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EVAL-ADVTS4152-EBZ Combination Power Supply Solution

EVAL-ADVTS4152-EBZ FEATURES

Integrated solution
- **Fault protection and surge stopper for load dump, cold crank, reverse polarity input, and overcurrent**
- **Pin-selectable backup battery charging using Li-Ion or $LiPeO_4$**
- **Seamless automatic switch from main input battery to backup batteries**
- **High overvoltage transient capability of up to 200 V while 5 V output continually**

Main input battery operating voltage range: 6.5 V to 38 V
Input battery backup charge voltage: 3.42 V to 4.13 V Li-Ion or LiPeO4
Battery input selectable switches (S1, S2, or S3)
Output voltage and current: 5.5 V maximum and 3 A maximum
Output ripple voltage: −3.85 mV

EQUIPMENT NEEDED

DC power supply or 12 V car battery
Oscilloscope
Li-Ion 3.7 V or 4.1 V $LiPeO_4$ battery
Resistive or electronic load
Load dump emulator

GENERAL DESCRIPTION

The EVAL-ADVTS4152-EBZ demonstration board is intended for systems that require a constant output voltage (V_{OUT}) of 5 V, such as a vehicle tracking system (VTS). The EVAL-ADVTS4152-EBZ runs by a main battery source with a backup battery in case an unwanted supply shortage results from the input.

The EVAL-ADVTS4152-EBZ features three main parts (LT4356-1, LT8609A, and LTC4040) that function as one to achieve the highest performance and reliability (see Figure 2).

The LT4356-1 is a surge stopper that protects high voltage transients such as load dumps to electronic automotive loads, with a wide range input capability of 4 V to 80 V and clamps to a desirable voltage output for most design needs. The LT4356-1 also provides protection against reverse input and cold crank.

The LT8609A is a compact, high efficiency, and high speed, synchronous monolithic, step-down switching regulator that outputs the desired maximum current of 3 A continuously.

The LTC4040 is a complete 3.5 V to 5.5 V supply rail battery backup system. This device contains a high current, step-up dc-to-dc regulator that backs up the supply from a single cell Lithium Ion (Li-Ion) or Lithium Iron Phosphate ($LiFePO_4$) and helps power the system when the main power supply cuts off.

This demonstration board has an electromagnetic interference (EMI) filter installed for automotive standard requirements and an optional ADT6401 temperature switch for over temperature protection if a design needs to protect against an abnormally high dc input.

EVAL-ADVTS4152-EBZ COMBINATION POWER SUPPLY BOARD

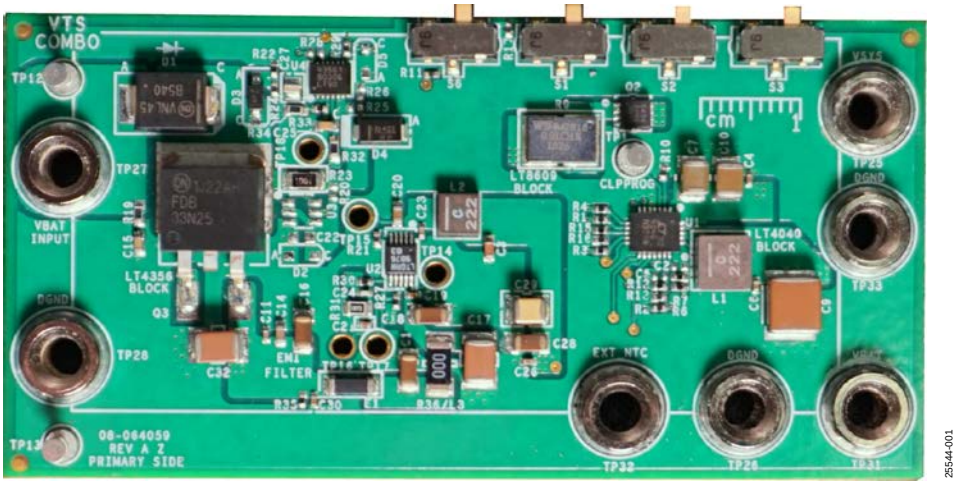

Figure 1.

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REVISION HISTORY

10/2020—Revision 0: Initial Version

EVAL-ADVTS4152-EBZ SPECIFICATIONS

Specifications at T_A = 25°C. Note that the battery charging output may vary by temperature and that the pin-selectable feature was tested at ambient 25°C.

Table 1.

Parameters	Test Conditions/Comments	Min	Typ	Max	Unit
INPUT BATTERY					
Operating Voltage Range, V_{BAT}	Without backup operating voltage range (V_{BACKUP})	6.5	12	38	V
	With V_{BACKUP}	0	12	38	V
Protection Range	Continues dc	−40		+80	V
	Surge voltage (at 400 ms)			210	V
V_{BACKUP}		2.7		5.0	V
Backup Charge Voltage		3.42		4.13	V
Start-Up Voltage, V_{IN}	Source from V_{BAT} (2 A load)	6.5			V
	Source from V_{BACKUP} (2 A load)	3.4			V
OUTPUT					
Voltage, V_{OUT}		4.5	5.0	5.5	V
Ripple Voltage			−3.85		mV
Current				3	A
BATTERY CHARGING	Pin selectable using the S3, S2, and S1 switches				
Battery Regulated Output Voltage					
For $LiFePO_4$ Option	S1 = 0, S2 = 0, S3 = 0	3.42	3.45	3.48	V
	S1 = 0, S2 = 1, S3 = 0	3.47	3.50	3.53	V
	S1 = 0, S2 = 0, S3 = 1	3.52	3.55	3.58	V
	S1 = 0, S2 = 1, S3 = 1	3.57	3.60	3.63	V
For Li-Ion Option	S1 = 1, S2 = 0, S3 = 0	3.92	3.95	3.98	V
	S1 = 1, S2 = 1, S3 = 0	3.97	4.00	4.03	V
	S1 = 1, S2 = 0, S3 = 1	4.02	4.05	4.08	V
	S1 = 1, S2 = 1, S3 = 1	4.07	4.10	4.13	V
SYSTEM EFFICIENCY	V_{BAT} = 12 V (output vs. input)			87	%

EVAL-ADVTS4152-EBZ HARDWARE

EVAL-ADVTS4152-EBZ MAIN PART LOCATIONS

See Figure 2 for the location of the LT4356-1, LT8609A, LTC4040, and optional ADT6401 on the EVAL-ADVTS4152-EBZ demonstration board.

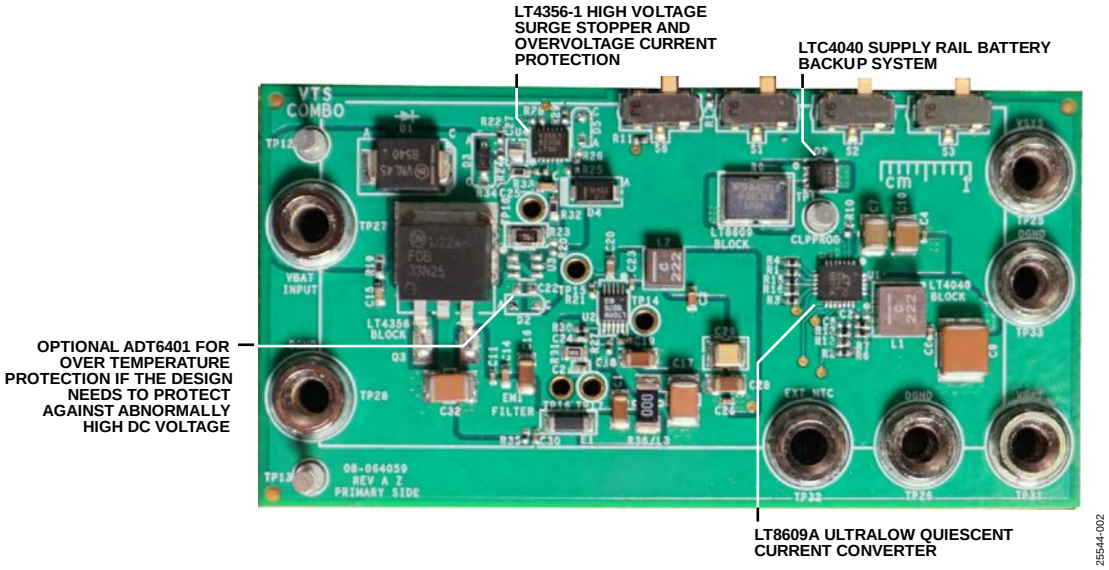

Figure 2. The EVAL-ADVTS4152-EBZ Demonstration Board Hardware

EVAL-ADVTS4152-EBZ FUNCTIONAL BLOCK DIAGRAM SECTIONS

The functional block diagram of the EVAL-ADVTS4152-EBZ consists of three major sections: the fault protection and surge stopper, the step-down regulator, and the backup supply (see Figure 3). These three sections work together to provide reliable and efficient power to downstream electronics, such as a VTS. The EVAL-ADVTS4152-EBZ can operate across a wide range input voltage of 80 V dc and surge voltage of up to 210 V.

Section 1: Fault Protection and Surge Stopper

The fault protection is mainly driven by the LT4356-1 IC. This IC protects the EVAL-ADVTS4152-EBZ from surge and overvoltage, which keeps the system working in the desired operating voltage range. When a surge event occurs, the LT4356-1 clamps the voltage at 38 V, allowing the EVAL-ADVTS4152-EBZ to maintain operation at the time standard for automotive while the surge happens. In addition, the EVAL-ADVTS4152-EBZ has two diodes, D1 and D3, that offer added protection. D1 provides reverse polarity protection, while D3 provides overvoltage lockout protection.

Figure 14 is the schematic diagram of the LT4356-1 on the EVAL-ADVTS4152-EBZ.

Section 2: Step-Down Regulator

The step-down regulator on the EVAL-ADVTS4152-EBZ is mainly handled by the LT8609A IC. The LT8609A is a high efficiency, high speed, synchronous monolithic, step-down switching regulator that keeps the output level at a constant voltage of 5 V and has a maximum current of 3 A. The LT8609A burst mode operation enables high efficiency down to a low output current while keeping the output ripple below 10 mV p-p.

The LT8609A has a SYNC pin that allows synchronization to an external clock or spread spectrum modulation for low EMI operation.

Figure 15 is the schematic diagram of the LT8609A on the EVAL-ADVTS4152-EBZ.

Section 3: Backup Supply

The backup supply (or battery backup power manager) on the EVAL-ADVTS4152-EBZ is mainly handled by the LTC4040 IC. The LTC4040 is a high current, step-up dc-to-dc regulator that backs up the supply from a single cell Li-Ion or $LiFePO_4$ battery.

When the main input supply is available, the LTC4040 chip step-up regulator operates in reverse as a step-down battery charger to the Li-Ion or the $LiFePO_4$. The charging voltage can be configured using the pin-selectable S1, S2, or S3 switches (see Table 1).

Figure 16 is the schematic diagram of the LTC4040 on the EVAL-ADVTS4152-EBZ.

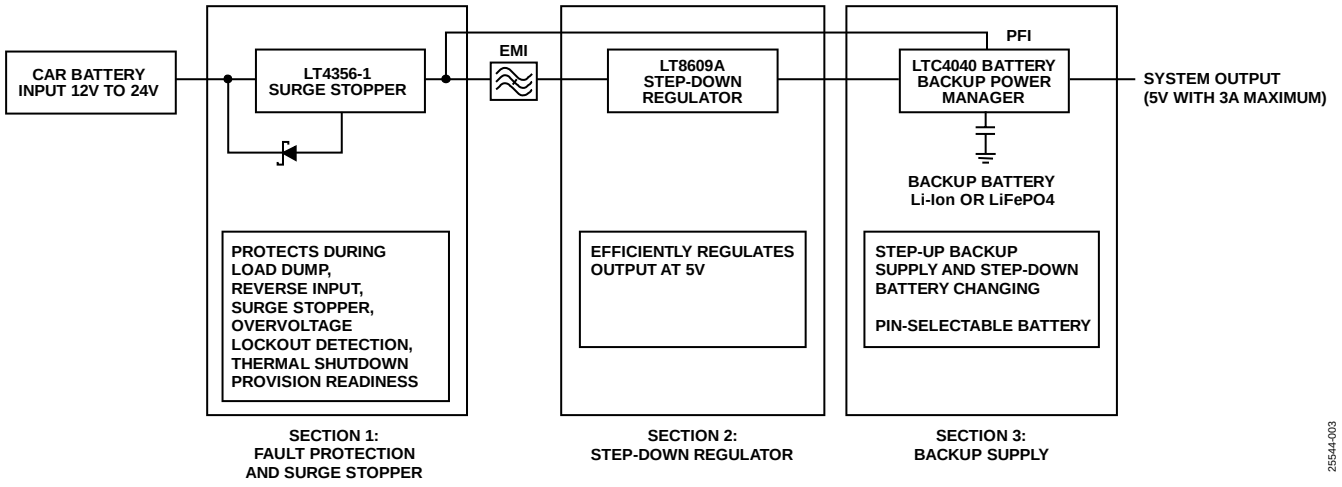

Figure 3. EVAL-ADVTS4152-EBZ Functional Block Diagram

NORMAL OPERATION EVAL-ADVTS4152-EBZ CONNECTIONS

EVAL-ADVTS4152-EBZ Combination Power Supply Typical Operation Setup

The EVAL-ADVTS4152-EBZ is typically installed between the car battery supply and downstream load. The backup battery is then attached to the VBACKUP pin to complete the system (see Figure 4). When the car battery applies a 12 V dc or a 24 V dc supply to the EVAL-ADVTS4152-EBZ, the demonstration board outputs a constant 5 V dc with a 3 A maximum current. When the EVAL-ADVTS4152-EBZ is connected, it is ready to use.

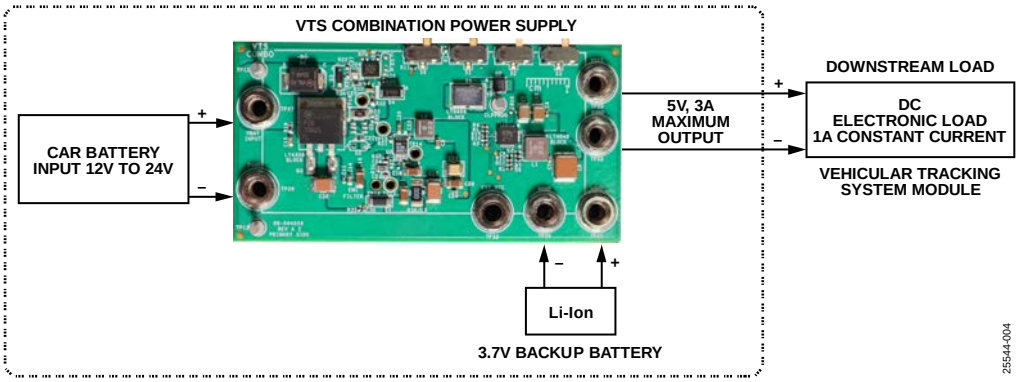

Figure 4. Typical EVAL-ADVTS4152-EBZ Setup in VTS System

EVAL-ADVTS4152-EBZ TEST SETUPS

Figure 5 through Figure 8 show the test setups for load dump, backup battery, overcurrent, and reverse polarity for automotive vehicles with a 12 V to approximately 24 V input system.

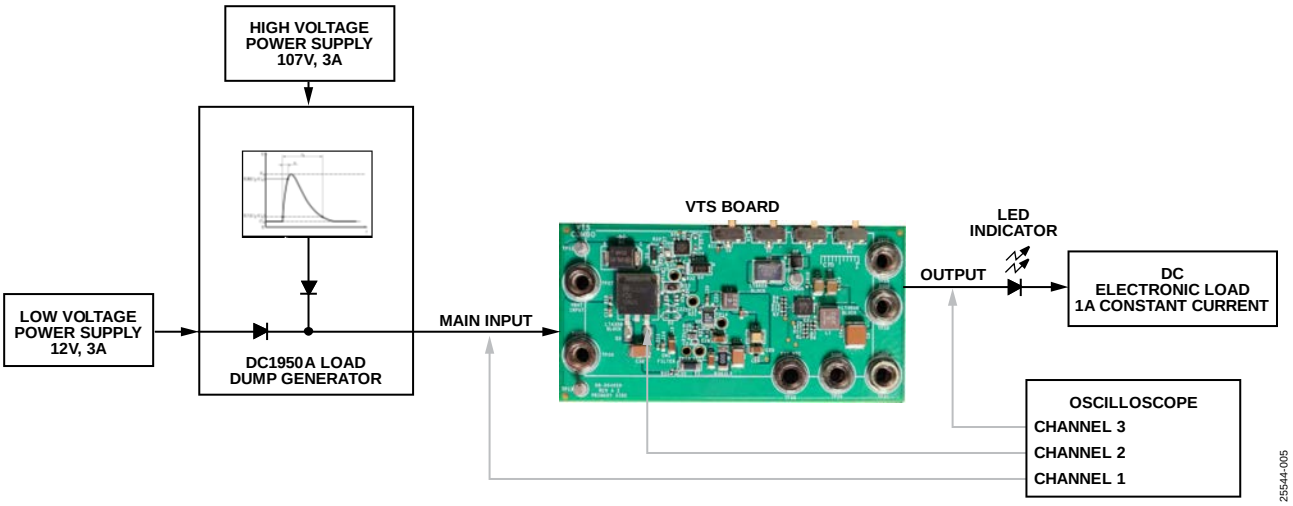

Figure 5. EVAL-ADVTS4152-EBZ Load Dump Test Setup

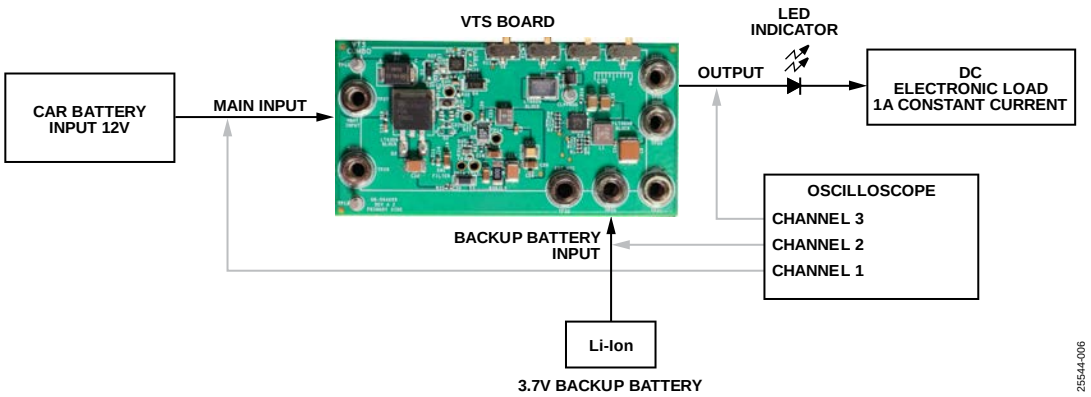

Figure 6. EVAL-ADVTS4152-EBZ Backup Battery Test Setup

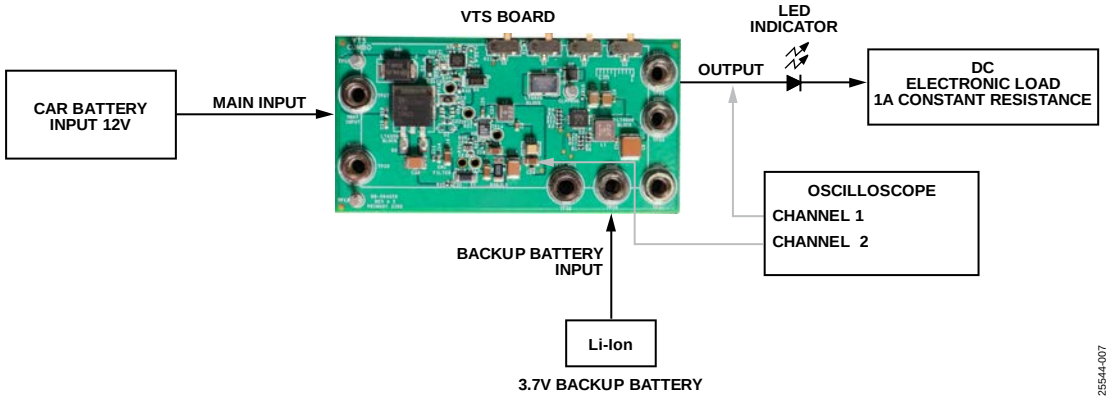

Figure 7. EVAL-ADVTS4152-EBZ Overcurrent Test Setup

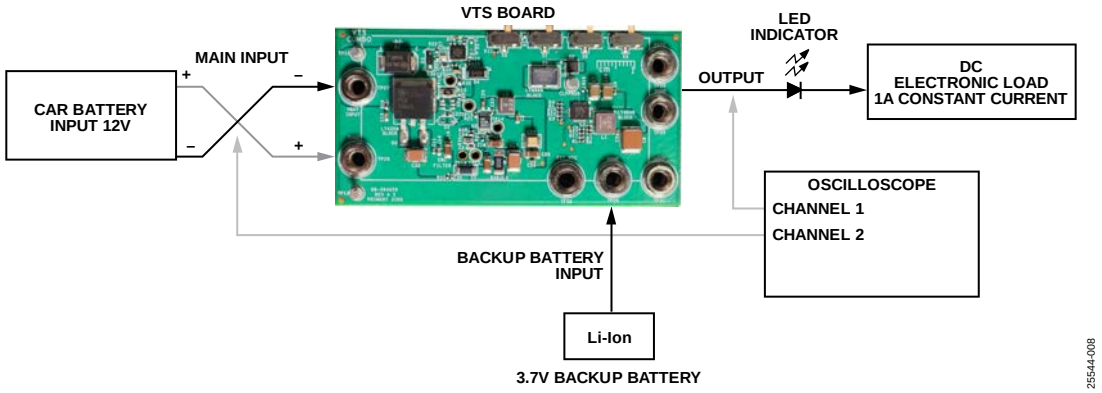

Figure 8. EVAL-ADVTS4152-EBZ Reverse Polarity Test Setup

EVAL-ADVTS4152-EBZ V_{OUT} RIPPLE WITH RESPECT TO V_{IN}, V_{BAT}, AND V_{BACKUP}

Table 2. V_{OUT} Ripple for V_{IN} = 12 V and 4.1 V

		Ripple Response (mV p-p)		
V_{IN}	**Source**	**1 A**	**2 A**	**3 A**
12	V_{BAT}	5.875	6.609	6.928
4.1	V_{BACKUP}	5.972	6.644	7.25

Table 3. V_{OUT} Ripple for V_{IN} = 16 V and 4.1 V

		Ripple Response (mV p-p)		
V_{IN}	**Source**	**1 A**	**2 A**	**3 A**
16	V_{BAT}	6.497	6.322	6.197
4.1	V_{BACKUP}	5.972	7.219	7.6

Table 4. V_{OUT} Ripple for V_{IN} = 20 V and 4.1 V

		Ripple Response (mV p-p)		
V_{IN}	**Source**	**1 A**	**2 A**	**3 A**
20	V_{BAT}	5.587	6.356	6.547
4.1	V_{BACKUP}	6.081	6.469	7.503

Table 5. V_{OUT} Ripple for V_{IN} = 24 V and 4.1 V

		Ripple Response (mV p-p)		
V_{IN}	**Source**	**1 A**	**1 A**	**1 A**
24	V_{BAT}	5.156	5.762	6.691
4.1	V_{BACKUP}	6.625	6.116	7.009

EVAL-ADVTS4152-EBZ TEST SETUP PLOT RESULTS

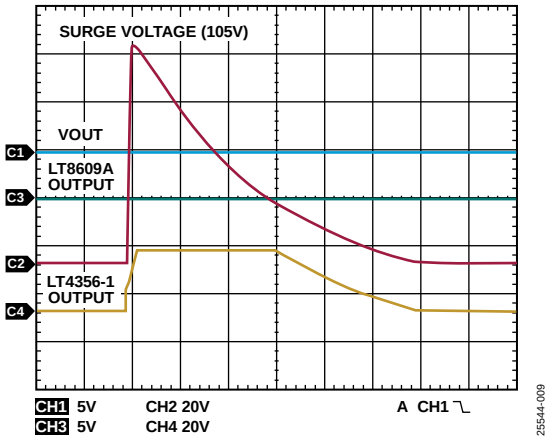

Figure 9. EVAL-ADVTS4152-EBZ Load Dump Results (The Highest Surge Voltage Can Go Up to 210 V, see Table 1)

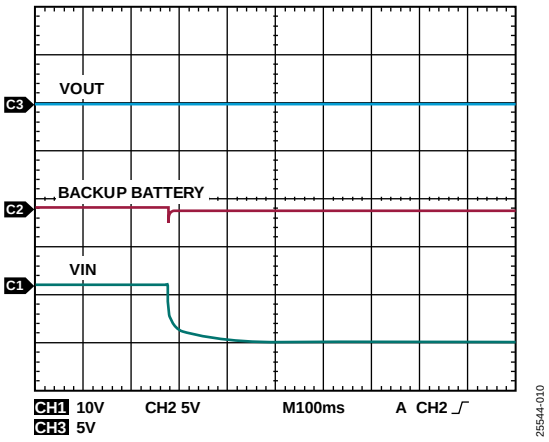

Figure 12. EVAL-ADVTS4152-EBZ Backup Battery Results

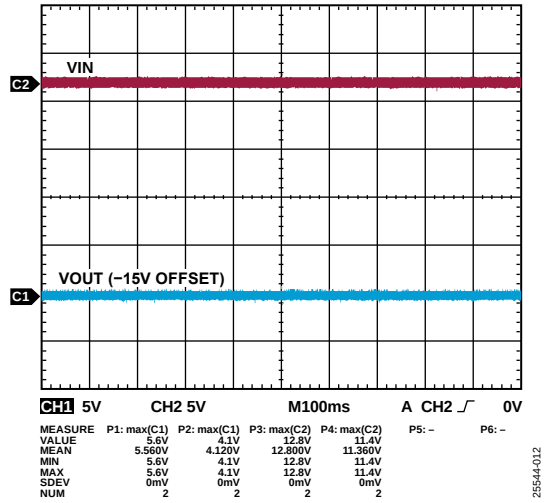

Figure 10. EVAL-ADVTS4152-EBZ Reverse Polarity Results

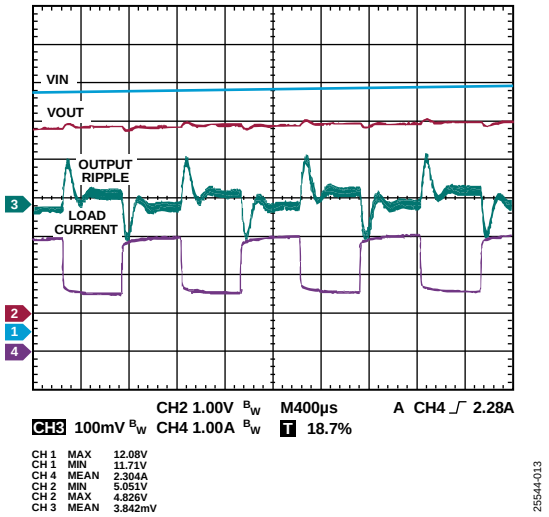

Figure 13. EVAL-ADVTS4152-EBZ V_{OUT} Ripple Results

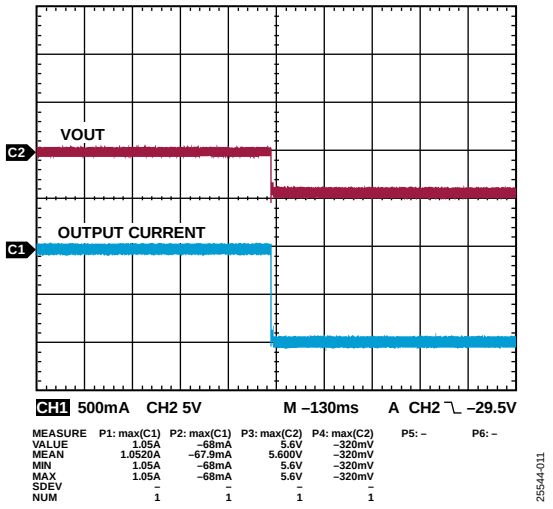

Figure 11. EVAL-ADVTS4152-EBZ Overcurrent Results

EVALUATION BOARD SCHEMATICS

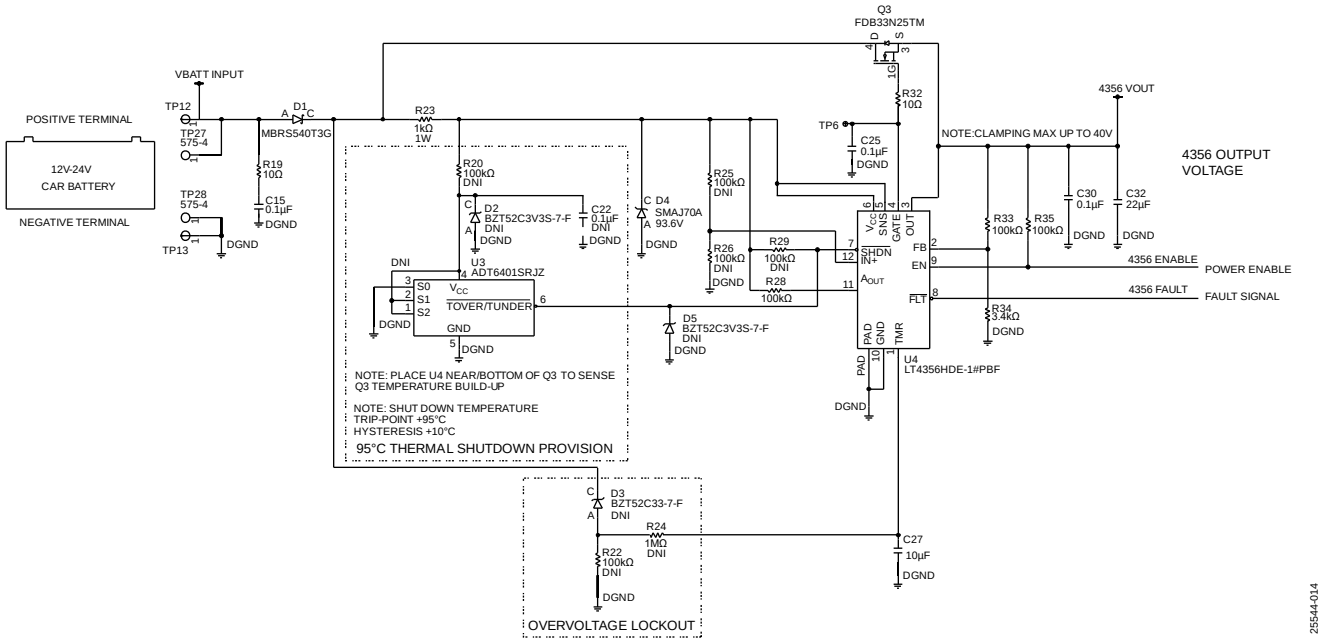

Figure 14. The LT4356-1 Section of the Schematic Diagram (Optional ADT6401 Shown)

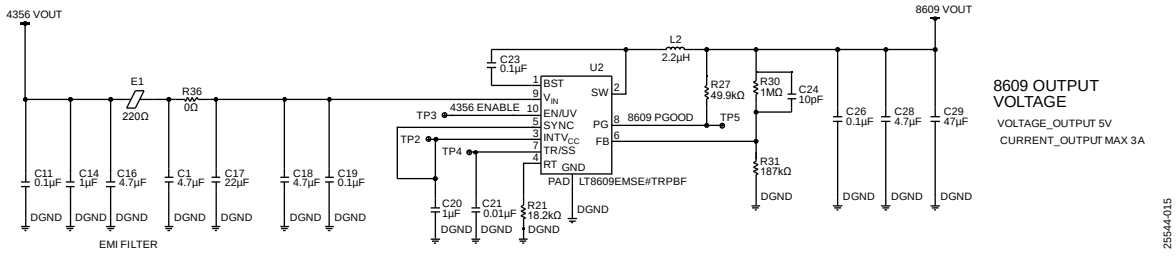

Figure 15. The LT8609A Section of the Schematic Diagram

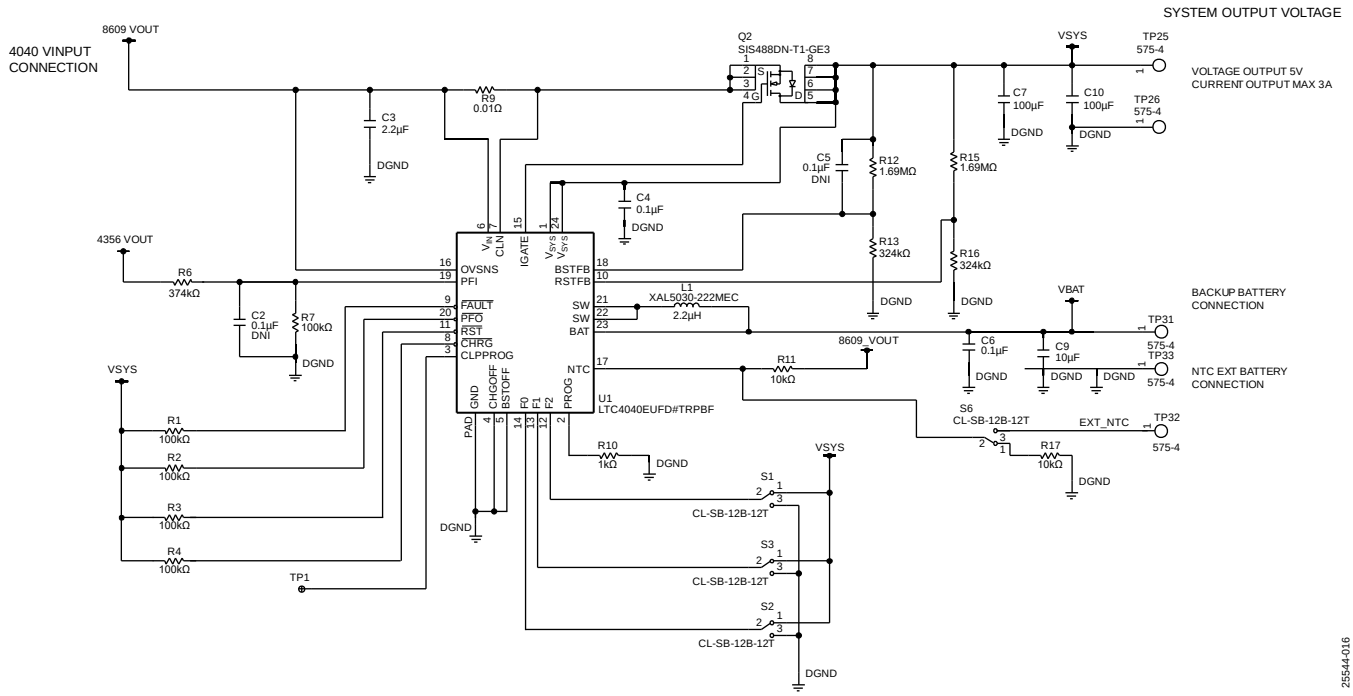

Figure 16. The LTC4040 Section of the Schematic Diagram

ORDERING INFORMATION

BILL OF MATERIALS

Table 6. Electrical Parts (Automotive Compliant)

Quantity	Reference Designator	Manufacturer	Manufacturer Part Number
1	Not applicable	Analog Devices Supplied	08_064059a
4	C1, C16, C18, C28	Murata	GRM31CR71H475KA12L
2	C7, C10	Taiyo Yuden	LMK325ABJ107MMHP
7	C4, C6, C11, C19, C23, C26, C30	Taiyo Yuden	UMK105BJ104KVHF
2	C14, C20	Taiyo Yuden	UMK107AB7105KA-T
2	C15, C25	Samsung	CL10B104KC8NNNC
2	C17, C32	TDK	C4532X7R1E226M250KC
1	C21	TDK	CGA2B3X7S2A103K050BB
1	C24	AVX	04025U100GAT2A
1	C27	AVX	0306ZC104KAT2A
1	C29	KEMET Corporation	C1210C476M4PACTU
1	C3	Murata	GRT188R61H225ME13D
1	C9	TDK	C5750X7R1H106M
1	D1	On Semiconductor	MBRS540T3G
1	D3	Diodes, Inc.	BZT52C33-7-F
1	D4	MDE Semiconductor, Inc	SMAJ70A
1	E1	Taiyo Yuden	FBMJ4516HM900-T
1	L1	Coilcraft	XAL5030-222MEC
1	L2	Coilcraft	XFL4020-222MEB
1	Q2	Vishay	SIS488DN-T1-GE3
1	Q3	Fairchild Semiconductor	FDB33N25TM
9	R1, R2, R3, R4, R7, R22, R29, R33, R35	Panasonic	ERJ-2GEJ104X
1	R10	Panasonic	ERJ-2RKF1001X
2	R11, R17	Panasonic	ERJ-2RKF1002X
2	R12, R15	Vishay	CRCW04021M69FKED
2	R13, R16	Panasonic	ERJ-2RKF3243X
2	R19, R32	Panasonic	ERJ-3EKF10R0V
1	R21	Panasonic	ERJ-2RKF1822X
1	R23	Susumu Co, LTD	HRG3216P-1001-D-T1
2	R24, R30	Panasonic	ERJ-2RKF1004X
1	R27	Yageo	RC0402FR-0749K9L
1	R31	Panasonic	ERJ-6ENF1873V
1	R34	Panasonic	ERJ-3EKF3401V
1	R36	Vishay	CRCW20100000Z0EF
1	R6	Panasonic	ERJ-2RKF3743X
1	R9	Vishay	WSHM2818R0100FEA
4	S1, S2, S3, S6	Copal Electronics Corporation	CL-SB-12B-12T
3	TP1, TP12, TP13	MILL-MAX	2501-2-00-80-00-00-07-0
7	TP25, TP26, TP27, TP28, TP31, TP32, TP33	Keystone Electronics	575-4
1	U1	Analog Devices, Inc.	LTC4040EUFD#TRPBF
1	U2	Analog Devices	LT8609EMSE#TRPBF
1	U4	Analog Devices	LT4356HDE-1#PBF

NOTES

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

UG25544-10/20(0)