{SW} = 2.2MHz$,
Dimming Frequency = 30Hz, 0.2ms, 1 String, 2 IR LEDs, $T_A = 25^\circ C$, Hiccup Mode, $V_{IN1} = 12V$



Key

FS_BUCK_OC



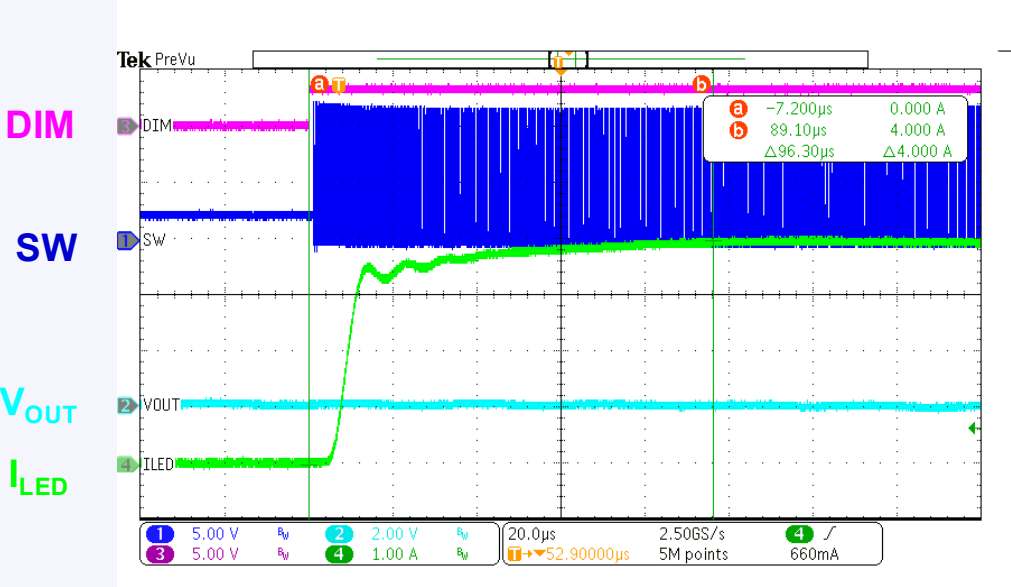
Clear

MPQ76233FS-AEC1 Dynamic Response



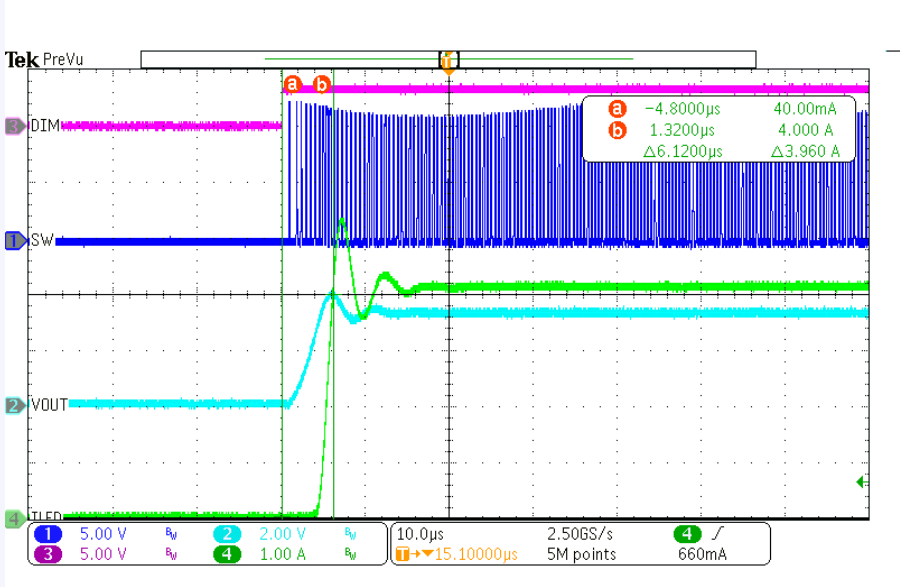
Test Conditions: $V_{IN} = 12V$, $I_{LED} = 4A$, $L = 2.2\mu H$, $f_{sw} = 2.2MHz$, 1 LED, DIM 30Hz/2ms

$C_{OUT} = 10\mu F$



MPQ7232

$C_{OUT} = 2.2\mu F$



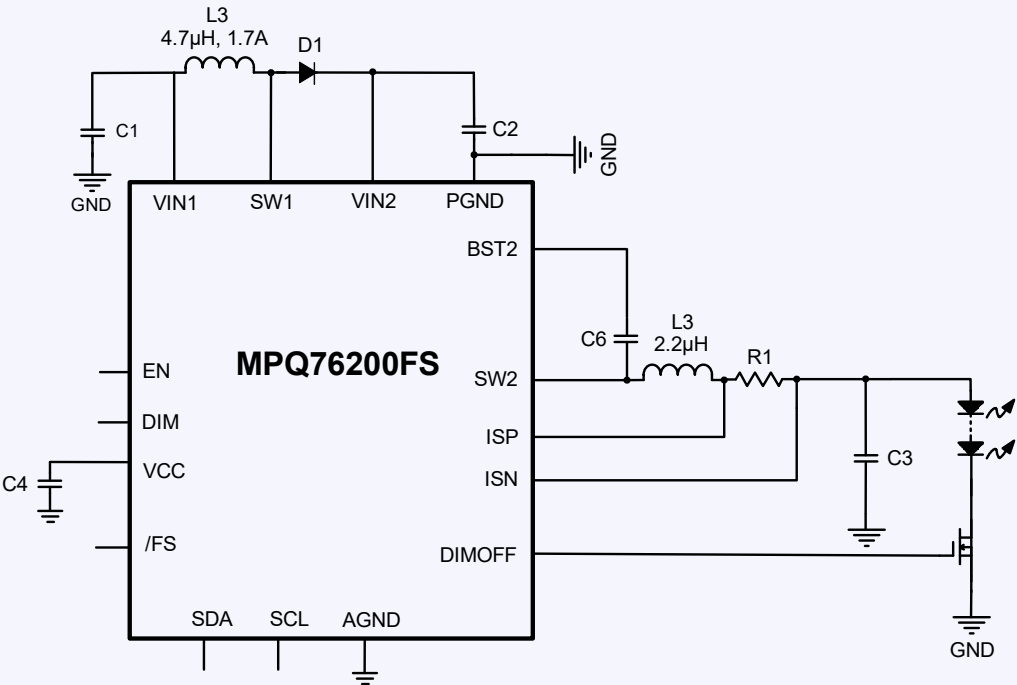
MPQ76233FS

MPQ76200FS-AEC1



MPSafe™, 40V, 6A, IR LED/VCSEL Driver with Eye Safety Features

- **Built to Handle Tough Automotive Transients:**
 - Load Dump Up to 40V, Cold Crank Down to 3.5V
- **Do More With Less:**
 - Pre-Boost + Buck LED Driver in One Package
 - CCM Boost Supports Multiple LED Strings at Higher Power Levels
 - Constant On Boost Mode Minimizes Tank Capacitor Size by 4x-6x
 - Integrated Low $R_{DS(ON)}$ FETs Using Advanced MPS BCD Process
 - Minimal External BOM Overhead
- **Optimized for EMI/EMC:**
 - 2.2MHz Switching Frequency (above AM Band)
 - Frequency Spread Spectrum (FSS)
 - MeshConnect™ Packaging
- **Achieve Functional Safety Goals:**
 - ISO 26262 Functional Safety Rating: ASIL-B
 - Eye Safety: Current, Dimming On Time, and Dimming Frame Rate Frequency Limit
 - Compatible with Common 30FPS, 60FPS, and 120FPS Dimming Requirements
 - Protections Include LED Short/Open and Thermal Shutdown
- **Vast Flexibility through Digital Configurability:**
 - Instantly Adjustable Output Current, Current Slew Rate, Dimming Frequency, Pulse Width, and More
 - I²C with Optional PEC
 - Communication Watchdog



Key Specifications

Input Voltage	Output Current	HS-FET/ LS-FET $R_{DS(ON)}$	Functional Safety	Package
5V to 36V	6A	120mΩ (Boost Off PoC), 25mΩ (Boost Off Batt.), 40mΩ/30mΩ (Buck)	ASIL-B	QFN-18 (3mmx4mm) WF

Applications

- Driver Monitoring Systems

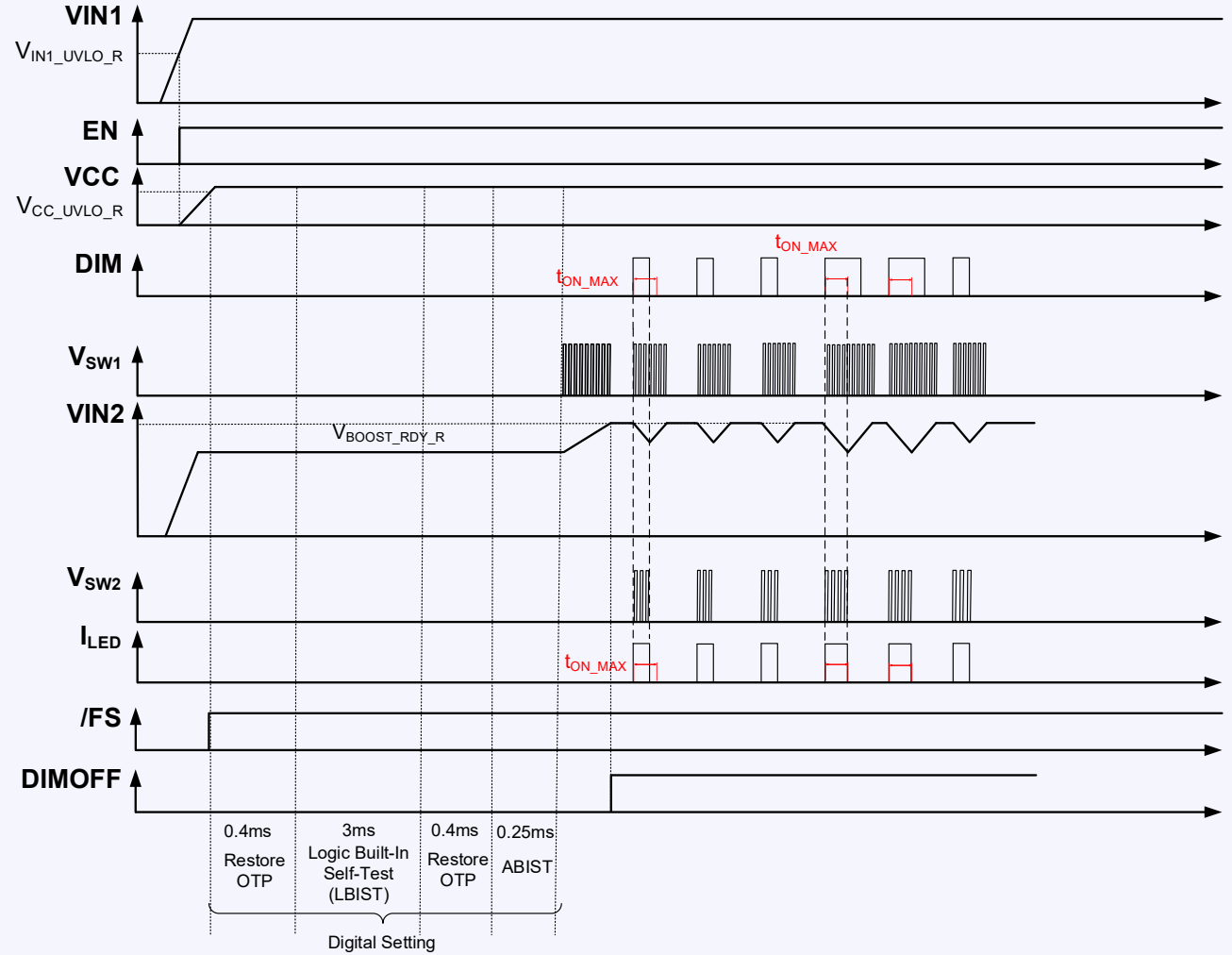
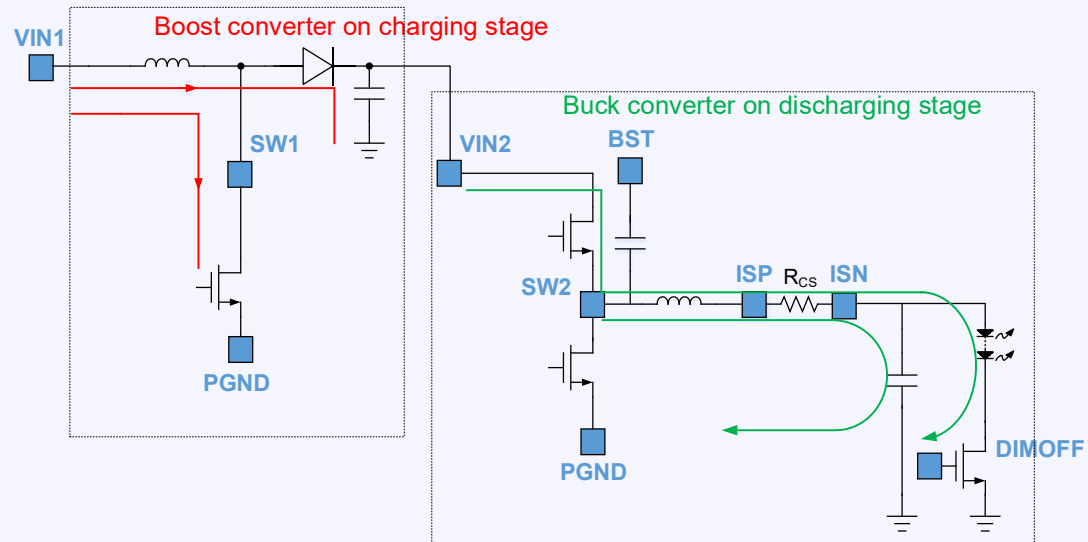
MPQ76200FS-AEC1 Protections



Boost	Fault Item	Description	Action if Fault Is Triggered	Show on /FS Pin	Fault Register	Disable Block
FS_BOOST	OV	Over-voltage condition on boost output	Latch/hiccup	/FS	Yes	Turns off boost/buck
	UV	Under-voltage condition on boost output	Latch/hiccup	/FS	Yes	Turns off boost/buck
Buck	Fault Item	Description	Action if Fault Is Triggered	Show on /FS Pin	Fault Register	Disable Block
FS_BUCK	OV	Over-voltage condition on buck output	Latch/hiccup	/FS	Yes	Turns off buck
	UV	Under-voltage condition on buck output	Latch/hiccup	/FS	Yes	Turns off buck
	OC	Peak over-current condition on buck converter	Latch/hiccup	/FS	Yes	Turns off buck
	STB	Output short to battery	Latch/hiccup	/FS	Yes	Turns off buck
	LEDOPEN	LED open	Latch/hiccup	/FS	Yes	Turns off buck
Thermal	Fault Item	Description	Action if Fault Is Triggered	Show on /FS Pin	Fault Register	Disable Block
FS_THERMAL	TWN	Thermal warning	No action	No	Yes	N/A
	TSD	Thermal shutdown	Latch/hiccup	/FS	Yes	Turns off buck/boost
DIM Pin	Fault Item	Description	Action if Fault Is Triggered	Show on /FS Pin	Fault Register	Disable Block
FS_DIM	DIM_MAX	DIM maximum on time	No action	Register	Yes	N/A
	DIM_FREQ	DIM frequency limit	No action	Register	Yes	N/A

MPQ76200FS-AEC1 Operation

- **Boost current limit during DIM on**
- Boost constant voltage during DIM off
- Buck constant current during DIM on
- Buck not switching during DIMOFF



MPQ76200FS-AEC1 Buffer Capacitor Calculation

$$V_{LED.string} = n \cdot V_{f.LED} \quad \text{where } n = \text{numbers of LEDs in series}$$

$$P_{out_buck} = V_{LED.string} \cdot I_{LED}$$

$$P_{in_buck} = \frac{P_{output.buck}}{\eta_{buck}}$$

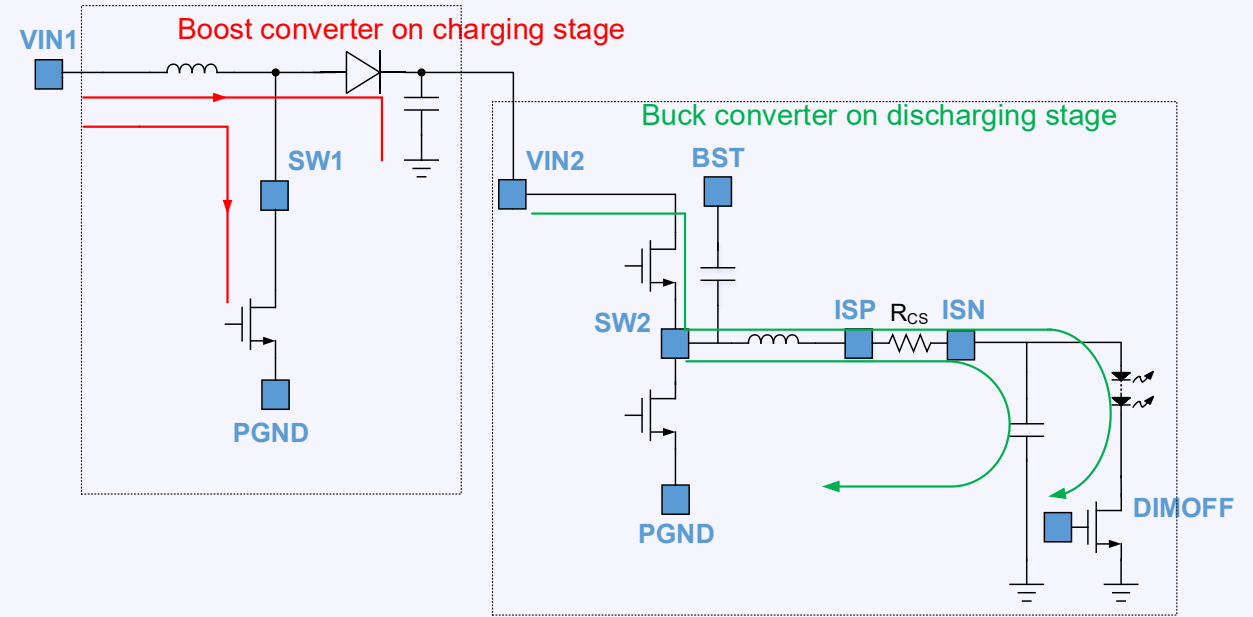
$$\Delta I_{L_{Vout.boost_MAX}} = \frac{V_{out_Boost.MAX} \cdot (V_{out_Boost.MAX} - V_{IN})}{L \cdot f_{sw} \cdot V_{out_Boost.MAX}}$$

$$\Delta I_{L_{Vout.boost_MIN}} = \frac{V_{out_Boost.MIN} \cdot (V_{out_Boost.MIN} - V_{IN})}{L \cdot f_{sw} \cdot V_{out_Boost.MIN}}$$

$$I_{in_{Vout.boost_MAX}} = I_{Boost.LS.OC} - \frac{\Delta I_{L_{Vout.boost_MAX}}}{2}$$

$$I_{in_{Vout.boost_MIN}} = I_{Boost.LS.OC} - \frac{\Delta I_{L_{Vout.boost_MIN}}}{2}$$

$$I_{in_AVG} = \frac{I_{in_{Vout.boost_MAX}} + I_{in_{Vout.boost_MIN}}}{2}$$



$$P_{in_boost} = I_{in_AVG} \cdot V_{IN}$$

$$P_{out_boost} = P_{in_boost} \cdot \eta_{boost}$$

Always delivering power with the boost

$$C_{bulk.cap} = 2 \cdot \frac{(P_{in_buck} - P_{out_boost}) \cdot DIM_{on}}{V_{out_Boost.MAX}^2 - V_{out_Boost.MIN}^2}$$

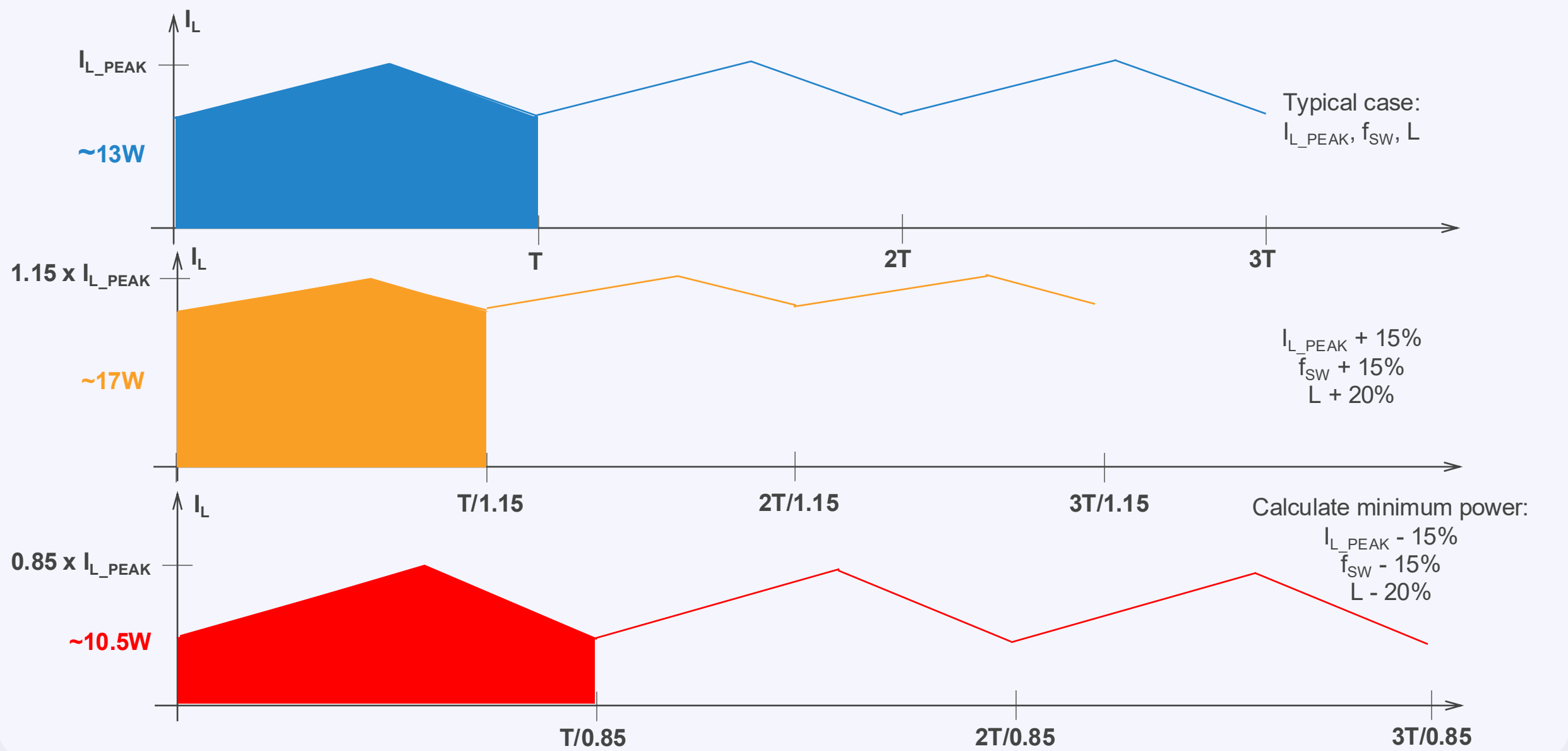
Example Profile

- I_{LED} : 5A with 6% Tolerance
- LED Forward Voltage = 4.5V
- 1 LED String
- 2ms Maximum Exposure Time
- 2.2MHz Operating Frequency with $\pm 10\%$ Phase Locked-Loop (PLL) Tolerance
- Boost Converter = 34V
- Boost Converter Under-Voltage Protection (UVP) = 14V
 - Capacitor Discharged to 15V
- V_{IN} is 12V Off Power over Coaxial (PoC)
- Estimated Worst-Case Efficiency: 85% for Buck, 82% for Boost

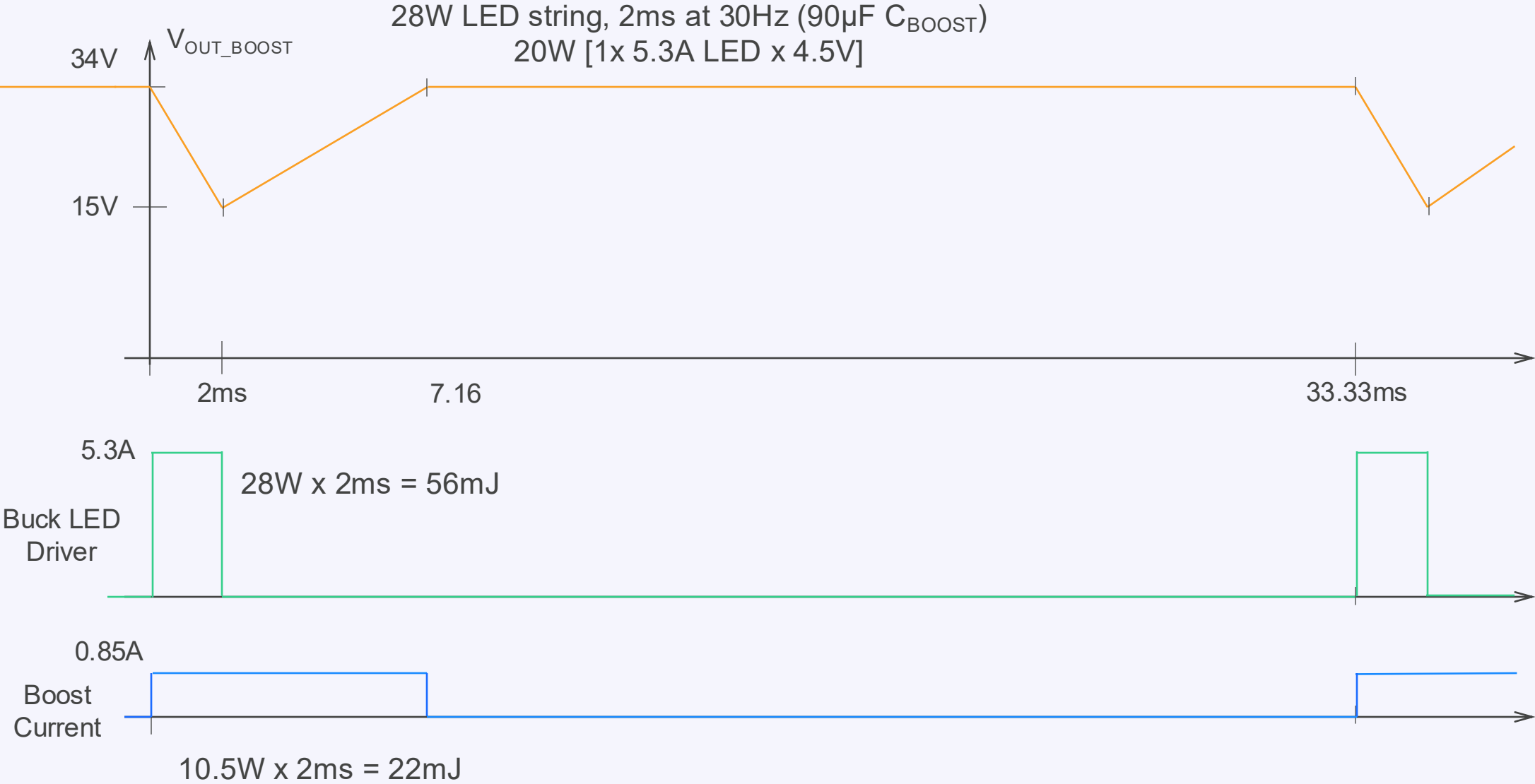
Results

- The required effective capacitance is **$\sim 90\mu F$** vs. Competitor Product ($\sim 130\mu F$) using the same buffer voltage on the capacitor
- In this example, the boost is always delivering **$\sim 10.6W$** in worst-case scenario and **$\sim 16.8W$** in the best-case scenario.
- The buck input power in the worst-case scenario is **$\sim 28W$** .
- The delta between 28W and 10.6W must be provided by the buffer capacitor.
- The charging time is at the maximum **$\sim 5.15ms$** with a **2ms** pulse results in **$\sim 26.15ms$** off time (t_{OFF}).
- At **30Hz**, the RMS input current is **650mA**; at **60Hz**, the RMS input current is **920mA**.

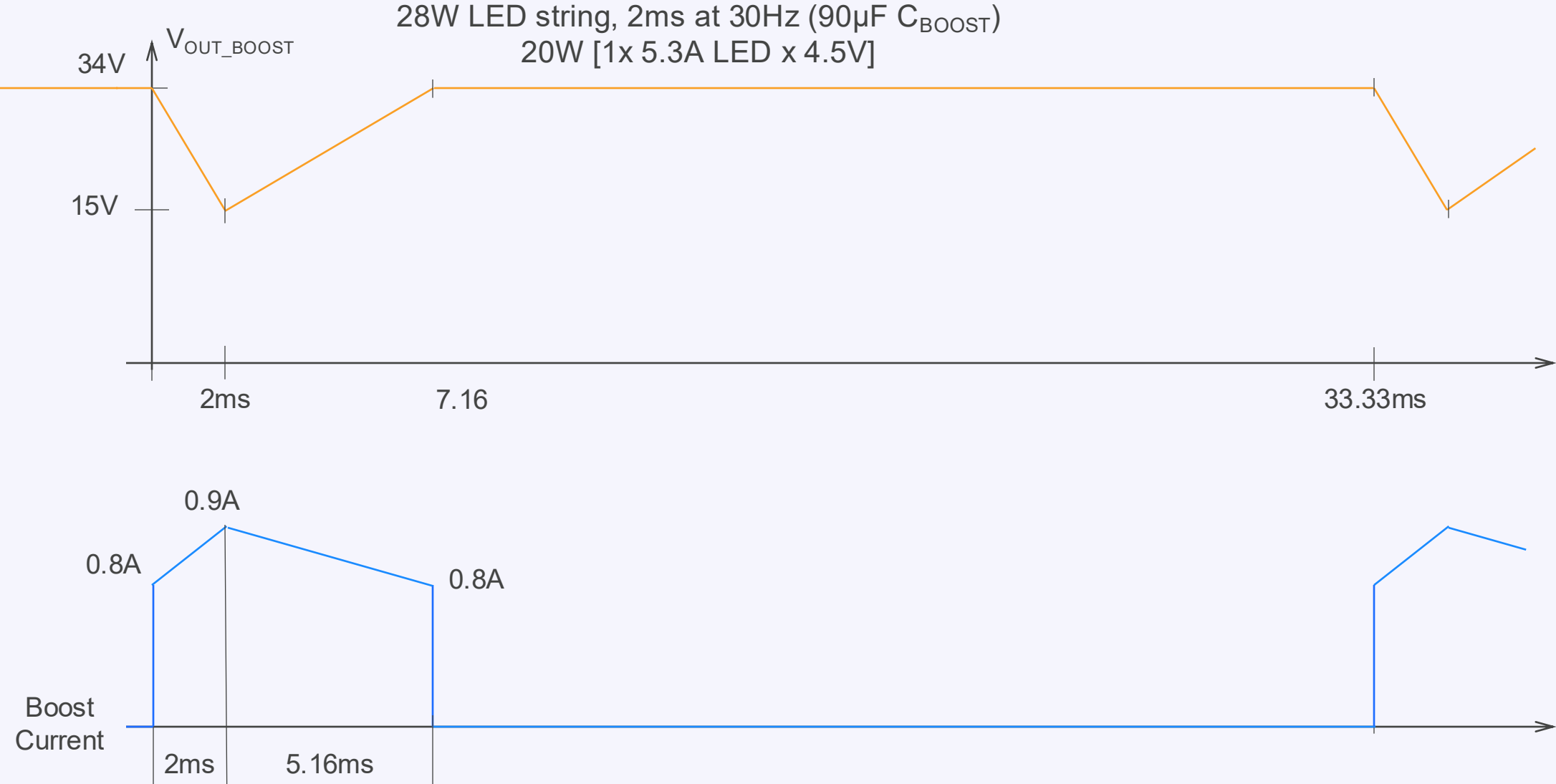
MPQ76200FS-AEC1 Boost Coil Current

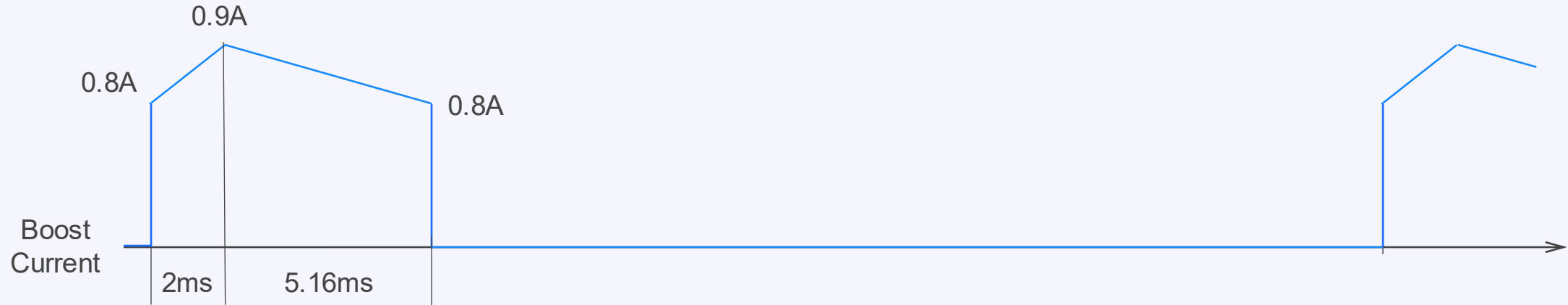


MPQ76200FS-AEC1 Operation



MPQ76200FS-AEC1 Operation





$$I_{in.RMS} = \sqrt{\frac{DIM_{on} + boost_{charge.time}}{3 \cdot \frac{1}{Frame Rate}} \cdot \left(I_{in_{Vout.boost_{MAX}}}^2 + I_{in_{Vout.boost_{MAX}}} \cdot I_{in_{Vout.boost_{MIN}}} + I_{in_{Vout.boost_{MIN}}}^2 \right)}$$

$$boost_{charge.time} = \frac{\frac{1}{2} \cdot C_{bulk.cap} \cdot (V_{out_{Boost.MAX}}^2 - V_{out_{Boost.MIN}}^2)}{P_{out_{boost}}}$$

The input current (I_{IN}) RMS can be estimated by:

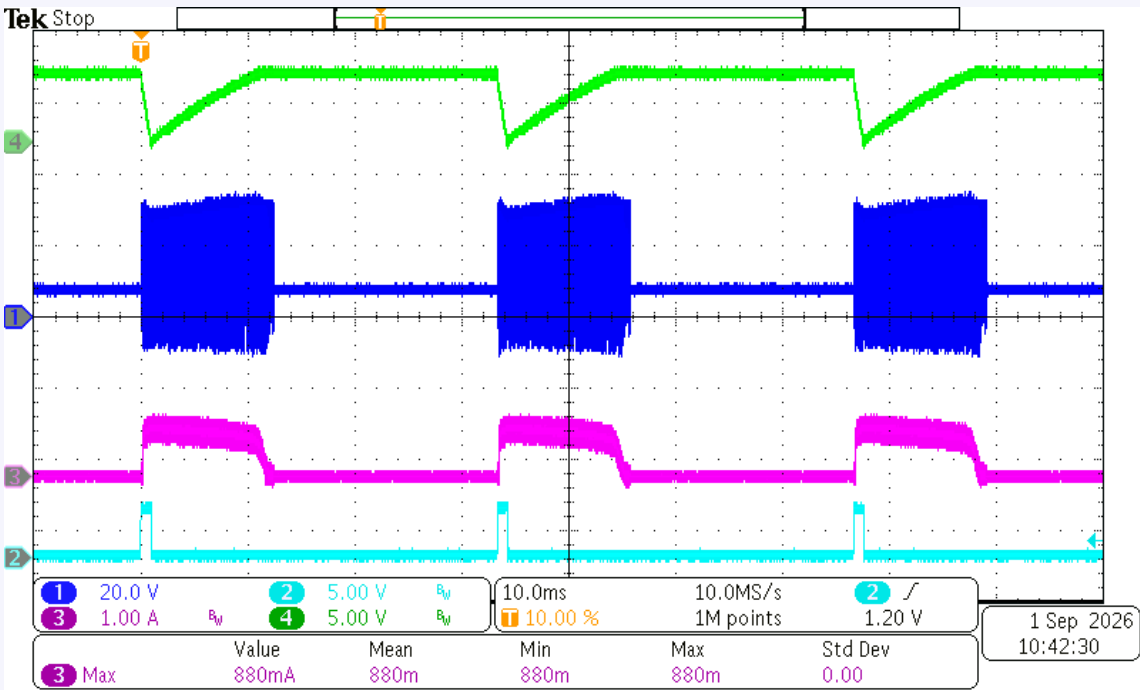
$$I_{in.RMS.aprox} = \frac{I_{in_{Vout.boost_{MAX}}} + I_{in_{Vout.boost_{MIN}}}}{2} \cdot \sqrt{\frac{DIM_{on} + boost_{charge.time}}{\frac{1}{Frame Rate}}}$$

MPQ76200FS-AEC1 Test Results

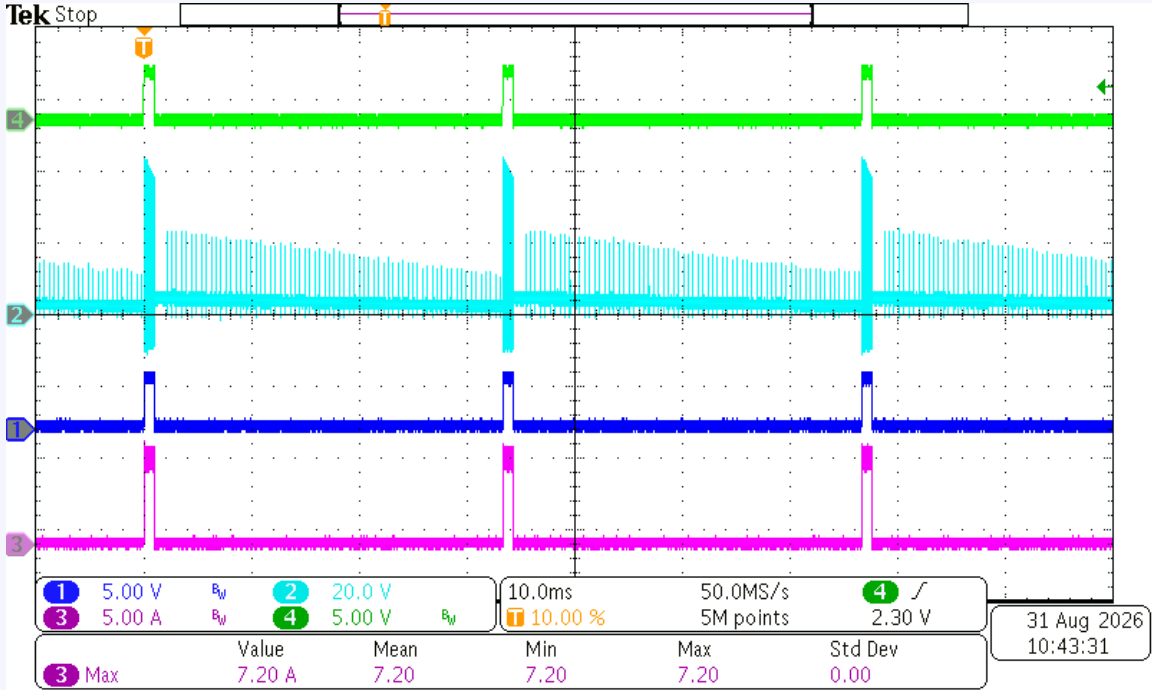


Test Conditions: $V_{IN1} = 8V$, $V_{IN2} = 32V$, $f_{SW1} = f_{SW2} = 2.2MHz$, $L1 = 10\mu H$, $L2 = 2.2\mu H$, $I_{LED} = 6A$,
2 LEDs in Series, $V_{LED} = 6V$, DIM = 30Hz/1ms, $C_{BULK} = 330\mu F$

Scope 1 (CH1 = SW1, CH2 = DIM, CH3 = I_{L1} , CH4 = V_{IN2})



Scope 2 (CH1 = DIMOFF, CH2 = SW2, CH3 = I_L , CH4 = DIM)

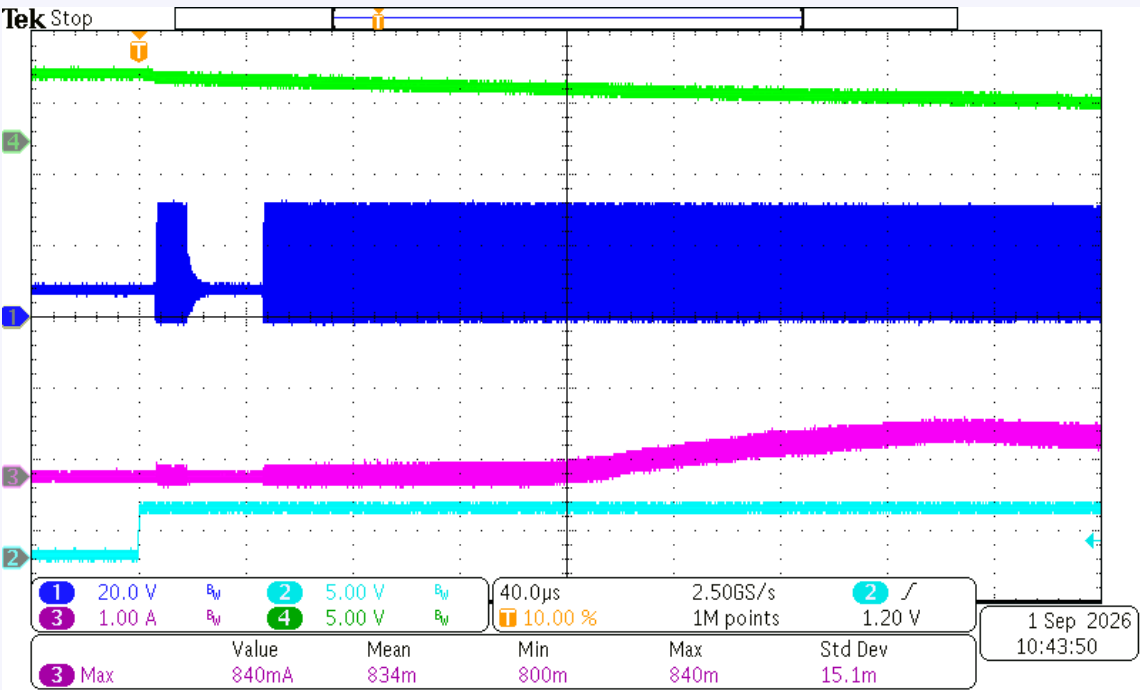


MPQ76200FS-AEC1 Test Results

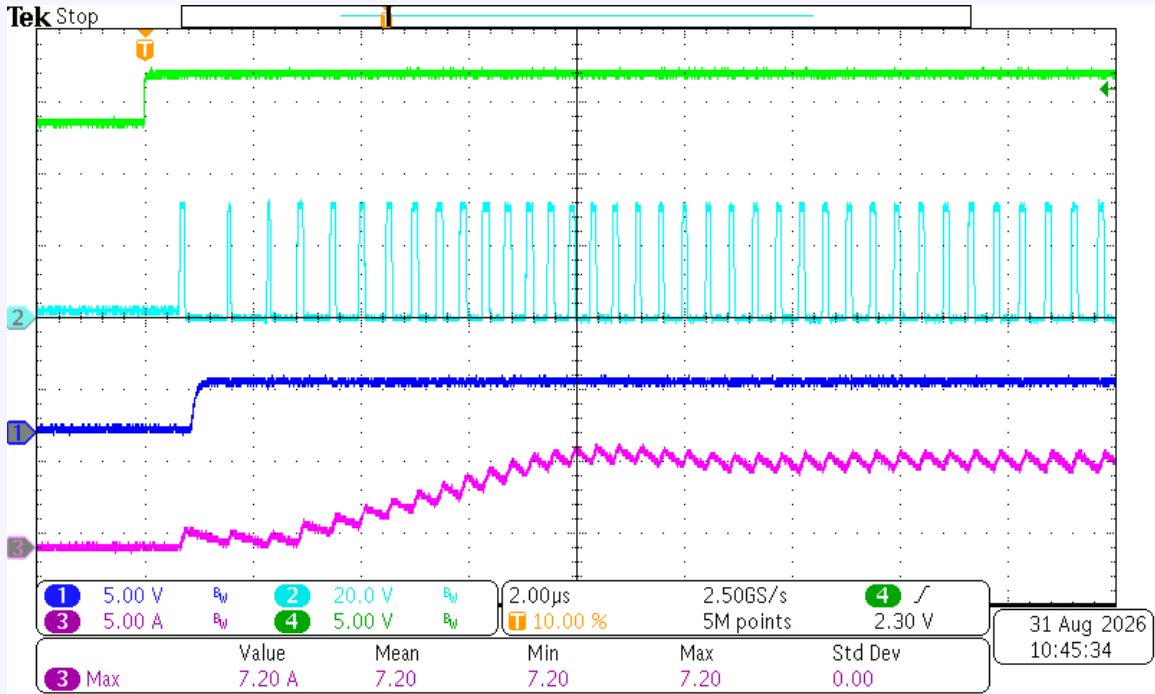


Test Conditions: $V_{IN1} = 8V$, $V_{IN2} = 32V$, $f_{SW1} = f_{SW2} = 2.2MHz$, $L1 = 10\mu H$, $L2 = 2.2\mu H$, $I_{LED} = 6A$,
2 LEDs in Series, $V_{LED} = 6V$, DIM = 30Hz/1ms, $C_{BULK} = 330\mu F$

Scope 1 (CH1 = SW1, CH2 = DIM, CH3 = I_{L1} , CH4 = V_{IN2})



Scope 2 (CH1 = DIMOFF, CH2 = SW2, CH3 = I_L , CH4 = DIM)

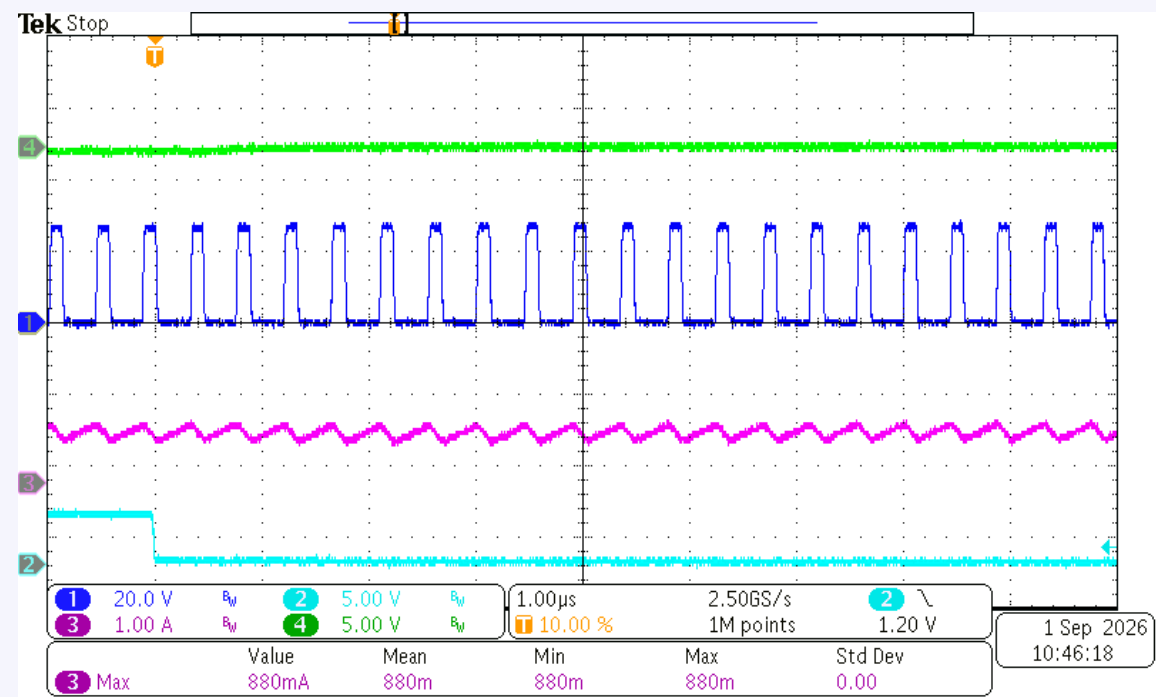


MPQ76200FS-AEC1 Test Results

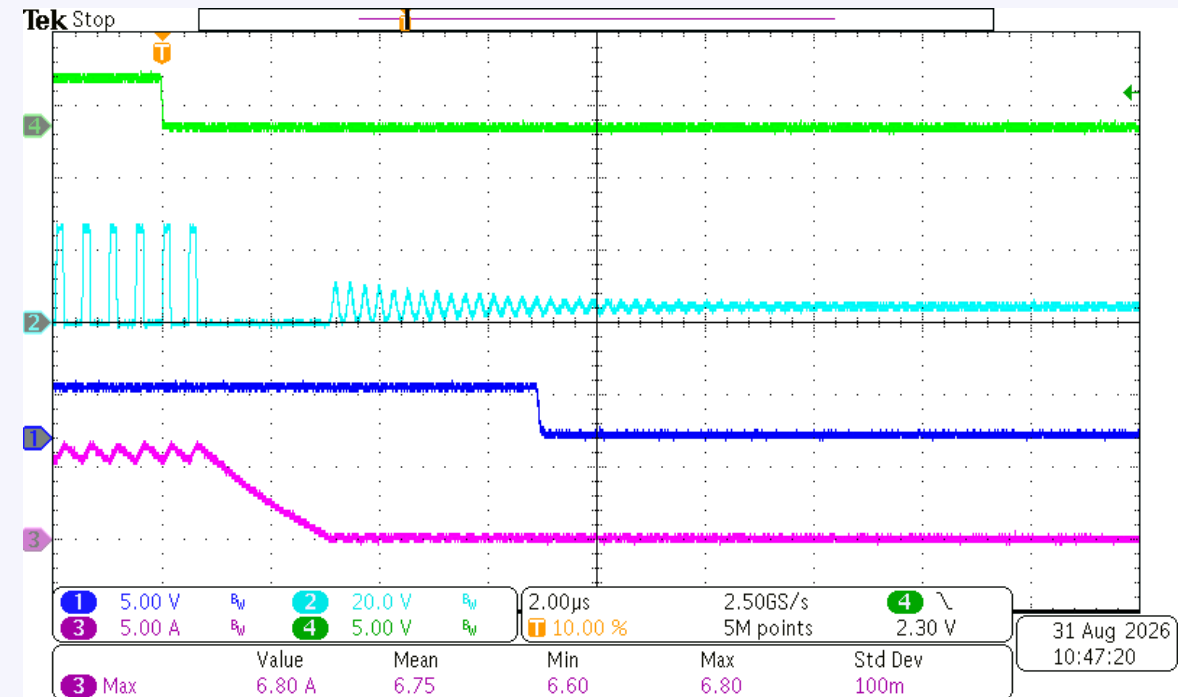


Test Conditions: $V_{IN1} = 8V$, $V_{IN2} = 32V$, $f_{SW1} = f_{SW2} = 2.2MHz$, $L1 = 10\mu H$, $L2 = 2.2\mu H$, $I_{LED} = 6A$,
2 LEDs in Series, $V_{LED} = 6V$, DIM = 30Hz/1ms, $C_{BULK} = 330\mu F$

Scope 1 (CH1 = SW1, CH2 = DIM, CH3 = I_{L1} , CH4 = V_{IN2})



Scope 2 (CH1 = DIMOFF, CH2 = SW2, CH3 = I_L , CH4 = DIM)



Buffer Capacitor Calculation for Typical Scenarios

For off-battery applications, the most typical scenarios are shown below using an estimated effective capacity for the buffer capacitor.

Inputs

- **Pulse Profile:**
 - 5A – 500 μ s
 - 2.8A – 4ms
- **Battery Range:** 9V to 18V
- **LED Forward Voltage:** 4V
- **Number of LEDs:** 2

Buffer Capacitor

- ~150 μ F off effective capacity is required, with the boost current limit set at 3A
- Can do >120Hz frame rate
- No capacitor is required if the low-side boost current limit is set to 6A

Inputs

- **Pulse Profile:**
 - 5A – 500 μ s
 - 2.8A – 4ms
- **Battery Range:** 9V to 18V
- **LED Forward Voltage:** 4V
- **Number of LEDs:** 4

Buffer Capacitor

- ~280 μ F off effective capacity is required, with the boost current limit set at 6A
- Can do >120Hz frame rate
- A 500 μ F capacitor is required if the low-side boost current limit is set to 3A

Buffer Capacitor Calculation for Typical Scenarios

For off power over coaxial (PoC) applications, the most typical scenarios are shown below using an estimated effective capacity for the buffer capacitor.

Inputs

- **Pulse Profile:**
 - 5A – 500 μ s
 - 2.8A – 4ms
- **PoC Voltage:** 12V
- **LED Forward Voltage:** 4V
- **Number of LEDs:** 1

Buffer Capacitor

- **80 μ F** off effective capacity is required, with the boost low-side current limit set at **0.8A**
- **~720mA** input RMS current for **60Hz**;
~510mA input RMS current for **30Hz**

Inputs

- **Pulse Profile:**
 - 5A – 500 μ s
 - 2.8A – 4ms
- **PoC Voltage:** 12V
- **LED Forward Voltage:** 4V
- **Number of LEDs:** 2

Buffer Capacitor

- **210 μ F** off effective capacity is required, with the boost current limit set at **1.2A**
- **~1A** input RMS current for **60Hz**;
~720mA input RMS current for **30Hz**

Inputs

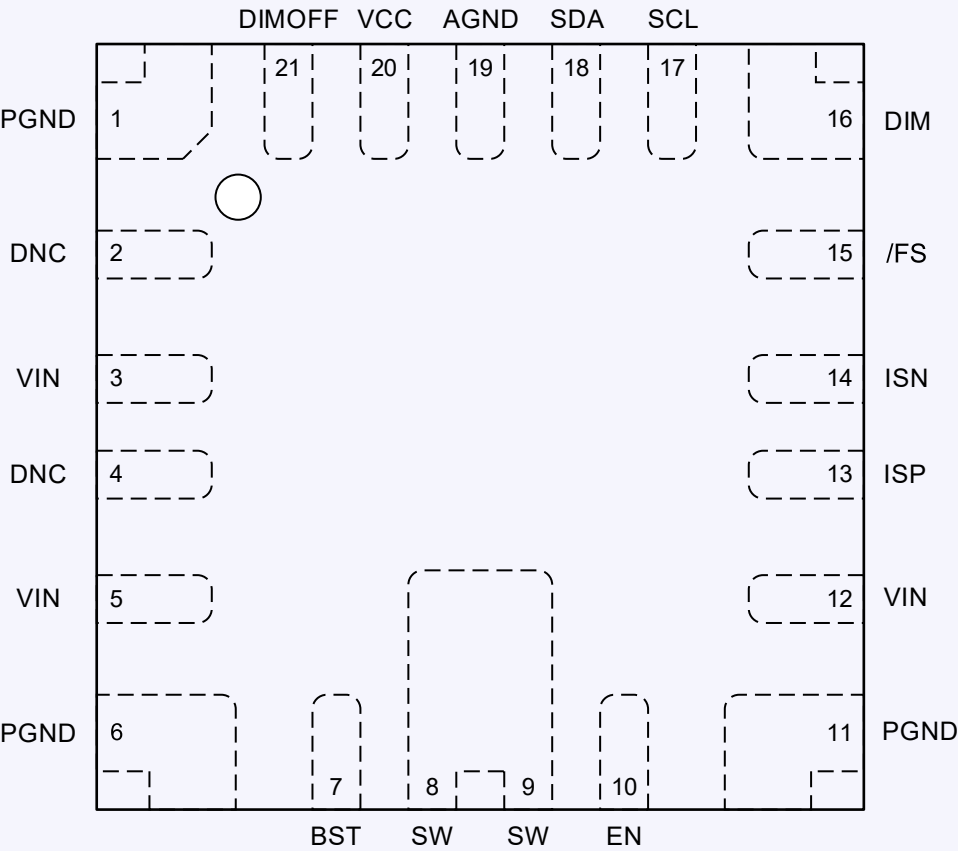
- **Pulse Profile:**
 - 5A – 500 μ s
 - 2.8A – 4ms
- **PoC Voltage:** 12V
- **LED Forward Voltage:** 4V
- **Number of LEDs:** 4

Buffer Capacitor

- **600 μ F** off effective capacity is required, with the boost current limit set at **1.2A**
- **~1.25A** input RMS current for **30Hz**

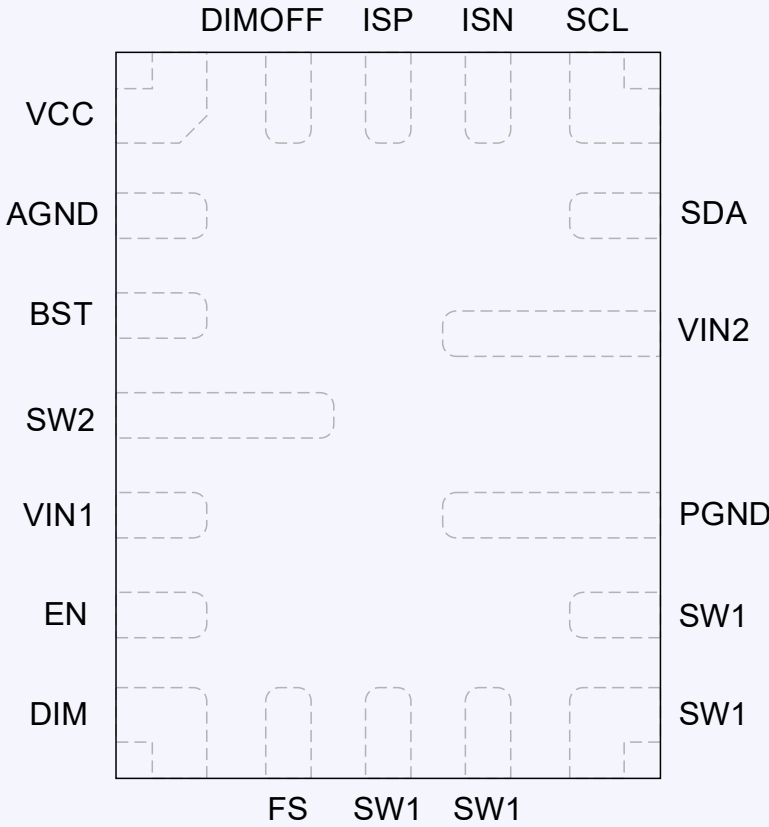
MPQ76233FS-AEC1

QFN-21 (4mmx4mm)



MPQ76200FS-AEC1

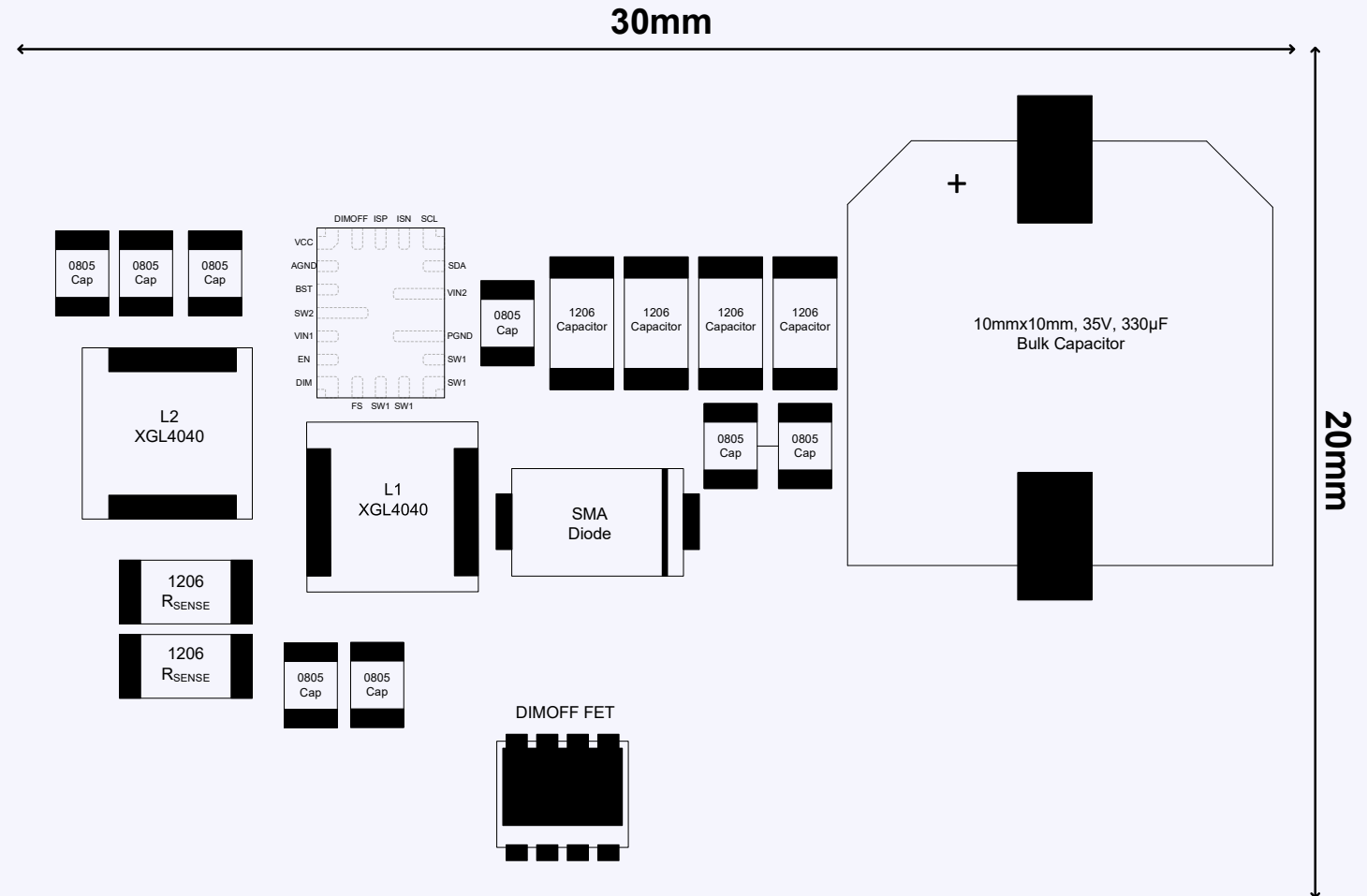
QFN-18 (3mmx4mm)



Integrated Preboost + CC Buck

Features

- A Deeply Thought-Out Package
- Fully Optimized **Buck Input** and **Boost Output Hot Loops** for Top-Tier **EMC Performance**
- Minimizes External Components to:
 - **0805 Capacitors x 8**
 - **1206 Capacitors x 4**
 - **1206 Shunt Resistors x 1 (or x 2)**
 - **Dim Off FET x 1**
 - **Inductors x 2** (Compact 4mmx4mmx4mm)
 - **SMA Diode x 1**
 - **Bulk** (10mmx10mm) Capacitor x 1



Thank you!