LTM4660
High Efficiency, PolyPhase 100A Hybrid Step-Down Power µModule Regulator 4× LTM4660, 100A

DESCRIPTION

Demonstration circuit 2959A-C is a high-efficiency, high-power-density hybrid step-down converter. It can deliver 12V/100A with an input voltage from 36V to 60V (up to 65V during transients). This demo board features PolyPhase® design using the LTM®4660, which uses an architecture that merges soft-switching switched capacitor topology with a traditional step-down converter to provide superior efficiency compared to the traditional switching architectures. It offers a high efficiency/high density and cost-effective solution for nonisolated intermediate bus applications in power distribution, datacom, and telecom.

The LTM4660 on DC2959A-C always operates in continuous conduction mode. The switching frequency can be programmed through a resistor or can be synchronized to an external clock signal. Due to its current mode control architecture, excellent current sharing and low output voltage ripple are achievable in the multiphase configuration.

Other benefits include low Electromagnetic Interference (EMI) emissions due to a soft-switched front end and reduced MOSFET stress.

The LTM4660 monitors system voltage, current, and temperature for faults. It stops switching and pulls the $\overline{\text{FAULT}}$ pin low when a fault condition occurs. An onboard timer can be set for appropriate restart/retry times. Additional features include ±1.5% output voltage accuracy over temperature, a power good output signal, short-circuit protection, monotonic output voltage start-up, optional external reference, undervoltage lockout, and internal charge balance circuitry.

The LTM4660 data sheet must be used in conjunction with this demo board manual.

Design files for this circuit board are available.

BOARD PHOTO

Part marking is either ink mark or laser mark

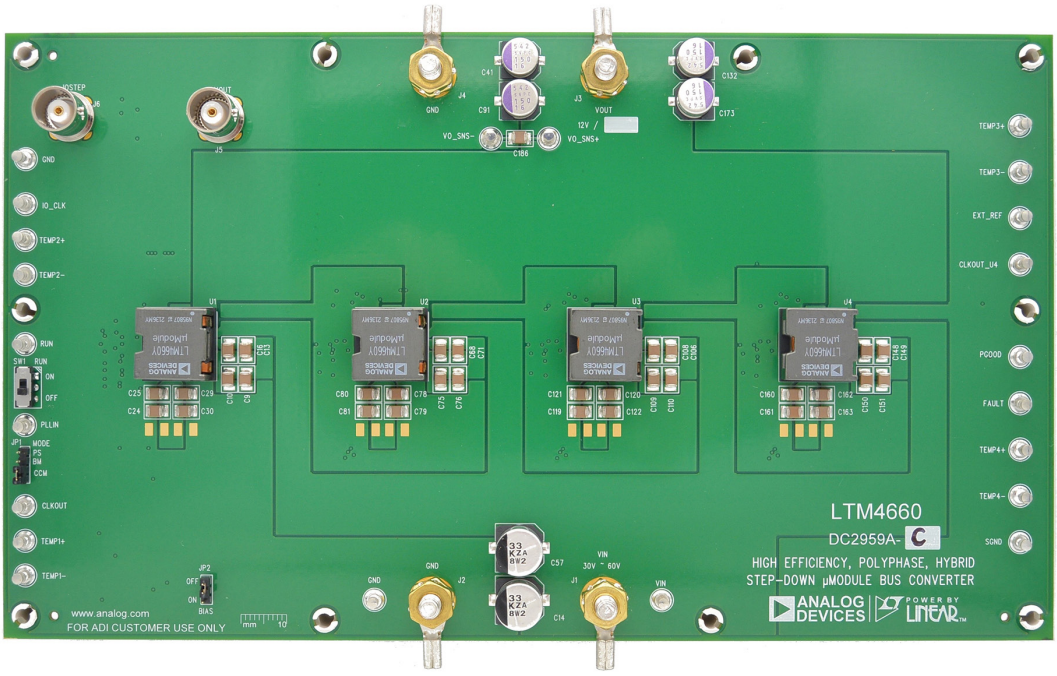


Figure 1. LTM4660/DC2959A-C Demo Circuit

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		36		60	V
Output Voltage, V_{OUT}	V_{IN} = 36V to 60V, I_{OUT} = 0A to 100A			12	V
Maximum Output Current, I_{OUT}	V_{IN} = 36V to 60V, V_{OUT} = 12V			100	A
Typical Efficiency	V_{IN} = 48V, V_{OUT} = 12V, I_{OUT} = 100A		96.8		%
Peak Efficiency	V_{IN} = 48V, V_{OUT} = 12V		97.2		%
Default Switching Frequency (at Start-Up)			350		kHz

QUICK START PROCEDURE

Demonstration circuit 2959A-C is easy to set up to evaluate the performance of the PolyPhase operation of the LTM4660. Due to the high input/output current, users should select the proper input supply/load/cable which can sustain the full load operation. See Figure 2 for the proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input power supply to VIN (36V to 60V) and GND (input return).
2. Connect the output load between VOUT and GND (Initial load: no load). See Figure 2.
3. Connect the DVMs to the input and output.
4. Check the default jumper/switch position: SW1 (RUN): OFF.
5. Turn on the input power supply and adjust the input voltage to 48V.

   NOTE: Make sure that the input voltage does not exceed 60V.

6. Turn on the switches: SW1: ON.
7. Check for the proper output voltages from VO_SNS+ to VO_SNS–.
8. Once the proper output voltage is established, adjust the load within the operating range and measure the efficiency, output ripple voltage, and other items.
9. After completing all tests, adjust the load to 0A and 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 3 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (–) terminals of an output capacitor. The probe's ground ring needs to touch the (–) lead, and 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 Q11 and Q12 in the dynamic load circuit stays in the safe region. Instead of using the onboard dynamic load circuit, an electric load can also be used for the load step test, which does not have the 2% max duty cycle limit for the load step.
3. The $EXTV_{CC}$ pin is connected by default to V_{OUT} through a jumper R3. Remove R3 before applying an external voltage to the $EXTV_{CC}$ pin.
4. Due to the feature of the controller inside LTM4660, it is normal to see increased switching frequency after long-time running, as higher temperature leads to higher switching frequency.

QUICK START PROCEDURE

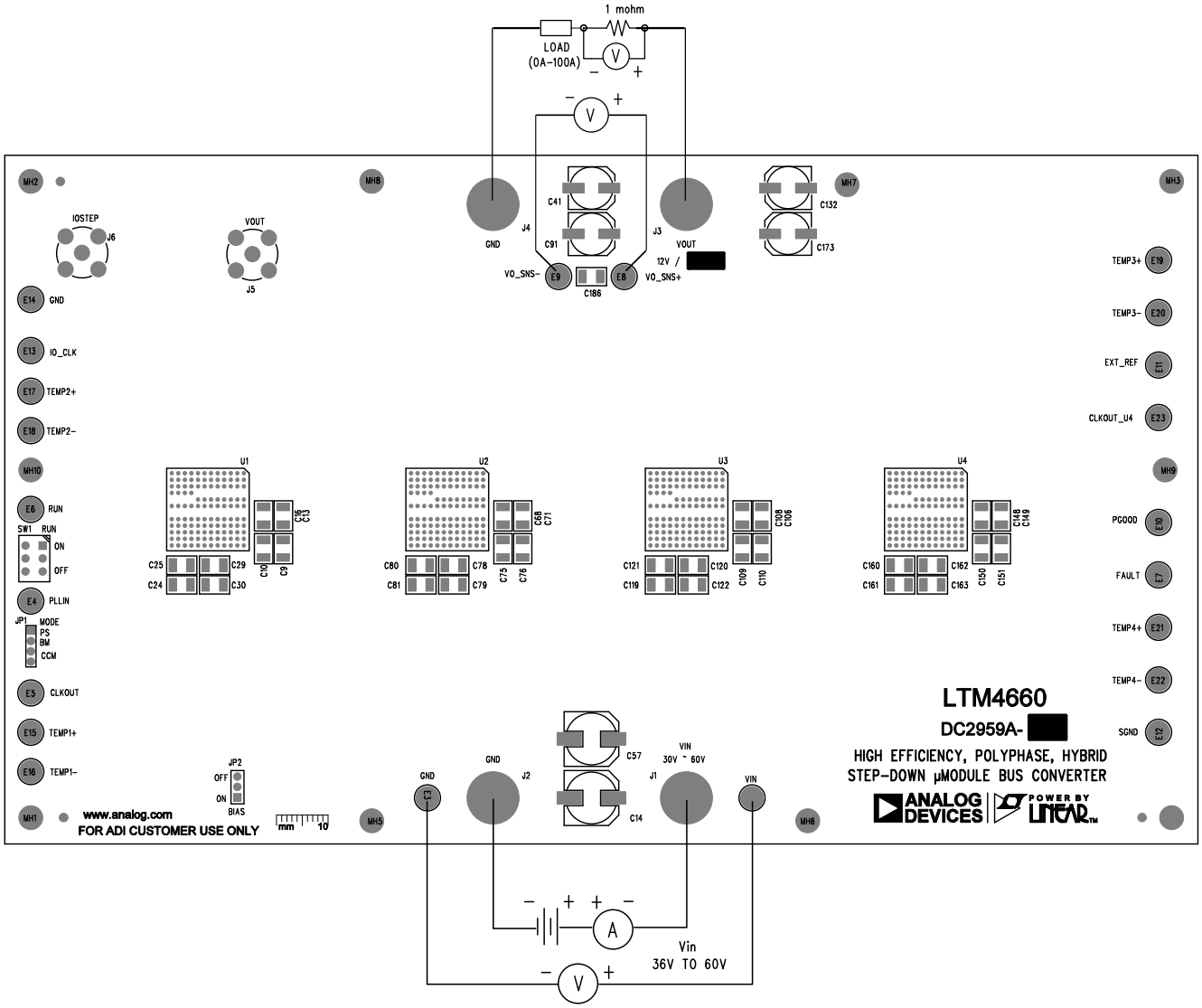


Figure 2. Proper Measurement Equipment Setup

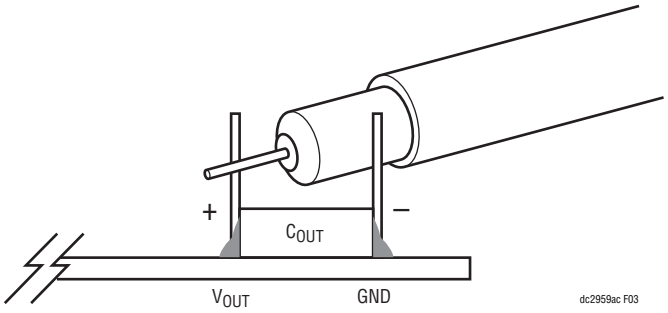


Figure 3. Measuring Output Voltage Ripple

TYPICAL PERFORMANCE CHARACTERISTICS

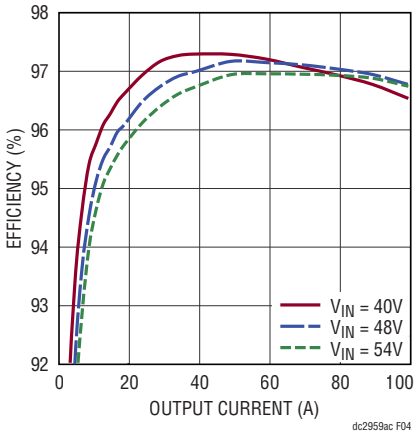


Figure 4. Efficiency vs Load Current at V_{OUT} = 12V, f_{SW} = 350kHz

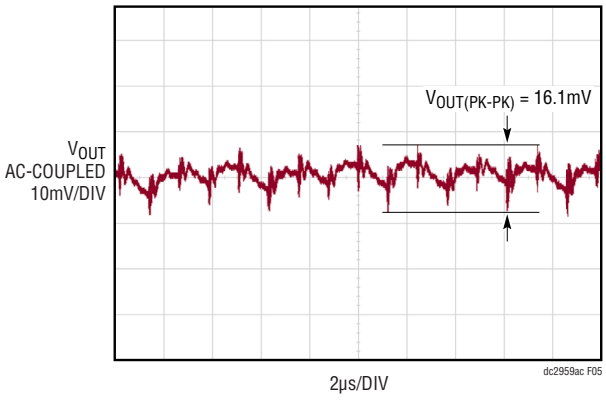


Figure 5. Output Voltage Ripple at V_{IN} = 48V, V_{OUT} = 12V, I_{OUT} = 100A, f_{SW} = 350kHz

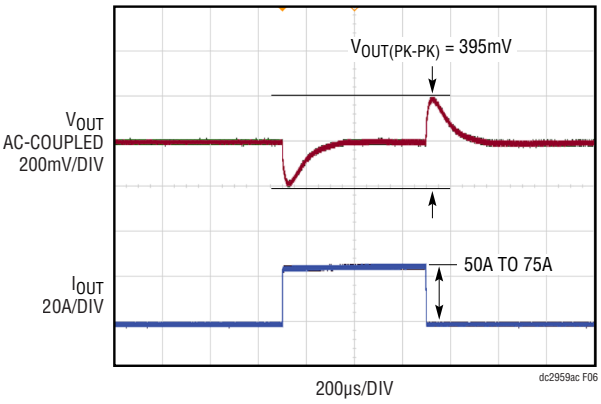


Figure 6. Load Step at V_{IN} = 48V, V_{OUT} = 12V, f_{SW} = 350kHz

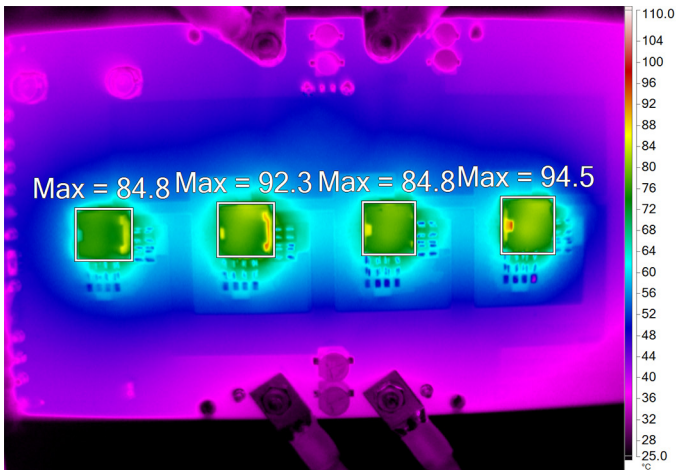


Figure 7. Thermal Performance V_{IN} = 48V, V_{OUT} = 12V, I_{OUT} = 100A, f_{SW} = 400kHz, T_A = 25°C, 400LFM, No Heatsink

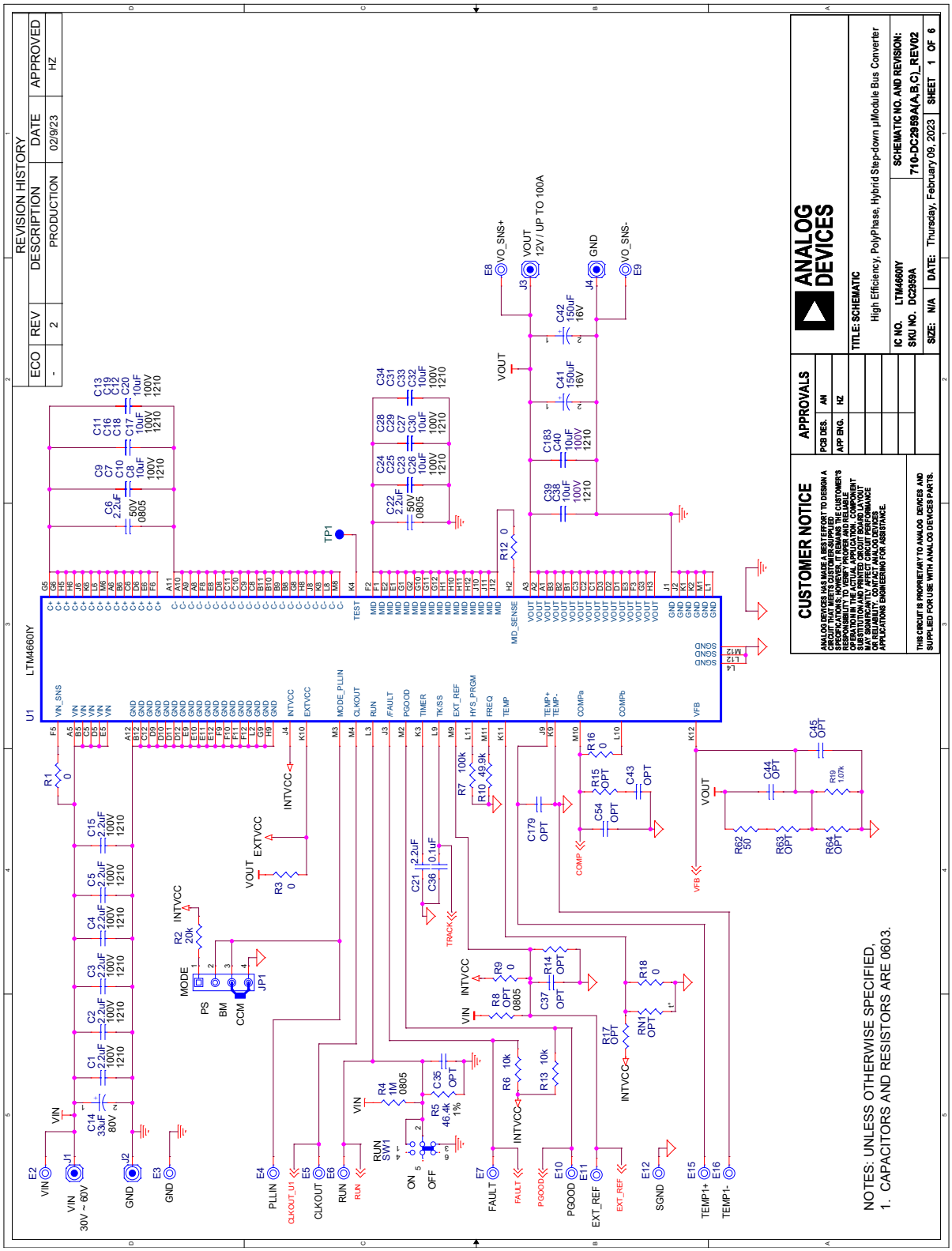
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	26	C1-C5, C15, C46, C47, C58-C63, C98-C103, C139-C144	CAP., 2.2µF, X7R, 100V, 10%, 1210	AVX, 12101C225KAT2A TDK, C3225X7R2A225K230AB MURATA, GRM32DR72A225KA12K; GRM32DR72A225KA12L
2	8	C6, C22, C64, C77, C104, C118, C145, C159	CAP., 2.2µF, X7R, 50V, 10%, 0805	AVX, 08055C225KAT2A NIC, NMC0805X7R225K50TRPLPF TDK, C2012X7R1H225K; C2012X7R1H225K125AC TAIYO YUDEN, UMK212BB7225KG-T
3	112	C7-C13, C16-C20, C23-C34, C38-C40, C65-C76, C78-C89, C93-C95, C105-C116, C119-C130, C134-C136, C146-C157, C160-C171, C175-C177, C183-C186	CAP., 10µF, X7S, 100V, 10%, 1210	MURATA, GRM32EC72A106KE05L
4	4	C14, C57, C97, C138	CAP., 33µF, ALUM. POLY. HYB., 80V, 20%, 10mm × 10.2mm SMD, RADIAL, AEC-Q200	PANASONIC, EEHZA1K330P
5	4	C21, C90, C131, C172	CAP., 2.2µF, X7S, 25V, 10%, 0603	MURATA, GRM188C71E225KE11D
6	1	C36	CAP., 0.1µF, X7S, 100V, 10%, 0603	TAIYO YUDEN, HMK107C7104KA-T TDK, C1608X7S2A104K080AB
7	8	C41, C42, C91, C92, C132, C133, C173, C174	CAP., 150µF, ALUM., OS-CON, 16V, 20%, 8mm × 6.9mm SMD, RADIAL	PANASONIC, 16SVPC150M
8	2	C49, C50	CAP., 22µF, X5R, 25V, 10%, 1210	KEMET, C1210C226K3PACTU MURATA, GRM32ER61E226KE15K; GRM32ER61E226KE15L SAMSUNG, CL32A226KAJNNNE TAIYO YUDEN, TMK325BJ226KM-P; TMK325BJ226KM-T AVX, 12103D226KAT2A
9	1	C51	CAP., 0.047µF, X7R, 25V, 10%, 0603	MURATA, GRM188R71E473KA01D NIC, NMC0603X7R473K25TRPF AVX, 06033C473KAT2A
10	1	C52	CAP., 220pF, C0G, 50V, 5%, 0603	AVX, 06035A221JAT2A MURATA, GRM1885C1H221JA01D WURTH ELEKTRONIK, 885012006059
11	1	C53	CAP., 1µF, X7R, 25V, 10%, 0603, AEC-Q200	MURATA, GCM188R71E105KA64D TAIYO YUDEN, TMK107AB7105KAHT TDK, CGA3E1X7R1E105K080AC
12	1	L3	IND., 68µH, PWR, SHIELDED, 20%, 0.74A, 0.42Ω, 2424, LPS6225	COILCRAFT, LPS6225-683MRB; LPS6225-683MRC
13	2	Q11, Q12	XSTR., MOSFET, N-CH, 40V, 14A, DPAK (TO-252)	VISHAY, SUD50N04-8M8P-4GE3
14	24	R1, R3, R9, R12, R16, R18, R26, R30, R36, R37, R40, R41-R44, R48, R50-R53, R58, R60, R61, R65	RES., 0Ω, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EA; CRCW06030000Z0EB; CRCW06030000Z0EC NIC, NRC06ZOTRF
15	2	R2, R22	RES., 20k, 5%, 1/10W, 0603, AEC-Q200	NIC, NRC06J203TRF VISHAY, CRCW060320K0JNEA PANASONIC, ERJ3GEYJ203V
16	1	R4	RES., 1M, 1%, 1/8W, 0805, AEC-Q200	PANASONIC, ERJ6ENF1004V VISHAY, CRCW08051M00FKEA
17	1	R5	RES., 46.4k, 1%, 1/10W, 0603	NIC, NRC06F4642TRF VISHAY, CRCW060346K4FKEA YAGEO, RC0603FR-0746K4L

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
18	3	R6, R13, R24	RES., 10k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060310K0FKEA KOA SPEER, RK73H1JTTD1002F PANASONIC, ERJ3EKF1002V
19	4	R7, R38, R45, R55	RES., 100k, 1%, 1/10W, 0603, AEC-Q200	VISAHY, CRCW0603100KFKEA NIC, NRC06F1003TRF PANASONIC, ERJ3EKF1003V YAGEO, RC0603FR-07100KL
20	4	R10, R39, R46, R56	RES., 49.9k, 1%, 1/10W, 0603	NIC, NRC06F4992TRF VISHAY, CRCW060349K9FKEA YAGEO, RC0603FR-0749K9L
21	1	R19	RES., 1.07k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1071V VISHAY, CRCW06031K07FKEA
22	1	R21	RES., 182k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1823V VISHAY, CRCW0603182KFKEA
23	1	R23	RES., 80.6k, 1%, 1/10W, 0603	VISHAY, CRCW060380K6FKEA NIC, NRC06F8062TRF YAGEO, RC0603FR-0780K6L
24	1	R25	RES., 0.1Ω, 1%, 1W, 2010, WSL-18 SERIES, SENSE, AEC-Q200	VISHAY, WSL2010R1000FEA18
25	1	R62	RES., 50Ω, 0.1%, 1/8W, 0603	VISHAY, FC0603E50R0BST1
26	4	U1-U4	IC, HYBRID STEP-DOWN NONISOLATED µModule® BUS CONVERTER, BGA	ANALOG DEVICES, LTM4660IY#PBF
27	1	U5	IC, SYNCHR. STEP-DOWN CONVERTER, MSOP-16 (MSE), 76V, 500mA	ANALOG DEVICES, LTC3630AEMSE#PBF; LTC3630AEMSE#TRPBF
Additional Demo Board Circuit Components				
1	0	C35, C37, C43-C45, C48, C54, C96, C137, C178-C182	CAP., OPTION, 0603	
2	0	R8	RES., OPTION, 0805	
3	0	R14, R15, R17, R20, R29, R47, R57, R63, R64	RES., OPTION, 0603	
4	0	RN1-RN4	THERMISTOR, OPTION, 0603	
Hardware: For Demo Board Only				
1	22	E2-E23	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, ST, THT, 50Ω	AMPHENOL RF, 112404
4	1	JP1	CONN., HDR, MALE, 1×4, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000411121
5	1	JP2	CONN., HDR, MALE, 1×3, 2mm, VERT, ST, THT, NO SUBS. ALLOWED	WURTH ELEKTRONIK, 62000311121
6	1	LB1	LABEL SPEC, DEMO BOARD SERIAL NUMBER	BRADY, THT-96-717-10
7	10	MH1-MH10	STANDOFF, NYLON, SNAP-ON, 0.625" (5/8), 15.9mm	KEYSTONE, 8834
8	1	PCB1	PCB, DC2959A	ANALOG DEVICES APPROVED SUPPLIER, 600-DC2959A
9	1	STNCL1	TOOL, STENCIL, DC2959A	ANALOG DEVICES APPROVED SUPPLIER, 830-DC2959A
10	1	SW1	SWITCH, SLIDE, DPDT, 0.3A, 6VDC, PTH	C&K, JS202011CQN
11	2	XJP1, XJP2	CONN., SHUNT, FEMALE, 2 POS, 2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



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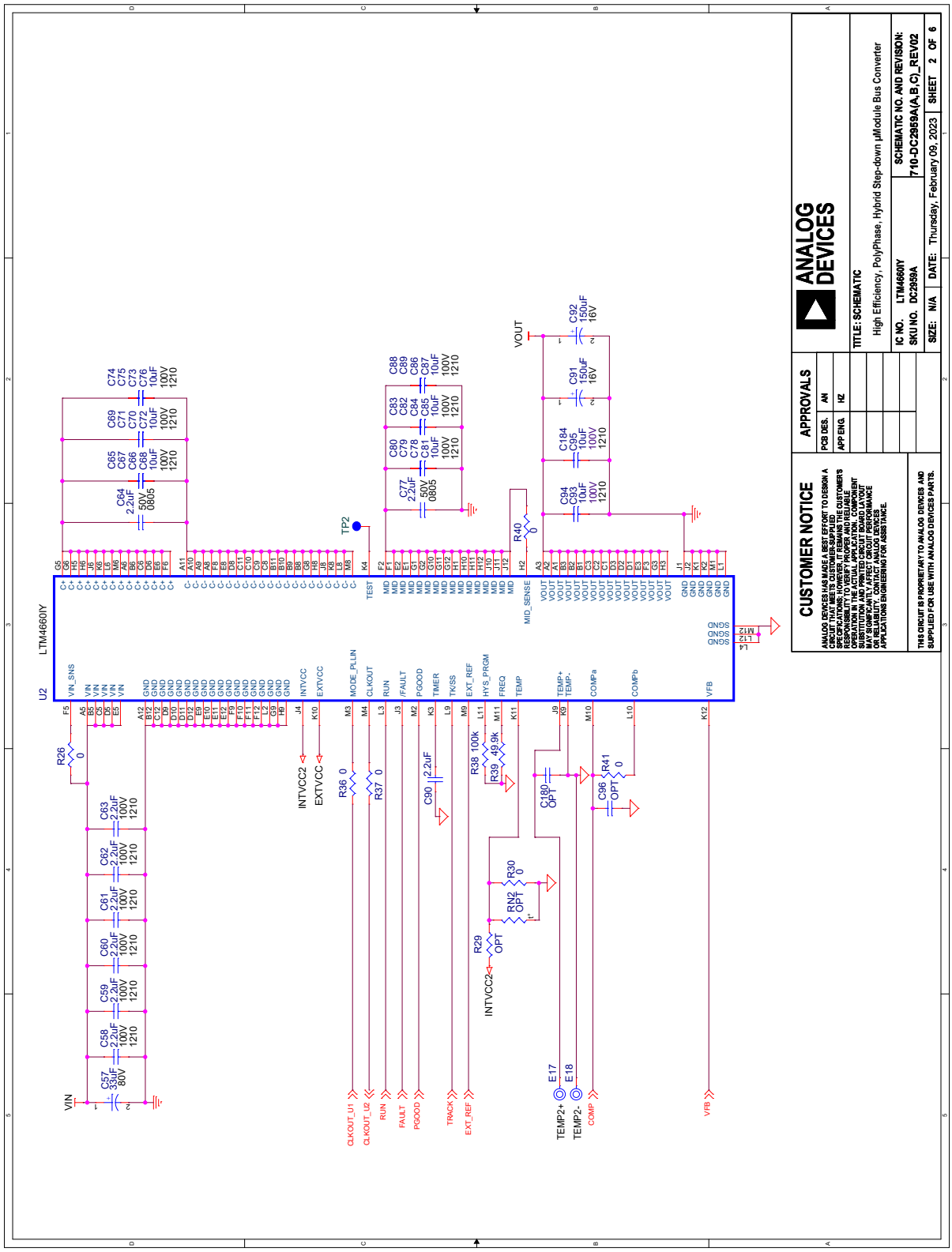

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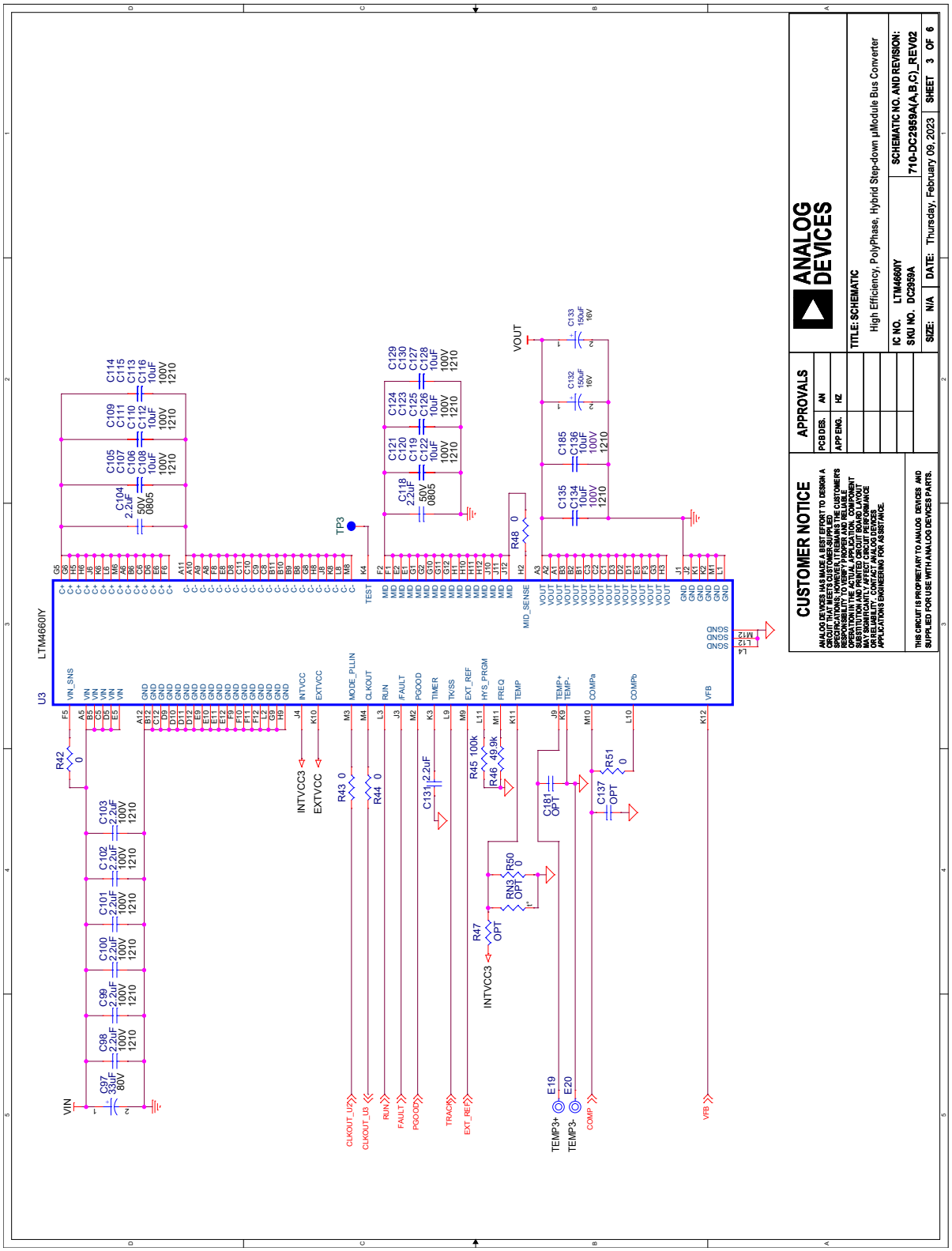

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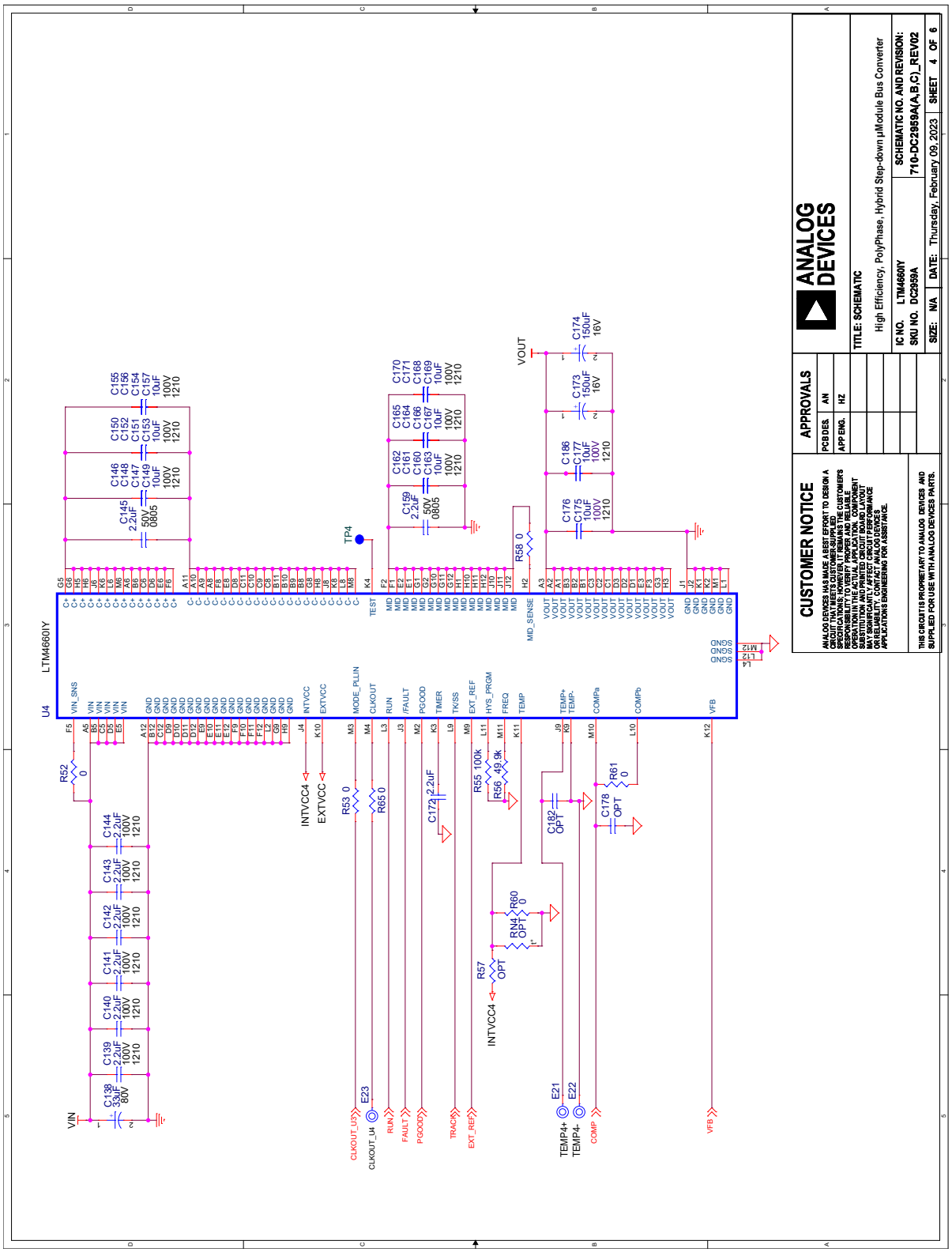

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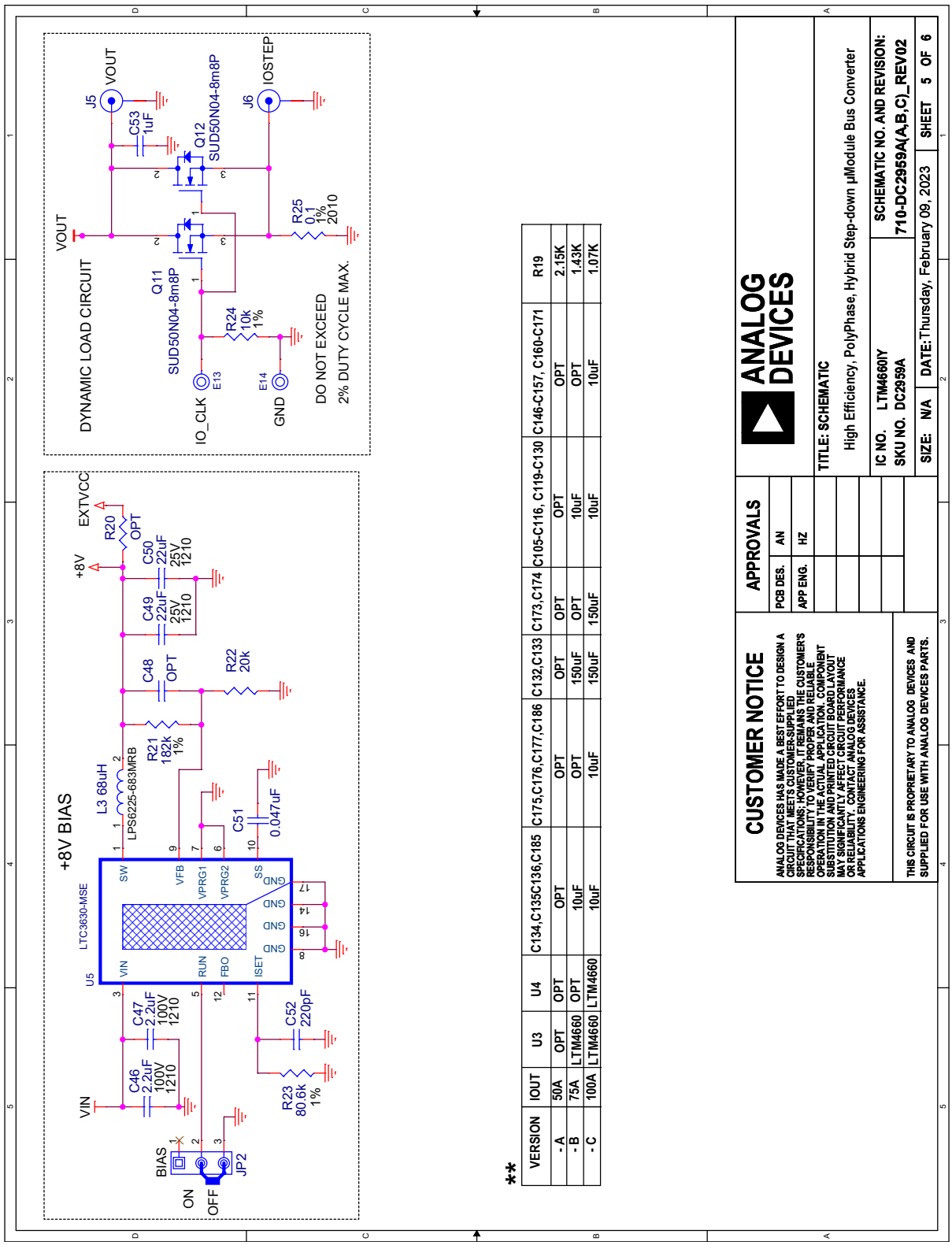

VERSION	IOUT	U3	U4	C134,C135C136,C185	C175,C176,C177,C186	C132,C133	C173,C174	C105-C116, C119-C130	C146-C157, C160-C171	R19
- A	50A	OPT	OPT	OPT	OPT	OPT	OPT	OPT	OPT	2.15K
- B	75A	LTM4660	OPT	10uF	OPT	150uF	OPT	10uF	OPT	1.43K
- C	100A	LTM4660	LTM4660	10uF	10uF	150uF	150uF	10uF	10uF	1.07K

**

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THIS CIRCUIT IS PROPRIETARY TO ANALOG DEVICES AND SUPPLIED FOR USE WITH ANALOG DEVICES PARTS.

APPROVALS	
PCB DES.	AN
APP ENG.	HZ

ANALOG DEVICES

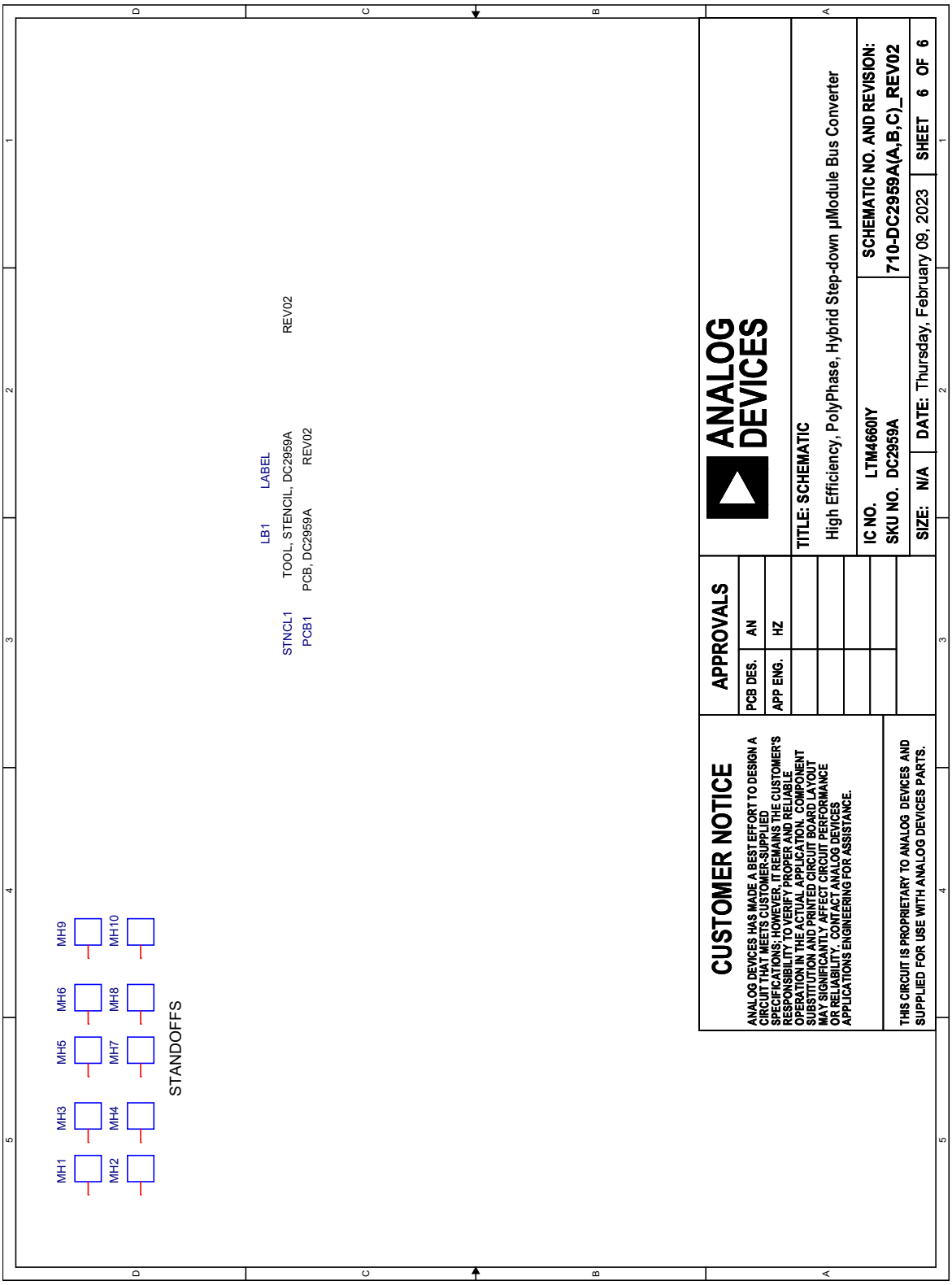
TITLE: SCHEMATIC
High Efficiency, PolyPhase, Hybrid Step-down µModule Bus Converter

IC NO. LTM4660IY
SKU NO. DC2959A

SCHEMATIC NO. AND REVISION:
710-DC2959A(A,B,C)_REV02

SIZE: N/A | DATE: Thursday, February 09, 2023 | SHEET 5 OF 6

SCHEMATIC DIAGRAM



REVISION HISTORY

REV	DATE	DESCRIPTION	PAGE NUMBER
0	06/23	Initial Release.	—

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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