

LT3791-1

60V Four-Switch Synchronous Buck-Boost Controller

DESCRIPTION

Demonstration circuit 2009A is a 60V four-switch synchronous buck-boost controller that demonstrates the high power capability of the LT3791-1. The output is 24V and the maximum output current is 5A. The switching frequency is 200kHz and efficiency is as high as 98% for a 24V input.

The operating input voltage range of DC2009A is from 12V to 57V. The output voltage, EN/UVLO, and OVLO are all programmed by resistor dividers. EN/UVLO is set so the circuit will turn off when the input voltage falls below 11.9V and will turn on when the input voltage rises above 13.4V. OVLO is set to engage for input voltages above 57V.

Current sense resistors program input and output current limits and also determine the monitoring voltages that indicate input and output current. IVINMON provides a 60mV/1A voltage that is used to monitor the input current. Input current limit occurs at 16.7A and is set by RIN1. ISMON provides a 150mV/1A voltage that is used to monitor the output current. The output current limit is 6.7A and is set by RS2.

The demo circuit features MOSFETs that compliment the 5V gate drive of the LT3791-1 to achieve high efficiency. 60V MOSFETs are used on the input side of the four-switch topology while 40V MOSFETs are used on the output side. Ceramic capacitors are used at both the circuit input and output because of their small size and high ripple current capability. In addition to ceramic capacitors, there is an aluminum polymer capacitor on the output that assures feedback loop stability, even at low temperatures. The input has an aluminum electrolytic capacitor in addition to ceramic capacitors. A two-stage L-C input filter can easily be added for electro-magnetic compatibility. The pcb has large copper planes and extensive vias for thermal performance.

The CLKOUT output and the SYNC input can be used to synchronize switching between two or more DC2009A circuits. A resistor from SYNC to ground must be removed prior to using the SYNC input.

$\overline{\text{SHORT}}$ and $\overline{\text{C/10}}$ are open-collector status flag outputs and are pulled up to the INTV_{CC} pin voltage. A resistor shorts the CCM pin to $\overline{\text{C/10}}$ and causes the circuit to change to discontinuous conduction mode (DCM) when $\overline{\text{C/10}}$ is active at light load currents. CCM can also be connected with a resistor to INTV_{CC} instead of $\overline{\text{C/10}}$ for continuous conduction mode (CCM) operation over the entire load range.

The CTRL input is pulled up to the V_{REF} pin through a 100k resistor to set the output current limit to its maximum, and an external voltage on CTRL can be used to lower the current limit. A capacitor at the SS pin programs soft-start and additionally SS is pulled up to the V_{REF} pin through a 100k resistor. The switching frequency is adjustable with a resistor.

The demo circuit is designed to be easily reconfigured to many other applications, including the example schematics in the data sheet. Consult the factory for assistance.

High power operation, four-switch buck-boost topology, fault protection and full monitoring make the LT3791-1 attractive for high power voltage regulator circuits and also circuits that require output current regulation such as battery chargers. The LT3791EFE-1 is available in a thermally enhanced 38-lead TSSOP package. The LT3791-1 data sheet must be read in conjunction with this demo manual to properly use or modify demo circuit DC2009A.

Design files for this circuit board are available at <http://www.linear.com/demo>

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PERFORMANCE SUMMARY

Specifications are at $T_A = 25^\circ\text{C}$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Minimum Input Voltage, V_{PVIN}	$V_{OUT} = 24\text{V}$ $I_{OUT} \leq 4.5\text{A}$		12		V
Maximum Input Voltage, V_{PVIN}	$V_{OUT} = 24\text{V}$ $I_{OUT} \leq 4.5\text{A}$		57		V
Maximum Output Current	$13.3\text{V} < V_{PVIN} < 57\text{V}$, CTRL = V_{REF} $V_{PVIN} = 12\text{V}$, CTRL = V_{REF}	5 4.5			A A
Input EN Voltage, $V_{PVIN(EN)}$	$R3 = 56.2\text{k}$, $R4 = 499\text{k}$, V_{PVIN} Rising		13.4		V
Input UVLO Voltage, $V_{PVIN(UVLO)}$	$R3 = 56.2\text{k}$, $R4 = 499\text{k}$, V_{PVIN} Falling		11.9		V
Input OVLO Turn-Off Voltage, $V_{PVIN(OVLO \text{ turn-off})}$	$R11 = 27.4\text{k}$, $R1 = 499\text{k}$, V_{PVIN} Rising		57.6		V
Input OVLO Turn-On Voltage, $V_{PVIN(OVLO \text{ turn-on})}$	$R11 = 27.4\text{k}$, $R1 = 499\text{k}$, V_{PVIN} Falling		56.2		V
Output Voltage V_{OUT}	$R19 = 60.4\text{k}$, $R20 = 3.83\text{k}$	23.6		24.7	V
Efficiency	$V_{PVIN} = 24\text{V}$, $I_{OUT} = 5\text{A}$ $V_{PVIN} = 12\text{V}$, $I_{OUT} = 4.5\text{A}$		98 96		% %
Switching Frequency	$R18 = 147\text{k}$		200		kHz
Input Current Limit	$RIN1 = 0.003\Omega$		16.7		A
Output Current Limit	$RS2 = 0.015\Omega$		6.7		A

QUICK START PROCEDURE

It is easy to set up demonstration circuit DC2009A to evaluate the performance of the LT3791-1. Refer to figure 1 for the proper measurement equipment setup and follow the procedure below:

NOTE: Make sure that the voltage applied to PV_{IN} does not exceed the absolute maximum voltage rating of 60V for the LT3791-1.

1. Connect the EN/UVLO terminal to ground with a clip-on lead. Connect the power supply (with power off), load, and meters as shown.

2. After all connections are made, turn on the input power and verify that the input voltage is between 14V and 57V.

3. Remove the clip-on lead from EN/UVLO. Verify that the output voltage is 24V.

NOTE: If the output voltage is low, temporarily disconnect the load to make sure that it is not set too high.

4. Once the proper output voltage is established, adjust the input voltage and load within the operating ranges and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

QUICK START PROCEDURE

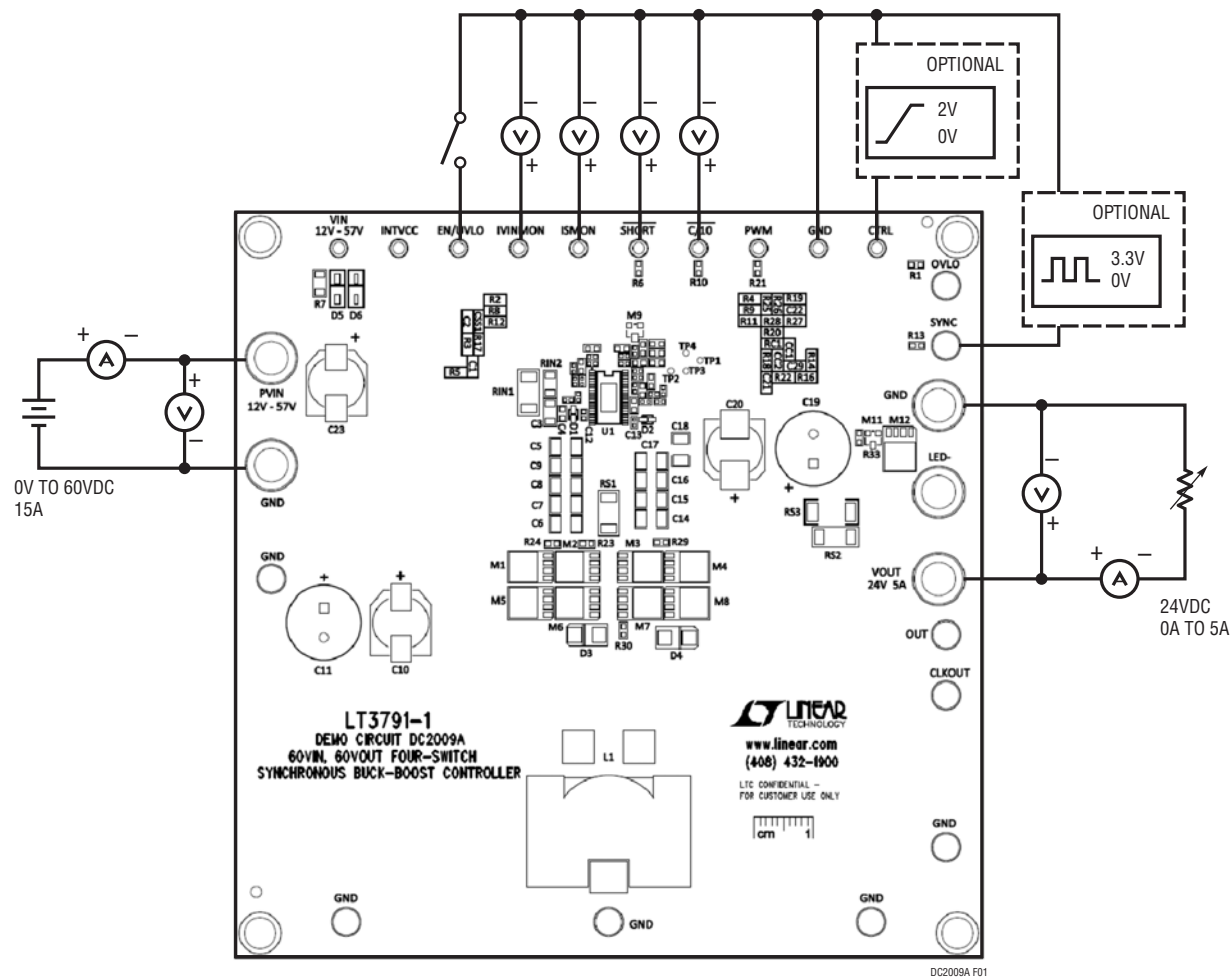


Figure 1. Proper Measurement Equipment Setup for DC2009A

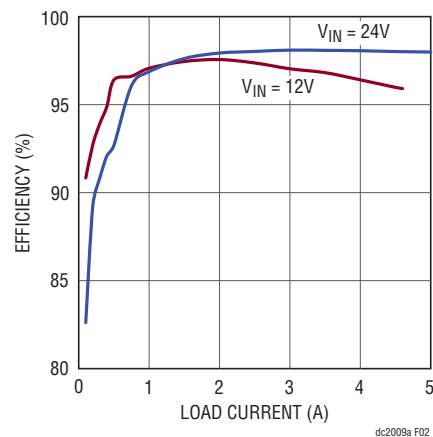


Figure 2. Efficiency

QUICK START PROCEDURE

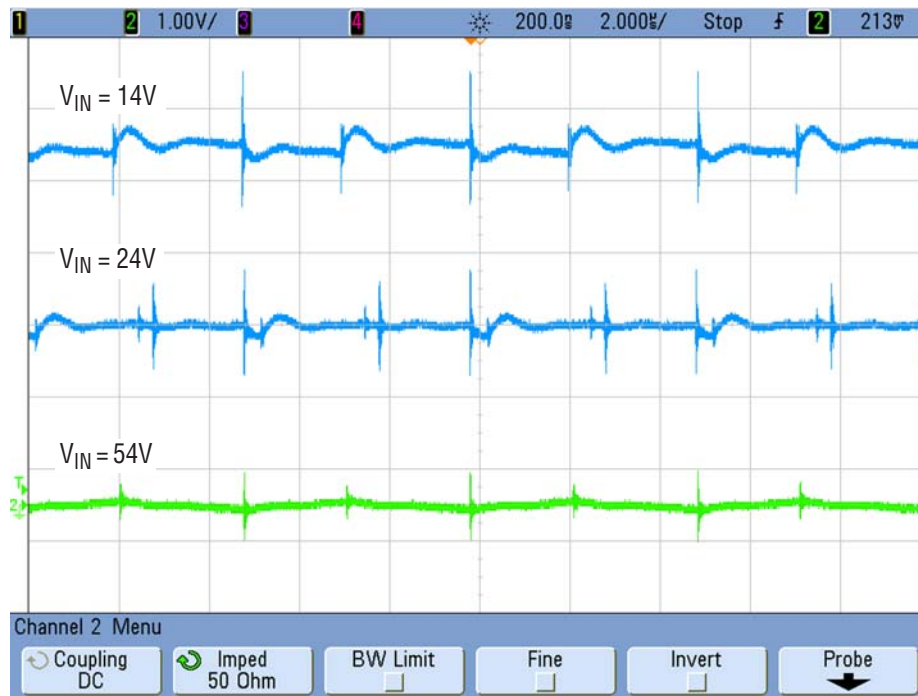


Figure 3. Output Voltage Ripple at 5A Output Current, $V_{OUT} = 24V$, 100MHz Bandwidth

QUICK START PROCEDURE

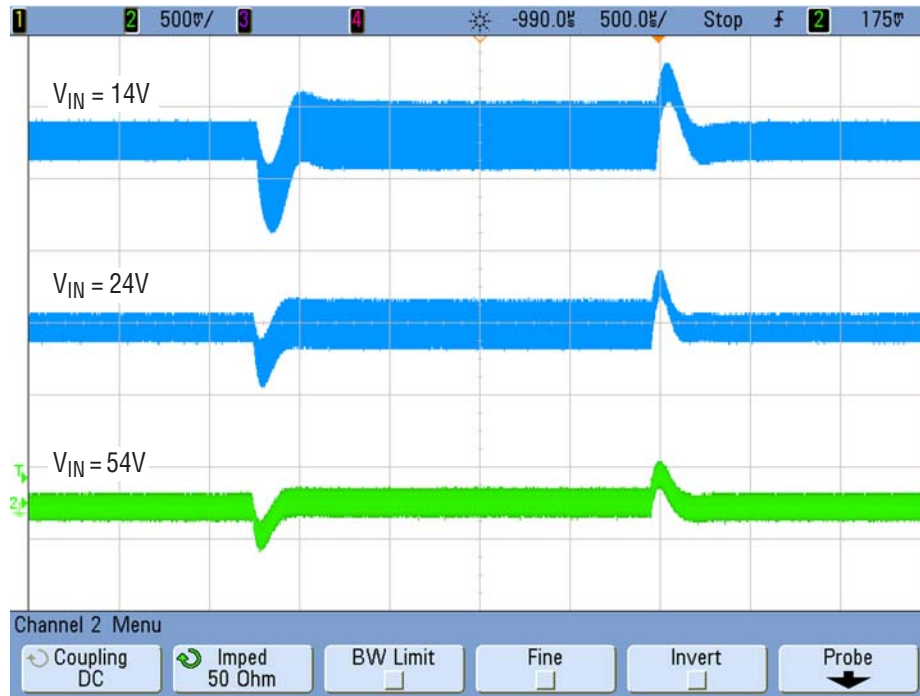


Figure 4. Output Voltage Load Transient Response, $V_{OUT} = 24V$, $I_{OUT} = 2.5A$ to $5A$ to $2.5A$, 20MHz Bandwidth

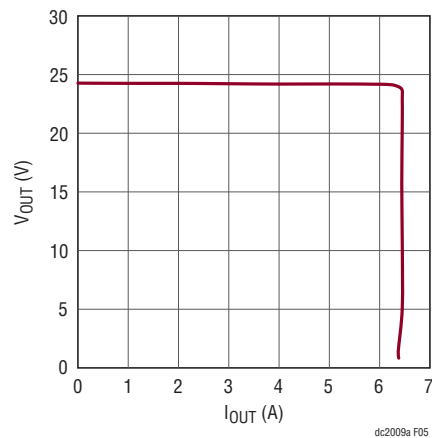


Figure 5. V_{OUT} in Current Limit, $V_{IN} = 24V$

DEMO MANUAL DC2009A

PARTS LIST

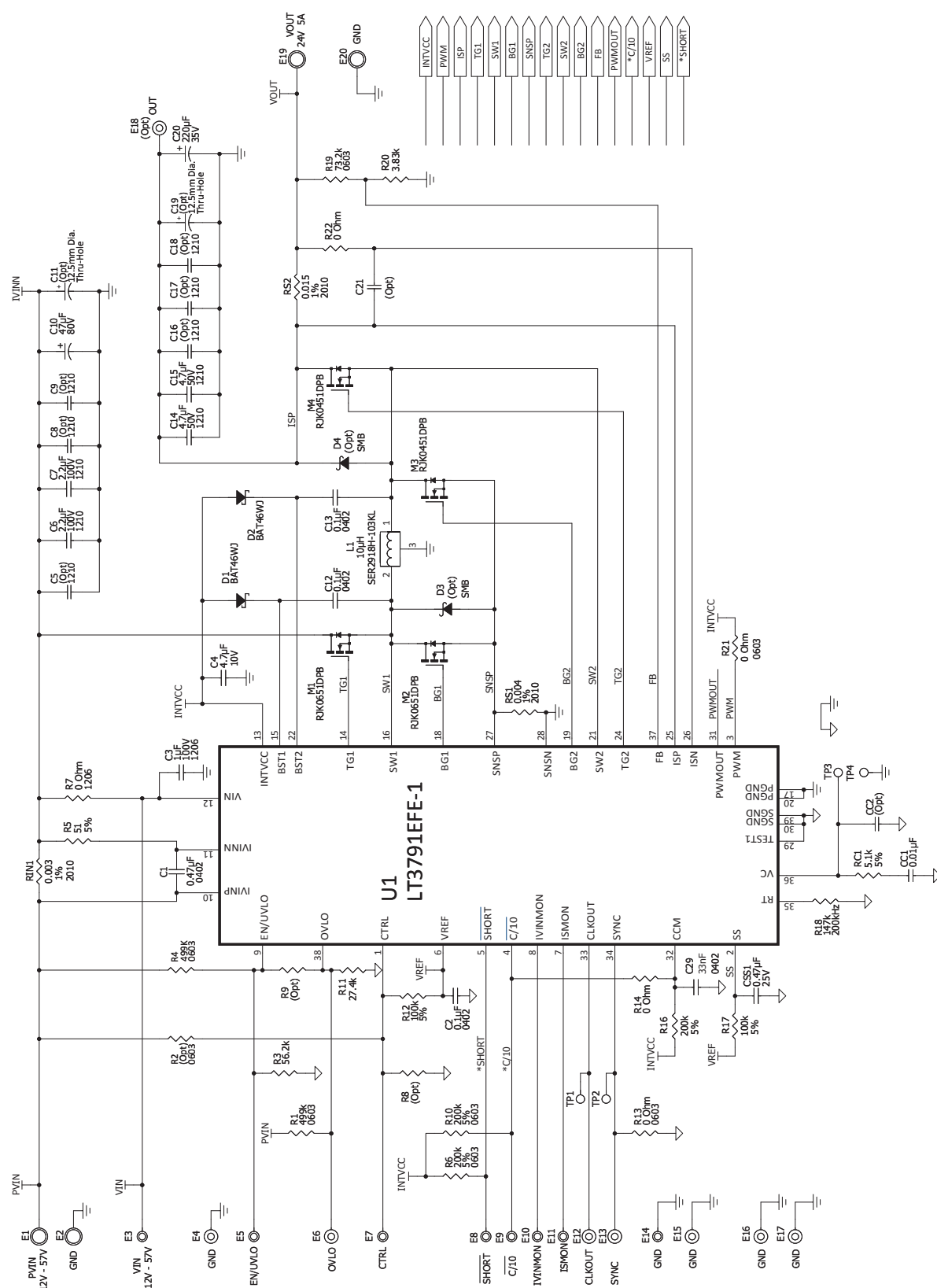
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	CC1	Cap., X7R, 0.01 μ F, 25V, 10%, 0603	AVX 06033C103KAT2A
2	1	CSS1	Cap., X7R, 0.47 μ F, 25V, 10%, 0603	TDK C1608X7R1E474K
3	1	C1	Cap., X5R, 0.47 μ F, 16V, 20%, 0402	TDK C1005X5R1C474MT
4	3	C2, C12, C13	Cap., X5R, 0.1 μ F, 16V, 10%, 0402	TDK C1005X5R1C104KT
5	1	C3	Cap., X5R, 1 μ F, 100V, 10%, 1206	Taiyo Yuden HMK316BJ105KL-T
6	1	C4	Cap., X5R, 4.7 μ F, 10V, 10%, 0603	Taiyo Yuden LMK107BJ475KA
7	2	C6, C7	Cap., X7R, 2.2 μ F, 100V, 20%, 1210	Taiyo Yuden HMK325B7225MN-T
8	1	C10	Cap., Alum. Elect. 47 μ F, 80V, \pm 20%, CON/JA0	United Chemi-Con EMZA800ADA470MJA0G
9	2	C14, C15	Cap., X5R, 4.7 μ F, 50V, 20%, 1210	Taiyo Yuden UMK325BJ475MM-T
10	1	C20	Cap., Alum. 220 μ F, 35V, 20%	SUNCON 35HVP220M
11	1	C29	Cap., X7R, 0.033 μ F, 16V, 10%, 0402	TDK C1005X7R1C333K
12	2	D1, D2	Schottky Barrier 100V, SOD323(SC-90)	NXP Semi. BAT46WJ
13	1	L1	Inductor, 10 μ H SER2900	Coilcraft SER2918H-103KL
14	2	M1, M2	MOSFET-N Channel, 60V/25A, LPAK	Renesas RJK0651DPB
15	2	M3, M4	MOSFET-N Channel, 40V/35A, LPAK	Renesas RJK0451DPB-00-J5
16	1	RC1	Res., Chip 5.1k, 0.06W, 5%, 0402	Vishay CRCW04025K10JNED
17	1	R1N1	Res., 0.003, 1/2W, 1%, 2010	Vishay WSL-2010-3L000-F-EA
18	1	RS1	Res., 0.004, 1/2W, 1%, 2010	Vishay WSL-2010-4L000-F-EA
19	1	RS2	Res., 0.015, 1W, 1%, 2010	Vishay WSL-2010-R0150-F-EA
20	2	R1, R4	Res., Chip 499k, 0.06W, 1%, 0603	Vishay CRCW0603499KFKEA
21	1	R3	Res., Chip 56.2k, 0.06W, 1%, 0402	Vishay CRCW040256K2FKED
22	1	R5	Res., Chip 51, 0.06W, 5%, 0402	Vishay CRCW040251R0JNED
23	2	R6, R10	Res., Chip 200k, 0.06W, 5%, 0603	Vishay CRCW0603200KJNEA
24	1	R11	Res., Chip 27.4k, 0.06W, 1%, 0402	Vishay CRCW040227K4FKED
25	1	R16	Res., Chip 200k, 0.06W, 5%, 0402	Vishay CRCW0402200KJNED
26	1	R17	Res., Chip 100k, 0.06W, 5%, 0402	Vishay CRCW0402100KJNED
27	1	R18	Res., Chip 147k, 0.06W, 1%, 0402	Vishay CRCW0402147KFKEA
28	1	R19	Res., Chip 73.2k, 0.06W, 1%, 0603	Vishay CRCW060373K2FKEA
29	1	R20	Res., Chip 3.83k, 0.06W, 1%, 0402	Vishay CRCW04023K83FKED
30	1	U1	I.C., Volt. Reg. Controller TSSOP(38)-FE	Linear Tech. Corp. LT3791EFE-1

PARTS LIST

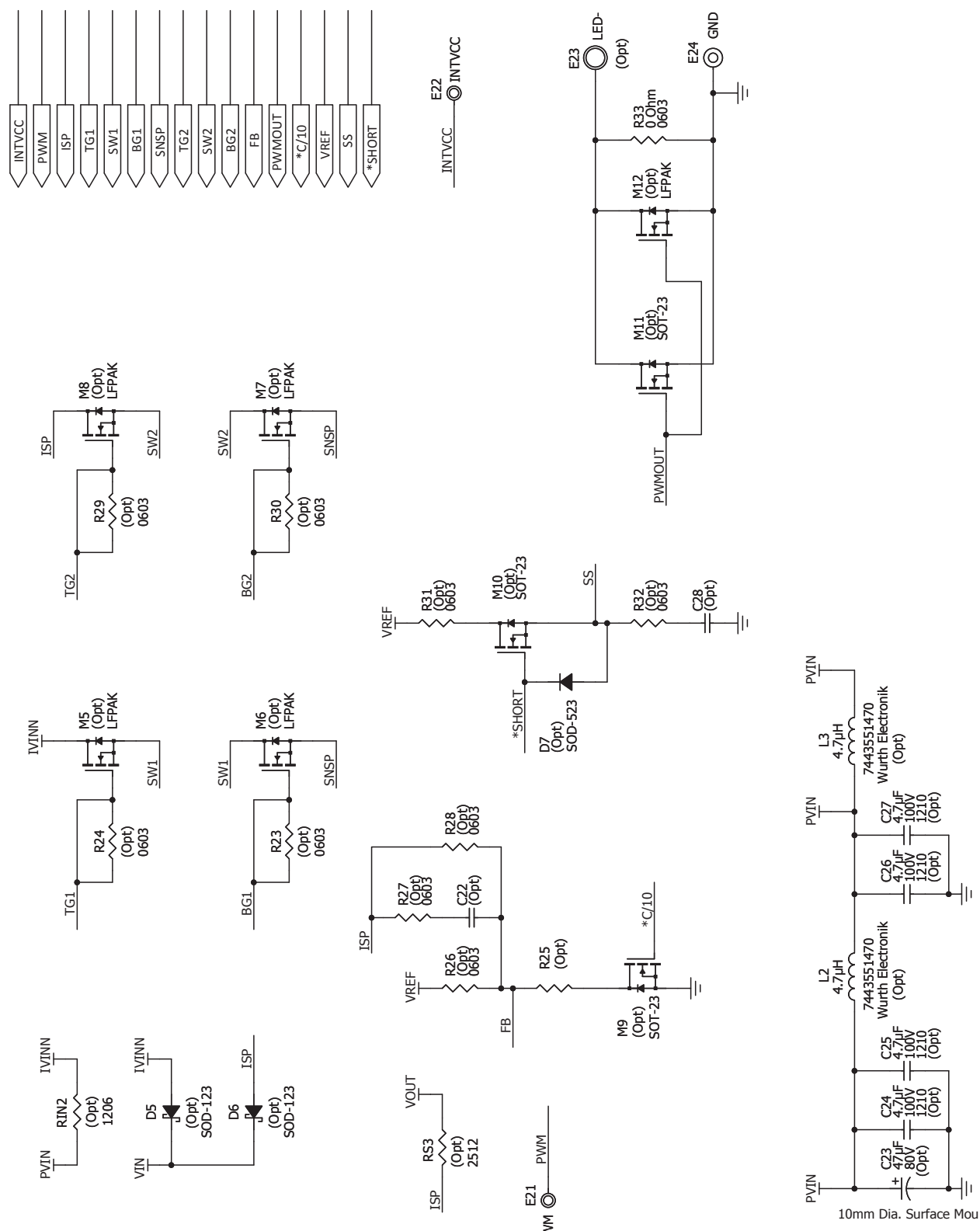
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Optional Demo Circuit Components				
1	0	CC2, C21, C22, C28	Cap., 0603	
2	0	C5, C8, C9, C16, C17, C18	Cap., 1210	
3	0	C11, C19	Cap., 12.5mm Dia.	
4	0	C23	Cap., Alum. Elect. 47 μ F, 80V, \pm 20%, CON/JAO	United Chemi-Con EMZA800ADA470MJA0G
5	0	C24, C25, C26, C27	Cap., X7S 4.7 μ F, 100V, 20%, 1210	TDK C3225X7S2A475MT
6	0	D3, D4	Schottky Diode SMB	
7	0	D5, D6	Diode, SOD-123	
8	0	D7	Diode, SOD-523	
9	0	L2, L3	Inductor, 4.7 μ H	Würth Elektronik 7443551470
10	0	M5, M6, M7, M8, M12	MOSFET, LFPK	
11	0	M9, M10, M11	MOSFET, SOT-23	
12	0	R1N2	Res., 1206	
13	0	RS3	Res., 2512	
14	0	R2, R23, R24, R26, R27, R28, R29, R30, R31, R32	Res., 0603	
15	1	R7	Res/Jumper, Chip 0 Ω , 1/4W, 1A, 1206	Vishay CRCW12060000Z0EA
16	0	R8, R9, R25	Res., 0402	
17	1	R12	Res., Chip 100k, 0.06W, 5%, 0402	Vishay CRCW0402100KJNED
18	3	R13, R21, R33	Res/Jumper, Chip 0 Ω , 1/16W, 1A, 0603	Vishay CRCW06030000Z0EA
19	2	R14, R22	Res/Jumper, Chip 0 Ω , 1/16W, 1A, 0402	Vishay CRCW04020000Z0ED
20	1	R16	Res., Chip 200k, 0.06W, 5%, 0402	Vishay CRCW0402200KJNED
Hardware				
1	4	E1, E2, E19, E20	Connector, Banana Jack	Keystone 575-4
2	10	E3, E5, E7, E8, E9, E10, E11, E14, E21, E22	Turret, Testpoint	Mill Max 2308-2-00-80-00-00-07-0
3	8	E4, E6, E12, E13, E15, E16, E17, E24	Turret, Testpoint	Mill Max 2501-2-00-80-00-00-07-0
4	0	E18	Turret, Testpoint	Mill Max 2501-2-00-80-00-00-07-0
5	0	E23	Connector, Banana Jack	Keystone 575-4
6	4	MH1-MH4	Stand-off, Nylon 0.5"	Keystone, 8833 (Snap On)

DEMO MANUAL DC2009A

SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



DEMO MANUAL DC2009A

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