

## Triple Output Synchronous Step-Up/ Dual Step-Down Supply

### DESCRIPTION

Demonstration circuit 2122A is a triple output synchronous step-up/dual step-down supply featuring the [LTC<sup>®</sup>3859AL](#). This demonstration circuit is designed for two buck 5V/5A, 8.5V/3A outputs supplied by a boosted 10V/7A output. Benefiting from this feature, the buck outputs are able to maintain regulation over a wide input voltage range of 4.5V to 36V which is suitable for automotive or other battery fed applications. Also, the demonstration circuit uses a drop-in layout that the main buck circuit components fit in an area of ¾" by 1½", while the main boost circuit area is ¾" by 1¾". The package style for the LTC3859AL is a 38-pin exposed pad QFN package.

The main features of the board include rail tracking (buck channels only), an internal 5V linear regulator for bias, separated RUN pins for each output, a PGOOD signal (CH1 only), an overvoltage indicator for CH3 and a Mode selector that allow the converter to run in CCM, pulse skip or Burst Mode<sup>®</sup> operation. Synchronization to an external clock is also possible. The LTC3859AL data sheet gives a complete description of these parts, operation and application information. The data sheet must be read in conjunction with this quick start guide for demo circuit 2122A.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC2122A>**

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### PERFORMANCE SUMMARY Specifications are at T<sub>A</sub> = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>IN</sub>	Input Supply Range		4.5		36	V
V <sub>OUT1</sub>	Output1 Voltage Range	V <sub>IN</sub> = 4.5V to 36V, I <sub>OUT1</sub> = 0A to 5A	4.90	5.0	5.10	V
V <sub>OUT2</sub>	Output2 Voltage Range	V <sub>IN</sub> = 4.5V to 36V, I <sub>OUT2</sub> = 0A to 3A	8.33	8.5	8.67	V
V <sub>OUT3</sub>	Output3 Voltage Range	V <sub>IN</sub> = 4.5V to 10V <sup>†</sup> , I <sub>OUT3</sub> = 0A to 7A*, I <sub>OUT1,2</sub> = 0A	9.80	10.0	10.20	V
f <sub>SW</sub>	Typical Free Running Switching Frequency			350		kHz
	Efficiency See Figures 3, 4 and 5 for Efficiency Curves	V <sub>IN</sub> = 10V, V <sub>OUT1</sub> = 5.0V, I <sub>OUT1</sub> = 5A V <sub>IN</sub> = 36V, V <sub>OUT1</sub> = 5.0V, I <sub>OUT1</sub> = 5A V <sub>IN</sub> = 10V, V <sub>OUT2</sub> = 8.5V, I <sub>OUT2</sub> = 3A V <sub>IN</sub> = 36V, V <sub>OUT2</sub> = 8.5V, I <sub>OUT2</sub> = 3A V <sub>IN</sub> = 4.5V, V <sub>OUT3</sub> = 10.0V, I <sub>OUT3</sub> = 7A*		97.8 92.0 95.4 92.8 94.4		% % % % %

<sup>†</sup>When V<sub>IN</sub> > V<sub>OUT3</sub> then V<sub>OUT3</sub> follows V<sub>IN</sub>.

\*Maximum output current roughly equivalent to 2A from V<sub>OUT3</sub> plus full load from V<sub>OUT1</sub> and V<sub>OUT2</sub>.

## QUICK START PROCEDURE

Demonstration circuit 2122A is easy to set up to evaluate the performance of the LTC3859AL. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

NOTE. When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the  $V_{IN}$  or  $V_{OUT}$  and GND terminals or directly across relevant capacitor. See Figure 2 for proper scope probe technique.

1. Place jumpers in the following positions:

- JP1:** ON
- JP2:** ON
- JP3:** Burst Mode
- JP4:** ON

2. With power off, connect the input power supply to  $V_{IN}$  and GND.

3. Turn on the power at the input.

NOTE. Make sure that the input voltage does not exceed 36V.

4. Check for the proper output voltages.

$V_{OUT1} = 4.900V$  to  $5.100V$ ,

$V_{OUT2} = 8.330V$  to  $8.670V$

$V_{OUT3} = 9.800V$  to  $10.200V$

NOTE. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.

5. Once the proper output voltages are established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

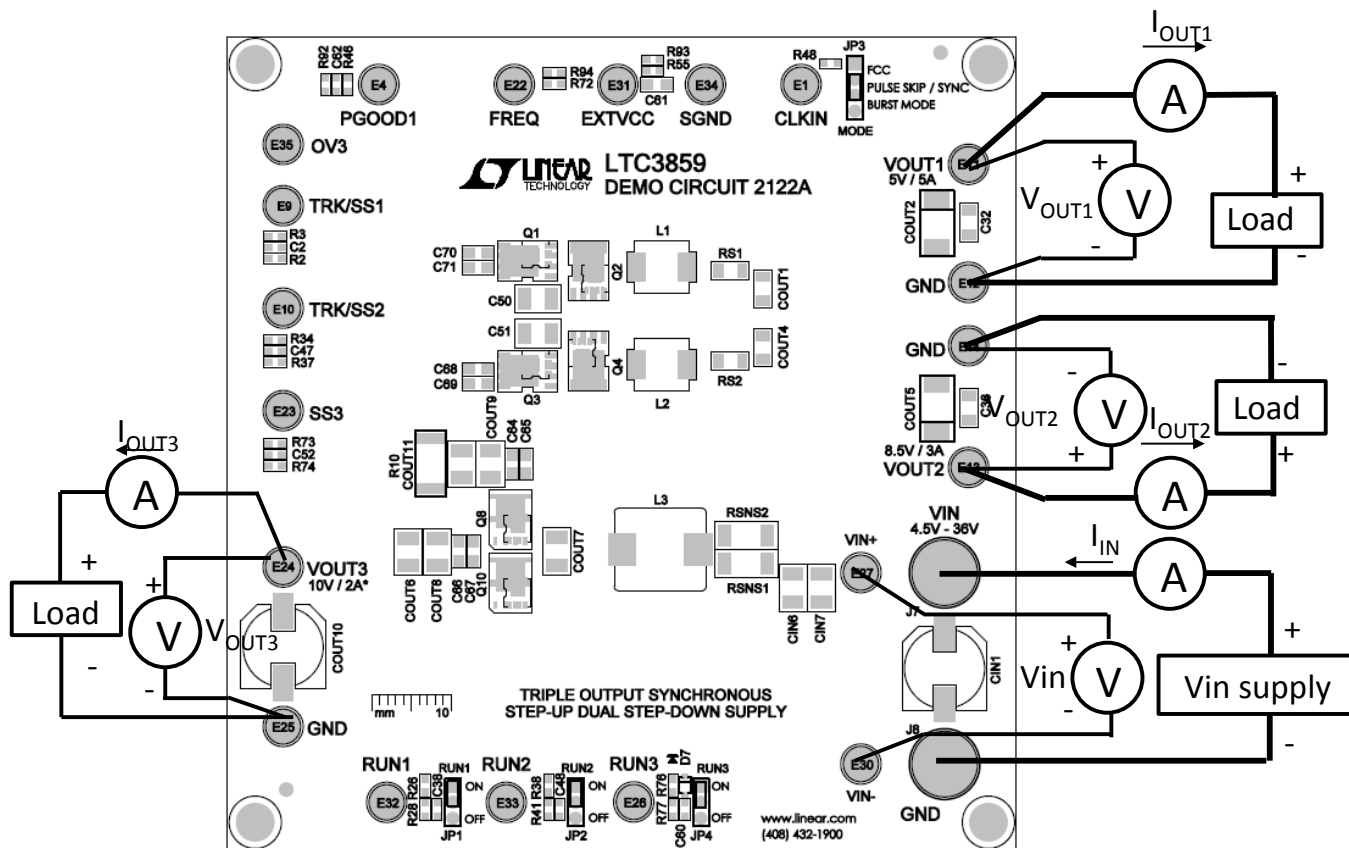


Figure 1. Proper Measurement Equipment Setup. (Please Note Polarity on  $V_{OUT2}$ )

## QUICK START PROCEDURE

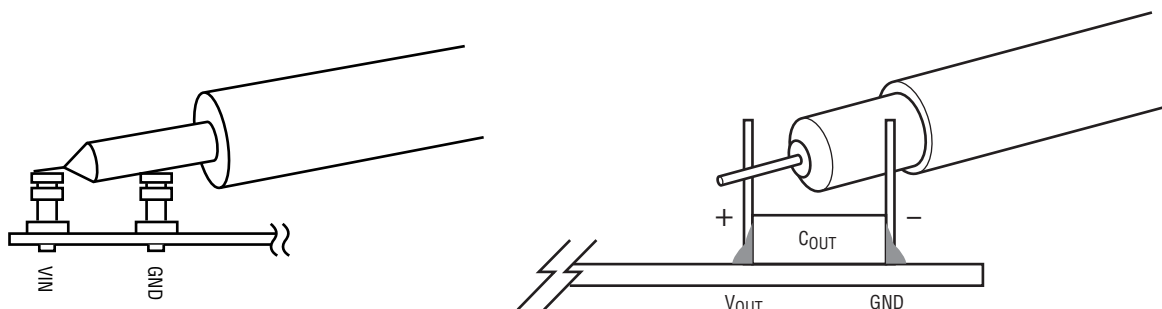


Figure 2. Measuring Input or Output Ripple Across Terminals or Directly Across Bulk Capacitor

## FREQUENCY SYNCHRONIZATION AND MODE SELECTION

A single output/dual phase converter may be preferred for high output current applications. The demonstration circuit 1425A's mode selector allows the converter to

run in FCC operation, pulse skip operation, Burst Mode or be synchronizing to an external clock by changing the position of JP3.

Table 2. Mode Selection and Synchronizing Operation Options

CONFIGURATION	MODE/PLLIN JUMPER
Forced Continuous Conduction Operation	FCC
Pulse Skip Mode Operation	P.S.
Burst Mode Operation	BURST
Synchronize to Ext. Clock (Ext. Clock Apply to CLKIN Turret)	Remove Jumper

## RAIL TRACKING

Demonstration circuit 2122A is configured for an on board soft-start circuit. The soft-start ramp rate can be adjusted by changing the value of C2 and C47. Demonstration circuit

2122A can also be modified to track an external reference. Refer to Table 3 and Table 4 for tracking options and to the data sheet for more details.

Table 3.  $V_{OUT1}$  Tracking Options

CONFIGURATION	R2	R3	C2	TRK/SS1 CAP
Soft-Start without Tracking (Default)	OPEN	OPEN	0.1 $\mu$ F	OPEN
$V_{OUT1}$ Tracking Scaled $V_{OUT2}$	Resistor Divider		OPEN	OPEN

Table 4.  $V_{OUT2}$  Tracking Options

CONFIGURATION	R34	R37	C47	TRK/SS2 CAP
Soft-Start without Tracking (Default)	0 $\Omega$	OPEN	0.1 $\mu$ F	OPEN
$V_{OUT2}$ Equals External Ramp	0 $\Omega$	OPEN	OPEN	External Ramp
$V_{OUT2}$ Tracking Scaled External Ramp	Resistor Divider		OPEN	External Ramp

## OPTIONAL INDUCTOR DCR CURRENT SENSING

Demonstration circuit 2122A provides an optional circuit for inductor DCR current sensing. Inductor DCR current sensing uses the DCR of the inductor to sense the inductor current instead of discrete sense resistors. The advantages of DCR sensing are lower cost, reduced board space and higher efficiency, but the disadvantage is a less accurate current limit. If DCR sensing is used, be sure to select an inductor current with a sufficiently high saturation current or use an iron powder type material.

Refer to Table 5 for optional inductor DCR current sensing setup and to the data sheet for more details.

### Low Quiescent Current Applications and Measurement

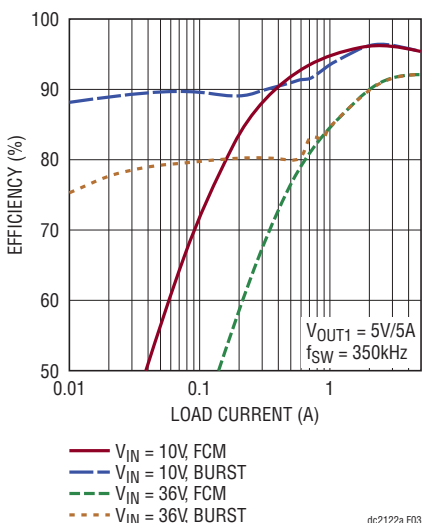
The typical quiescent current ( $I_Q$ ) of the LTC3859AL controller is  $28\mu A$  in sleep mode as specified in the LTC3859AL data sheet. However, the input current of the DC2122A board can be higher than this value because of additional circuit outside of the IC. To reduce the total input current, large value FB divider resistors should be used. In addition, some of the optional pull-up resistors should be removed from the board. Refer to Table 6 for the low input quiescent current setup.

**Table 6. Low Input Quiescent Current Configuration**

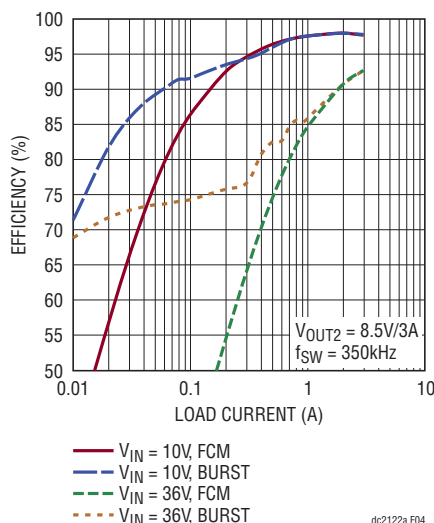
Reference Designator	R46	R48	R92
Function	PGOOD1	MODE	OV3
Stuffing Option	OPEN	OPEN	OPEN

**Table 5. Optional Inductor DCR Current Sensing**

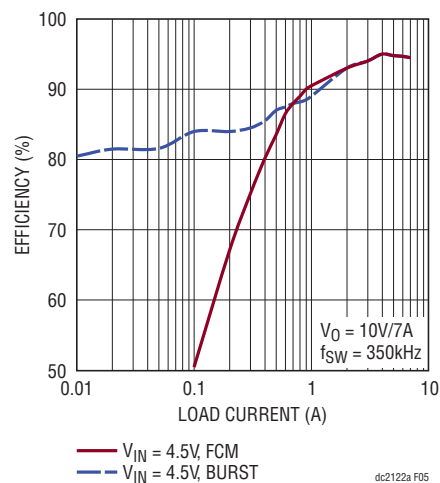
CONFIGURATION	CHANNEL1	RS1	R29	R30	C14	R45	R47	R61
	CHANNEL2	RS2	R39	R40	C15	R51	R53	R62
	CHANNEL3	RSNS1,2	R80	R81	C56	R89	R90	R91
Current Sense Resistor (Default)	Ref. Sch.	Ref. Sch.	Ref. Sch.	Ref. Sch.	Ref. Sch.	OPEN	OPEN	OPEN
Inductor DCR Current Sensing	0Ω Copper	OPEN	OPEN	OPEN	Calculated Value from Data Sheet			0Ω



**Figure 3. Channel 1 Typical Efficiency vs Load Current**



**Figure 4. Channel 2 Typical Efficiency vs Load Current**



**Figure 5. Channel 3 Typical Efficiency vs Load Current (Equivalent to 2A from V\_OUT3 Plus Full Load from V\_OUT1 and V\_OUT2)**

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	2	CIN1, COUT10	CAP, 220µF 20% 50V ELEC	SANYO 50CE220LX
2	7	COUT6, CIN6, COUT7, CIN7, COUT8, C50, C51	CAP, 1210 10µF 10% 50V X7S	TDK C3225X7S1H106K250AB
3	1	COUT1	CAP, 1206 22µF 20% 10V X7R	AVX 1206ZD226KAT2A
4	1	COUT2	CAP, 7343 220µF 20% 6.3V POSCAP	SANYO 6TPB220ML
5	1	COUT4	CAP, 1206 4.7µF 20% 16V X7R	TDK C3216X7R1C475M
6	1	COUT5	CAP, 7343 68µF 20% 10V POSCAP	SANYO 10TPC68M
7	7	C2, C4, C17, C20, C21, C47, C52	CAP, 0603 0.1µF 10% 25V X7R	TDK C1608X7R1E104K
8	2	C11, C61	CAP, 0805 4.7µF 10% 6.3V X5R	AVX 08056D475KAT2A
9	4	C14, C15, C56, C62	CAP, 0603 1nF 10% 50V X7R	AVX 06035C102KAT2A
10	1	C41	CAP, 0603 1500pF 10% 50V X7R	AVX 06035C152KAT2A
11	1	C42	CAP, 0603 100pF 5% 50V NPO	AVX 06035A101JAT2A
12	1	C43	CAP, 0603 68pF 10% 50V NPO	AVX 06035A680KAT2A
13	1	C44	CAP, 0603 2.2nF 10% 50V X7R	AVX 06035C223KAT2A
14	1	C53	CAP, 0603 820pF 5% 50V X7R	AVX 06035A821JAT2A
15	1	C54	CAP, 0603 10nF 10% 50V X7R	TDK C1608X7R1H103K
16	8	C64, C65, C66, C67, C68, C69, C70, C71	CAP, 0805 1µF 10% 50V X7R	MURATA GRM21BR71H105KA12L
17	2	D1, D2	DIODE, SCHOTTKY SOD323	CENTRAL SEMI CMDSH-4E
18	1	D6	DIODE, SCHOTTKY 40V 0.12A SOT323-3	INFINEON BAS140W
19	1	L1	IND, 4.9µH	WURTH 744314490
20	1	L2	IND, 6.5µH	WURTH 744314650
21	1	L3	IND, 1.2µH	WURTH 744325120
22	4	Q1, Q2, Q3, Q4	XSTR, N-CHANNEL MOSFET 40V 40A	INFINEON BSZ097N04LS
23	2	Q8, Q10	XSTR, N-CHANNEL MOSFET 40V 100A	INFINEON BSC027N04LS
24	2	RSNS1, RSNS2	RES, 2010 0.004Ω 1% 1/2W	VISHAY WSL20104L000FEA
25	1	RS1	RES, 1206 0.006Ω 5% 1/4W	VISHAY WSL12066L000FEA
26	1	RS2	RES, 1206 0.008Ω 5% 1/4W	VISHAY WSL12068L000FEA
27	3	R9, R25, R86	RES, 0603 2.2Ω 5% 1/10W	VISHAY CRCW06032R20JNEA
28	1	R10	RES, 2512 0Ω JUMPER	VISHAY CRCW25120000Z0ZG
29	1	R27	RES, 0603 357kΩ 1% 1/10W	VISHAY CRCW0603357KFKEA
30	14	R29, R30, R34, R36, R39, R40, R70, R72, R73, R80, R83, R84, R87, R93	RES, 0603 0Ω JUMPER	VISHAY CRCW06030000Z0EA
31	2	R31, R35	RES, 0603 15kΩ 5% 1/10W	VISHAY CRCW060315K0JNEA
32	3	R32, R33, R79	RES, 0603 68.1kΩ 1% 1/10W	VISHAY CRCW060368K1FKEA
33	1	R43	RES, 0603 649kΩ 1% 1/10W	VISHAY CRCW0603649KFKEA
34	3	R46, R48, R92	RES, 0603 100kΩ 5% 1/10W	VISHAY CRCW0603100KJNEB
35	1	R75	RES, 0603 3.6kΩ 1% 1/10W	NIC NR06J362TRF
36	1	R78	RES, 0603 499kΩ 1% 1/10W	VISHAY CRCW0603499KFKEA
37	1	R81	RES, 0603 100Ω 1% 1/10W	VISHAY CRCW0603100RFKEA
38	1	U1	IC, SYNCHRONOUS BOOST CONVERTER AND DUAL BUCK CONVERTER	LINEAR TECH. LTC3859ALEUHF

# DEMO MANUAL DC2122A

## PARTS LIST

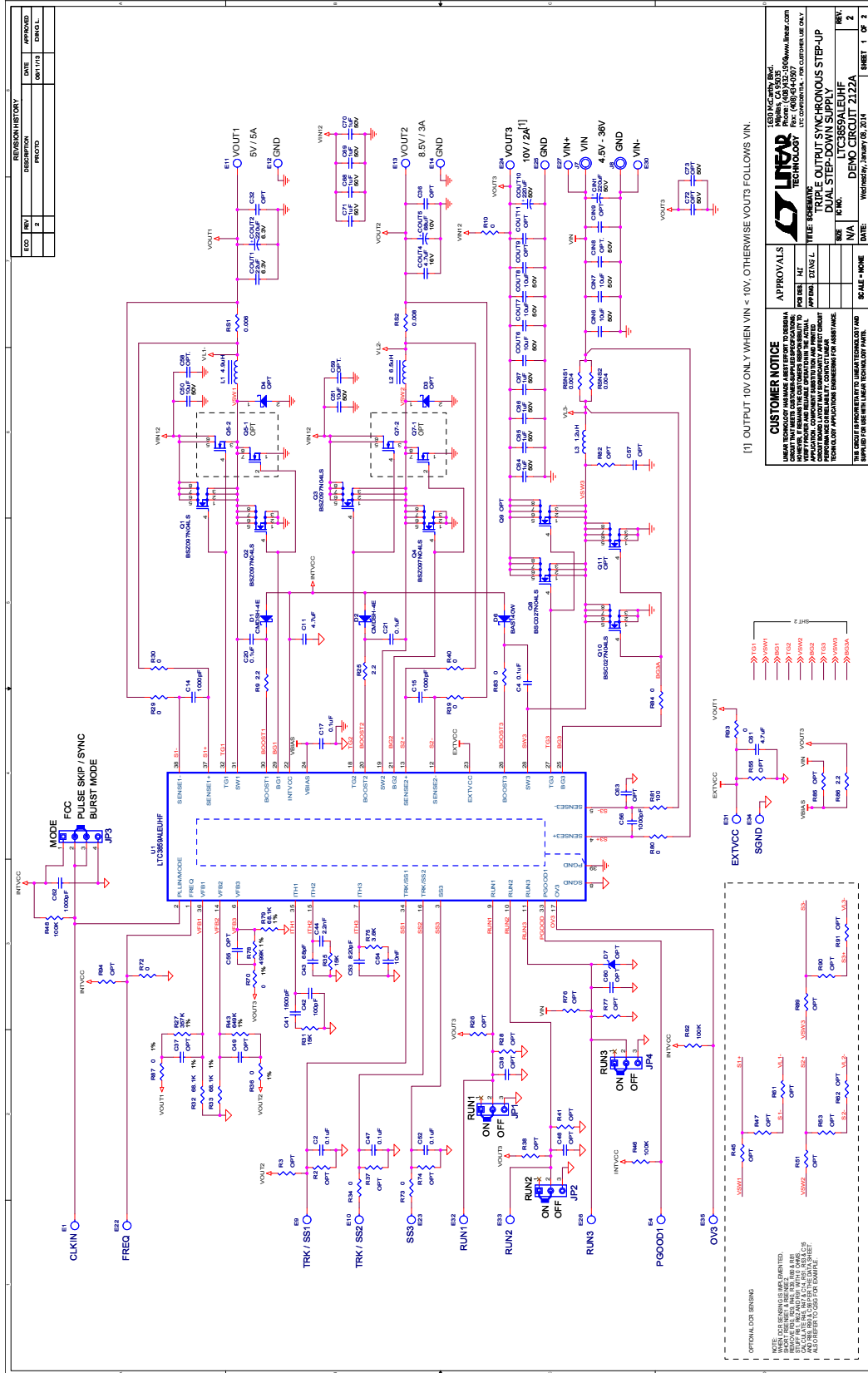
### Additional Demo Board Circuit Components

1	0	CIN8, C58, C59	CAP, 1210 OPTION	OPTION
2	0	COUT9, CIN9, COUT11	CAP, 1210 10 $\mu$ F 10% 50V X7R OPTION	TAIYO YUDEN GMK316BJ106ML-T OPTION
3	0	C32, C36	CAP, 1206 OPTION	OPTION
4	0	C37, C38, C48, C49, C55, C57, C60, C63	CAP, 0603 OPTION	OPTION
5	0	C72, C73	CAP, 0805 OPTION	OPTION
6	0	D7	DIODE, ZENER OPTION	OPTION
7	0	D3, D4	DIODE, SCHOTTKY 40V 3A OPTION	DIODES INC. B340B-13-F OPTION
8	0	Q5	XSTR, N-CHANNEL MOSFET OPTION	VISHAY Si4910DY OPTION
9	0	Q7, Q9, Q11	XSTR, N-CHANNEL MOSFET OPTION	OPTION
10	0	Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q19	XSTR, OPTION	OPTION
11	0	R2, R3, R26, R28, R37, R38, R41, R45, R47, R51, R53, R55, R61, R62, R74, R76, R77, R85, R89, R90, R91, R94	RES, 0603 OPTION	OPTION
12	0	R82	RES, 1206 OPTION	OPTION

### Hardware: For Demo Board Only

1	20	E1, E4, E9, E10, E11, E12, E13, E14, E22, E23, E24, E25, E26, E27, E30, E31, E32, E33, E34, E35	TURRET	MILL-MAX 2501-2-00-80-00-00-07-0
2	3	JP1, JP2, JP4	HEADER, 3PIN, 2mm	WURTH 620 003 111 21
3	1	JP3	HEADER, 4PIN	WURTH 620 004 111 21
4	2	J7, J8	JACK, BANANA	KEYSTONE 575-4
5	4	JP1, JP2, JP3, JP4	SHUNT, 2mm	WURTH 608 002 134 21
6	4		STANDOFF, SNAP ON	WURTH 702 935 000

**SCHEMATIC DIAGRAM**



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# DEMO MANUAL DC2122A

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