LTC7825
High Efficiency 2:1 Monolithic Switched Capacitor Divider

DESCRIPTION

Demonstration circuit DC2993A-B is a dual-phase, high efficiency, high density, open loop charge pump (inductorless) DC/DC converter. This demo board is a voltage divider whose input voltage range is 4.5V to 24V. The output voltage is a fixed ratio of half the input voltage (V_{IN}/2) and can supply 24A of load current. The DC2993A-B provides a highly efficient solution of 96.5% at full load, running at 380kHz.

This demo board features two LTC®7825, a fully integrated 24V/12A switched capacitor DC/DC converter with overvoltage and overcurrent protections in a 4mm × 5mm QFN package. Refer to the LTC7825 data sheet for more detailed information.

The DC2993A-B requires no load current start-up. Load current can be applied after V_{OUT} is established. Refer to the "Voltage Divider Pre-Balance Before Switching" section in the LTC7825 data sheet for more details regarding the start-up of the voltage divider. This board offers an input disconnect MOSFET controlled by LTC7825 OVG pin to provide overvoltage protection to the power stage when V_{IN} is higher than 24V. The board also features some protection functions, such as overcurrent and thermal shutdown, making it a reliable solution.

NOTE: For the single-phase operation feature, refer to the DC2993A-A demo manual.

Design files for this circuit board are available.

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		4.5		24	V
Output Voltage, V_{OUT}	V_{IN} = 4.5V to 24V, I_{OUT} = 0A to 24A		V_{IN}/2		V
Maximum Output Current, I_{OUT}	V_{IN} = 4.5V to 24V, V_{OUT} = V_{IN}/2		24		A
Typical Efficiency	V_{IN} = 20V, V_{OUT} = 10V, I_{OUT} = 24A, $EXTV_{CC}$ = V_{OUT}		96.5		%
Peak Efficiency	V_{IN} = 20V, V_{OUT} = 10V, $EXTV_{CC}$ = V_{OUT}		98.3		%
Switching Frequency			380		kHz

QUICK START PROCEDURE

Demonstration circuit DC2993A-B is easy to setup for evaluating the LTC7825. See Figure 1 for the proper measurement equipment setup and follow the procedure below.

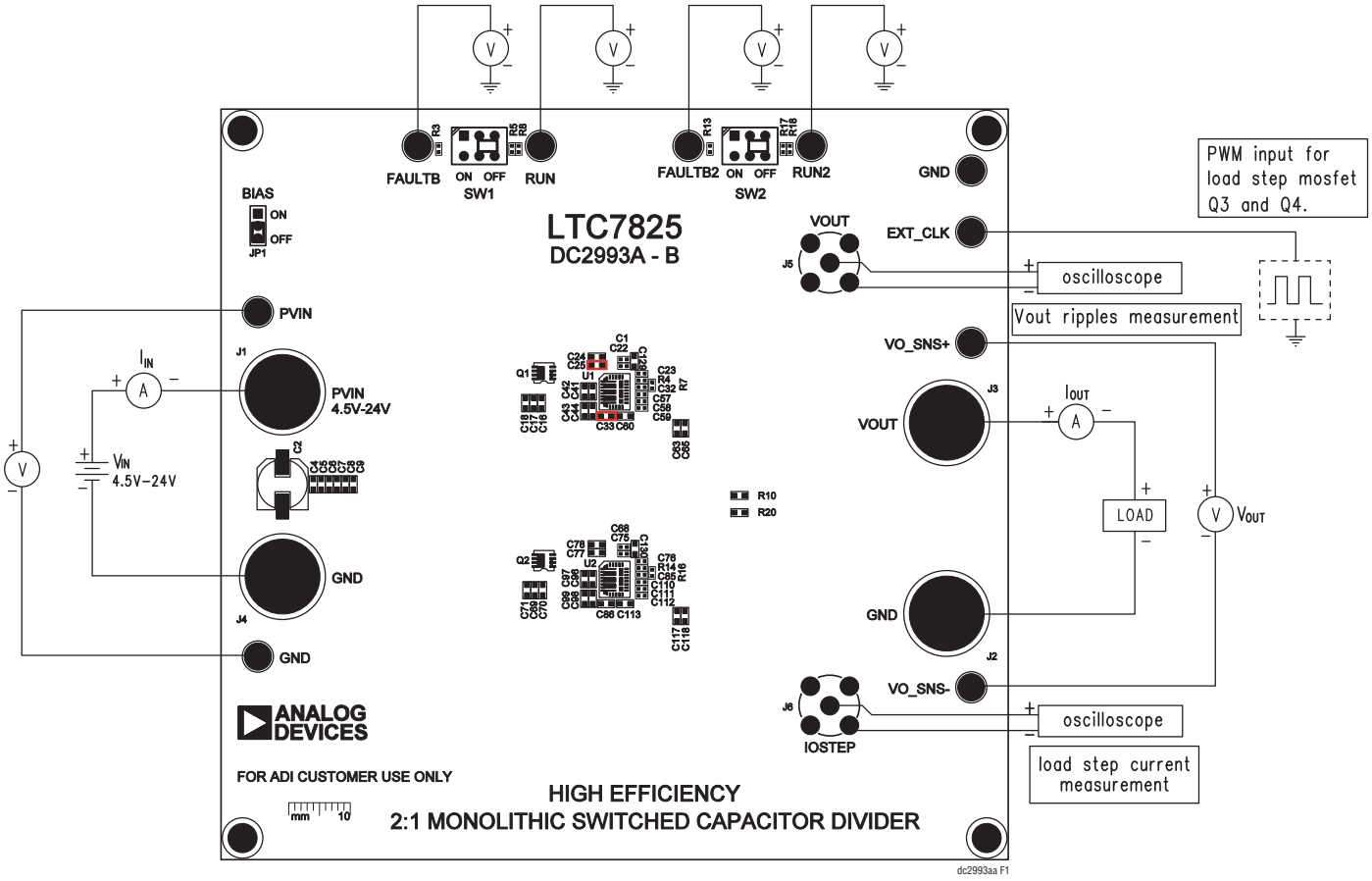
1. With power off, connect the input power supply to VIN (4.5V to 24V) and GND (input return).
2. Connect the output loads between VOUT and GND (initial load: no load). See Figure 1.
3. Connect the DVMs to the input and output.
4. Check the default jumper/switch position: SW1 (RUN): OFF; SW2 (RUN): OFF; JP1 (BIAS): OFF.
5. Turn on the input power supply and adjust the voltage to 20V.

   NOTE: Make sure the input voltage does not exceed 24V.
6. Turn on the switches: JP1, SW1 and SW2: ON.
7. Check the proper output voltages from VO_SNS+ to VO_SNS–.
8. Once the proper output voltage is established, adjust the loads within the operating range and measure the efficiency, output voltage ripple and other parameters.
9. After completing all tests, adjust the load to 0A, turn off the switch: SW1 and SW2 and JP1, power off the input power supply.

Notes

1. When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 2 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (–) terminals of an output capacitor. The probe tip needs to touch the (+) lead.
2. When doing the load step test with the onboard dynamic load circuit, please make sure the load step-up pulse duty cycle does not exceed 2%, and the pulse duration is less than 500µs so that the temperature of the MOSFETs Q3 and Q4 in the dynamic load circuit stay in the safe region. Instead of using the onboard dynamic load circuit, an electronic load can also be used for the load step test, which does not have the 2% maximum duty cycle limit for the load step.
3. It is recommended to set the electronic load in CR (constant resistance) mode for evaluation of the DC2993A-B board. Some electronic loads draw negative current in CC (constant current) mode when evaluating the output overcurrent protection feature of DC2993A-B, which can violate the absolute maximum voltage rating –0.3V for V_{OUT} and V_{LOW} pin.

QUICK START PROCEDURE



NOTES:
*FOR ACCURATE EFFICIENCY MEASUREMENTS: MEASURE VIN ON C25 AND VOUT ON C33.
**IT IS RECOMMENDED TO SET THE ELECTRONIC LOAD IN CR (CONSTANT RESISTANCE) MODE FOR EVALUATION RATHER THAN CC MODE.

Figure 1. Proper Measurement Equipment Setup

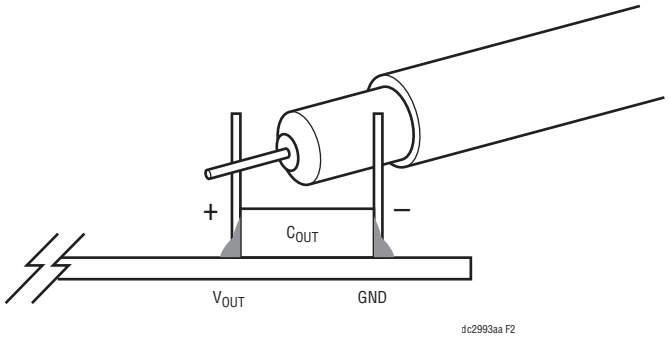


Figure 2. Measuring Output Voltage Ripple

TEST RESULTS

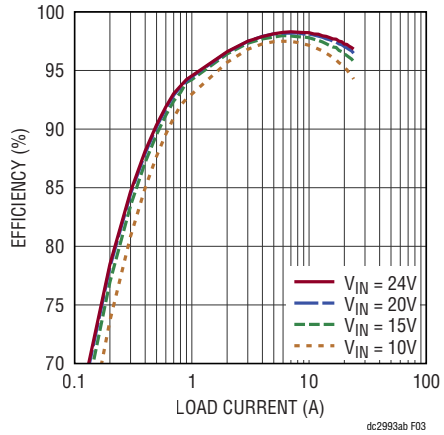


Figure 3. Efficiency vs Load Current at Various V_{IN}, $V_{OUT} = V_{IN}/2$, f_{SW} = 380kHz

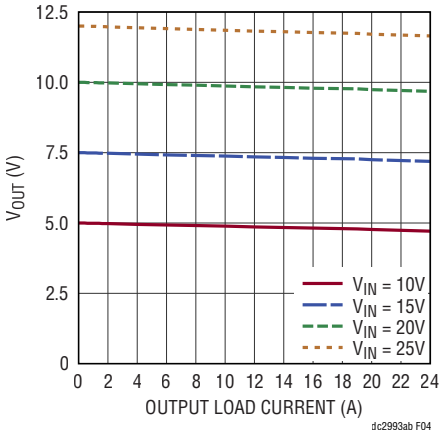


Figure 4. Load Regulation for 24A Design at Various V_{IN}, $V_{OUT} = V_{IN}/2$, f_{SW} = 380kHz

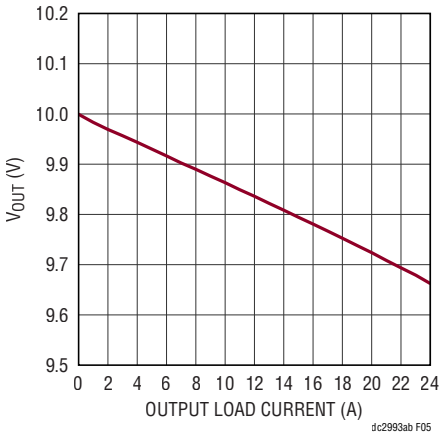


Figure 5. Load Regulation for 24A Design at V_{IN} = 20V, V_{OUT} = 10V, f_{SW} = 380kHz

TEST RESULTS

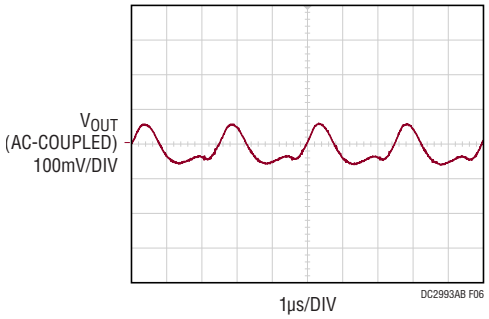


Figure 6. Output Voltage Ripple V_{IN} = 20V, V_{OUT} = 10V, I_{OUT} = 24A, f_{SW} = 380kHz

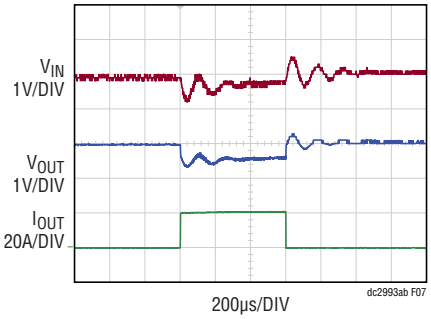


Figure 7. 0A to 20A Load Step at V_{IN} = 20V, V_{OUT} = 10V, f_{SW} = 380kHz

TEST RESULTS

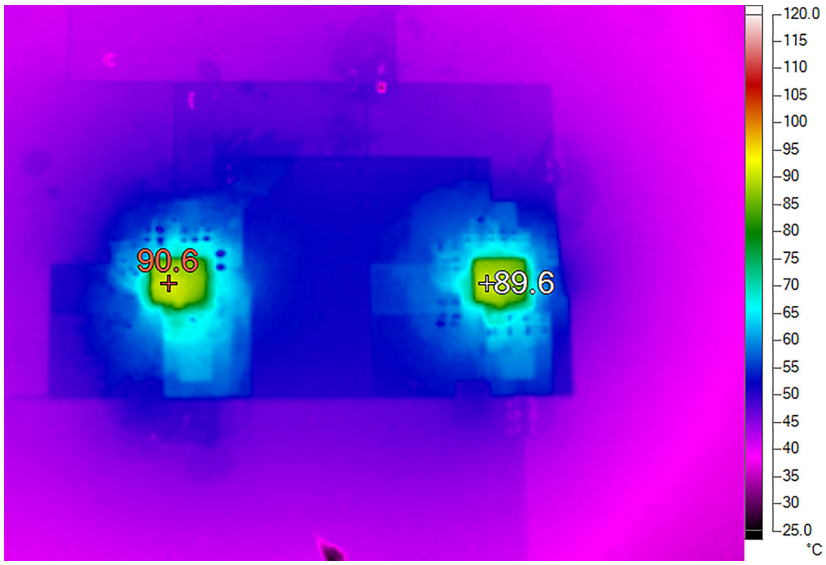


Figure 8. Thermal Performance V_{IN} = 20V, V_{OUT} = 10V, f_{SW} = 380kHz, I_{OUT} = 24A, T_A = 23°C, 200FPM Airflow

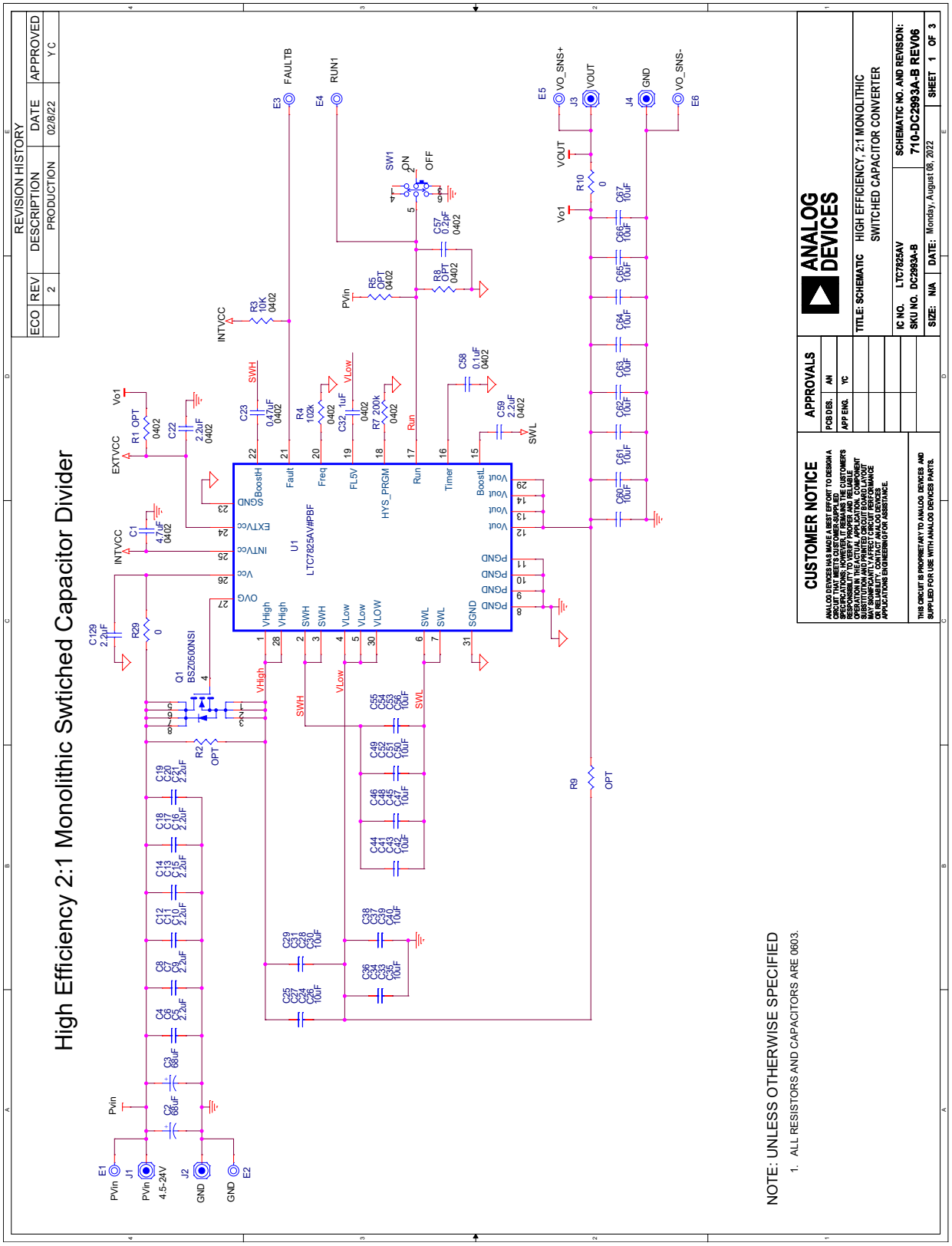
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	C1, C68	CAP., 4.7µF, X5R, 10V, 10%, 0402, NO SUBS. ALLOWED	TDK, C1005X5R1A475K050BC
2	2	C2, C3	CAP., 68µF, ALUM POLY, 50V, 20%, SMD, 8.3mm × 8.3mm	NICHICON, GYA1H680MCQ1GS
3	26	C4-C21, C69-C74, C129, C130	CAP., 2.2µF, X5R, 50V, 10%, 0603	TAIYO YUDEN, UMK107BBJ225KA-T MURATA, GRM188R61H225KE11D
4	4	C22, C59, C75, C112	CAP., 2.2µF, X5R, 25V, 10%, 0402	MURATA, GRM155R61E225KE11D TDK, C1005X5R1E225K050BC
5	2	C23, C76	CAP., 0.47µF, X5R, 50V, 10%, 0402	MURATA, GRM155R61H474KE11D TAIYO YUDEN, UMK105ABJ474KV-F
6	80	C24-C31, C33-C56, C60-C67, C77- C84, C86-C109, C113-C120	CAP., 10µF, X5R, 25V, 20%, 0603, NO SUBS. ALLOWED	MURATA, GRM188R61E106MA73D
7	2	C32, C85	CAP., 1µF, X5R, 25 V,10%, 0402	MURATA, GRM155R61E105KA12D; GRM155R61E105KE11D SAMSUNG, CL05A105KA5NQNC
8	2	C57, C110	CAP., 0.2pF, C0G, 50V, ±0.1pF, 0402	MURATA, GJM1555C1HR20BB01D
9	2	C58, C111	CAP., 0.1µF, X7R, 25V, 10%, 0402, NO SUBS ALLOWED	MURATA, GRM155R71E104KE14
10	2	C121, C122	CAP., 2.2µF, X7R, 100V, 10%, 1210	TDK, C3225X7R2A225K230AB
11	0	C123	CAP., OPTION, 0603	
12	2	C124, C125	CAP., 22µF, X5R, 25V, 10%, 1210	KEMET, C1210C226K3PACTU MURATA, GRM32ER61E226KE15K; GRM32ER61E226KE15L SAMSUNG, CL32A226KAJNNNE TAIYO YUDEN, TMK325BJ226KM-P; TMK325BJ226KM-T AVX, 12103D226KAT2A
13	1	C126	CAP., 0.047µF, X7R, 50V, 10%, 0603	AVX, 06035C473KAT2A KEMET, C0603C473K5RACTU MURATA, GRM188R71H473KA61D NIC, NMC0603X7R473K50TRPF TDK, C1608X7R1H473K080A
14	1	C127	CAP., 220pF, X7R, 50V, 10%, 0603	AVX, 06035C221KAT2A KEMET, C0603C221K5RACTU NIC, NMC0603X7R221K50TRPF
15	1	C128	CAP., 1µF, X7R, 25V, 10%, 0603	MURATA, GRM188R71E105KA12D TAIYO YUDEN, TMK107B7105KA-T KEMET, C0603C105K3RACTU TDK, C1608X7R1E105K080AB
16	2	U1, U2	IC, HIGH EFFICIENCY, 2:1 STEP-DOWN RATIO, SWITCHED CAPACITOR CONVERTER	ANALOG DEVICES, LTC7825AV#PBF
17	1	U3	IC, SYNCHR. STEP-DOWN CONVERTER, MSOP-16 (MSE), 76V, 500mA	ANALOG DEVICES, LTC3630AEMSE#PBF; LTC3630AEMSE#TRPBF

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Circuit Components				
1	0	R1, R5, R8, R11, R17, R18	RES., OPTION, 0402	
2	0	R2, R9, R12, R19	RES., OPTION, 0603	
3	2	R3, R13	RES., 10k, 0.1%, 1/16W, 0402	YAGEO, RT0402BRD0710KL
4	2	R4, R14	RES., 102k, 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCF0402FT102K VISHAY, CRCW0402102KFKED
5	2	R7, R16	RES., 200k, 1%, 1/16W, 0402	NIC, NRC04F2003TRF PANASONIC, ERJ2RKF2003X VISHAY, CRCW0402200KFKED YAGEO, RC0402FR-07200KL
6	4	R10, R20, R29, R30	RES., 0Ω, 1/10W, 0603, METAL STRIP AEC-Q200	VISHAY, WSL060300000ZEA9
7	2	R21, R23	RES., 0Ω, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EA; CRCW06030000Z0EB; CRCW06030000Z0EC NIC, NRC06Z0TRF
8	1	R22	RES., 90.9k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EC, CRCW060390K9FKEA PANASONIC, ERJ3EKF9092V KOA SPEER, RK73H1JTTD9092F NIC, NRC06F9092TRF
9	1	R24	RES., 10k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1002V VISHAY, CRCW060310K0FKEA; CRCW060310K0FKEB KOA SPEER, RK73H1JTTD1002F
10	1	R25	RES., 80.6k, 1%, 1/10W, 0603	VISHAY, CRCW060380K6FKEA NIC, NRC06F8062TRF YAGEO, RC0603FR-0780K6L
11	1	R26	RES., 10k, 1%, 1/10W, 0603	VISHAY, CRCW060310K0FKEC NIC, NRC06F1002TRF YAGEO, RC0603FR-0710KL
12	2	R27, R28	RES., 0.2Ω, 1%, 1/2W, 2010, SENSE, AEC-Q200	VISHAY, WSL2010R2000FEA
13	1	STNCL1	TOOL, STENCIL, 700-DC2993A	ANALOG DEVICES, 830-DC2993A
14	2	SW1, SW2	SWITCH, SLIDE, DPDT, 0.3A, 6VDC, PTH	C&K, JS202011CQN
15	1	XJP1	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421
Hardware: For Demo Board Only				
1	10	E1-E10	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	4	J1-J4	EVAL BOARD STUD HARDWARE SET, #10-32	ANALOG DEVICES, 720-0010
3	2	J5, J6	CONN., RF, BNC, RCPT JACK, 5-PIN, STR, THT, 50Ω	AMPHENOL RF, 112404
4	1	JP1	CONN., HDR, MALE, 1×3, 2mm, VERT, STR, THT, NO SUBS. ALLOWED	WURTH ELEKTRONIK, 62000311121
5	1	L1	IND., 68µH, PWR, SHIELDED, 20%, 0.74A, 0.42Ω, 2424, LPS6225	COILCRAFT, LPS6225-683MRB; LPS6225-683MRC
6	1	LB1	LABEL SPEC, DEMO BOARD SERIAL NUMBER	BRADY, THT-96-717-10
7	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.625"	KEYSTONE, 8834
8	1	PCB1	PCB, DC2993A	MAO BANG, 600-DC2993A
9	2	Q1, Q2	XSTR., MOSFET, N-CH, 30V, 40A, PG-TSDSON-8 FL	INFINEON, BSZ0500NSI; BSZ0500NSIATMA1
10	2	Q3, Q4	XSTR., MOSFET, N-CH, 40V, 14A, TO-252 (DPAK)	VISHAY, SUD50N04-8M8P-4GE3

SCHEMATIC DIAGRAM



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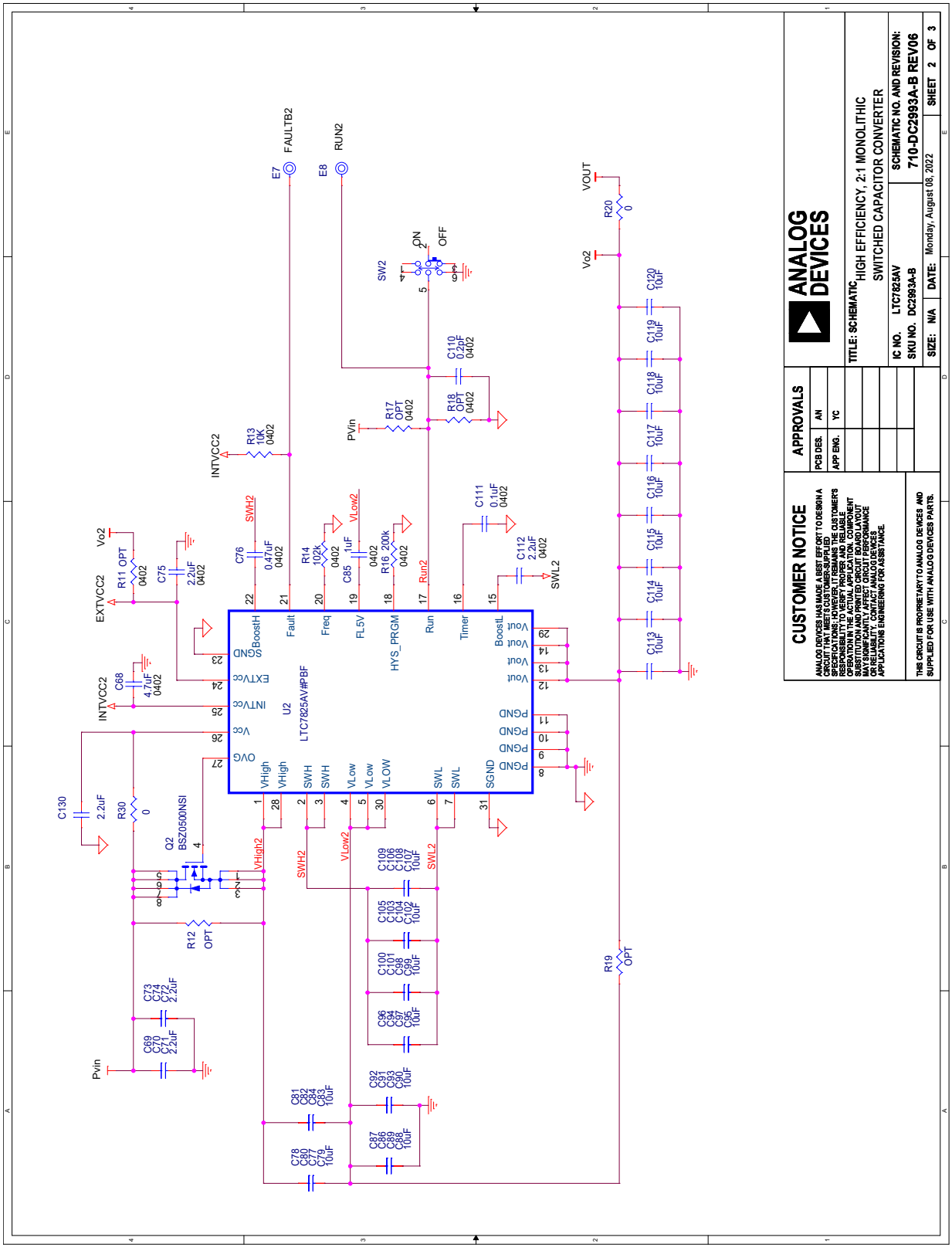
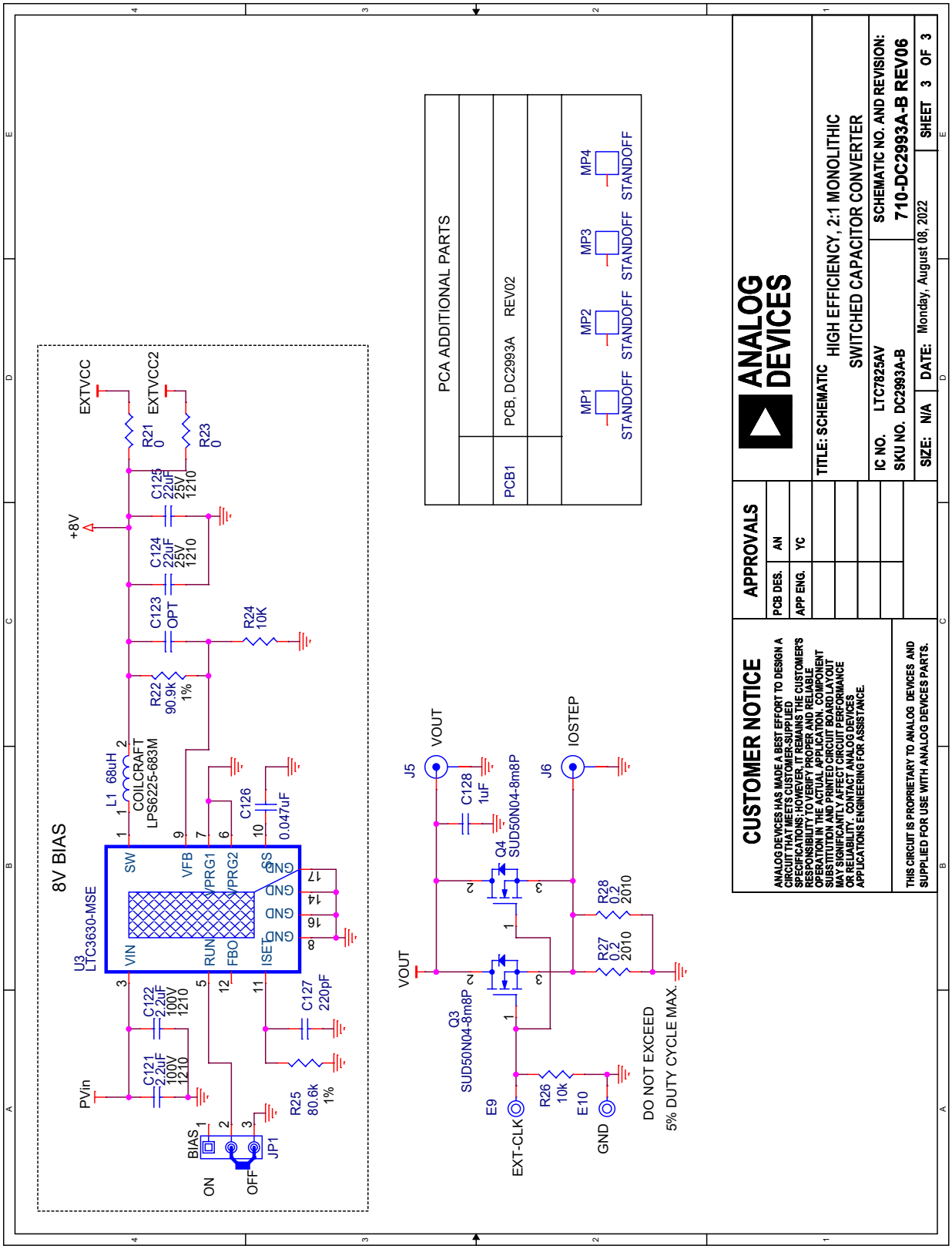


SCHEMATIC DIAGRAM



REVISION HISTORY

REV	DATE	DESCRIPTION	PAGE NUMBER
0	05/23	Initial Release	1–11

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.