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

Emergency call devices (e-call) for automotive need to be powered reliably during the complete phase of the emergency call. In an emergency situation which requires the emergency call in a car, the car may have been severely damaged including a breakdown of the car battery supply. For this reason usually an integrated backup power solution is required. This reference design shows a complete power solution for such an e-call application including the backup power. It uses a battery configuration with a maximum terminal voltage of less than 9V for backup power. For providing power to all required circuit blocks it uses suitable switching regulators. It also manages seamless transition from main to backup power and back during all possible power conditions in the car. Charging the backup battery is included as well.

1 Overview

For regulating the supply voltage for the required circuit blocks and for interfacing with the high voltage of the main car battery rail, switchmode power supplies are used. Figure 1 shows the structure of the circuit. At normal conditions the system is supplied from the main car battery rail. Over voltage protection is active in case of overvotlage events to limit input voltage for DC/DC converts. All regulators supplying the individual circuit blocks are connected to this system rail. During backup operation the power path control block switches the backup battery to the system rail. Depending on the battery type and the state of charge of the battery, it is expected that the system voltage during backup operation can vary between 5V and 9V. The nominal main car battery voltage and the backup system voltage range defines the topology for all regulators supplying the individual circuit blocks. To keep the solution size small and to avoid interference with other systems in the car, the switching converters are selected to be capable to operate at switching frequencies above 2 MHz at nominal load conditions.

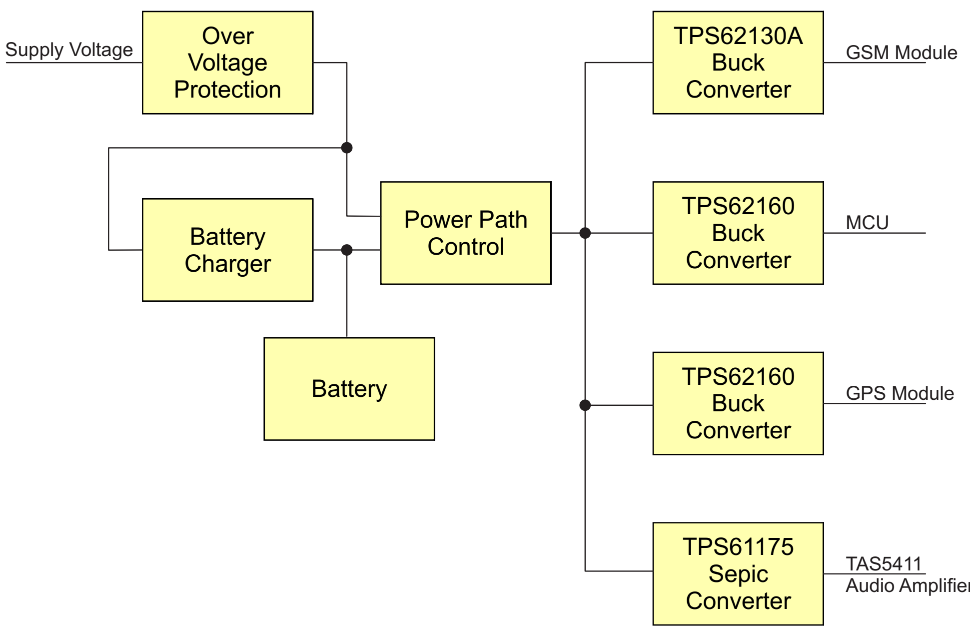

Figure 1. Block Diagram

2 Measurements

As shown in Figure 1 the functional blocks of the system are supplied with 4 dedicated regulators. For the GSM module a supply voltage of 3.8 V is needed. This requires buck conversion, so TPS62130 is selected for this rail. The MCU and the related logic components which are used to control the system require 1.8 V. This only needs a step down converter like the TPS62160 which is selected here. For the 5 V required for the GPS or GLONASS system the TPS62160 is used in buck operation. The audio amplifier TAS5411 is supplied with 9 V. This requires a sepic converter like the TPS61175 which is used here.

Most of the converters operate at switching frequencies above 2 MHz by default and the frequency cannot be adjusted. For the converters which allow programming the switching frequency, frequencies above 2 MHz are selected. Details on how to configure the features of the individual devices in this circuit can be found in their respective datasheet (TPS62130A, TPS62160, TPS61175, TAS5411).

The peak load expected for the GSM module is 2.5 A with a duty cycle of 25%. All other rails are designed for maximum 1 A. All power measurements have been done at a nominal average load current. Nominal average load current for the testing of the GSM rail is 0.62 A, for the MCU rail 0.5 A, for the GPS rail 0.8 A and for the audio amplifier 0.5 A. Standby operation is defined with each of the rails operating at 10% of their maximum output power.

The measurements documented in this report are captured at the defined nominal load condition and at the defined standby load condition.

2.1 *Total Efficiency*

Table 1 shows the efficiency of the total solution at the defined nominal average output conditions. The input currents are measured for operation from the main input supply and for operation from the backup battery.

Table 1. Efficiency at Nominal Load

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input (normal operation)	14.0	0.99	13.79
Battery Input (backup operation)	7	1.93	13.51
GSM Module	3.8	0.62	2.39
MCU and Logic	1.8	0.50	0.90
GPS Module	5.0	0.80	3.97
Audio Amplifier	9.0	0.50	4.51
Efficiency			
Main input operation	**85.16%**		
Battery operation	**87.01%**		

Table 2 shows the efficiency of the total solution at the defined standby average output conditions. The input currents are measured for operation from the main input supply and for operation from the backup battery.

Table 2. Efficiency at Standby Load

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input (normal operation)	14.0	0.24	3.19
Battery Input (backup operation)	7	0.43	3.02
GSM Module	3.8	0.25	0.95
MCU and Logic	1.8	0.10	0.18
GPS Module	5.0	0.10	0.50
Audio Amplifier	9.0	0.10	0.90
Efficiency			
Main input operation	**78.96%**		
Battery operation	**83.62%**		

2.2 Functional Power Blocks

In this section measurement results for the individual converters are shown which are specific for this implementation. Since the converters are configured very similar to their default recommended configuration standard performance measurements like for example DC regulation, efficiency at various line and load conditions and typical load transient measurements are not repeated here. They can be found in the individual datasheets of the converters (TPS62130A, TPS62160, TPS61175, TAS5411).

2.2.1 Input Overvoltage protection

The input voltage range of the e-call is up to 40V. The higher input voltage than main battery voltage can appear for example during start of the engine. In this case it is not necessary to provide nominal output power from e-call power tree. To protect DC/DC converts from higher input voltage than maximum recommended operating voltage the overvoltage protection is implemented because the converters selected for the power tree are DC/DC converters are rated maximum recommended operating voltage 17 and 18V . The overvoltage protection clamps the voltage at the input of the DC/DC converters below maximum operating voltage. This solution of the overvoltage protection allows continuos operation of the power tree and avoid reset of the MCU ,GPS module or any other load connected to DC/DC converters output. Figure 2 shows input voltage of the e-call power tree during overvoltage event and intermediate voltage which is supplying the converters.

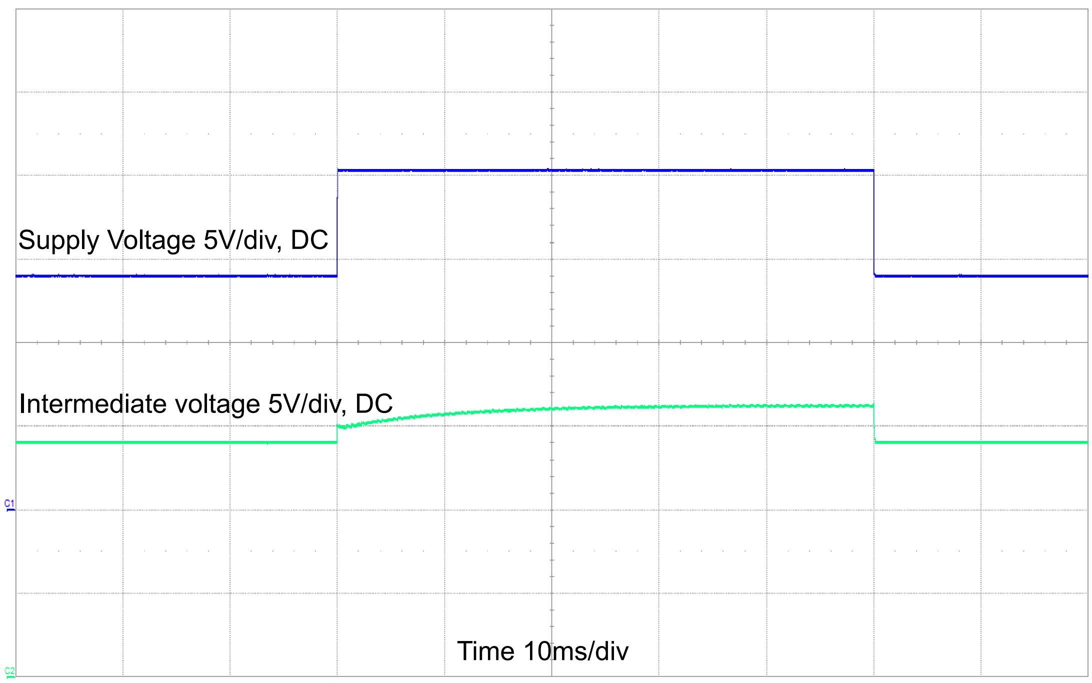

Figure 2. Input Overvoltage event

2.2.2 Power Path Control

Figure 3 shows all supply voltage rails during a transition from the main input supply rail to backup supply and back. At main input supply operation the intermediate voltage is used to supply the system. When the main power is disconnected the intermediate voltage drops to the backup battery voltage. Since the backup battery is discharging the voltage is decreasing over time. As soon as the main power is back the intermediate voltage is again at the main supply voltage.

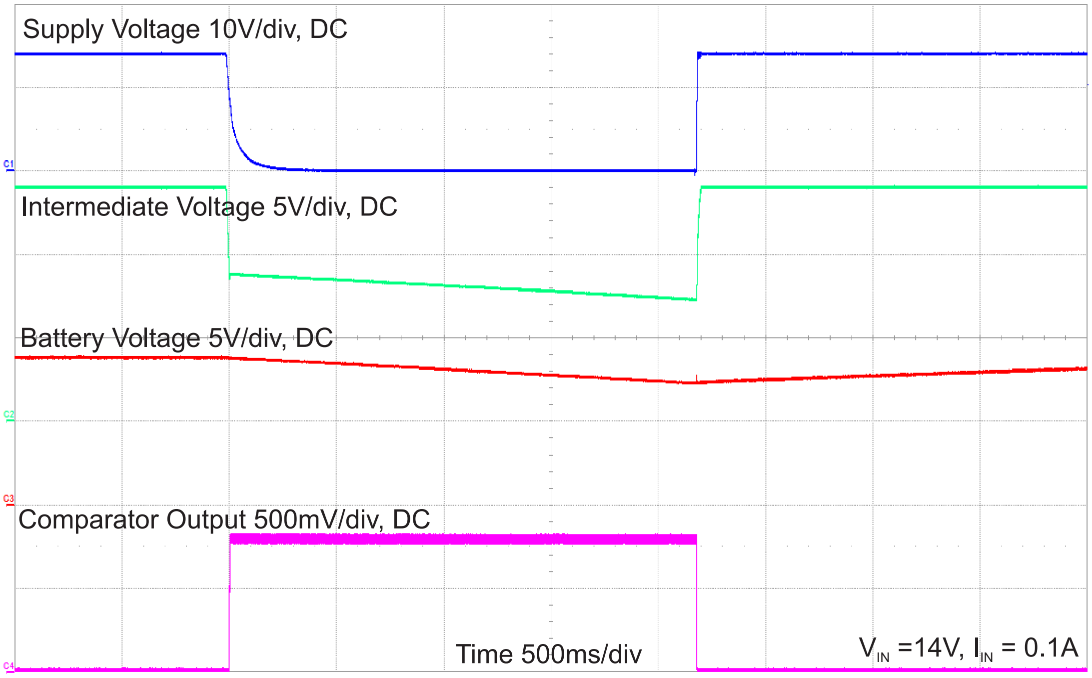

Figure 3. Power Path Control

2.2.3 Modem Supply

Figure 4 shows voltage and current waveforms related to the operation of the modem. The test condition here is a load current pulse of 2.5 A for 500 ms which is considered worst case for GSM communication. The high current pulses can be supplied by the buck converter which is used here. The waveforms of inductor current and output voltage show the control performance of this solution and the waveform of the intermediate voltage shows the impact on the intermediate voltage which is supplying the converter.

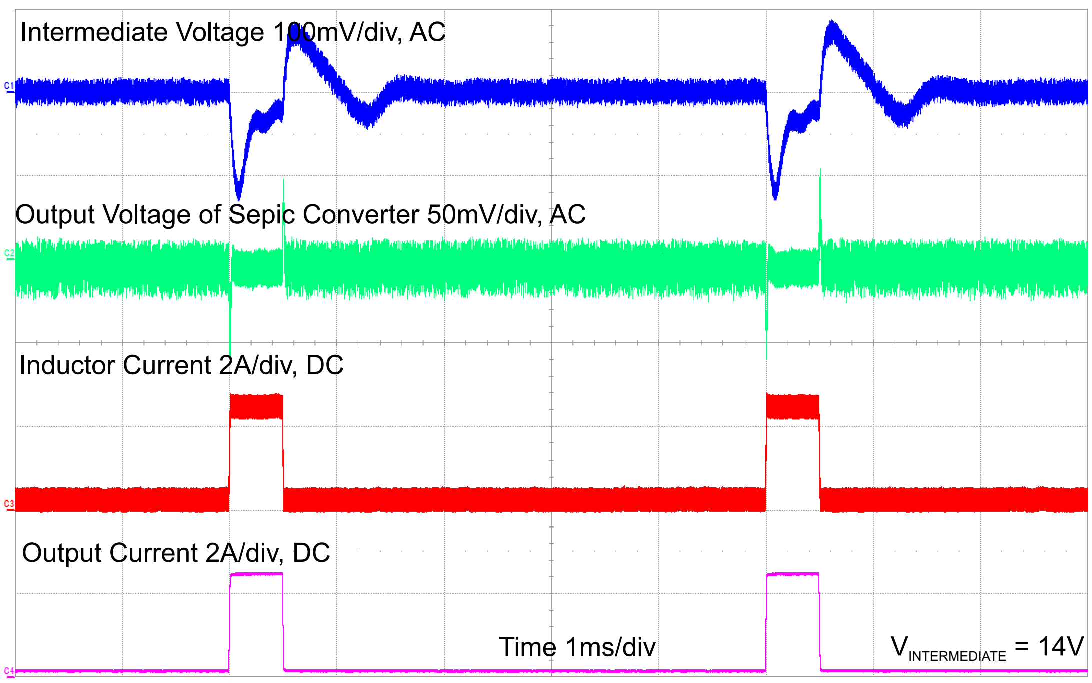

Figure 4. Modem Power Supply

2.2.4 Audio Supply

Figure 5 shows voltage and current waveforms related to the operation of the supply of the audio amplifier. The audio amplifier was operated with a test signal with a frequency of 2 kHz at a load of 8.7Ω.

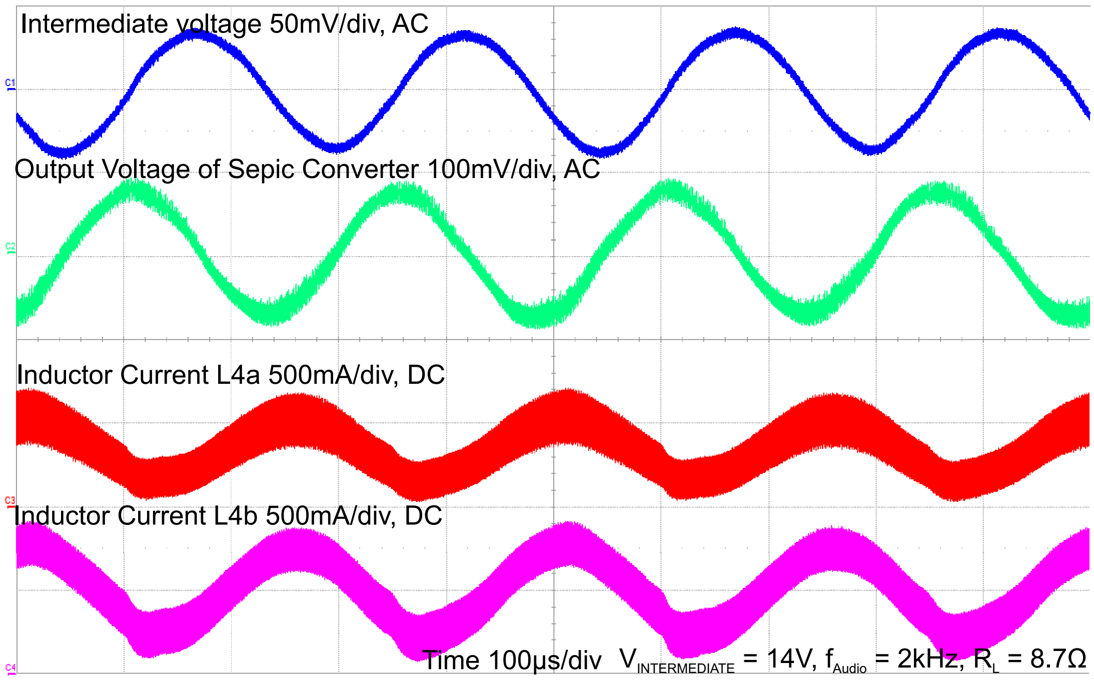

Figure 5. Audio Power Supply