LT3790
60V Four-Switch Synchronous Buck-Boost Controller

DESCRIPTION

The DC2123A is a 60V four-switch synchronous buck-boost controller that demonstrates the high power capability of the LT®3790. 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 LT3790 is capable of high power operation. DC2123A can be altered for either lower input voltage operation with the same output power or for increased output power with higher minimum input voltage. V_{IN} can be reduced to $8V_{IN}$ minimum and still deliver 120W output by changing RS1 to 2mΩ, RIN1 to 1.5mΩ, and R3 (UVLO) to 88.7k. If V_{IN} remains always above 20V, I_{OUT} can be increased to $12A^+$ (for 290W output) with the above changes, and an additional change of ROUT to 4mΩ.

The operating input voltage range of DC2123A 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 160mV/1A voltage that is used to monitor the output current. The output current limit is 7.5A and is set by RS2.

The demo circuit features MOSFETs that compliment the 5V gate drive of the LT3790 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 DC2123A 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 0Ω resistor to set the output current limit to its maximum, and an external voltage on CTRL can be used to lower the current limit if the resistor is removed. 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 LT3790 attractive for high power voltage regulator circuits and also circuits that require output current regulation such as battery chargers. The LT3790EFE is available in a thermally enhanced 38-lead TSSOP package. The LT3790 data sheet must be read in conjunction with this demo manual to properly use or modify demo circuit DC2123A.

Design files for this circuit board are available at http://www.linear.com/demo/DC2123A

PERFORMANCE SUMMARY

Specifications are at $T_A = 25°C$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Minimum Input Voltage, V_{PVIN}	$V_{OUT} = 24V$ $I_{OUT} \le 4.5A$		12		V
Maximum Input Voltage, V_{PVIN}	$V_{OUT} = 24V$ $I_{OUT} \le 5A$		57		V
Maximum Output Current	$13.3V < V_{PVIN} < 57V$, CTRL = V_{REF} $V_{PVIN} = 12V$, CTRL = V_{REF}	5 4.5			A A
Input EN Voltage, $V_{PVIN(EN)}$	R3 = 56.2k, R4 = 499k, V_{PVIN} Rising		13.4		V
Input UVLO Voltage, $V_{PVIN(UVLO)}$	R3 = 56.2k, R4 = 499k, V_{PVIN} Falling		11.9		V
Input OVLO Turn-Off Voltage, $V_{PVIN(OVLO\ turn\text{-}off)}$	R11 = 27.4k, R1 = 499k, V_{PVIN} Rising		57.6		V
Input OVLO Turn-On Voltage, $V_{PVIN(OVLO\ turn\text{-}on)}$	R11 = 27.4k, R1 = 499k, V_{PVIN} Falling		56.2		V
Output Voltage V_{OUT}	R19 = 71.5k, R34 = 1.37k, R20 = 3.83k	23.5		24.5	V
Efficiency	$V_{PVIN} = 24V$, $I_{OUT} = 5A$		98		%
Switching Frequency	R18 = 147k		200		kHz
Input Current Limit	RIN1 = 0.003Ω		16.7		A
Output Current Limit	RS2 = 0.008Ω		7.5		A

QUICK START PROCEDURE

It is easy to set up demonstration circuit DC2123A to evaluate the performance of the LT3790. 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 LT3790.

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 12V 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

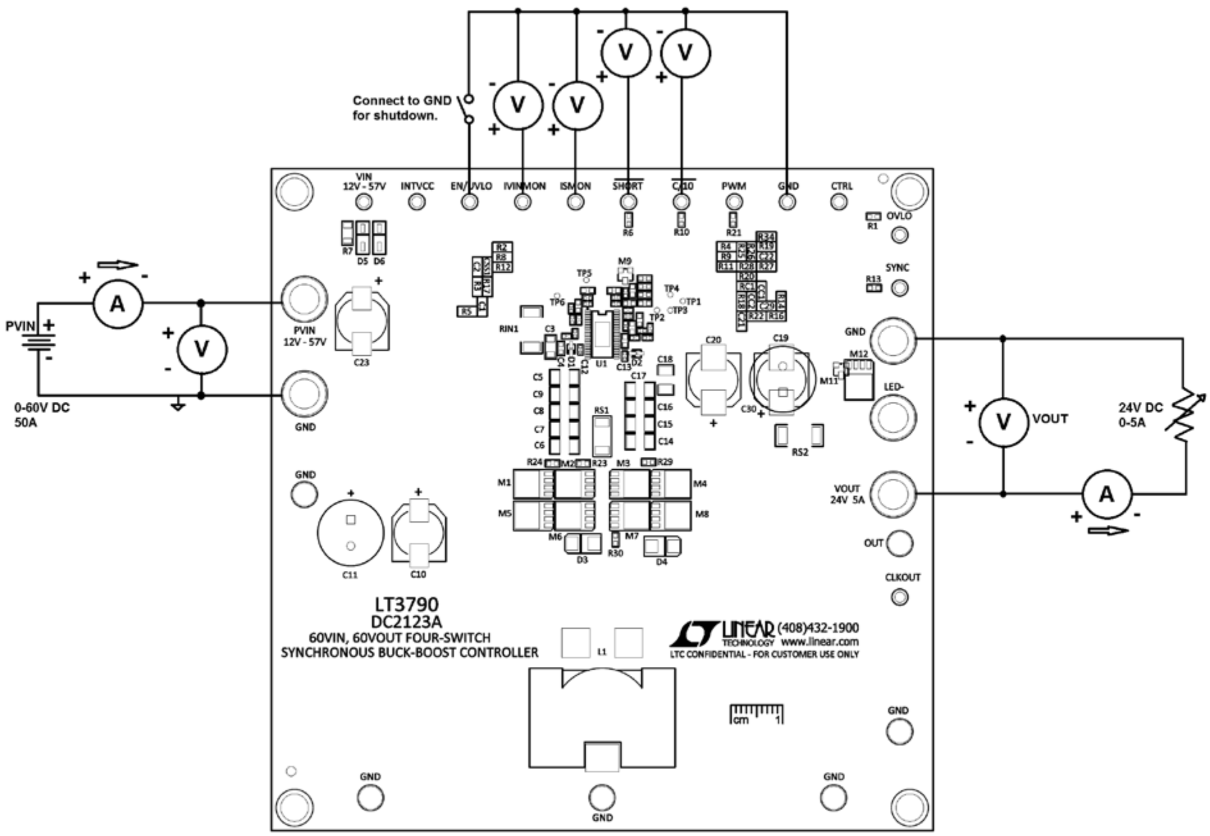


Figure 1. Proper Measurement Equipment Setup for DC2123A

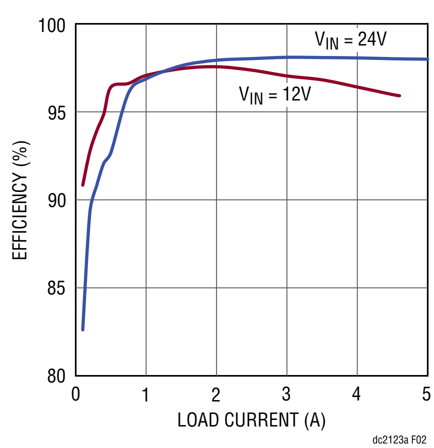


Figure 2. Efficiency

QUICK START PROCEDURE

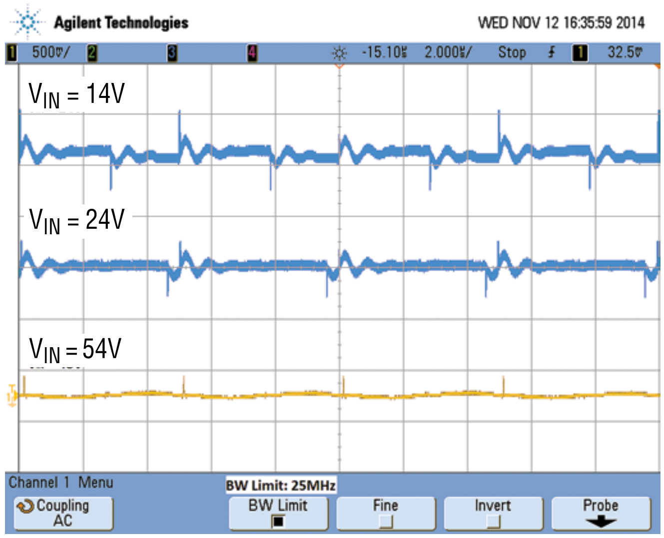


Figure 3. Output Voltage Ripple at 5A Output Current, V_{OUT} = 24V, 25MHz Bandwidth

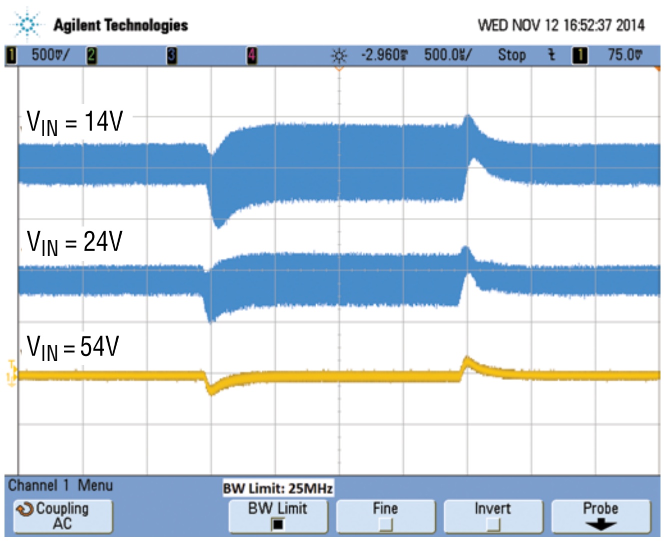


Figure 4. Output Voltage Load Transient Response, V_{OUT} = 24V, I_{OUT} = 2.5A to 5A to 2.5A, 25MHz Bandwidth

QUICK START PROCEDURE

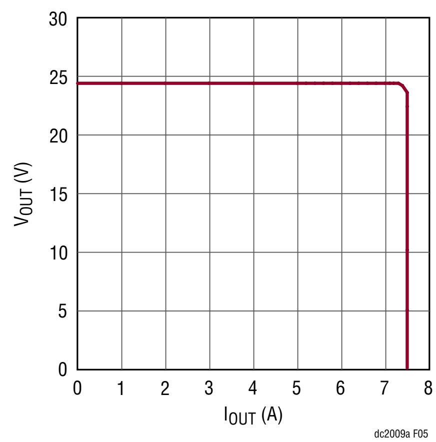


Figure 5. V_{OUT} in Current Limit, V_{IN} = 24V

DIFFERENCES BETWEEN LT3790 AND LT3791-1

The LT3790 is an improved version of the LT3791-1 and is recommended for use in new designs. Some external component values may change, but otherwise, the LT3790 is functionally equivalent to the LT3791-1. The differences between the two products are:

1. The LT3790 has a 60mV (typical) full-scale $V_{(ISP-ISN)}$ current sense voltage, compared to 100mV (typical) for the LT3791-1. This change allows lower power current sense resistors to be used for most applications.
2. The LT3790 CTRL pin linear range is from 0V to 1.1V, and has a turn-off threshold of 50mV(typical), compared to a 200mV to 1.1V linear range and 175mV (typical) turn-off threshold for the LT3791-1. These changes make it easier to parallel two or more LT3790 ICs for higher power levels.
3. The LT3790 $\overline{C/10}$ pin pulls low when the $V_{(ISP-ISN)}$ voltage is less than 1/10 full scale, compared to the LT3791-1, where $\overline{C/10}$ pulls low when both $V_{(ISP-ISN)}$ is less than 1/10 full scale and V_{FB} is greater than 1.15V(typical). Since the $\overline{C/10}$ pin is used to allow DCM mode for some applications, this change ensures that negative current does not occur at light loads for a broader range of applications.

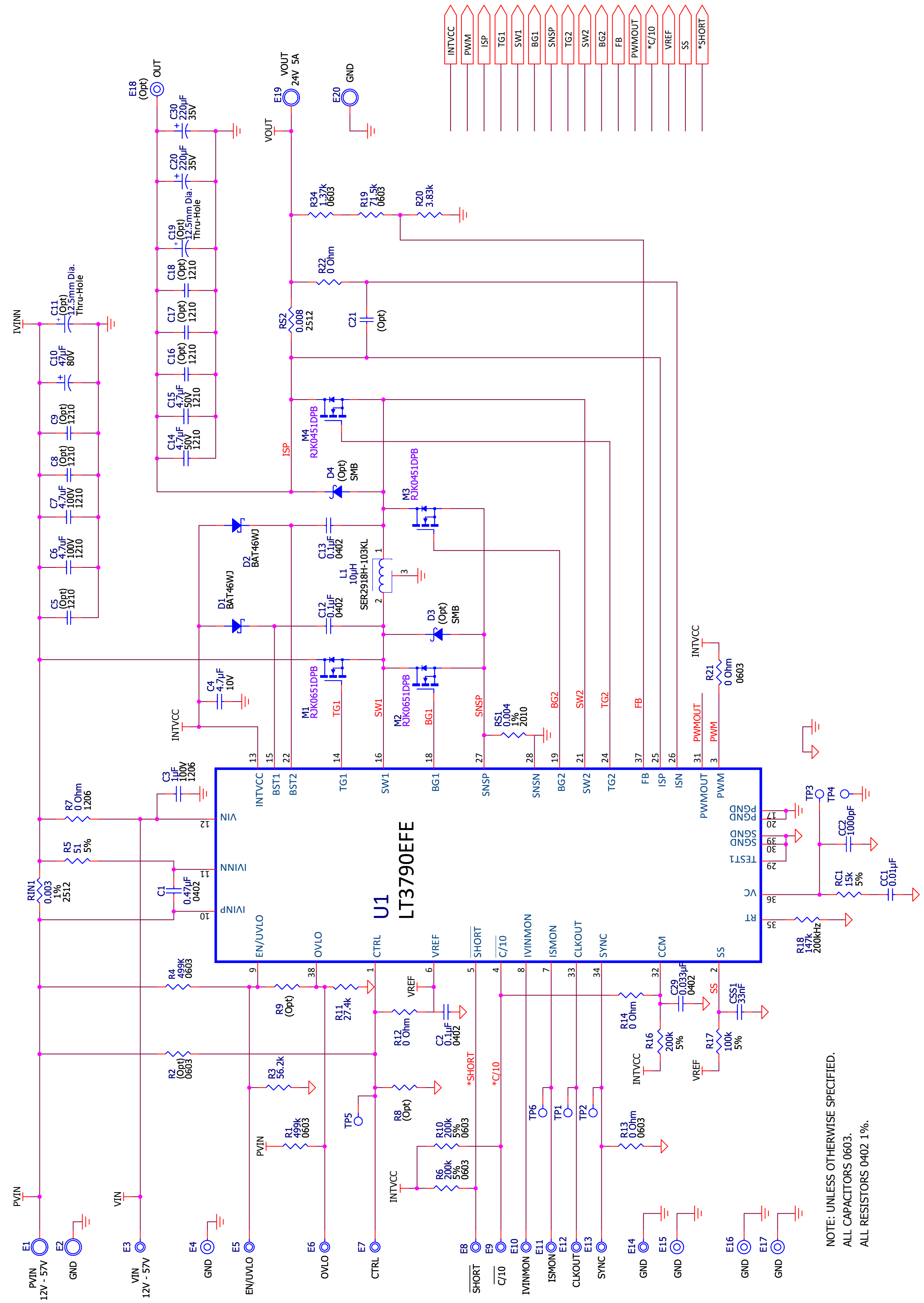
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Electrical Components				
1	1	CC1	Cap., X7R 0.01µF 25V 10% 0603	AVX 06033C103KAT2A
2	1	CC2	Cap., NPO 1000pF 25V 10% 0603	AVX 06033A102KAT1A
3	1	CSS1	Cap., X7R 33nF 25V 10% 0603	AVX 06033C333KAT1A
4	1	C1	Cap., X5R 0.47µF 16V 20% 0402	TDK C1005X5R1C474MT
5	3	C2, C12, C13	Cap., X5R 0.1µF 16V 10% 0402	TDK C1005X5R1C104KT
6	1	C3	Cap., X5R 1µF 100V 10% 1206	Taiyo Yuden HMK316BJ105KL-T
7	1	C4	Cap., X5R 4.7µF 10V 10% 0603	Taiyo Yuden LMK107BJ475KA
8	2	C6, C7	Cap., X7S 4.7µF 100V 10% 1210	TDK C3225X7S2A475K200AB
9	1	C10	Cap., Alum. Elect. 47µF 80V ± 20%	United Chemi-Con EMZA800ADA470MJA0G
10	2	C14, C15	Cap., X5R 4.7µF 50V 20% 1210	Taiyo Yuden UMK325BJ475MM-T
11	2	C20, C30	Cap., Hybrid Cond. Polymer 220µF 35V 20%	SUN Electronic Industries 35HVP220M
12	1	C29	Cap., X7R 0.033µF 16V 10% 0402	TDK C1005X7R1C333K
13	2	D1, D2	Schottky Barrier 100V SOD323 (SC-90)	NXP Semi. BAT46WJ
14	1	L1	Inductor, 10µH SER2900	Coilcraft SER2918H-103KL
15	2	M1, M2	Mosfet-N Channel, 60V/25A LFPAK	Renesas RJK0651DPB-00-J5
16	2	M3, M4	Mosfet-N Channel, 40V/35A LFPAK	Renesas RJK0451DPB-00-J5
17	1	RC1	Res., Chip 15k 0.06W 5% 0402	Vishay CRCW040215K0JNED
18	1	RIN1	Res., 0.003 1W 1% 2512	Vishay WSL25123L000FEA
19	1	RS1	Res., 0.004 1/2W 1% 2010	Vishay WSL20104L000FEA
20	1	RS2	Res., 0.008 1W 1% 2512	Panasonic ERJ-M1WSF8M0U
21	2	R1, R4	Res., Chip 499k 0.06W 1% 0603	Vishay CRCW0603499KFKEA
22	1	R3	Res., Chip 56.2k 0.06W 1% 0402	Vishay CRCW040256K2FKED
23	1	R5	Res., Chip 51 0.06W 5% 0402	NIC NRC04F51R0TRF
24	2	R6, R10	Res., Chip 200k 0.06W 5% 0603	Vishay CRCW0603200KJNEA
25	1	R11	Res., Chip 27.4k 0.06W 1% 0402	Vishay CRCW040227K4FKED
26	1	R16	Res., Chip 200k 0.06W 5% 0402	Vishay CRCW0402200KJNED
27	1	R17	Res., Chip 100k 0.06W 5% 0402	Vishay CRCW0402100KJNED
28	1	R18	Res., Chip 147k 0.06W 1% 0402	Vishay CRCW0402147KFKED
29	1	R19	Res., Chip 71.5k 0.06W 1% 0603	Vishay CRCW060371K5FKEA
30	1	R20	Res., Chip 3.83k 0.06W 1% 0402	Vishay CRCW04023K83FKED
31	1	U1	I.C., 60V Buck-Boost Volt. Reg.	Linear Tech. Corp. LT3790EFE#PBF

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Optional Electrical Components				
1	0	C5, C8, C9, C16, C17, C18 (Opt)	Cap., 1210	
2	0	C11, C19 (Opt)	OPTIONAL	
3	0	C21, C22, C28	Cap., 0603	
4	0	C23	OPTIONAL	
5	0	C24, C25, C26, C27 (Opt)	OPTIONAL	
6	0	D3, D4 (Opt)	Schottky Diode, SMB	
7	0	D5, D6 (Opt)	Diode, SOD-123	
8	0	D7 (Opt)	Diode, SOD-523	
9	0	L2, L3 (Opt)	OPTIONAL	
10	0	M5, M6, M7, M8, M12 (Opt)	OPTIONAL	
11	0	M9, M10, M11 (Opt)	OPTIONAL	
12	0	R2, R23, R24, R26-R32	Res., 0603 OPTIONAL	
13	1	R7	Res.,Chip 0Ω 1206	Yageo RC1206FR-070RL
14	0	R8, R9, R25	Res., 0402 OPTIONAL	
15	3	R12, R14, R22	Res., Chip 0Ω 0402	Vishay CRCW04020000Z0ED
16	2	R13, R21	Res., Chip 0Ω 0603	Vishay CRCW06030000Z0EA
17	1	R34	Res., Chip 1.37k 0.06W 1% 0603	Panasonic ERJ-3EKF1371V
Hardware				
1	4	E1, E2, E19, E20	Connector, Banana Jack	Keystone 575-4
2	13	E3, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E21, E22	Turret, Testpoint	Mill Max 2308-2-00-80-00-00-07-0
3	5	E4, E15, E16, E17, E24	Turret, Testpoint	Mill Max 2501-2-00-80-00-00-07-0
4	0	E18 (Opt)	OPTIONAL	
5	0	E23 (Opt)	OPTIONAL	
6	4	MH1-MH4	Standoff Nylon 0.50"	Keystone, 8833 (Snap-On)

SCHEMATIC DIAGRAM



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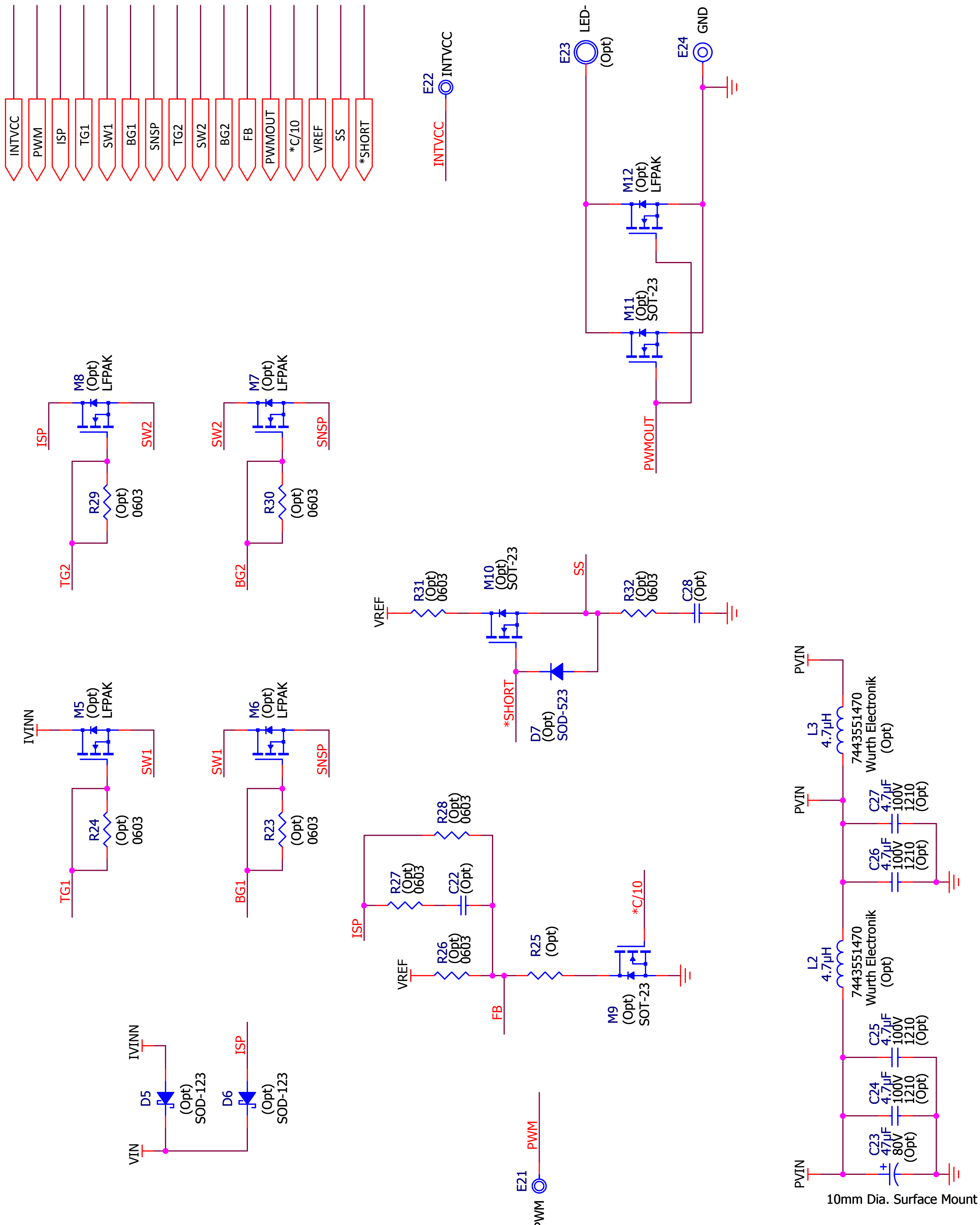

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