

# Power Solutions for Automotive e-Call Systems

June 2016

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# What is eCall?

- EU Regulations:

**REGULATION (EU) 2015/758 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL**

**of 29 April 2015**

**concerning type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service and amending Directive 2007/46/EC**

- Definitions:

**Definitions**

For the purposes of this Regulation and in addition to the definitions laid down in Article 3 of Directive 2007/46/EC, the following definitions apply:

- (1) ‘112-based eCall in-vehicle system’ means an emergency system, comprising in-vehicle equipment and the means to trigger, manage and enact the eCall transmission, that is activated either automatically via in-vehicle sensors or manually, which carries, by means of public mobile wireless communications networks, a minimum set of data and establishes a 112-based audio channel between the occupants of the vehicle and an eCall PSAP;

- Schedules:

- (12) The equipping of vehicles of existing types to be manufactured after 31 March 2018 with the 112-based eCall in-vehicle system should be promoted in order to increase penetration. In respect of types of vehicles type-approved before 31 March 2018, an eCall system may be retrofitted on a voluntary basis.

# Requirements

# Basic Functional Blocks

- GSM Modem
- MCU for System Control, Housekeeping
- Positioning System GPS, GLONASS
- Audio
- Battery

# Power Requirements

Functional block	Typical supply voltage	Required power for operation	Required power in stand by
GSM Modem	3.3V-4V	>6W	10mW-20mW
MCU	1.8V	<2W	can be 0mW
GPS, GLONASS	5V	<5W	can be 0mW
Audio	9V	10W	0W

# Power Requirements – Battery

- Individual specifications drive battery requirements
  - Talk time during backup power
  - Temperature requirements
  - Rechargeable ?
- Popular chemistries and configurations:
  - NiMH 3-5SxP
  - LiFePO 1-2SxP
  - Lilon 1-2SxP
  - Li primary cells
- Backup battery configuration defines power tree

# Power Supply Reference Designs – PMP9768 and PMP9769

# Automotive E-Call Power Supply Reference Design with low Intermediate Voltage – PMP9769



## Solution Features

- Complete power solution for an automotive e-call system
- Operating input voltage range up to 40-V
- Provides supply voltage for all required e-call functional blocks
- Up to 87% total efficiency while operating at backup power
- Up to 90% total efficiency in standby at backup power
- All DCDC converters used can operate at switching frequencies above 2-MHz

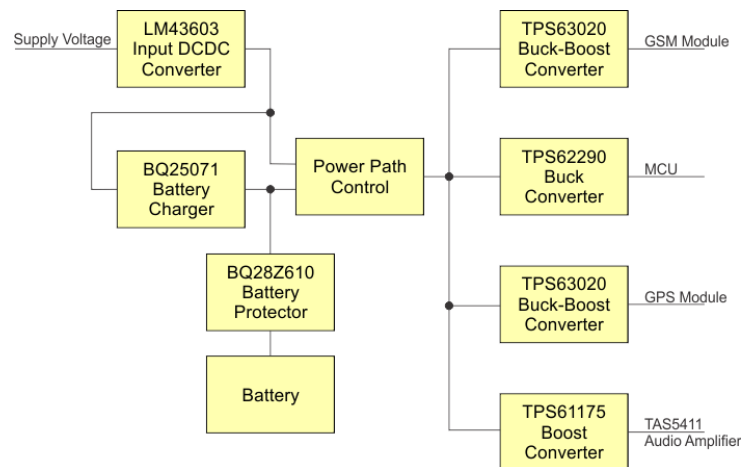
## Solution Benefits

- Simple & very low-cost design, small BOM
- Ideal for one cell LiFePO4 or powering from 12V SLI battery
- Out of AM radio range, small inductors
- Automotive packages, AEC-Q100

## Tools & Resources



- [PMP9769 Tools Folder](#)
- **Design Files:** Schematics, BOM, Gerbers, Software, and more
- **Device Datasheets:**
  - [TPS63020-Q1](#)
  - [TPS61175-Q1](#)
  - [TPS62290-Q1](#)



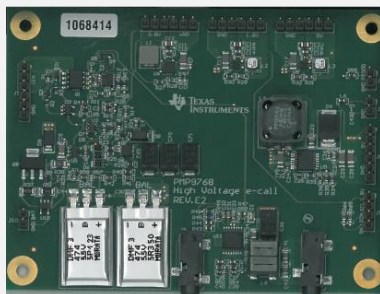


# Automotive E-Call Power Supply Reference Design with High Intermediate Voltage – PMP9768

## Solution Features

- Complete power solution for automotive e-call systems
- Operating input voltage range up to 40-V
- Provides supply voltage for all required e-call functional blocks
- Up to 87% total efficiency when operating from the backup power
- Up to 84% total efficiency in standby when operating from the backup power

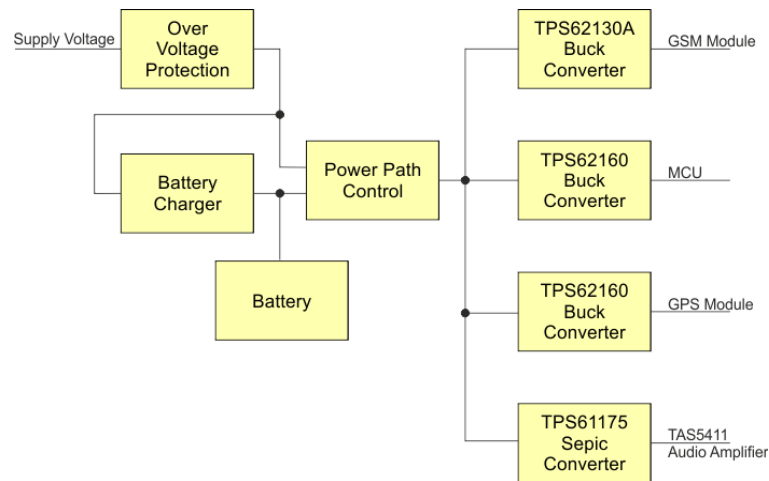
## Tools & Resources



- [PMP9768 Tools Folder](#)
- **Design Files:** Schematics, BOM, Gerbers, Software, and more
- **Device Datasheets:**
  - [TPS62130A-Q1](#)
  - [TPS61175-Q1](#)
  - [TPS62160-Q1](#)
  - [TAS5421-Q1](#)
  - [CSD25402Q3A](#)
  - [TL331-Q1](#)
  - [TLVH431A-Q1](#)

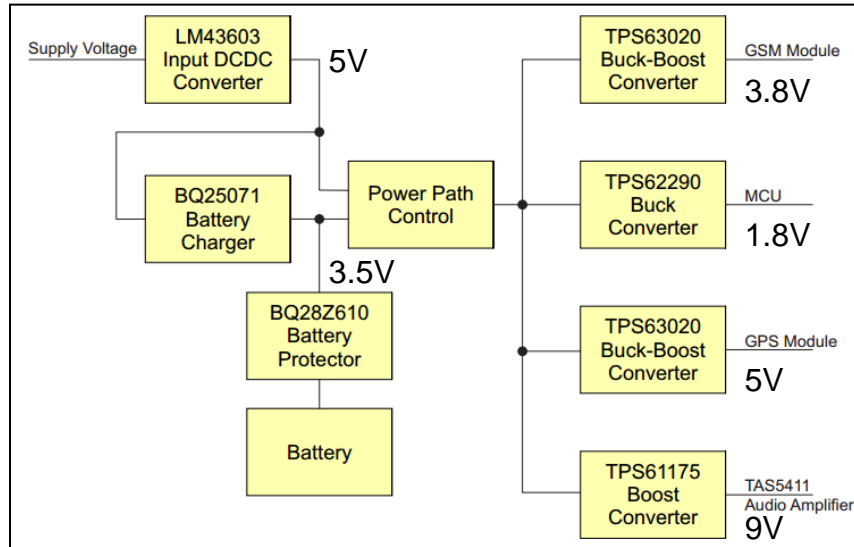
## Solution Benefits

- Simple & very low-cost design, small BOM
- Ideal for two cell LiFePO4 or powering from 12V SLI battery
- Out of AM radio range, small inductors
- Automotive packages, AEC-Q100

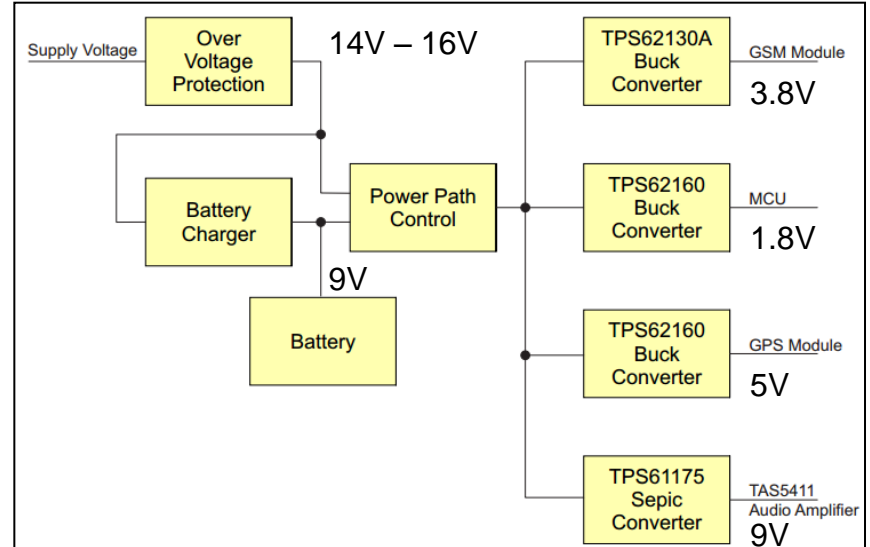


# Block Diagrams

## Low voltage configuration



## High voltage configuration



# Power and Efficiency – Standby Operation

## Low voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	14	0.003	0.04
GSM Module	3.8	0.005	0.02
GPS Module	5	0	0.00
MCU and Logic	1.8	0	0.00
Audio Amplifer	9	0	0.00
			0.02
<b>Efficiency</b>			<b>45%</b>

Input current at no load 1 mA

## High voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	14	0.004	0.05
GSM Module	3.8	0.005	0.02
GPS Module	5	0	0.00
MCU and Logic	1.8	0	0.00
Audio Amplifer	9	0	0.00
			0.02
<b>Efficiency</b>			<b>36%</b>

Input current at no load 1.5 mA

# Power and Efficiency – Light Load Operation

## Low voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	14	0.225	3.15
GSM Module	3.8	0.2	0.76
GPS Module	5	0.1	0.50
MCU and Logic	1.8	0.1	0.18
Audio Amplifer	9	0.1	0.90
			2.34
<b>Efficiency</b>			<b>74%</b>

## High voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	14	0.214	3.00
GSM Module	3.8	0.2	0.76
GPS Module	5	0.1	0.50
MCU and Logic	1.8	0.1	0.18
Audio Amplifer	9	0.1	0.90
			2.34
<b>Efficiency</b>			<b>78%</b>

# Power and Efficiency – Light Load on Backup

## Low voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	3.5	0.747	2.61
GSM Module	3.8	0.2	0.76
GPS Module	5	0.1	0.50
MCU and Logic	1.8	0.1	0.18
Audio Amplifer	9	0.1	0.90
			2.34
<b>Efficiency</b>			<b>90%</b>

## High voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	7	0.399	2.79
GSM Module	3.8	0.2	0.76
GPS Module	5	0.1	0.50
MCU and Logic	1.8	0.1	0.18
Audio Amplifer	9	0.1	0.90
			2.34
<b>Efficiency</b>			<b>84%</b>

# Power and Efficiency – Nominal Load Operation

## Low voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	14	1.13	15.77
GSM Module	3.8	0.5	1.90
GPS Module	5	0.8	4.00
MCU and Logic	1.8	0.5	0.90
Audio Amplifer	9	0.5	4.50
			11.30
<b>Efficiency</b>			<b>72%</b>

## High voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	14	0.95	13.32
GSM Module	3.8	0.5	1.90
GPS Module	5	0.8	4.00
MCU and Logic	1.8	0.5	0.90
Audio Amplifer	9	0.5	4.50
			11.30
<b>Efficiency</b>			<b>85%</b>

# Power and Efficiency – Nominal Load on Backup

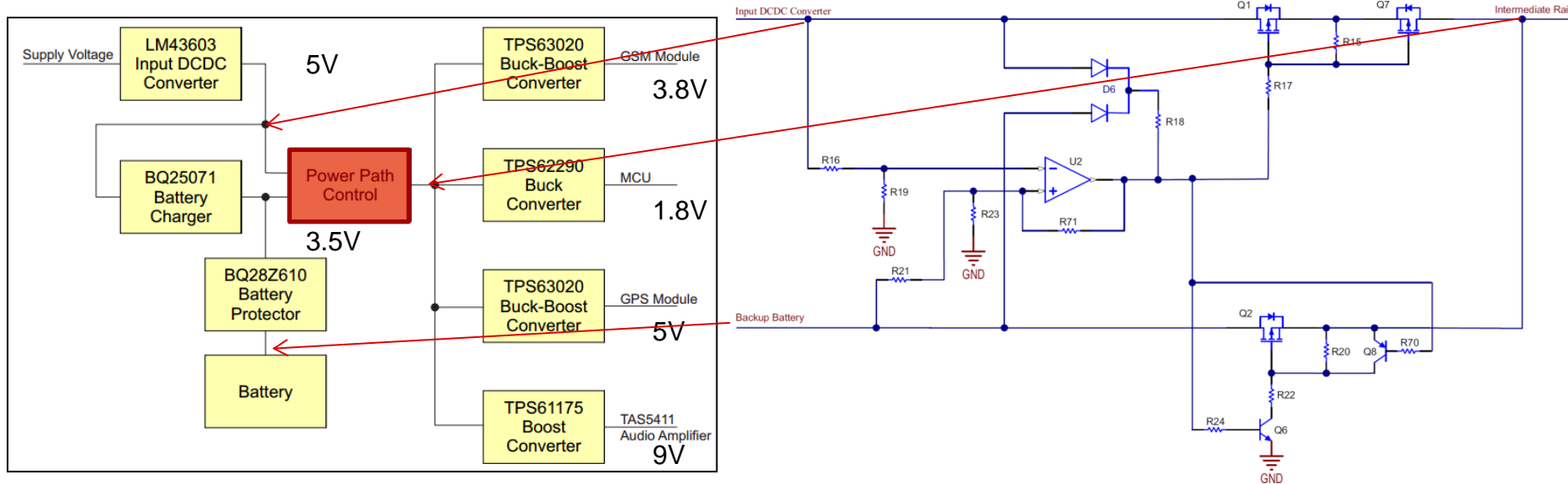
## Low voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	3.5	3.71	13.00
GSM Module	3.8	0.5	1.90
GPS Module	5	0.8	4.00
MCU and Logic	1.8	0.5	0.90
Audio Amplifer	9	0.5	4.50
			11.30
<b>Efficiency</b>			<b>87%</b>

## High voltage configuration

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input	7	1.85	12.98
GSM Module	3.8	0.5	1.90
GPS Module	5	0.8	4.00
MCU and Logic	1.8	0.5	0.90
Audio Amplifer	9	0.5	4.50
			11.30
<b>Efficiency</b>			<b>87%</b>

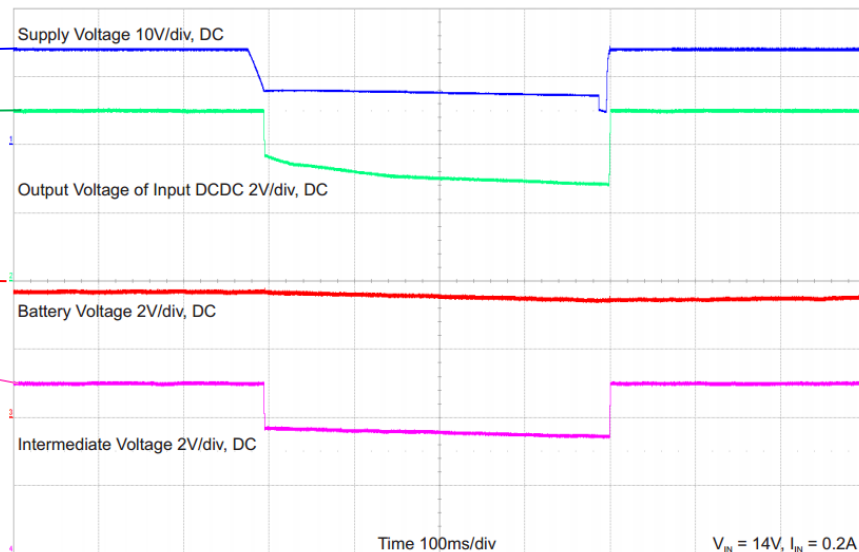
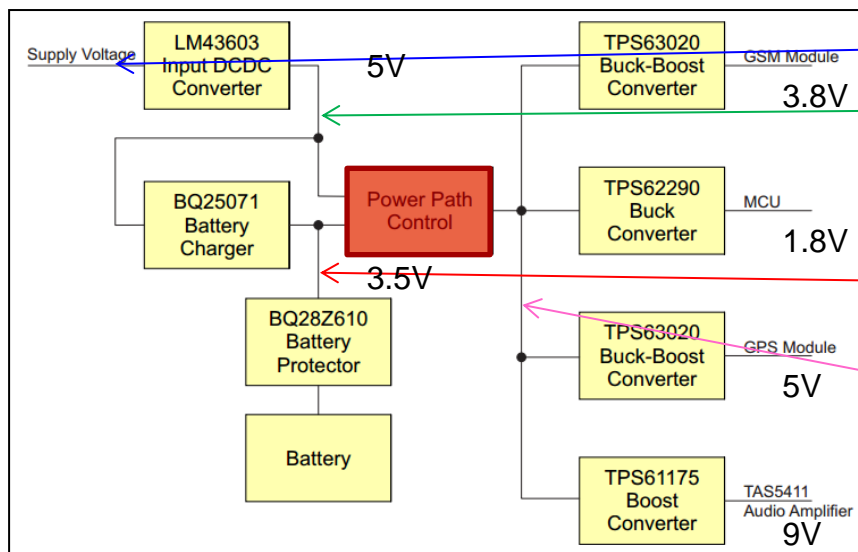
# Power Path Control – Low Voltage – PMP9769



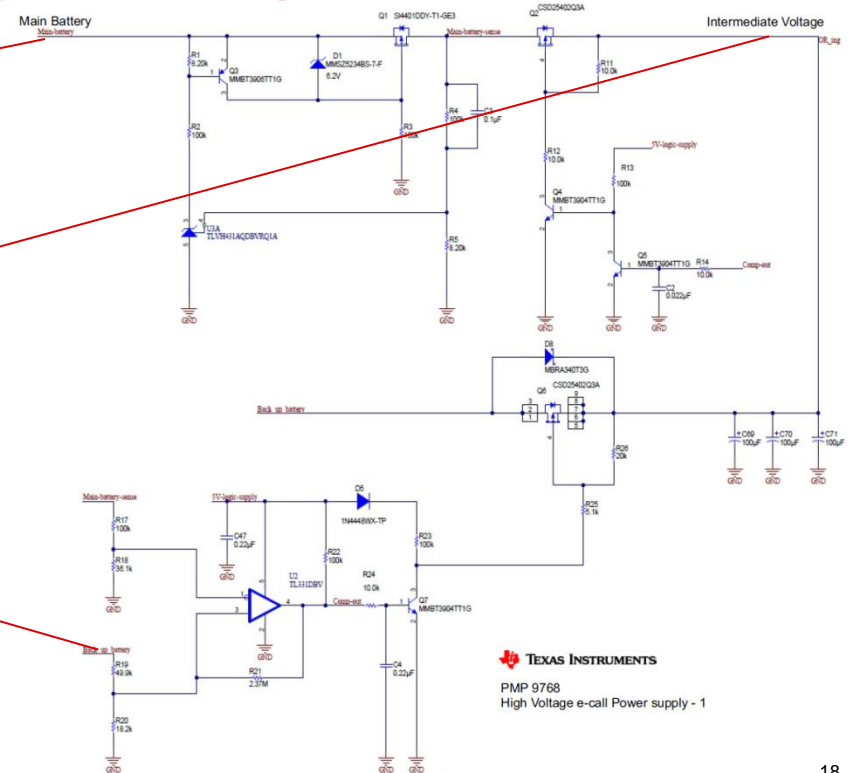
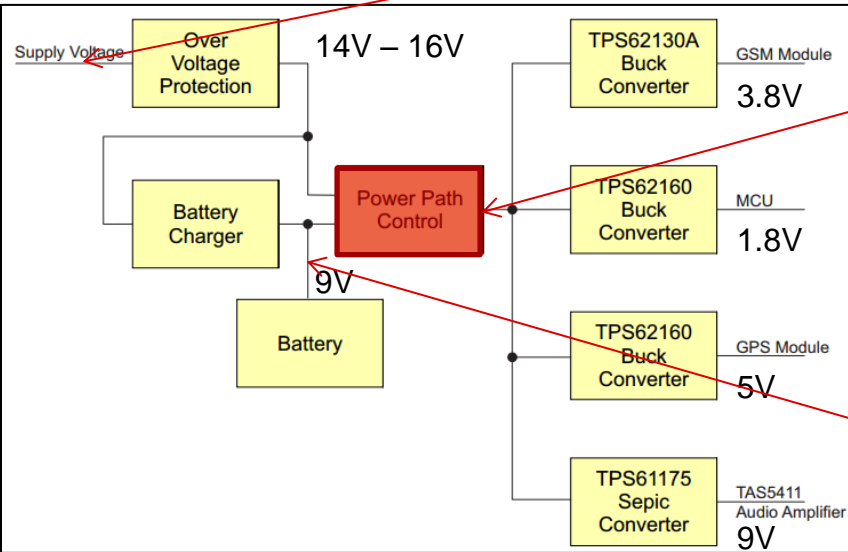


# Measurements – Power Path Control

## Low Voltage – PMP9769



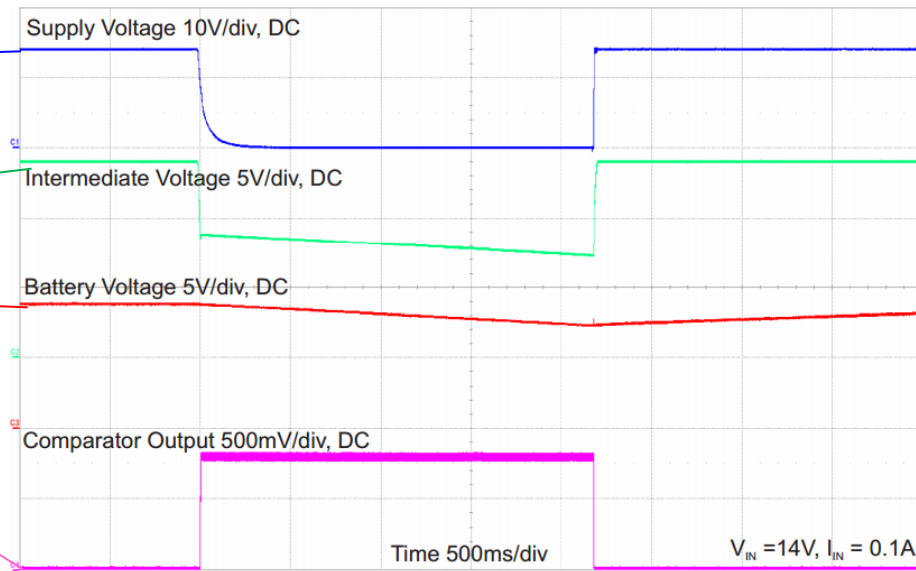
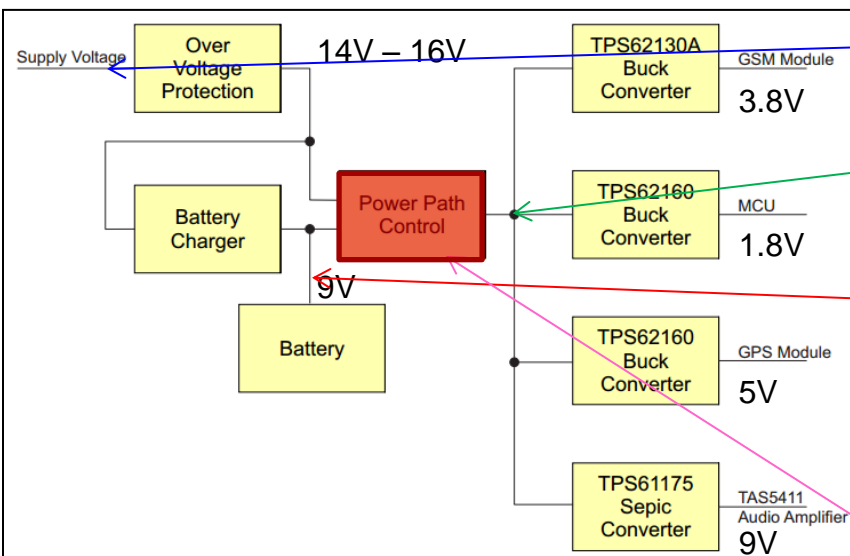
# Power Path Control – High Voltage – PMP9768



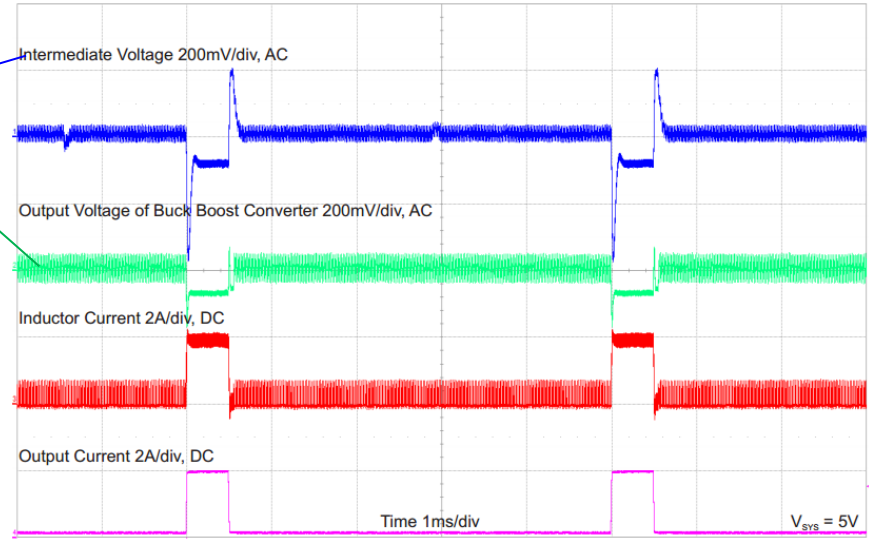
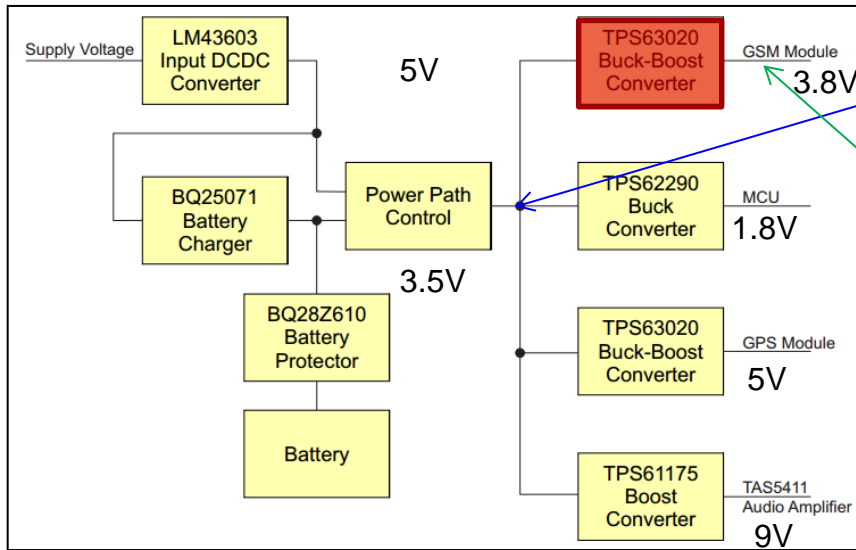
TEXAS INSTRUMENTS  
PMP 9768  
High Voltage e-call Power supply - 1

# Measurements – Power Path Control

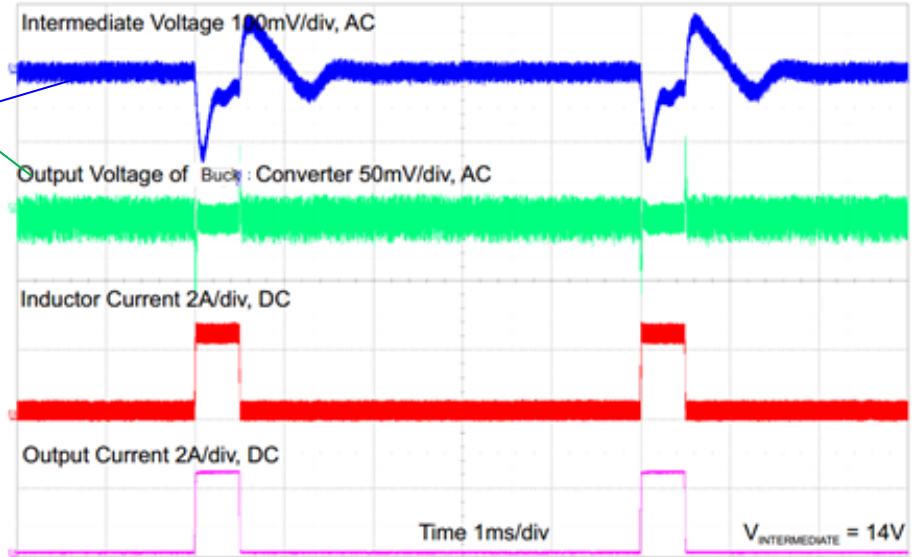
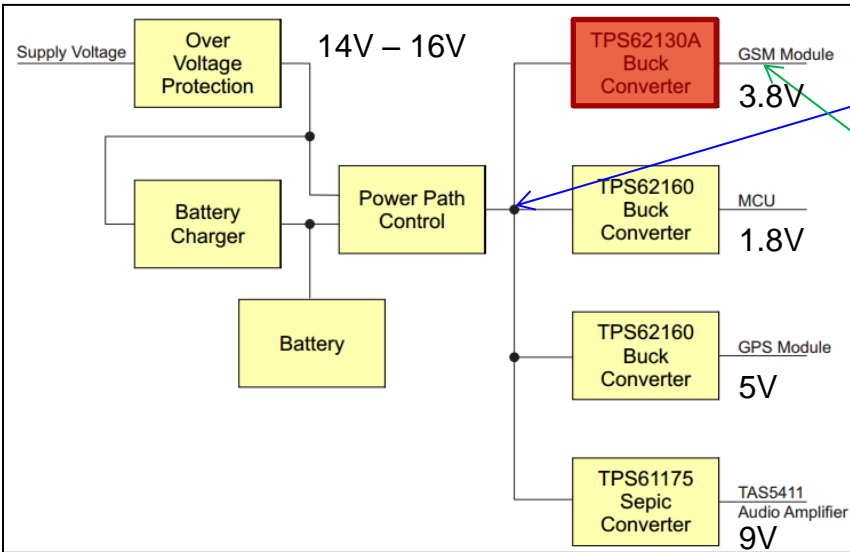
## High Voltage – PMP9768



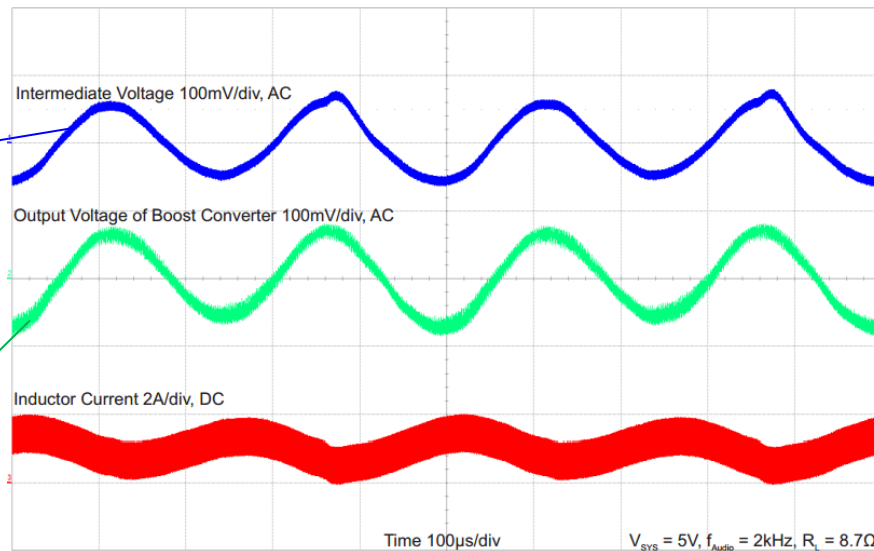
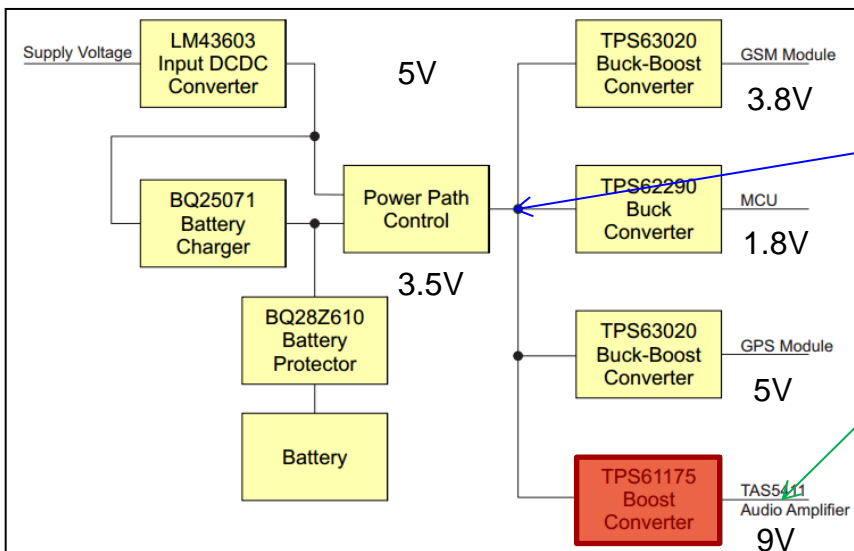
# Low Voltage – PMP9769 GSM Modem Supply



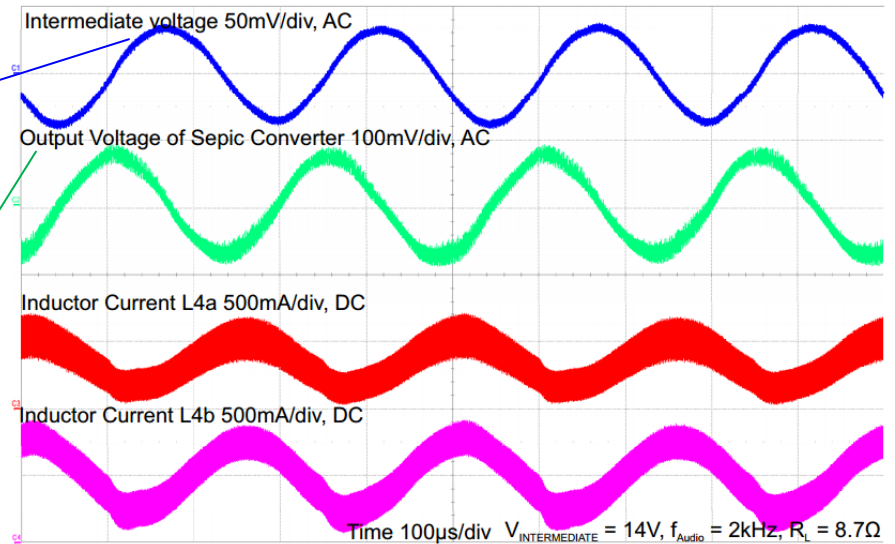
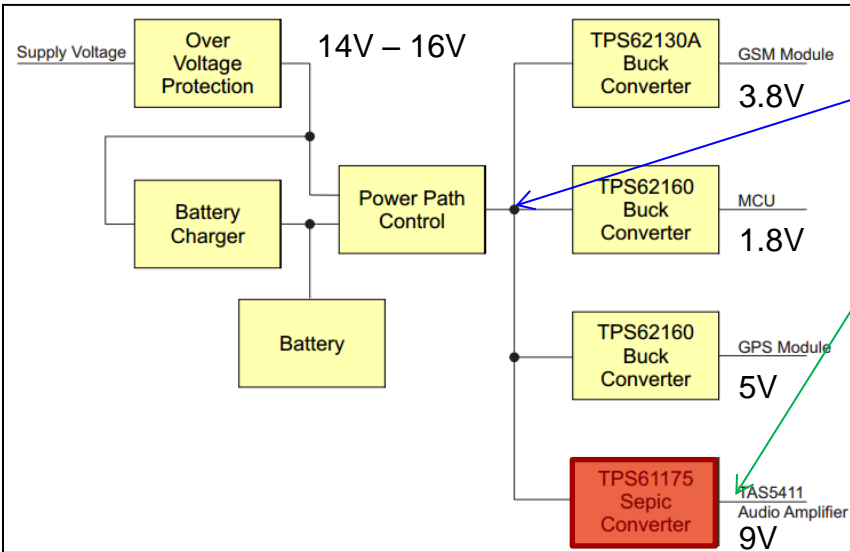
# High Voltage – PMP9768 GSM Modem Supply



# Low Voltage – PMP9769 Audio Supply



# High Voltage – PMP9768 Audio Supply



# LPDCDC Application Support on E2E

[http://e2e.ti.com/support/power\\_management/non-isolated\\_dcdc/f/196](http://e2e.ti.com/support/power_management/non-isolated_dcdc/f/196)



# Battery Gauge Device

# Key battery gauges for automotive

## bq27441

IT Pre-programmed profiles  
Power: 93/21/0.6uA  
200 – 8000 mAh battery capacity  
-40C to 85C operating temp range  
12p SON 2.5x4mm

## bq27220

CEDV+  
Pre-programmed selectable profiles  
Power: 50/9/0.6uA  
100 – 29000 mAh battery capacity  
-40C to 85C operating temp range  
9p CSP 1.6x1.6mm

## bq28z610

Gauge + Protector  
IT Fuel gauge  
High NFET Drive  
100 – 14000 mAh battery capacity  
-40C to 85C operating temp range  
12p SON 4x2.5 mm

1 Series battery

1-2 Series battery

# bq28z610: Battery gauge + integrated protector for 1-2s cells

## Features

- ❑ Li Ion/LiFePO4 Pack with 1s to 2s cell
- ❑ Operational modes; Normal, Sleep and Shipmode
- ❑ Operates Down to 2.2V
- ❑ Accurate Cell Measurement  $\pm 1\text{mV}$
- ❑ Current sense with  $1\text{m}\Omega$  sense resistor
- ❑ Cell balancing for 2s with internal switches
- ❑ Protection for : Over/Under Voltage, Over Current Charging/Discharging, Short Circuit Charge/Discharge, Over Temperature
- ❑ Ex. Thermistor biasing output and monitor
- ❑ Battery Trip Point Alert
- ❑ I2C Interface
- ❑ Works with 1.8V I/O
- ❑ SON 12pin Package (2.5mmx4mmx0.9mm)

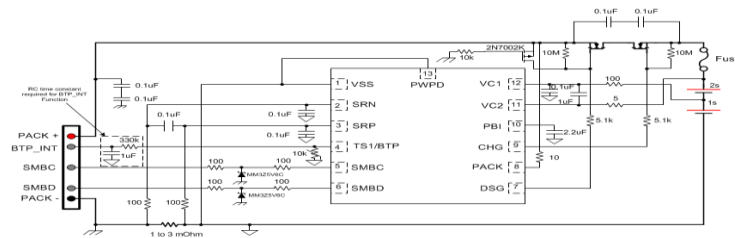
## Applications

- ❑ Automotive Telematics, eCall
- ❑ Tolling
- ❑ Insurance Tracking
- ❑ Fleet management

## Benefits

- ❑ Reduce space and cost with integrated gauge and protector function in single package
- ❑ Intelligent charging control for a wide variety of chargers/bq24773
- ❑ Supports high current applications with low voltage drop across the low value  $1\text{m}\Omega$  sense resistor
- ❑ Low voltage operation supports wider variety of cells
- ❑ Ability to communicate to MCU with fault condition and protection FETs OFF
- ❑ Lifetime data supports warranty claim verification
- ❑ Authenticates legitimate battery pack (SHA-1)
- ❑ Low BOM (less than 27 – 2s system)
- ❑ Lower total solution area footprint

## Typical Application Schematic



Note: 1) The BTP\_INT function is optional and may be required for some operating systems. If NOT required the 1µF and 330k can be DNP.  
2) The input filter capacitors of 0.1µF for the SRN and SRP pins must be located near the pins of the device.

# bq27220 - 1S System/Pack-Side Fuel Gauge

## Features

- Single Cell Li-ion/LiFePO4 Fuel Gauge
  - Powered directly from battery
  - Supports embedded /removable battery
  - Flexible to be placed in system/pack side
- Ultra low power Normal/Sleep/Shutdown of 50/9/0.6uA
- Accumulated passed charge counter
- CEDV algorithm Technology
  - Remaining Capacity and State of Charge
  - State of Health (SOH) reporting battery age estimation
  - Auto-compensation for aging, temperature, rate of charge/discharge
  - Multiple selectable pre-programmed profiles for 4.2V, 4.35V & 4.4V cells
  - OTP open space for 3 additional CEDV profiles
- Configurable Alert Interrupt to Host
- External sense resistor supports high chg/dsg currents
- Internal temperature sensor/External thermistor

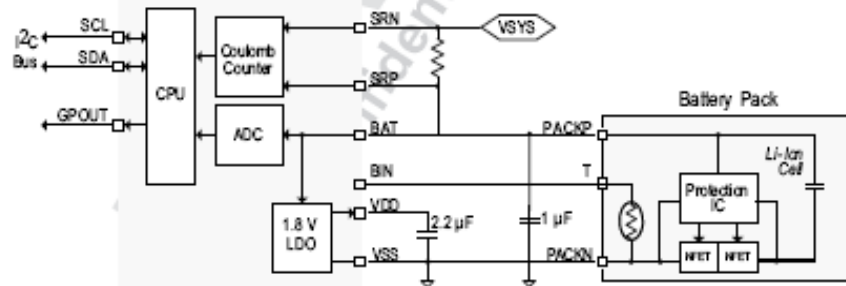
## Applications

- Keyfob
- Current sensing
- Automotive eCall
- Insurance tracking

## Benefits

- Selectable chemistry profiles:
  - Extremely easy to setup and go to production
  - Solve customer inventory management across multiple projects
  - Additional CEDV profile parameters self-tuned by customer without needing TI's support
  - Quick time to market with no added development
- Accumulated passed charge used as current sensor for tracking passed charge
- Configurable interrupts save system power and frees up host from continuous polling
- External sense resistor supports high chg/dsg currents
- External thermistor supports accurate gauging over temp
- 400KHz I2C enables faster configuration

## Typical Application Schematic



# bq27441 1S System Side Fuel Gauge

## Features

- Single Cell Li-ion Fuel Gauge
- Power directly from battery
- Impedance Track Technology
  - Remaining Capacity and State of Charge
  - State of Health (SOH) reporting
  - Auto-compensation for aging, temperature, rate of charge/discharge
  - Pre-programmed profiles 4.2V & 4.35V cells
- Internal temperature sensor
- I2C 400KHz serial interface
- 12 pin QFN (2.5mm x 4mm)

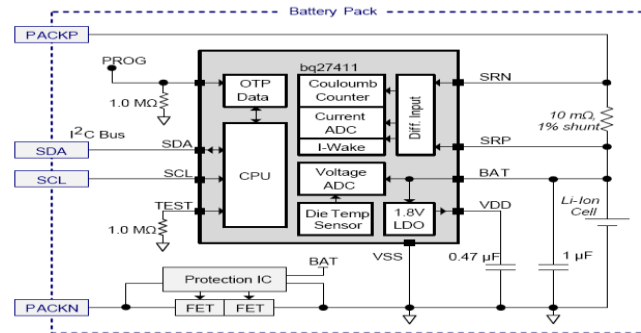
## Applications

- Keyfob
- Automotive eCall
- Insurance tracking

## Benefits

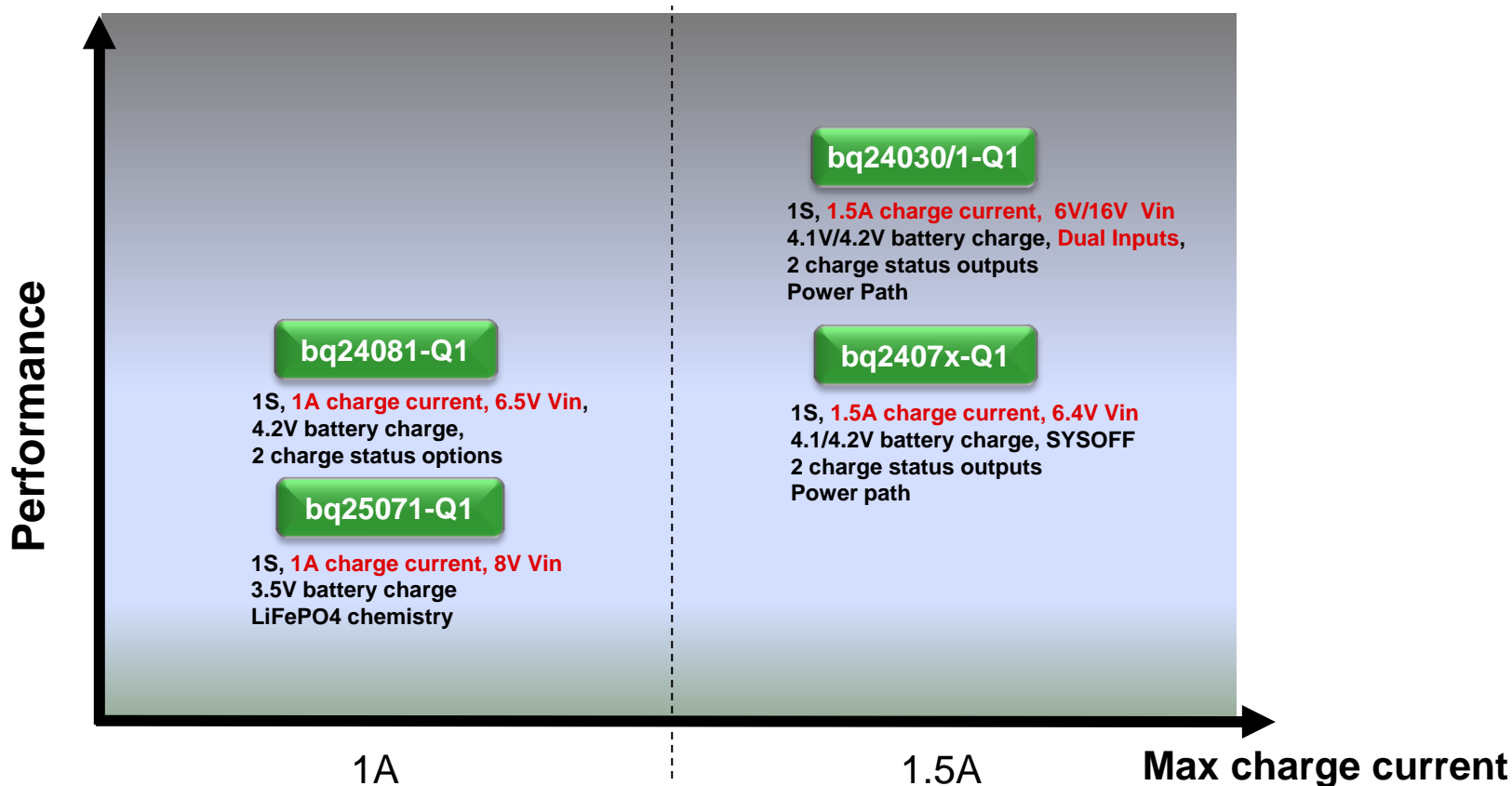
- Temperature sensing without extra component
- Easy to use with minimum configuration
- SOH provides battery age estimation
- 400KHz I2C enables faster pack maker production line configuration
- QFN package supports easier production line handling

## Typical Application Schematic



# Battery Charger for Automotive

# Key Linear Chargers for Automotive



# **bq25071-Q1**

Automotive, 1A, Single Cell LiFePO<sub>4</sub>, 30V Input Rating, Integrated LDO

## **Features**

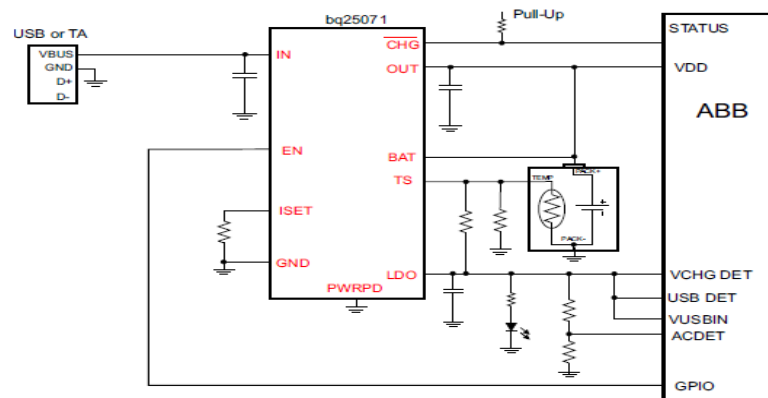
- AEC-Q100 qualified
- Single cell LiFePO<sub>4</sub> charging algorithm
- 30V input rating, with 10.5V OVP
- 50mA integrated LDO
- Programmable ICHG through ISET and EN
- Thermal regulation and protection
- Charging status indication
- 2-mm x 3-mm SON10 Package

## **Applications**

- Tolling
- Insurance Tracking
- Fleet Management
- eCall
- Display Key

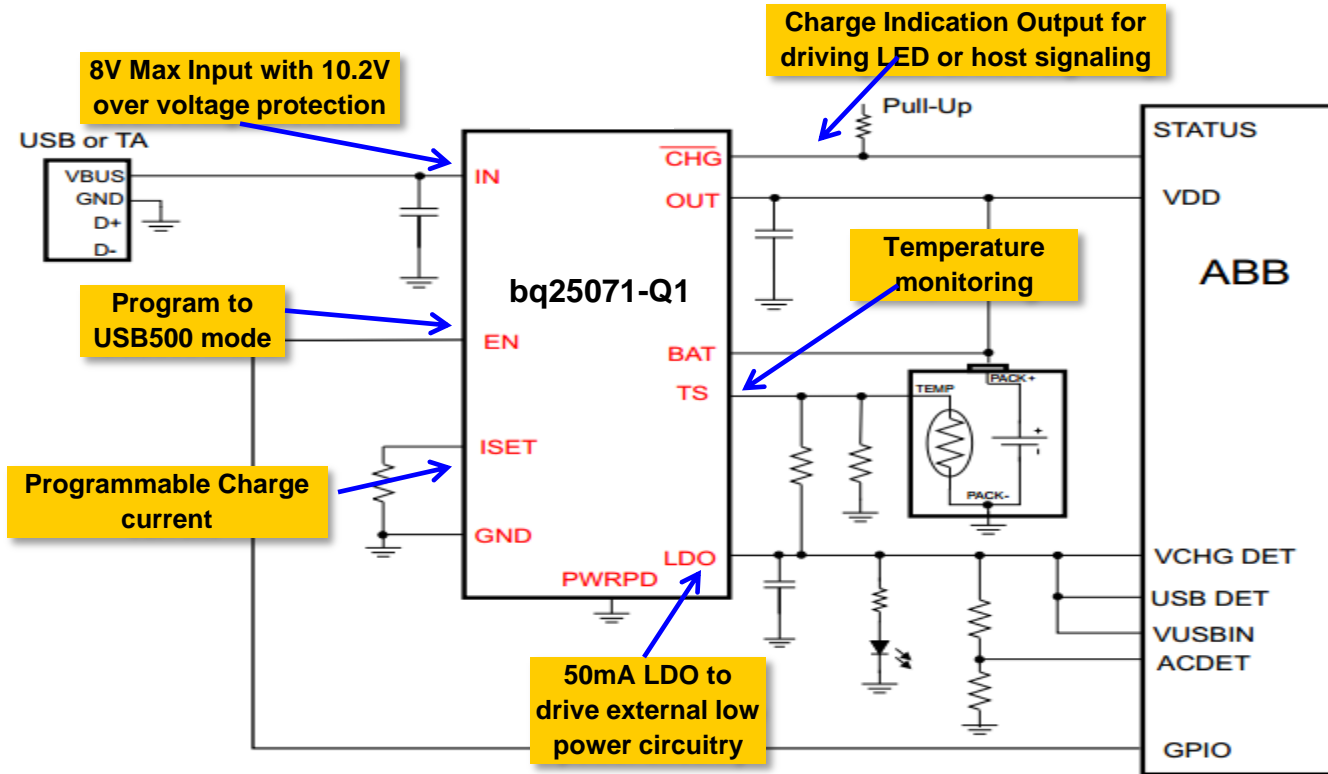
## **Benefits**

- Automotive grade product
- Safety
- Supports low-cost unregulated adapters
- Integration for space-limited applications
- Flexibility





# bq25071-Q1 Typical Application Circuit



# bq24081-Q1

Automotive, 1A, Li-ion and Li-polymer charger

## Features

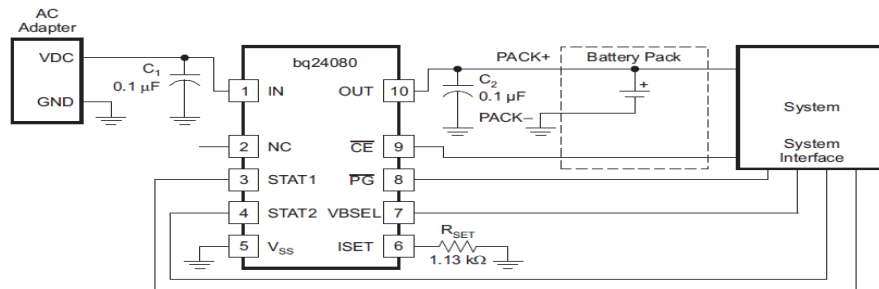
- AEC-Q100 qualified
- Integrated power FET and current sensor for up to 1-A charge applications from AC adapter
- Pre-charge conditioning with safety timer
- Charge and power-good status output
- Integrated charge-current monitor
- Fixed 7-Hour fast charge safety timer
- Small 3-mm x 3-mm VSON10 Package

## Applications

- Tolling
- Insurance Tracking
- Fleet Management
- eCall
- Display Key

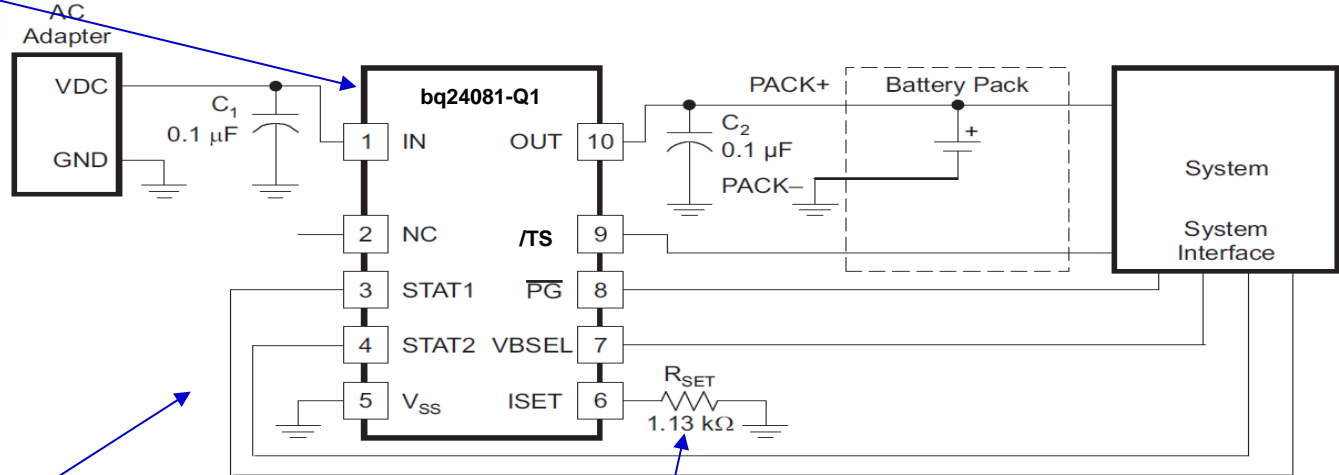
## Benefits

- Automotive grade product
- Small and low cost solution
- Maximizes battery capacity, cycle life and safety
- Ideal for Low-Dropout Charger Designs
- Automatic Sleep Mode for Low Power Consumption



# bq24081-Q1 Typical Application Circuit

Integrated FET and Current Sensing



Connect LEDs or directly to system to report charging status

Ext. R set the charging current

# bq24030/1-Q1

## Automotive, 1.5A, System Power-Path

### Features

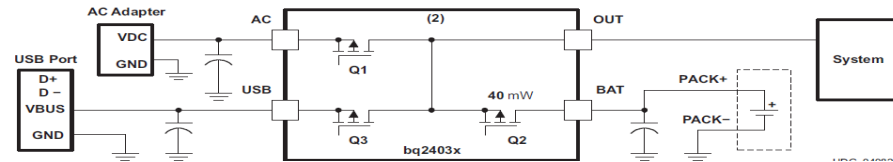
- AEC-Q100 qualified
- Integrated Dynamic Power-Path Management
- AC Adapter or USB port to simultaneously power the system and charge the battery
- Autonomous power source selection (AC Adapter or USB)
- Integrated USB charge control with selectable 100-mA and 500-mA maximum input current regulation limits
- Dynamic total current management for USB
- 3.5-mm x 4.5-mm QFN Package

### Applications

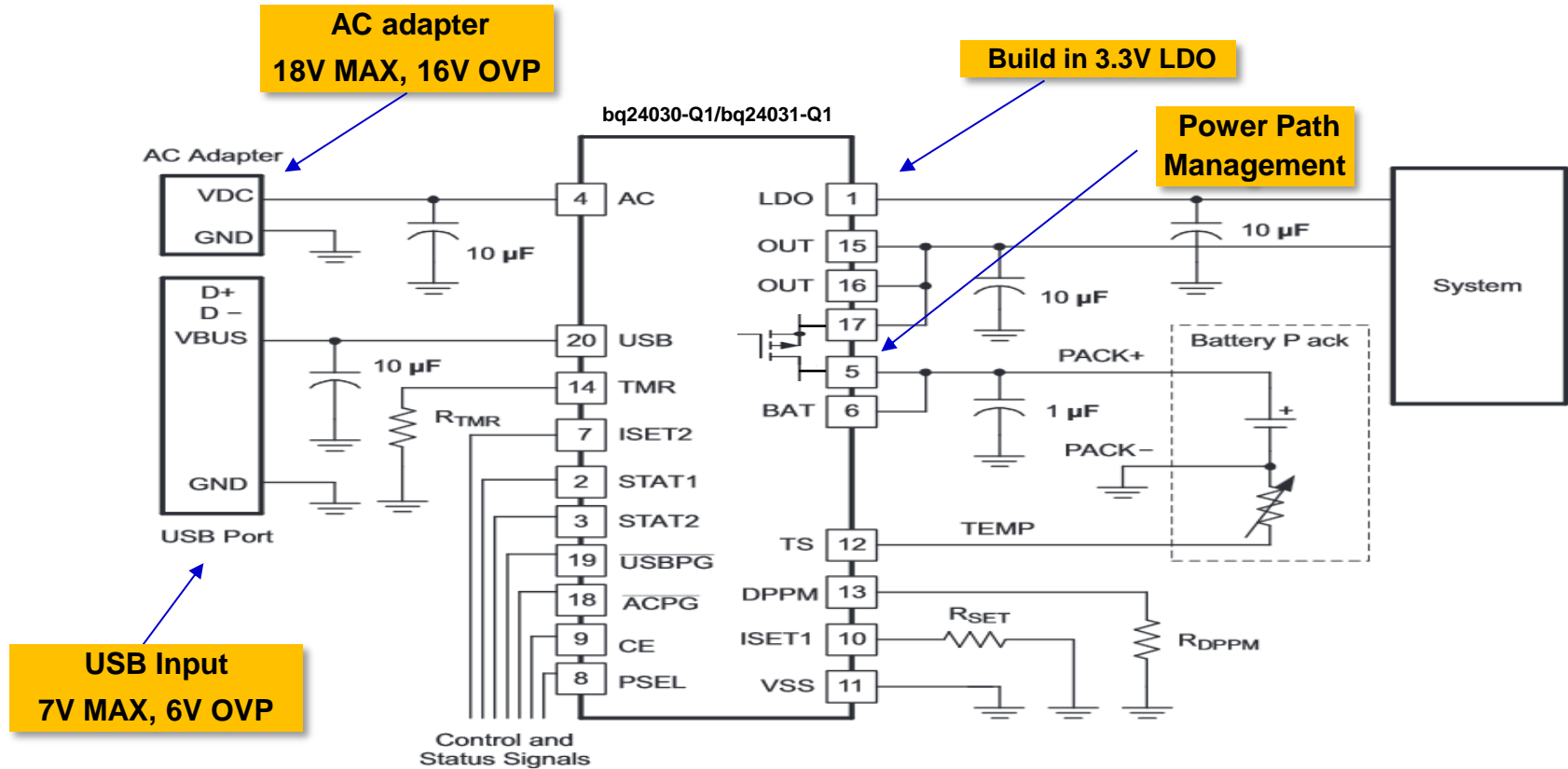
- Tolling
- Insurance Tracking
- Fleet Management
- eCall
- Display Key

### Benefits

- Automotive grade product
- Reduces the impact of charge and discharge cycles on the battery, allows for proper charge termination, and allows the system to run with an absent or defective battery pack
- Selects priority of the input sources
- Allows the use of one input connector
- Allows the selection of a lower current rated adapter based on the average load, rather than a high peak transient load



# bq24030/1-Q1 Typical Application Circuit



# bq2407x-Q1

## Automotive Qualified Li-Ion Battery Charger with NTC Monitoring & Power Path

### Features

- Automotive AEC-Q100 qualified
- Input current limiting: 100 or 500 mA for USB, user-programmable for non-USB applications
- 28V max  $V_{in}$  with OVP at 6.5V, 2A max input and output currents, 1.5A max charge current
- Dynamic Power Management with integrated input and charge FETs
- Programmable timers which can be disabled
- 3x3mm 16pin QFN package

### Applications

- Tolling
- Insurance Tracking
- Fleet Management
- eCall
- Display Key

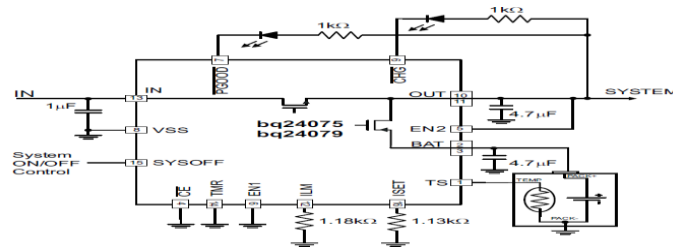
### Benefits

- Support mini-USB interface
- Protects against voltage transients
- Maximize use of input power; save cost in AC adapters; allows instant turn-on
- More safety and flexibility
- Small integrated solution

### Available Options

Part Number	VREG	OVP	VOUT	SYSOFF
bq24075-Q1	4.2V	6.6V	5.5V	Yes
bq24079-Q1*	4.1V	6.6V	5.5V	Yes

\* RTM 1Q17



# bq2407x-Q1 Typical Application Circuit

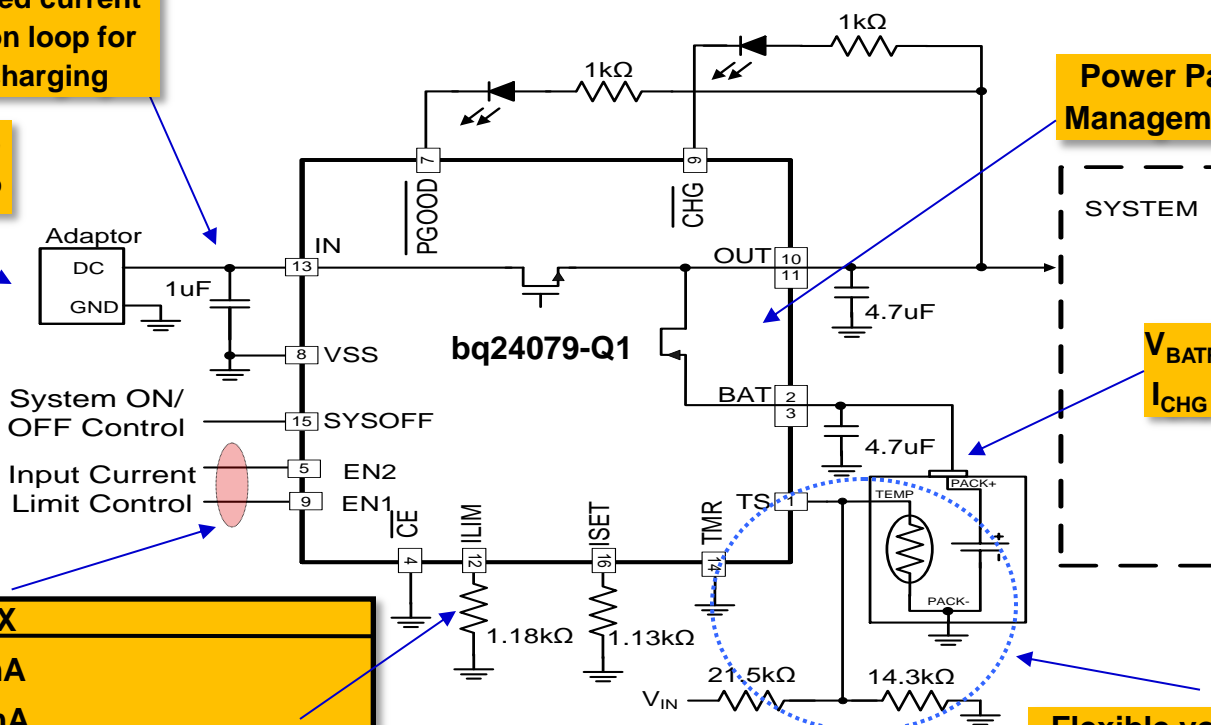
VIN based current reduction loop for USB charging

AC adapter or USB  
28V MAX, 6.5V OVP

Power Path Management

$V_{BATREG} = 4.2V$   
 $I_{CHG} = 1.5A MAX$

Flexible voltage-based battery NTC monitoring



System ON/  
OFF Control

Input Current  
Limit Control

EN2	EN1	$I_{IN} MAX$
L	L	100 mA
L	H	500 mA
H	L	Resistor Programmable
H	H	Chip disable, USB suspend

# Thank you

For more information visit [TI.com/power](http://TI.com/power)