ANALOG DEVICES

LT8686S

42V Quad, Gangable, Synchronous, Monolithic Step-Down Regulator

DESCRIPTION

Demonstration circuit 3126A is a quad power supply featuring the LT®8686S. LT8686S is a 42V quad channel current mode monolithic synchronous step-down regulator. LT8686S combines two 42V capable 2A buck regulators with two 8V capable 2A buck regulators. The demo board is designed for 5V, 3.3V, 1.8V, and 1.2V outputs from a nominal 12V input, with switching frequency set at 2MHz. The 5V and 3.3V converters are powered from a wide range of 6V to 42V. The 1.8V and 1.2V converters are powered from the 5V output by default or from 3V to 8V supply alternatively. The current capability is 2A for all 4 outputs when running individually.

DC3126A provides two 42V regulators that can be combined to deliver up to 4A of output current using a singular inductor. Similarly, the two 8V regulators can be combined to deliver up to 4A of output current using a singular inductor. The allowed channel combinations are given in the data sheet.

The independent track/soft-start and power good for each output simplify the complex design of quad-output power converters. Each output can be independently disabled into low quiescent current shutdown mode with its own TRK/SS pin.

A user-selectable SYNC/MODE pin on the demo board provides two primary modes to operate the part: pulse-skipping mode and low ripple Burst Mode® operation, plus the option of selecting frequency spread-spectrum for each to improve the EMI/EMC performance. Burst Mode delivers higher efficiency at light load than pulse-skipping mode. In pulse-skipping mode, full switching frequency is maintained to lower load currents than Burst Mode. The SYNC/MODE pin can also be used to synchronize the switching frequency to an external clock. The switching frequency for all regulators can be programmed either via oscillator resistor or external clock over a 350kHz to 3MHz range. At all frequencies, a 180° phase shift is maintained between channel 1 and channel 2, channel 3 and channel 4, reducing the input peak current and voltage ripple.

The demo board has an EMI filter installed on the bottom layer. The conducted and radiated EMI performance of the board is shown on Figure 4. The red line in Figure 4 is CISPR25 Class 5 peak limit. The figure shows that the circuit passes the test with a wide margin. To achieve EMI/EMC performance as shown in Figure 4, the input EMI filter is required, and the input voltage should be applied at VEMI turret.

The LT8686S data sheet gives a complete description of the part operation and application information. The data sheet must be read in conjunction with this quick start guide for DC3126A. The LT8686S is assembled in a 5mm × 5mm LQFN package with exposed pads for low thermal resistance. Proper board layout is essential for both low EMI operation and best thermal performance.

Design files for this circuit board are available.

PERFORMANCE SUMMARY Specifications are at T_A = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN_HV}	HV Regulators Input Voltage (V_{IN1}/V_{IN2}) Range		6*	12	42	V
V_{IN_LV}	LV Regulators Input Voltage (V_{IN3}/V_{IN4}) Range		3		8**	V
V_{OUT1}	Output1 Voltage	V_{IN_HV} = 12V	4.8	5	5.2	V
V_{OUT2}	Output2 Voltage	V_{IN_HV} = 12V	3.17	3.3	3.43	V
V_{OUT3}	Output3 Voltage	V_{IN_LV} = 5V	1.73	1.8	1.87	V
V_{OUT4}	Output4 Voltage	V_{IN_LV} = 5V	1.15	1.2	1.25	V
I_{OUT1}	Maximum Output1 Current	No Load on Downstream Channel	2			A
I_{OUT2}	Maximum Output2 Current		2			A
I_{OUT3}	Maximum Output3 Current		2			A
I_{OUT4}	Maximum Output4 Current		2			A
f_{SW}	Switching Frequency		1.8	2	2.25	MHz
EFF	Efficiency	V_{IN_HV} = 12V, f_{SW} = 2MHz, V_{OUT1} = 5V, I_{OUT1} = 1A		93.3		%
		V_{IN_HV} = 12V, f_{SW} = 2MHz, V_{OUT2} = 3.3V, I_{OUT2} = 1A		90.8		%
		V_{IN_LV} = 5V, f_{SW} = 2MHz, V_{OUT3} = 1.8V, I_{OUT3} = 1A		92.1		%
		V_{IN_LV} = 5V, f_{SW} = 2MHz, V_{OUT4} = 1.2V, I_{OUT4} = 1A		88.6		%

*The operating input voltage range for V_{IN1} and V_{IN2} is 3V to 42V. The 6V minimum input voltage spec is limited by the 5V output voltage.

**The operating input voltage range for V_{IN3} and V_{IN4} is 3V to 8V. The absolute maximum input voltage for V_{IN3} and V_{IN4} is 10V.

QUICK START PROCEDURE

Demonstration circuit 3126A is easy to set up to evaluate the performance of the LT8686S. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

1. With power off, place the jumpers in the following positions:

JP1	JP2	JP3	JP4	JP5	JP6
EN/UVLO	EN2	EN3	EN4	BIAS	SYNC/MODE
ON	ON	ON	ON	VOUT1	BURST

2. With power off, connect the input power supply to VEMI+ and VEMI–.
3. With power off, connect the loads from VOUT1, VOUT2, VOUT3 and VOUT4 to GND.
4. Voltmeters can be placed across the output terminals to get accurate output voltage measurements.
5. Turn on the power at the input.

   NOTE: Make sure that the input voltage does not exceed 42V.
6. Check for proper output voltages. The output should be regulated at 5V (±4%), 3.3V (±4%), 1.8V (±4%), 1.2V (±4%).

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

QUICK START PROCEDURE

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

   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 output voltage ripple by touching the probe tip directly across the output capacitor. See Figure 2 for the proper scope technique.

8. An external clock can be added to the SYNC terminal when SYNC function is used (JP6 on the SYNC position). Please make sure that R25 resistor should be chosen to set the LT8686S switching frequency close to the synchronization frequency.

9. (Option) Operation with Different Input Voltages

   The low voltage channels, channel 3 and channel 4, can operate with different input voltages instead of 5V VOUT1. DC3126A provides onboard 0Ω jumper (R29) connecting VIN_LV to VOUT1 by default. The 0Ω jumper can be removed to disconnect VIN_LV from VOUT1. Different input voltages for channel 3 and channel 4 should be applied between VIN_LV and GND.

   NOTE: Make sure that the VIN_LV input voltage does not exceed 8V.

10. (Option) Combining Channels (CH1 + CH2, CH3 + CH4) Configuration

    DC3126A can combine two regulators to create channels with higher current ratings using a single inductor. Channel 1 and channel 2 can be combined to deliver up to 4A of output current. Similarly, Channel 3 and channel 4 can be combined to deliver up to 4A of output current. Channel 1 and channel 3 are main channels, channel 2 and channel 4 are subordinates.

The following simple modification is required:

1. Tie SW1 and SW2 pins together with a low impedance connection. Tie SW3 and SW4 together with a low impedance connection. Since SW1 and SW2, SW3 and SW4 are connected, there is only one inductor needed for each output rail. Calculate and insert the inductors needed for L1 and L3, remove L2 and L4.
2. Tie BST1 and BST2 pins together with 0Ω resistors (R9, R12). Tie BST3 and BST4 pins together with 0Ω resistors (R15, R18).
3. Tie FB2 and FB4 pins to INTVCC with 0Ω resistors (R31, R32). Keep the resistor divider networks on main channels and remove the resistor divider networks on subordinate channels.
4. Float (do not use) PG2 and PG4. Only PG1 and PG3 are active.
5. Float (do not use) TRK/SS2 and TRK/SS4. Only TRK/SS1 and TRK/SS3 are active.
6. Tie EN/UVLO and EN2 together with 0Ω resistor (R27), EN3 and EN4 together with 0Ω resistor (R30).

QUICK START PROCEDURE

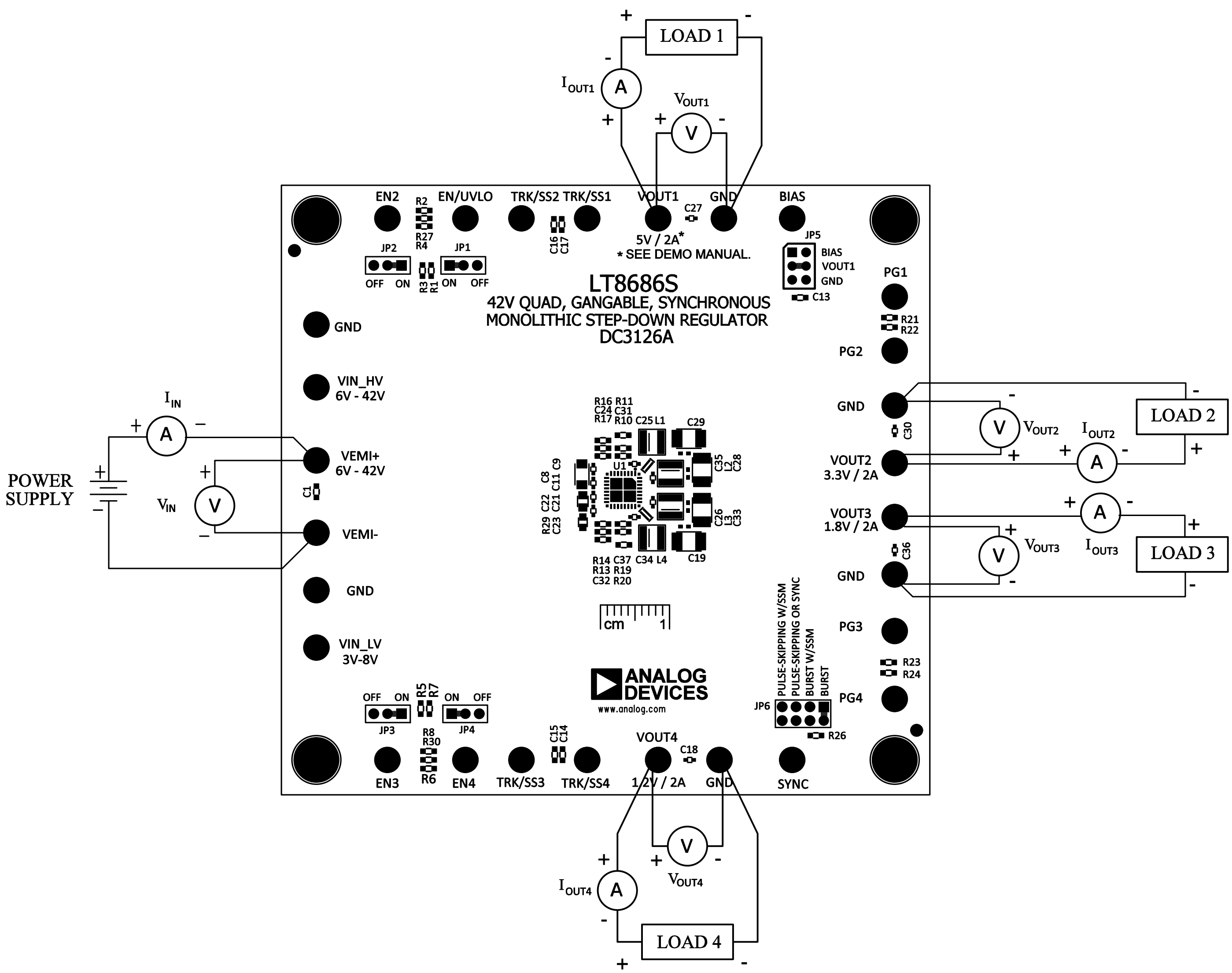

Figure 1. Proper Measurement Equipment Setup

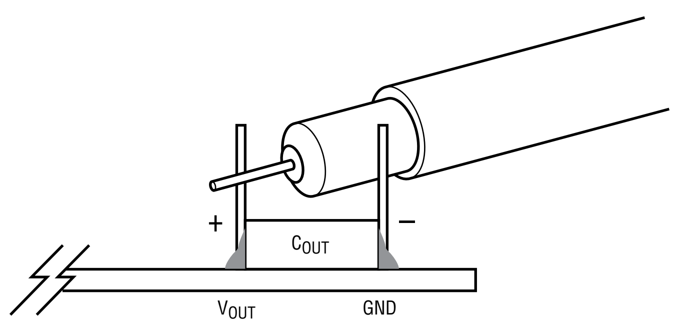

Figure 2. Scope Probe Placement for Measuring Input or Output Voltage Ripple

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TYPICAL PERFORMANCE CHARACTERISTICS

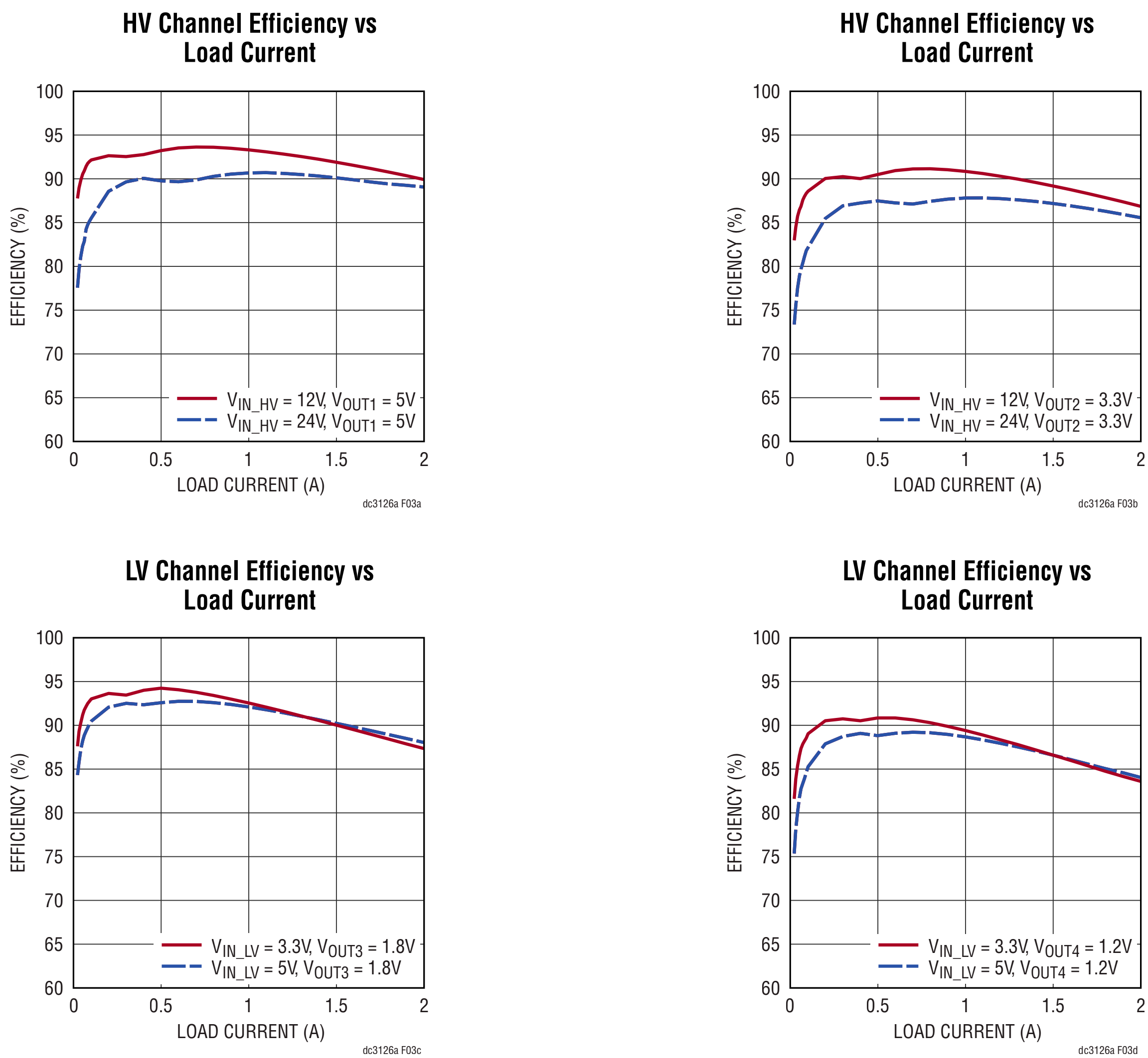
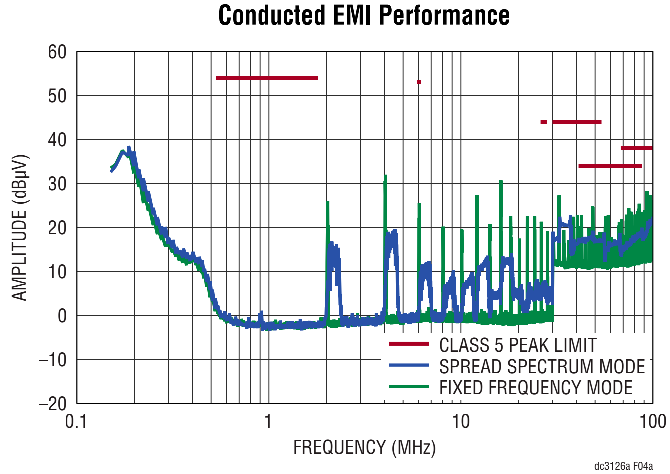
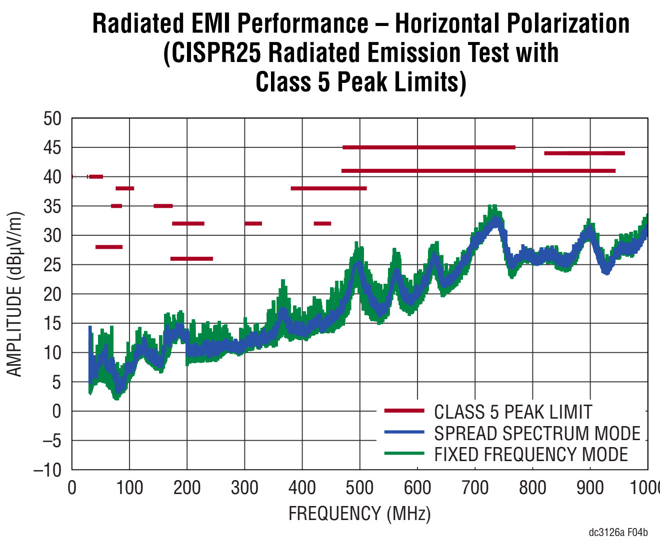


Figure 3. HV and LV Channel Efficiency vs Load Current at V_{IN_HV} = 12V at 24V, V_{IN_LV} = 3.3V at 5V, Burst Mode, and 2MHz Switching Frequency

TYPICAL PERFORMANCE CHARACTERISTICS





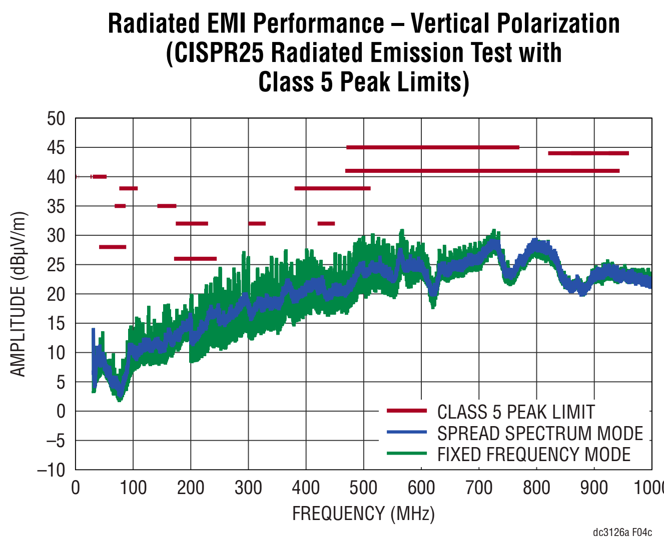


Figure 4. LT8686S Demo Circuit EMI Performance in CISPR25 Conducted and Radiated Emission Test (VEMI = 14V, V_{OUT1} = 5V, V_{OUT2} = 3.3V, V_{OUT3} = 1.8V, V_{OUT4} = 1.2V, I_{OUT1} = 2A (Includes Current Supplying V_{IN3} and V_{IN4}), I_{OUT2} = I_{OUT3} = I_{OUT4} = 2A, 2MHz Switching Frequency)

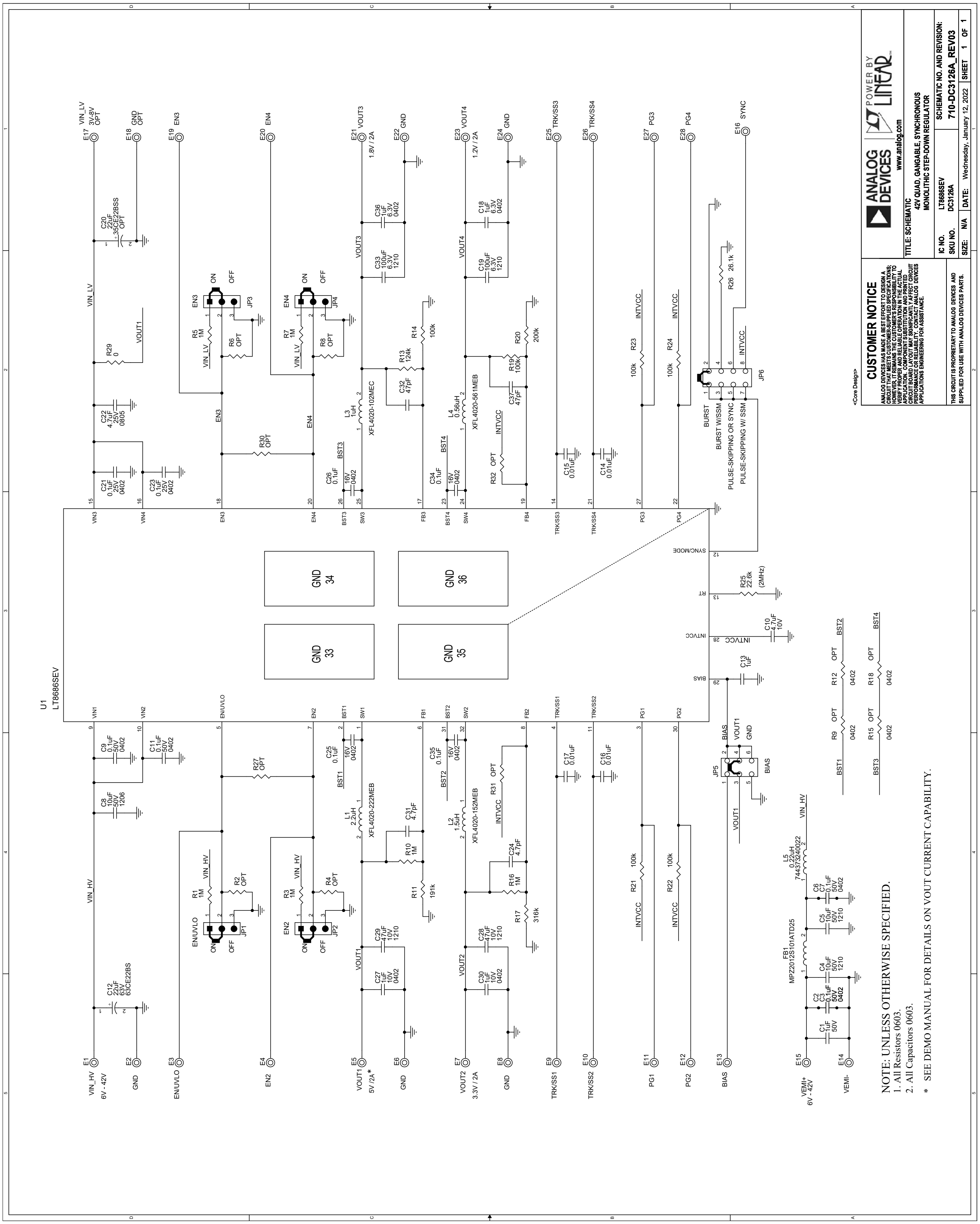
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	C1, C13	CAP., 1μF, X5R, 50V, 10%, 0603	MURATA, GRT188R61H105KE13D
2	6	C2, C3, C6, C7, C9, C11	CAP., 0.1μF, X7R, 50V, 10%, 0402	MURATA, GCM155R71H104KE02D
3	2	C4, C5	CAP., 10μF, X7R, 50V, 10%, 1210	MURATA, GRM32ER71H106KA12L
4	1	C8	CAP., 10μF, X7R, 50V, 10%, 1206	SAMSUNG, CL31B106KBHNNNE
5	1	C10	CAP., 4.7μF, X5R, 10V, 10%, 0603	AVX, 0603ZD475KAT2A
6	1	C12	CAP., 22μF, ALUM ELECT, 63V, 20%, SMD, RADIAL, CE-BS SERIES	SUN ELECTRONIC INDUSTRIES CORP, 63CE22BS
7	4	C14, C15, C16, C17	CAP., 0.01μF, X7R, 25V, 10%, 0603	MURATA, GRM188R71E103KA01D
8	2	C18, C36	CAP., 1μF, X7R, 6.3V, 10%, 0402	MURATA, GRM155R70J105KA12D
9	2	C19, C33	CAP., 100μF, X7S, 6.3V, 20%, 1210	MURATA, GRM32EC70J107ME15L
10	2	C21, C23	CAP., 0.1μF, X7R, 25V, 10%, 0402	MURATA, GCM155R71E104KE02D
11	1	C22	CAP., 4.7μF, X7R, 16V, 20%, 0805	TAIYO YUDEN, MCASE21GAB7475MTNA01
12	2	C24, C31	CAP., 4.7pF, X7R, 10V, 10%, 0603	AVX, 06033A4R7KAT2A
13	4	C25, C26, C34, C35	CAP., 0.1μF, X7R, 16V, 10%, 0402	MURATA, GCM155R71C104KA55D
14	2	C27, C30	CAP., 1μF, X5R, 10V, 10%, 0402	MURATA, GRM155R61A105KE15D
15	2	C28, C29	CAP., 47μF, X7R, 10V, 10%, 1210	MURATA, GRM32ER71A476KE15L
16	2	C32, C37	CAP., 47pF, C0G, 25V, 10%, 0603	AVX, 06035A4R7BAT2A
17	1	FB1	IND., 100Ω AT 100MHz, FERRITE BEAD, 25%, 4A, 20mΩ, 0805	TDK, MPZ2012S101ATD25
18	1	L1	IND., 2.2μH, PWR, SHIELDED, 20%, 8A, 23.5mΩ	COILCRAFT, XFL4020-222MEB
19	1	L2	IND., 1.5μH, PWR, 20%, 9.1A, 15.8mΩ, SMD, SHIELDED	COILCRAFT, XFL4020-152MEB
20	1	L3	IND., 1μH, PWR, SHIELDED, 20%, 11A, 11.9mΩ, SMD	COILCRAFT, XFL4020-102MEB
21	1	L4	IND., 0.56μH, PWR, 20%, 6A, 5.53mΩ, SMD	XFL4020-561MEB
22	1	L5	IND., 0.22μH, PWR, SHIELDED, 30%, 9.5A, 7.3mΩ, 4020	WURTH ELEKTRONIK, 744373240022
23	6	R1, R3, R5, R7, R10, R16	RES., 1M, 1%, 1/10W, 0603	VISHAY, CRCW06031M00FKEA
24	1	R11	RES., 191k, 1%, 1/10W, 0603	PANASONIC, RK73H1JTTD1913F
25	1	R13	RES., 124k, 1%, 1/10W, 0603	PANASONIC, ERJ3EKF1243V
26	6	R14, R19, R21, R22, R23, R24	RES., 100k, 1%, 1/10W, 0603	PANASONIC, ERJ3EKF1003V
27	1	R17	RES., 316k, 1%, 1/10W, 0603	VISHAY, CRCW0603316KFKEA
28	1	R20	RES., 200k, 1%, 1/10W, 0603	VISHAY, CRCW0603200KFKEA
29	1	R25	RES., 22.6k, 1%, 1/10W, 0603	NIC, NRC06F2262TRF
30	1	R26	RES., 26.1k, 1%, 1/10W, 0603	PANASONIC, ERJ3EKF2612V
31	1	R29	RES., 0Ω, JUMPER, 45A, 0603, COPPER, SENSE	VISHAY, WSL060300000ZEA9
32	1	U1	IC, 42V QUAD SYNC. MONOLITHIC STEP-DOWN REGULATOR, LQFN-32	ANALOG DEVICES, LT8686SJV#PBF

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Circuit Components				
1	0	C20	CAP., 22µF, 35V, 20%, SMD, RADIAL, CE-BSS SERIES	SUN ELECTRONIC INDUSTRIES CORP, 35CE22BSS
2	0	R9, R12, R15, R18	RES., OPTION, 0402	
3	0	R2, R4, R6, R8, R27, R30, R31, R32	RES., OPTION, 0603	
4	0	E17, E18	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
Hardware: For Demo Board Only				
1	26	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E19, E20, E21, E22, E23, E24, E25, E26, E27, E28	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	4	JP1, JP2, JP3, JP4	CONN., HDR, MALE, 1×3, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000311121
3	1	JP5	CONN., HDR, MALE, 2×3, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000621121
4	1	JP6	CONN., HDR, MALE, 2×4, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000821121
5	4	MP1, MP2, MP3, MP4	STANDOFF, NYLON, SNAP-ON, 0.50"	KEYSTONE, 8833
6	6	XJP1, XJP2, XJP3, XJP4, XJP5, XJP6	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



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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.

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