Test Report
TIDUBF1–January 2016

PMP 9769 - Automotive E-Call Power Supply Reference Design with Low 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 5 V 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 which supplies the LM43603 step down converter. This step down converter generates a 5 V system rail which is switched through a power path control block to generate the system rail. 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 2.5 V and 4.2 V. The regulated 5-V input 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.

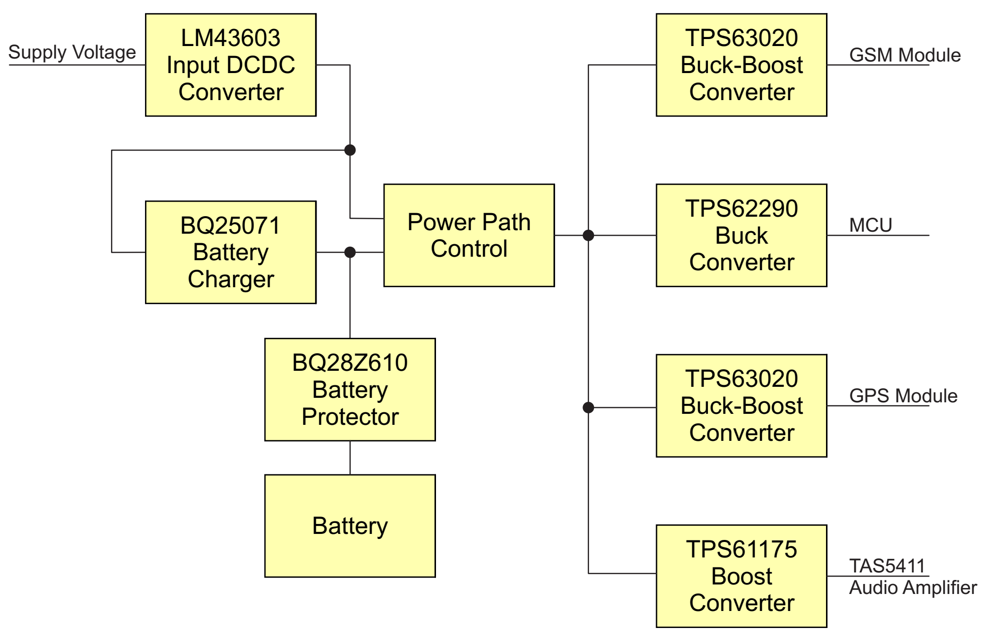

Figure 1. Block Diagram

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 boost conversion, so TPS63020 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 TPS62290 which is selected here. For the 5 V required for the GPS or GLONASS system the TPS63020 is used in boost only operation. The audio amplifier TAS5411 is supplied with 9 V. This requires a boost only 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 (TPS63020, TPS62290, TPS61175, TAS5411).

The peak load expected for the GSM module is 2 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 0.5 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. Since operating from the main input supply is a using a 2 stage power conversion the efficiency at that condition is significantly lower.

Table 1. Efficiency at Nominal Load

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input (normal operation)	14.0	1.13	15.77
Battery Input (backup operation)	3.5	3.71	13.00
GSM Module	3.8	0.50	1.90
MCU and Logic	1.8	0.50	0.90
GPS Module	5.0	0.80	4.00
Audio Amplifier	9.0	0.50	4.50
Efficiency			
Main input operation	**72%**		
Battery operation	**87%**		

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. Since operating from the main input supply is a using a 2 stage power conversion the efficiency at that condition is significantly lower as well in standby operation.

Table 2. Efficiency at Standby Load

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input (normal operation)	14.0	0.23	3.16
Battery Input (backup operation)	3.5	0.75	2.61
GSM Module	3.8	0.20	0.76
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

Table 2. Efficiency at Standby Load (continued)

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Efficiency			
Main input operation	**74%**		
Battery operation	**90%**		

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 (TPS63020, TPS62290, TPS61175, TAS5411).

2.2.1 Input DCDC Converter

The efficiency numbers shown in Table 1 and Table 2 for main input operation are measured with the input DCDC converter, the LM43603, configured to operate at 2 MHz. Due to the wide input voltage range this converter can operate, the self heating of this converter can be significant. Figure 2 shows the temperature distribution around this converter at room temperature.

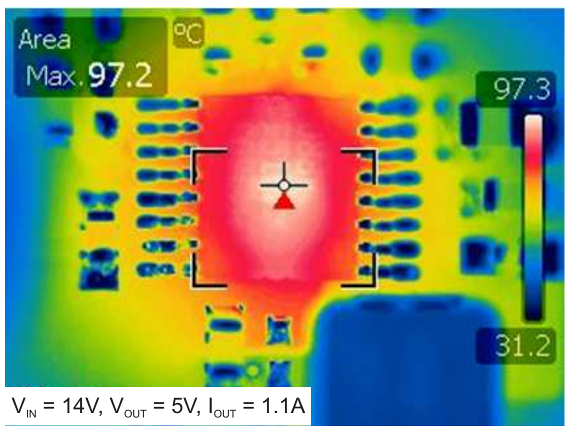

Figure 2. Input DCDC Converter Temperature Distribution

To lower the temperatures around this converter the switching losses can be reduced by decreasing the switching frequency. Figure 3 shows the temperature distribution around the converter at room temperature when operating at 700 kHz switching frequency.

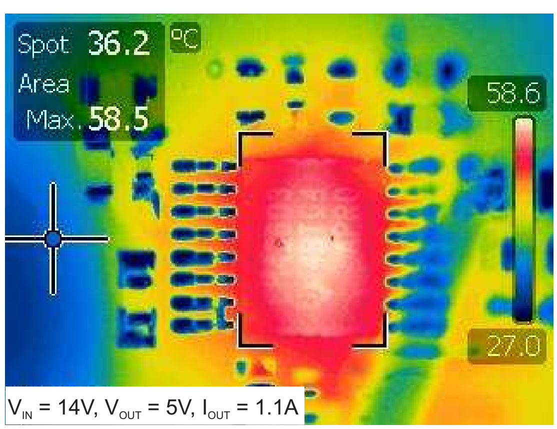

Figure 3. Input DCDC Converter Temperature Distribution

It is obvious in Figure 3 that the lower switching frequency caused a significant reduction of the losses in this converter. This also means that the efficiency of the total solution has increased when operating at the main input power.

Table 3 and Table 4 show the measurement data for the 700-kHz operation. Although the efficiency at main input power operation has significantly increased, due to the single stage conversion the efficiency at backup operation still is higher.

Table 3. Efficiency at Nominal Load

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input (normal operation)	14.0	1.01	14.08
Battery Input (backup operation)	3.5	3.71	13.00
GSM Module	3.8	0.50	1.90
MCU and Logic	1.8	0.50	0.90
GPS Module	5.0	0.80	4.00
Audio Amplifier	9.0	0.50	4.50
Efficiency			
Main input operation	**80%**		
Battery operation	**87%**		

Table 4. Efficiency at Standby Load

Voltage Rail	Voltage [V]	Current [A]	Power [W]
Main Input (normal operation)	14.0	0.20	2.82
Battery Input (backup operation)	3.5	0.75	2.61
GSM Module	3.8	0.20	0.76
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	**83%**		
Battery operation	**90%**		

2.2.2 Power Path Control

Figure 4 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 used to supply the system is regulated to 5 V. 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 generated by the input step down regulator.

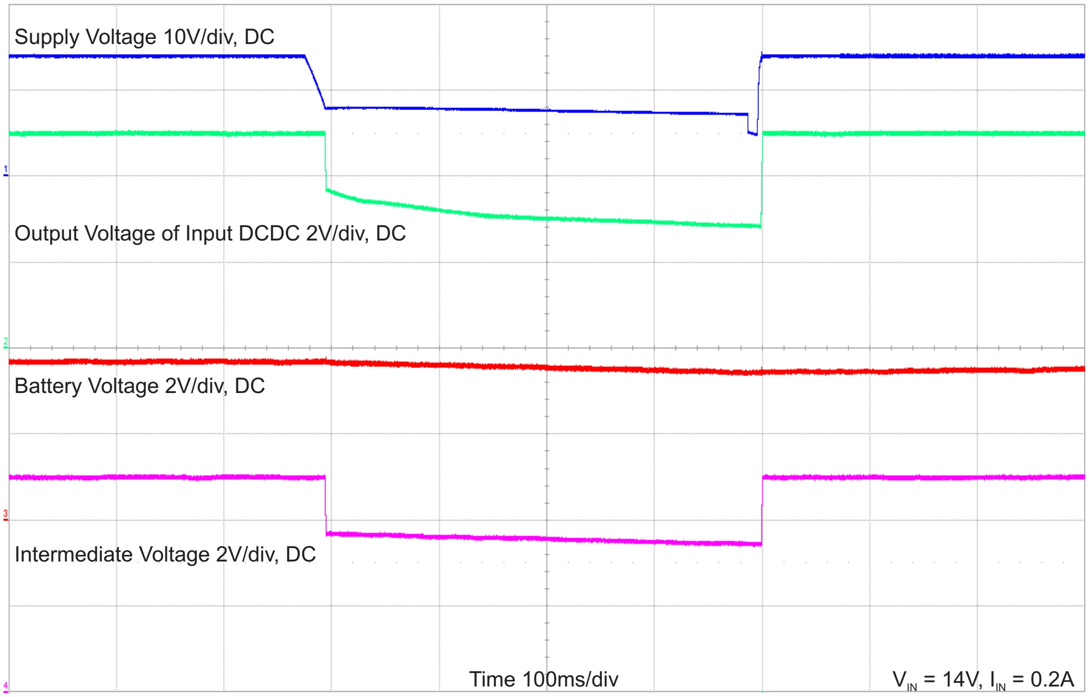

Figure 4. Power Path Control

2.2.3 Modem Supply

Figure 5 shows voltage and current waveforms related to the operation of the modem. The test condition here is a load current pulse of 2 A for 500 ms which is considered worst case for GSM communication. The high current pulses can be supplied by the buck-boost 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.

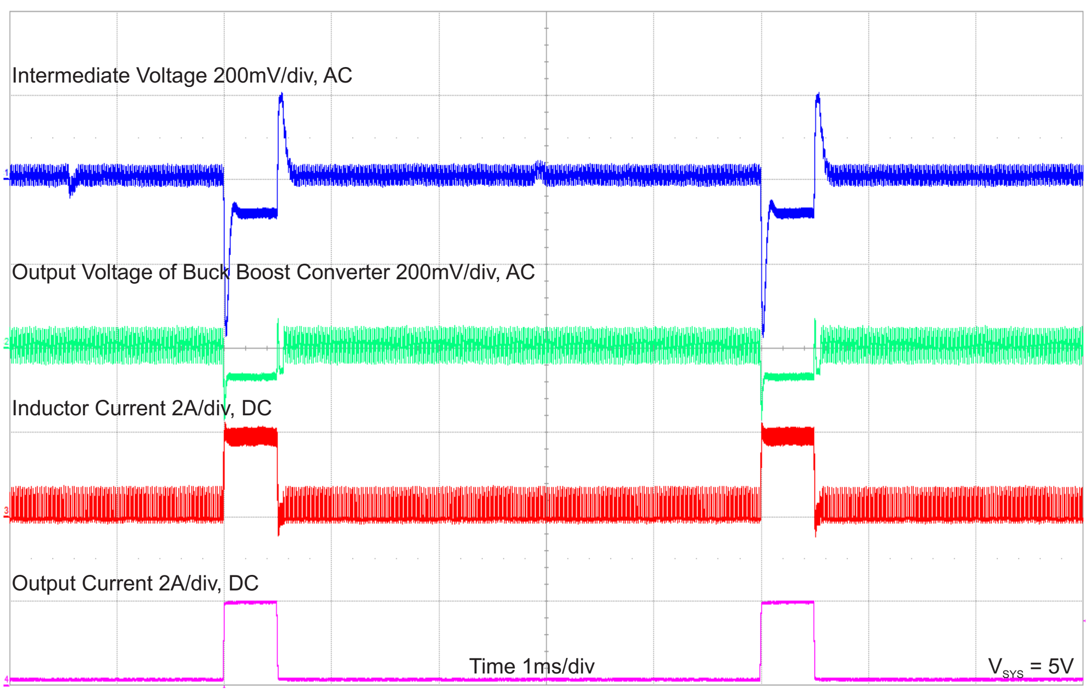

Figure 5. Modem Power Supply

2.2.4 Audio Supply

Figure 6 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 8.7 Ω.

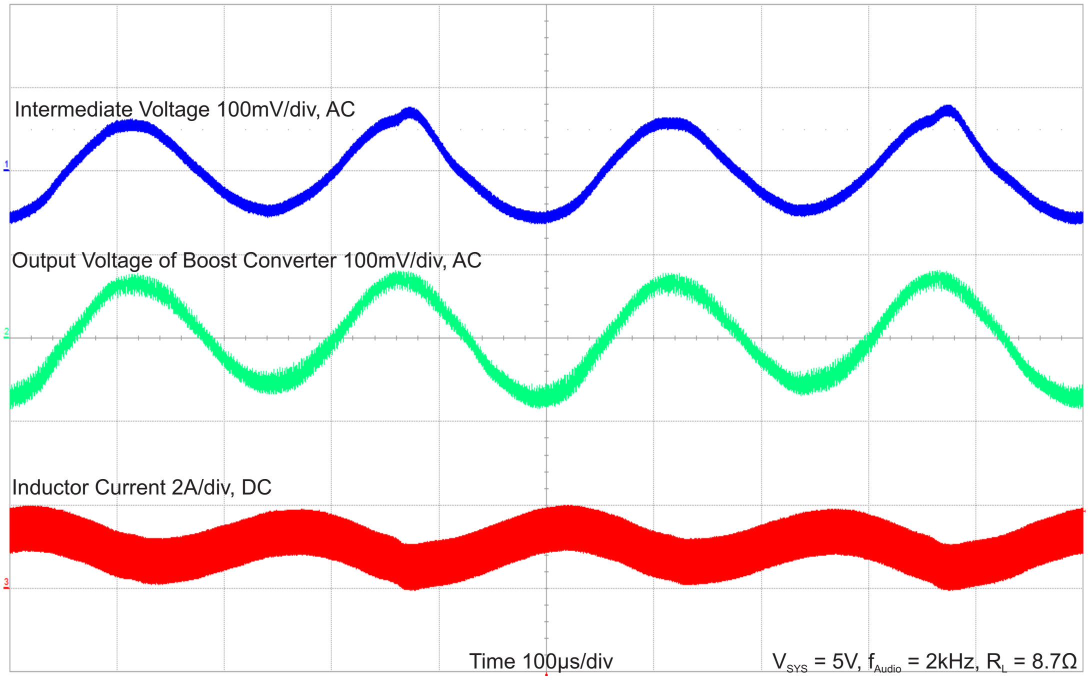

Figure 6. Audio Power Supply