

LTM4660

High Efficiency, PolyPhase 75A Hybrid Step-Down Power μ Module Regulator 3x LTM4660, 75A

DESCRIPTION

Demonstration circuit 2959A-B is a high efficiency, high power density hybrid step-down converter. It can deliver 12V/75A 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-B 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 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 **FAULT** pin low when a fault condition occurs. An onboard timer can be set for appropriate restart/retry times. Additional features include $\pm 1.5\%$ 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.

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BOARD PHOTO Part marking is either ink mark or laser mark

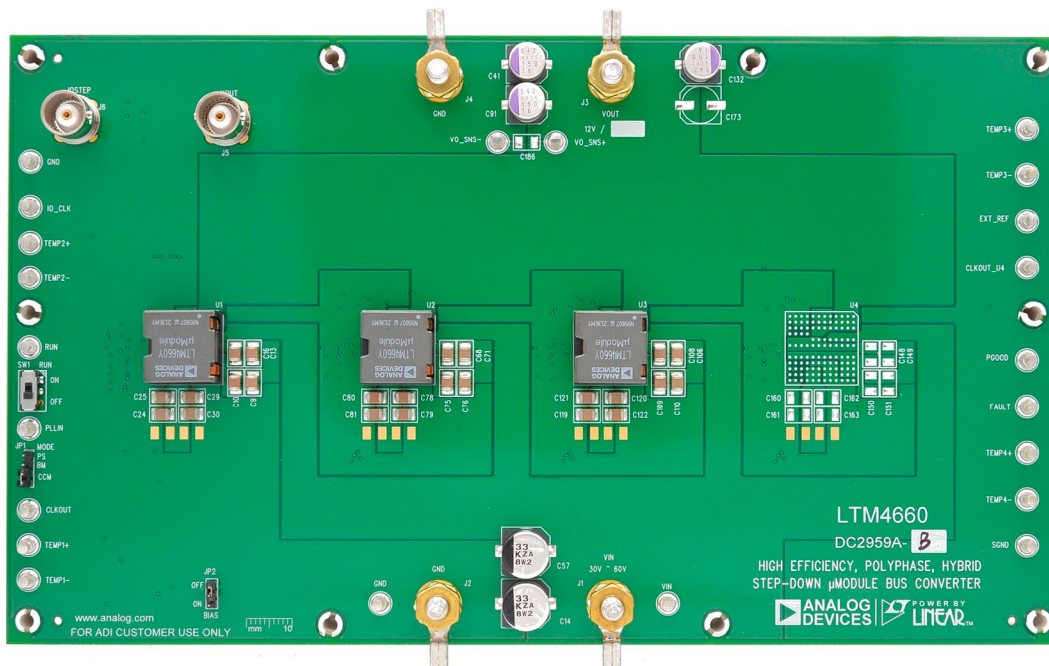


Figure 1. LTM4660/DC2959A-B Demo Circuit

PERFORMANCE SUMMARY Specifications are at $T_A = 25^\circ\text{C}$

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|-----|------|-----|-------|
| Input Voltage Range, V_{IN} | | 36 | | 60 | V |
| Output Voltage, V_{OUT} | $V_{IN} = 36\text{V to } 60\text{V}$, $I_{OUT} = 0\text{A to } 75\text{A}$ | | | 12 | V |
| Maximum Output Current, I_{OUT} | $V_{IN} = 36\text{V to } 60\text{V}$, $V_{OUT} = 12\text{V}$ | | | 75 | A |
| Typical Efficiency | $V_{IN} = 48\text{V}$, $V_{OUT} = 12\text{V}$, $I_{OUT} = 75\text{A}$ | | 96.8 | | % |
| Peak Efficiency | $V_{IN} = 48\text{V}$, $V_{OUT} = 12\text{V}$ | | 97.2 | | % |
| Default Switching Frequency (at Start-Up) | | | 350 | | kHz |

QUICK START PROCEDURE

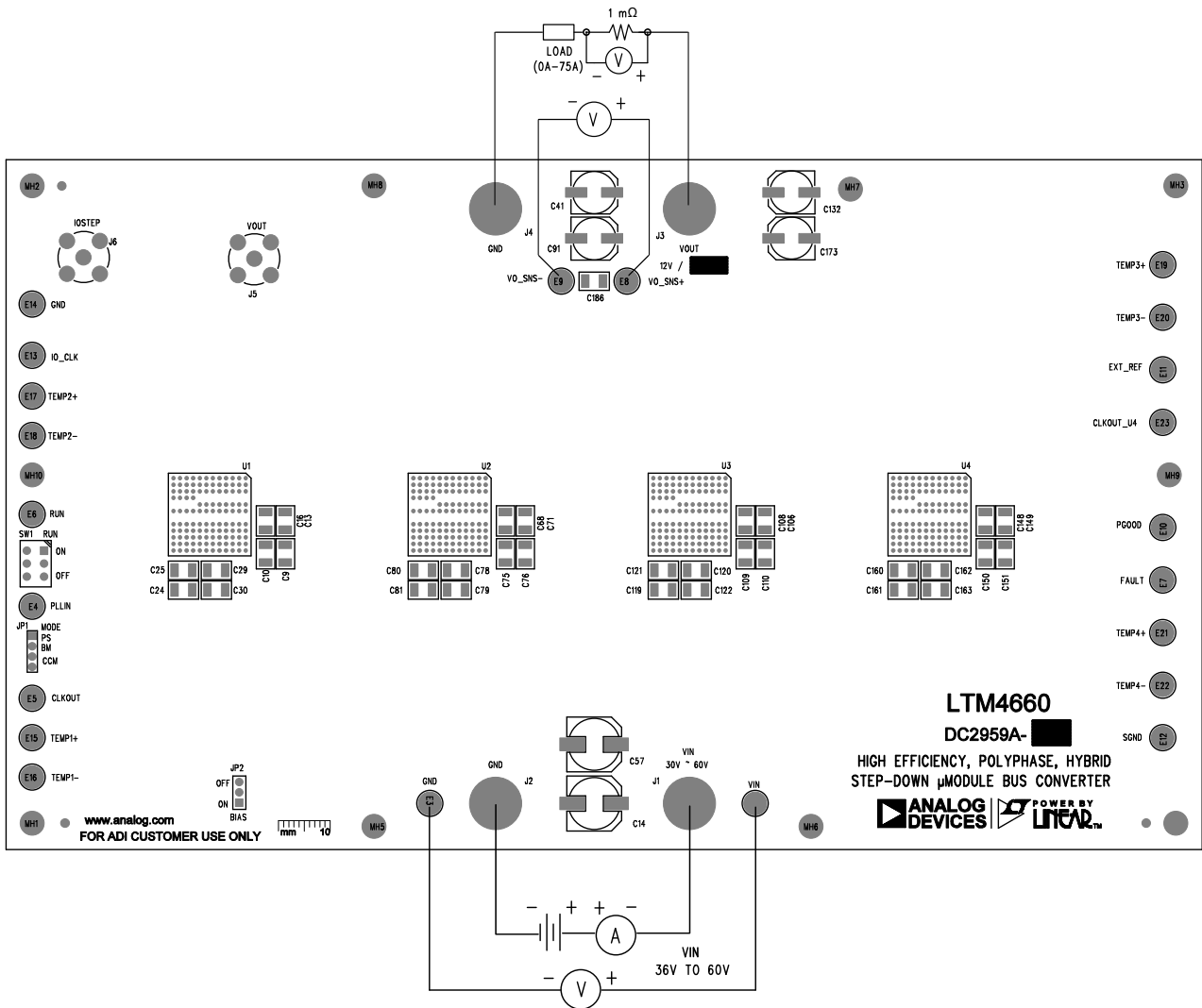
Demonstration circuit 2959A-B is easy to set up to evaluate the performance of PolyPhase operation of the LTM4660. Due to the high input/output current, users should select the proper input supply/load/cable which can sustain the full load operation. Refer to Figure 2 for the proper measurement equipment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

1. With power off, connect the input power supply to V_{IN} (36V to 60V) and GND (input return).
2. Connect the output load between V_{OUT} and GND (Initial load: no load). Refer to 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 500 μs 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



TYPICAL PERFORMANCE CHARACTERISTICS

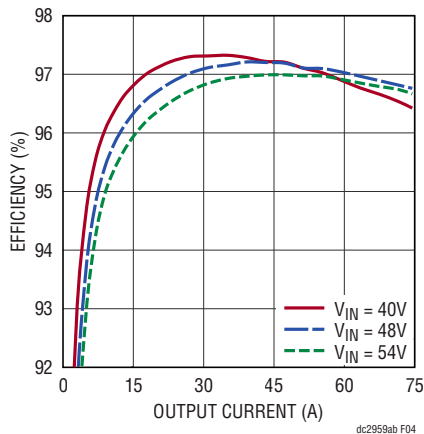


Figure 4. Efficiency vs Load Current at $V_{OUT} = 12V$, $f_{SW} = 350kHz$

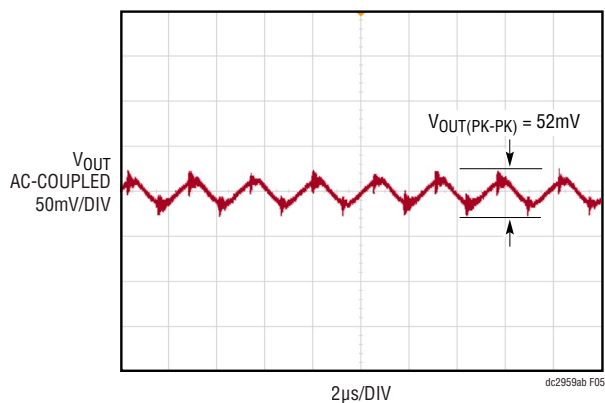


Figure 5. Output Voltage Ripple at $V_{IN} = 48V$, $V_{OUT} = 12V$, $I_{OUT} = 75A$, $f_{SW} = 350kHz$

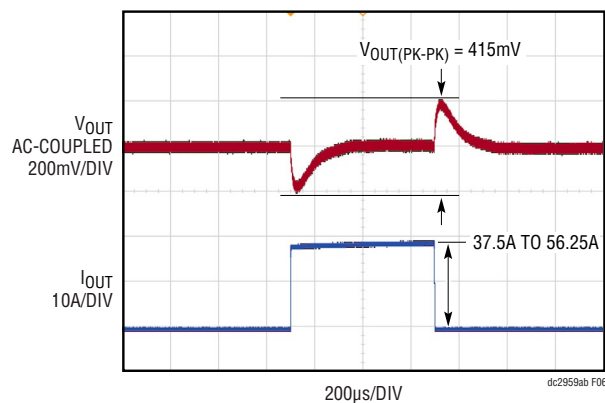


Figure 6. Load Step at $V_{IN} = 48V$, $V_{OUT} = 12V$, $f_{SW} = 350kHz$

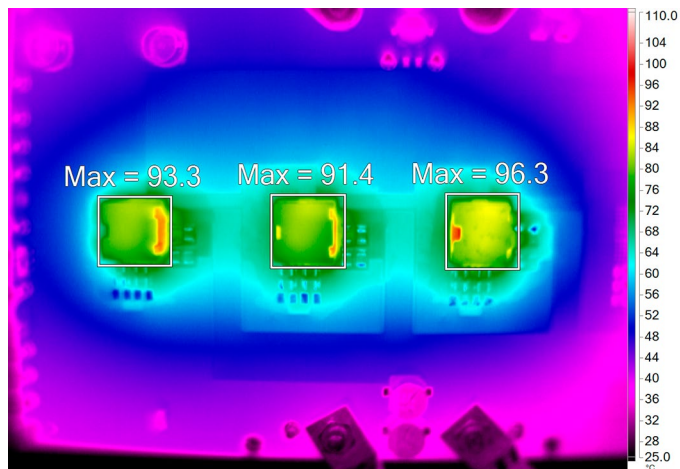


Figure 7. Thermal Performance $V_{IN} = 48V$, $V_{OUT} = 12V$, $I_{OUT} = 75A$, $f_{SW} = 400kHz$, $T_A = 25^\circ C$, 300LFM, No Heatsink

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 | 84 | C7-C13, C16-C20, C23-C34, C38-C40, C65-C76, C78-C89, C93-C95, C105-C116, C119-C130, C134-C136, C183-C185 | 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 | 6 | C41, C42, C91, C92, C132, C133 | 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-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, ERJ3GGEYJ203V |
| 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 |
| 18 | 3 | R6, R13, R24 | RES., 10k, 1%, 1/10W, 0603, AEC-Q200 | VISHAY, CRCW060310K0FKEA KOA SPEER, RK73H1JTTD1002F PANASONIC, ERJ3EKF1002V |

DEMO MANUAL DC2959A-B

PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|------|-----|--------------------|---|--|
| 19 | 4 | R7, R38, R45, R55 | RES., 100k, 1%, 1/10W, 0603, AEC-Q200 | VISHAY, 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., 1.43k, 1%, 1/10W, 0603 | NIC, NRC06F1431TRF PANASONIC, ERJ3EKF1431V VISHAY, CRCW06031K43FKEA |
| 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 | 3 | U1-U3 | IC, HYBRID STEP-DOWN NON-ISOLATED 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 |

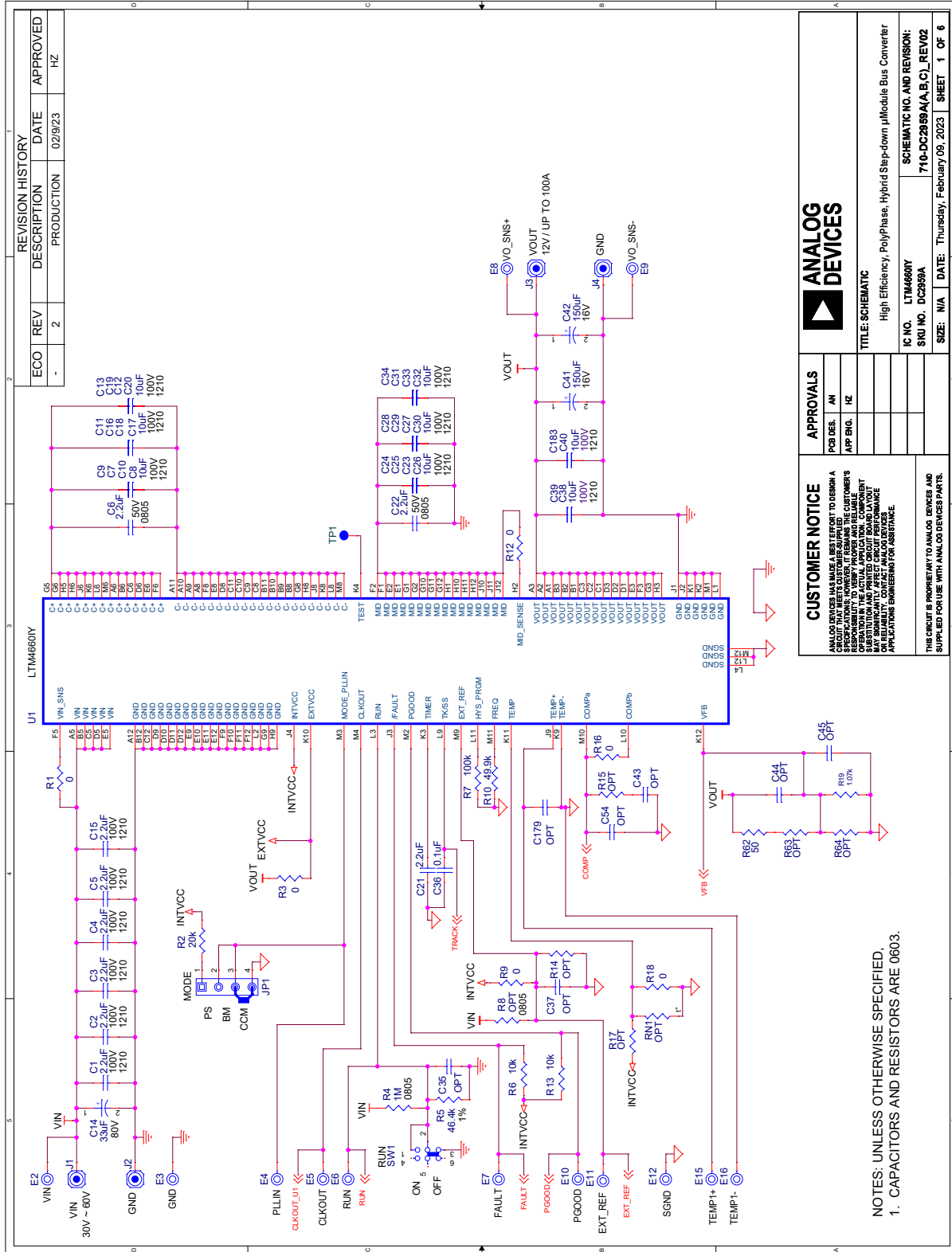
Additional Demo Board Circuit Components

| | | | | |
|---|---|---|--------------------------------|--|
| 1 | 0 | C146-C157, C160-C171, C175-C177, C186 | CAP, OPTION, 1210 | |
| 2 | 0 | C35, C37, C43-C45, C48, C54, C96, C137, C178-C182 | CAP, OPTION, 0603 | |
| 3 | 0 | C173, C174 | CAP, OPTION, ALUM. ELECT., SMD | |
| 4 | 0 | R8 | RES., OPTION, 0805 | |
| 5 | 0 | R14, R15, R17, R20, R29, R47, R57, R63, R64 | RES., OPTION, 0603 | |
| 6 | 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, 1x4, 2mm, VERT, ST, THT | WURTH ELEKTRONIK, 62000411121 |
| 5 | 1 | JP2 | CONN., HDR, MALE, 1x3, 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



| REVISION HISTORY | | | | |
|------------------|-----|-------------|---------|----------|
| ECO | REV | DESCRIPTION | DATE | APPROVED |
| - | 2 | PRODUCTION | 02/9/23 | HZ |

ANALOG DEVICES

High Efficiency, PolyPhase, Hybrid Step-down µModule Bus Converter

TITLE: SCHEMATIC

IC NO. LTM4600Y

SKU NO. DC2959A

SIZE: N/A

DATE: Thursday, February 09, 2023

SHEET 1 OF 6

CUSTOMER NOTICE

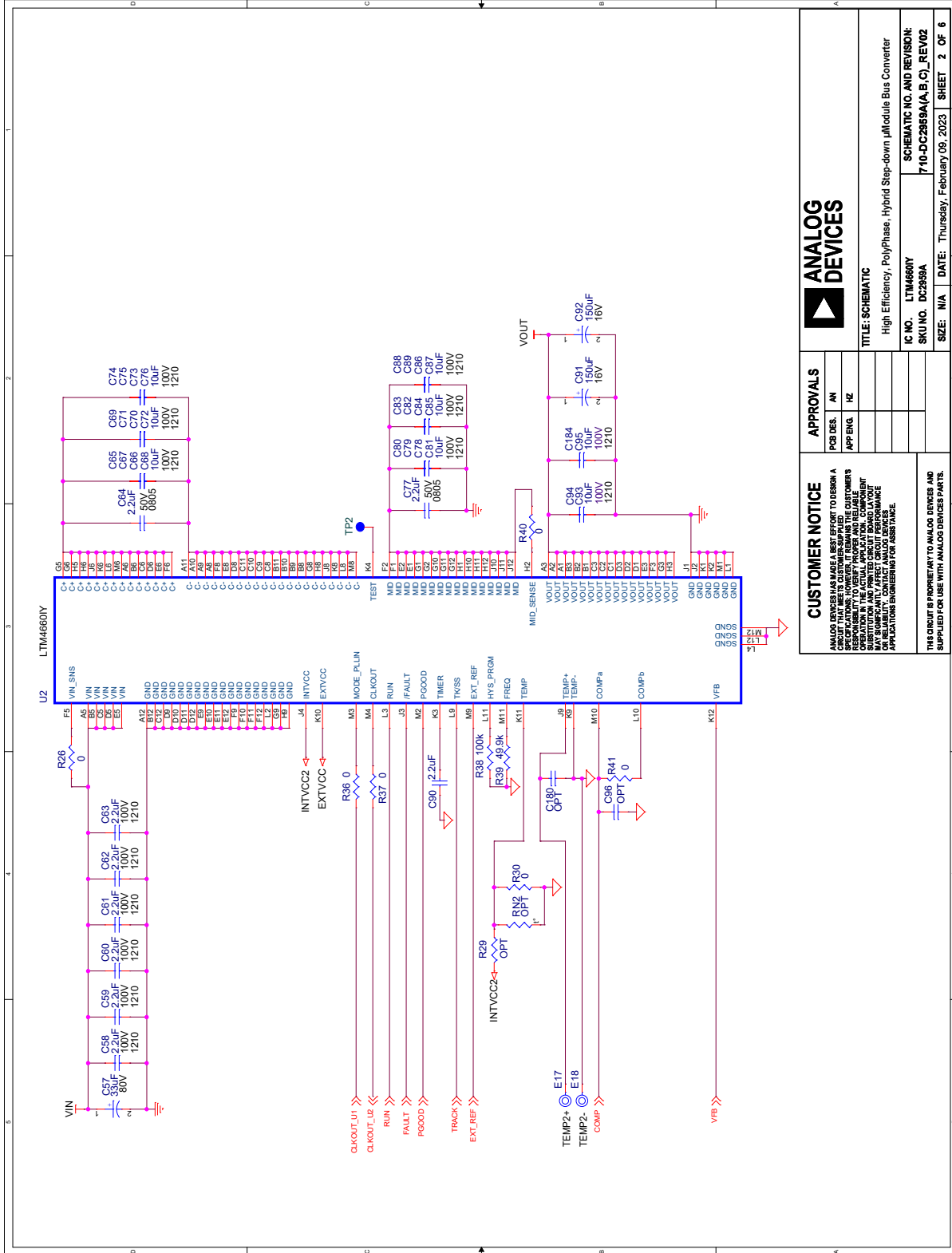
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NOTES: UNLESS OTHERWISE SPECIFIED.
1. CAPACITORS AND RESISTORS ARE 0603.

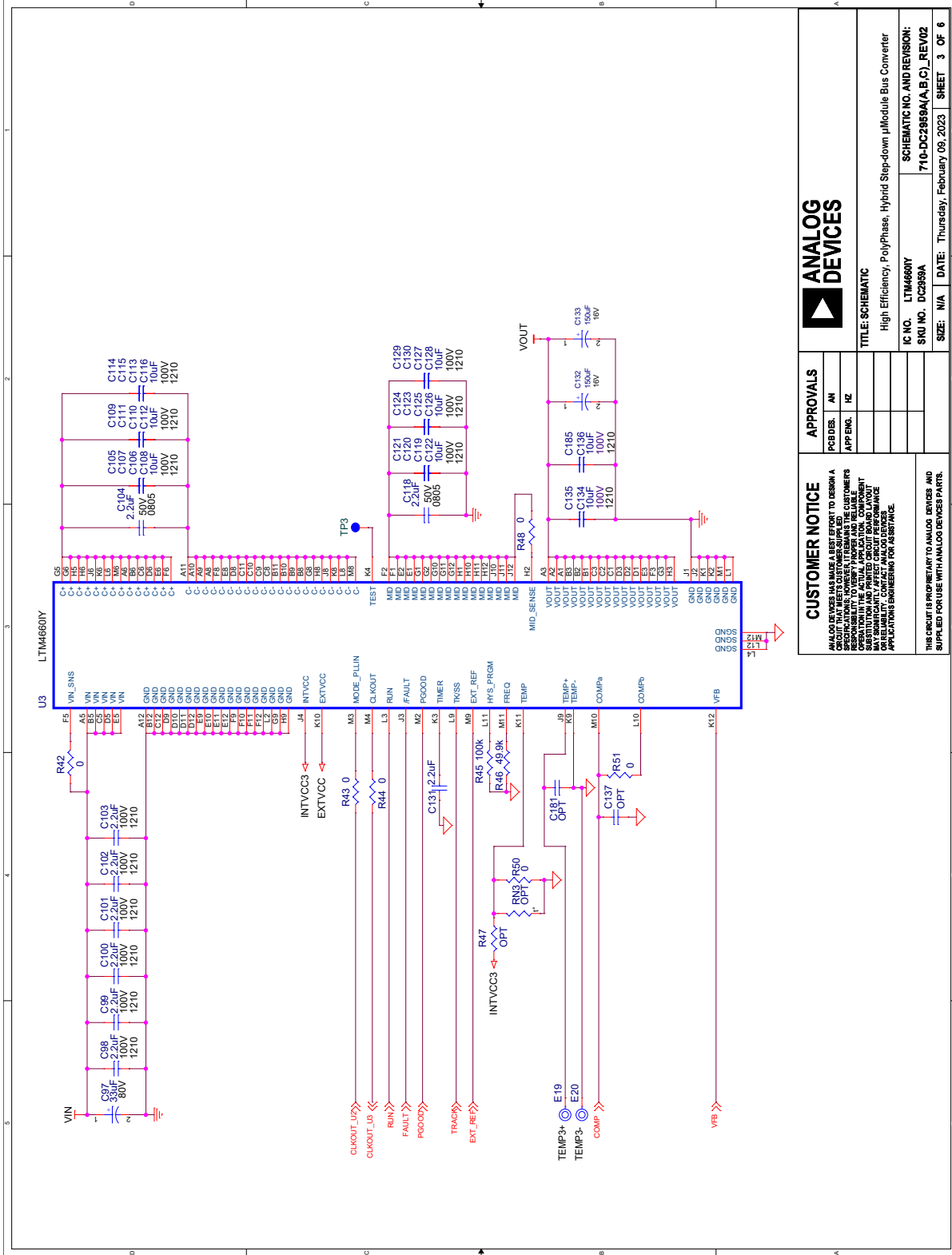
DEMO MANUAL DC2959A-B

SCHEMATIC DIAGRAM



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| | | APPROVALS | |
| | | PCB DES. | APP. ENG. |
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| ANALOG DEVICES | | TITLE: SCHEMATIC High Efficiency, PolyPhase, Hybrid Step-down μ Module 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 2 OF 6 | | | |

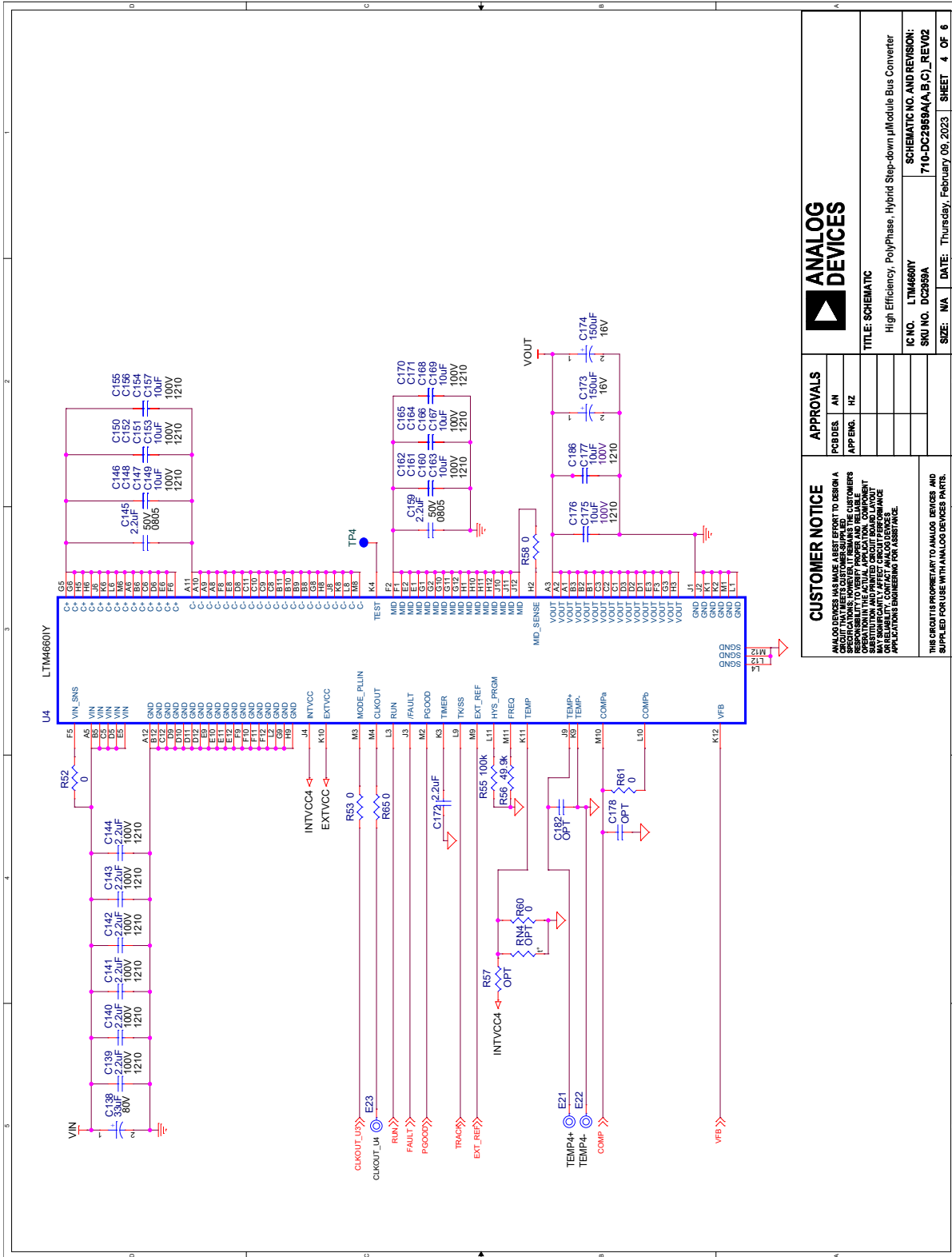
SCHEMATIC DIAGRAM



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|---|--|--|
| | APPROVALS | |
| | PCB DES: AH | APP ENG: HZ |
| CUSTOMER NOTICE ANALOG DEVICES HAS MADE BEST EFFORT TO DESIGN A SPECIFIC SOLUTION. HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY THE OPERATION OF THE COMPONENTS IN THE ACTUAL APPLICATION. COMPONENTS MAY BE SUBJECT TO VARIATIONS IN PERFORMANCE. ANALOG DEVICES ASSUMES NO LIABILITY FOR ANY PERFORMANCE DEFICIENCIES OR APPLICATIONS ENGINEERING FOR ADVANTAGE. | | |
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| ANALOG DEVICES | | |
| TITLE: SCHEMATIC High Efficiency, PolyPhase, Hybrid Step-down μ Module Bus Converter | | |
| IC NO. LTM4600Y | SCHEMATIC NO. AND REVISION: 710-DC2959A(B,C)_REV02 | |
| SKU NO. DC2959A | SIZE: N/A | DATE: Thursday, February 09, 2023 SHEET 3 OF 6 |

DEMO MANUAL DC2959A-B

SCHEMATIC DIAGRAM

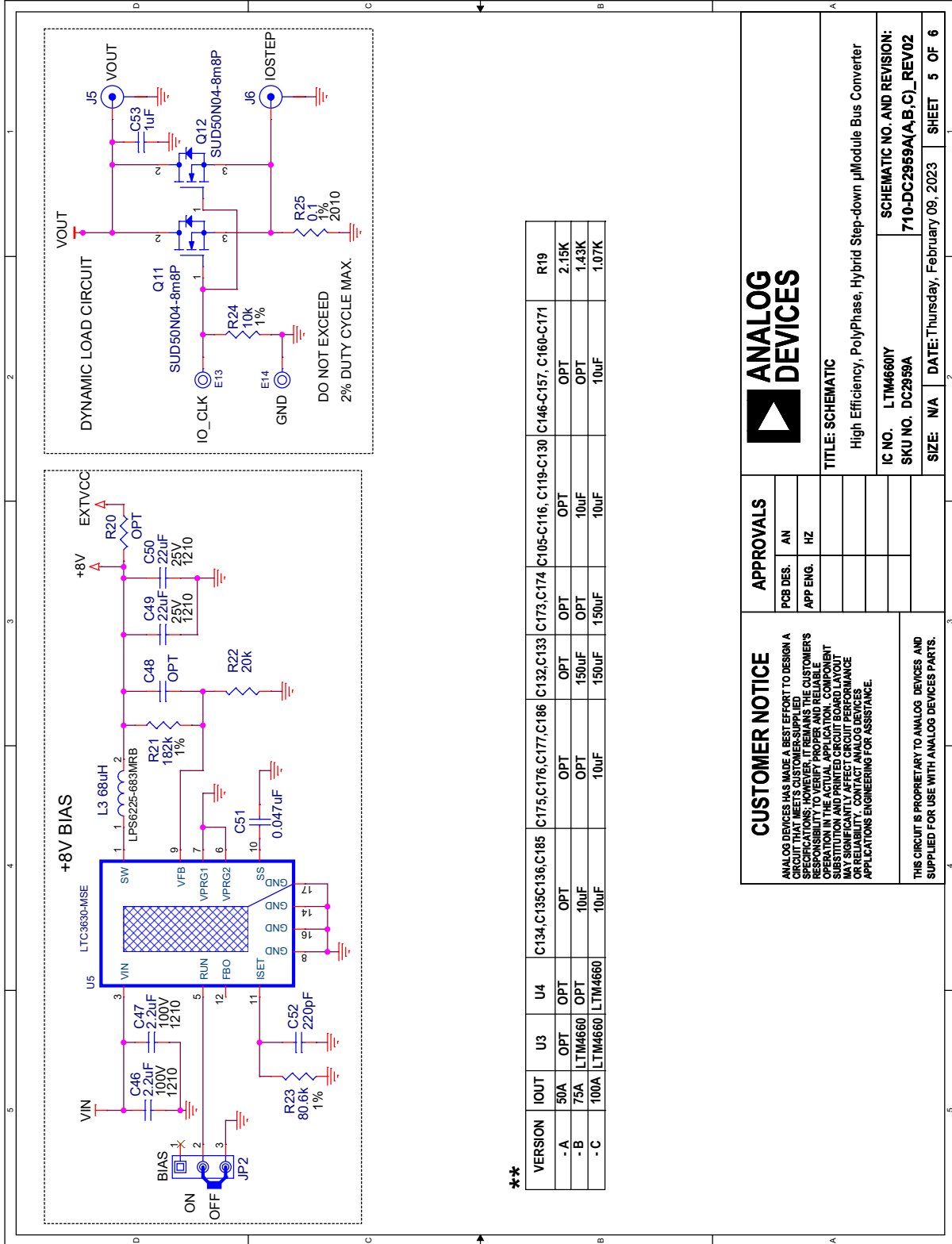


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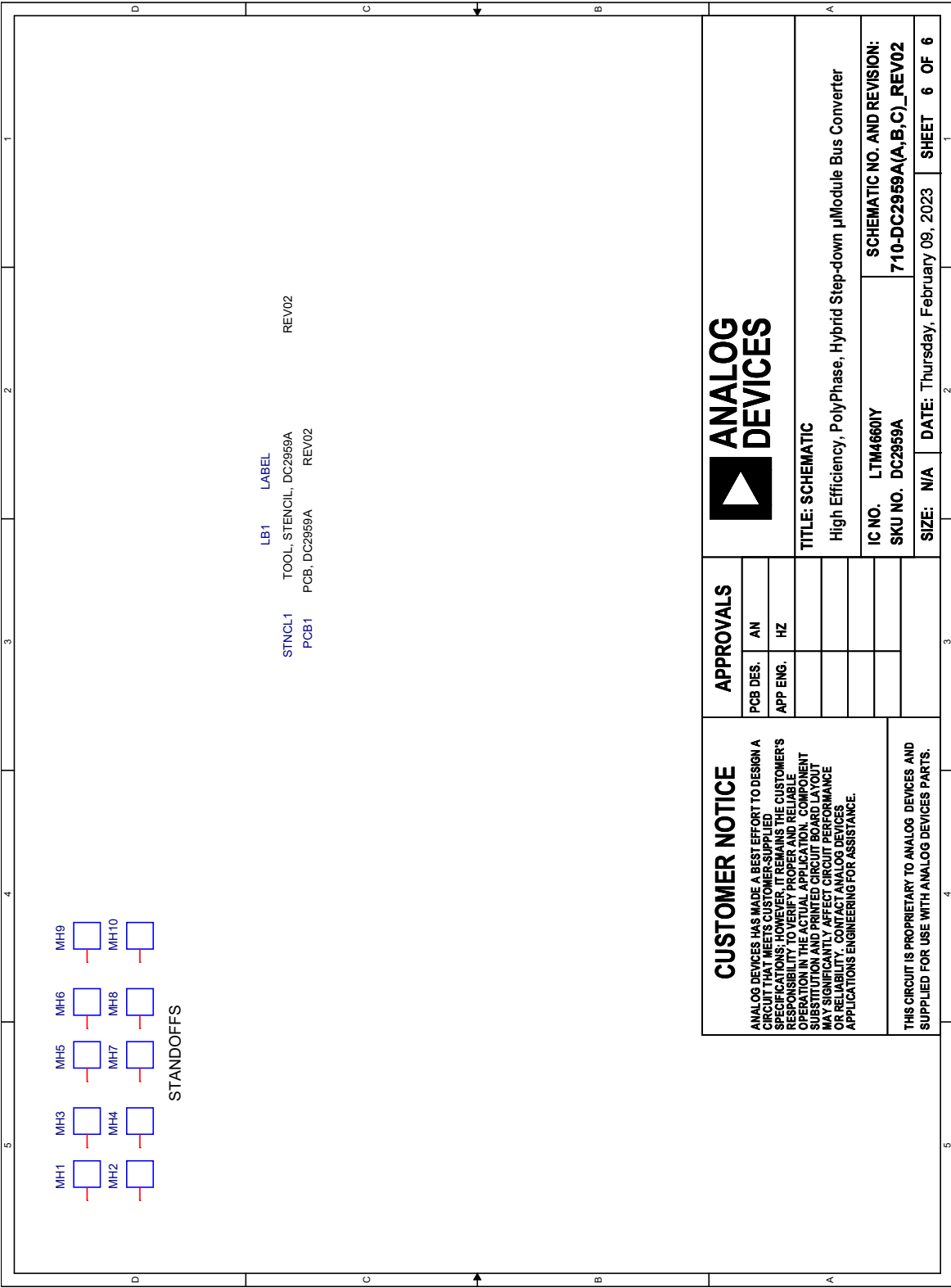
| APPROVALS | |
|-----------|----|
| PCB DES. | AN |
| APP ENG. | RZ |

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|---|-----------------------------------|
| TITLE: SCHEMATIC | |
| High Efficiency, PolyPhase, Hybrid Step-down μ Module Bus Converter | |
| IC NO. LTM4660Y | SCHEMATIC NO. AND REVISION: |
| SKU NO. DC2959A | 710-DC2959A(A,B,C)_REV02 |
| SIZE: NA | DATE: Thursday, February 09, 2023 |
| SHEET 4 OF 6 | |

SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



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| APPROVALS | |
|-----------|----|
| PCB DES. | AN |
| APP ENG. | HZ |
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REVISION HISTORY

| REV | DATE | DESCRIPTION | PAGE NUMBER |
|-----|-------|------------------|-------------|
| 0 | 05/23 | 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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