

# LTM4647 High Efficiency, PolyPhase 120A Step-Down Power $\mu$ Module Regulator

## DESCRIPTION

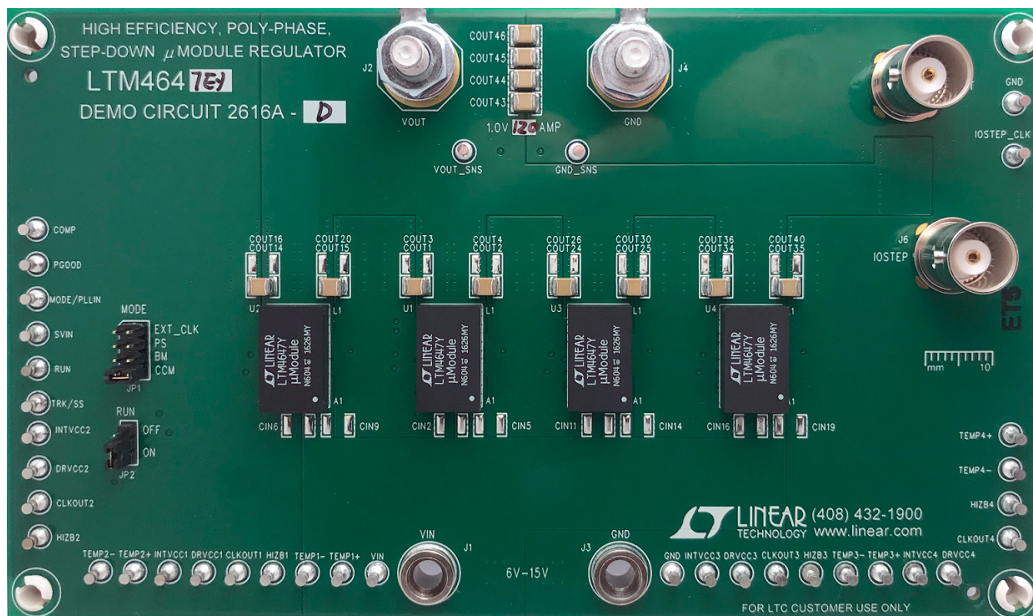
Demonstration circuit 2616A-D features a polyphase design using the [LTM®4647EY](#), a 30A high efficiency, switch mode step-down power  $\mu$ Module regulator. The input voltage range is from 6V to 15V. To use DC2616A-D for input voltage range from 4.7V to 6V, connect INTV<sub>CC</sub> to SV<sub>IN</sub> (change R22, R42, R55, R68 from OPT to 0 $\Omega$ ), DRV<sub>CC</sub> to V<sub>IN</sub> (change R21, R38, R52, R65 from 0 $\Omega$  to OPT, R2, R39, R53, R66 from OPT to 0 $\Omega$ ). The output voltage range is 0.6V to 1.8V. The DC2616A-D can deliver a nominal 120A output current with four LTM4647 modules in parallel. As explained in the data sheet, output current derating is necessary for certain V<sub>IN</sub>, V<sub>OUT</sub>, and thermal conditions. The board operates in continuous conduction

mode in heavy load conditions. For high efficiency at low load currents, the MODE\_PLLIN jumper selects pulse-skipping mode for noise sensitive applications or burst mode operation in less noise sensitive applications. The MODE\_PLLIN pin also allows the LTM4647 to synchronize to an external clock signal. The phase shift between two adjacent phases is 90 degrees. DC2616A-D has the option of choosing both internal and external compensation circuit for LTM4647. The LTM4647 data sheet must be read in conjunction with this demo manual prior to working on or modifying demo circuit DC2616A-D.

[Design files for this circuit board are available.](#)

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## BOARD PHOTO



# DEMO MANUAL DC2616A-D

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

| PARAMETER                         | CONDITIONS   | VALUE                   |
|-----------------------------------|--|-------------------------|
| Input Voltage Range               |  | 6V to 15V               |
| Output Voltages                   |  | $1.0\text{V} \pm 1.2\%$ |
| Maximum Continuous Output Current | De-rating is Necessary for Certain Operating Conditions. See Data Sheet for Details.     | 120ADC                  |
| Operating Frequency               |  | 600kHz                  |
| Efficiency                        | $V_{IN} = 12\text{V}$ , $V_{OUT} = 1.0\text{V}$ , $I_{OUT} = 120\text{A}$                | 84.0% Figure 2          |
| Load Transient                    | $V_{IN} = 12\text{V}$ , $V_{OUT} = 1.0\text{V}$ , $I_{STEP} = 0\text{A}$ to $30\text{A}$ | 81mV Figure 3           |

## QUICK START PROCEDURE

Demonstration circuit DC2616A-D is an easy way to evaluate the performance of polyphase operation of the LTM4647EY. Due to the high input/output current, the user should select the proper input supply/load/cable which can sustain the full load operation. Please refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

1. Place jumpers in the following positions for a typical application:

| MODE | RUN |
|------|-----|
| CCM  | ON  |

2. With power off, connect the input power supply, load and meters as shown in Figure 1. Preset the load to 0A and  $V_{IN}$  supply to 12V.
3. Turn on the power supply at the input. The output voltage should be  $1.0\text{V} \pm 1.2\%$  (0.988V to 1.012V).

4. Vary the input voltage from 6V to 15V and adjust the load current from 0A to 120A. Observe the output voltage regulation, ripple voltage, efficiency, and other parameters.
5. (Optional) For optional load transient test, apply an adjustable pulse signal between IOSTEP\_CLK and GND test points. The pulse amplitude sets the load step current amplitude. Keep the pulse width short (<1ms) and pulse duty cycle low (<5%) to limit the thermal stress on the load transient circuit.
6. (Optional) LTM4647 can be synchronized to an external clock signal. Apply a clock signal (0V to 5V, square wave) on the MODE\_PLLIN test point.
7. (Optional) The outputs of LTM4647 can track another supply. The output voltage tracks the voltage on TRACK when a valid signal is applied on the test point.

QUICK START PROCEDURE

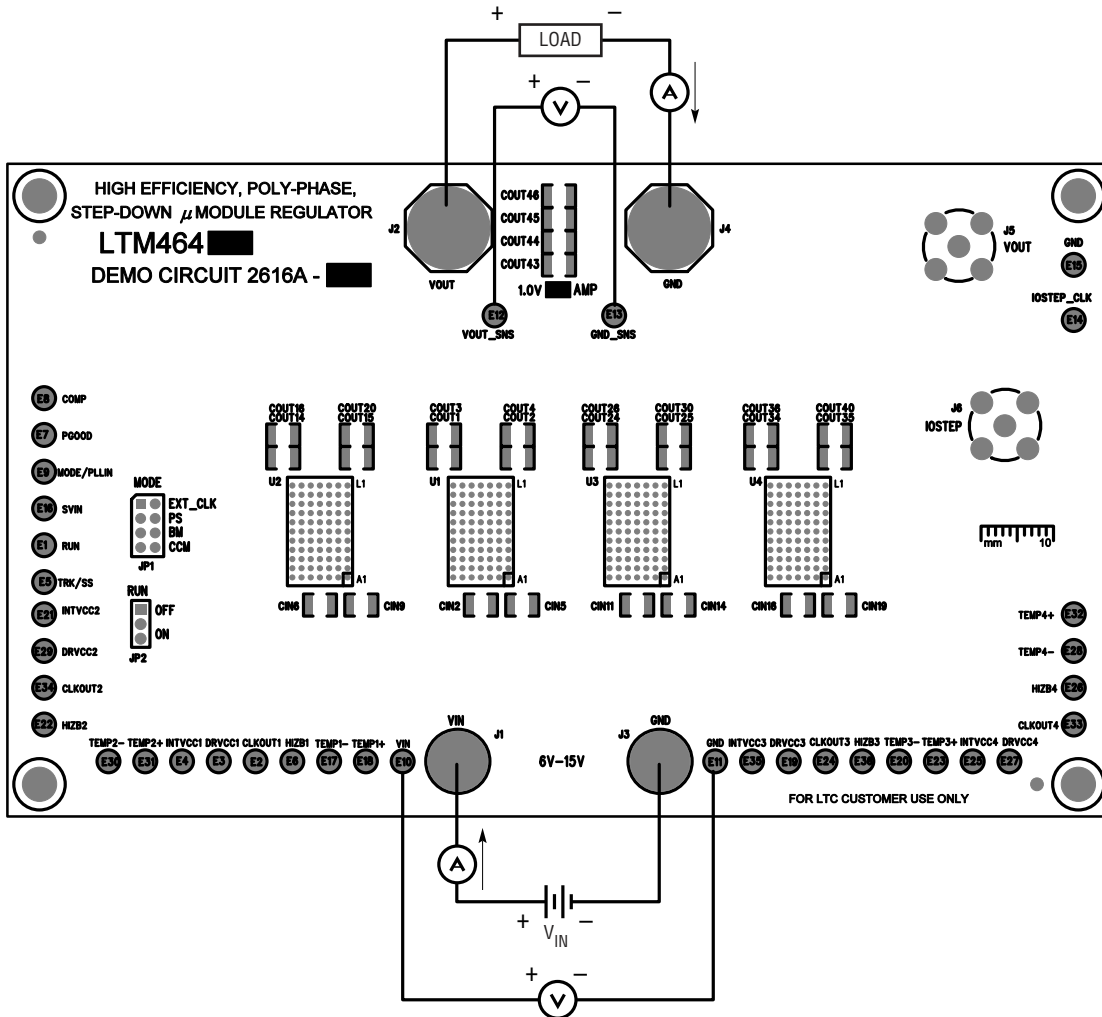


Figure 1. Measurement Setup of DC2616A-D

## QUICK START PROCEDURE

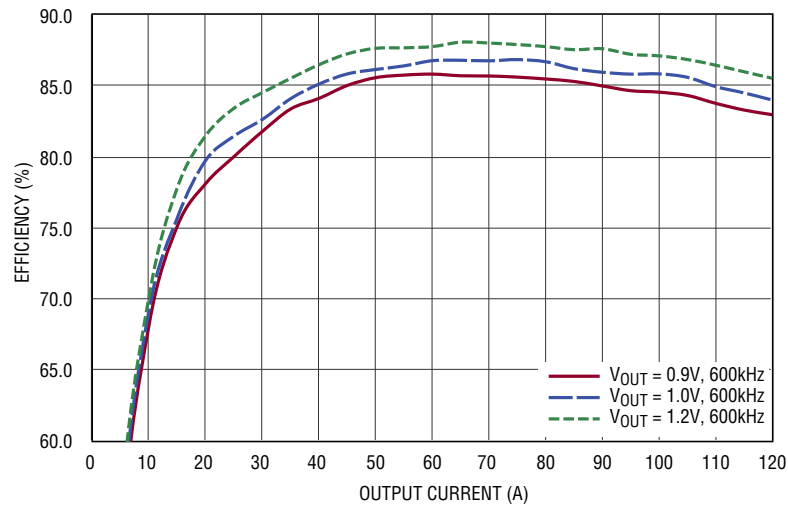


Figure 2. Measured Efficiency at  $V_{IN} = 12V$ ,  $f_{SW} = 600kHz$ , CCM

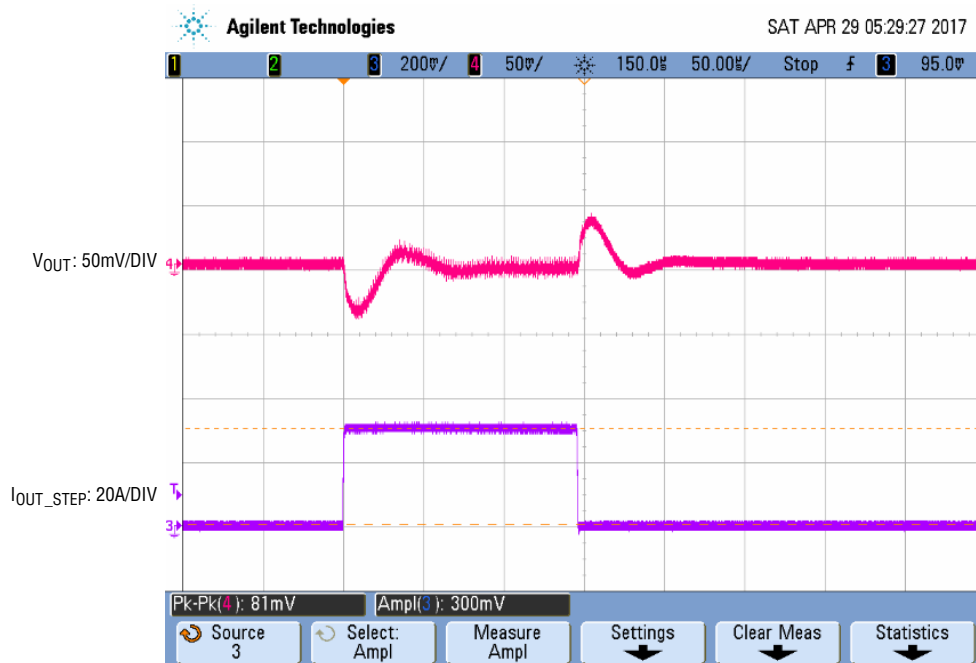


Figure 3. Measured Load Transient  
 $V_{IN} = 12V$ ,  $V_{OUT} = 1.0V$ ,  $I_{STEP} = 0A$  to  $30A$

**QUICK START PROCEDURE**

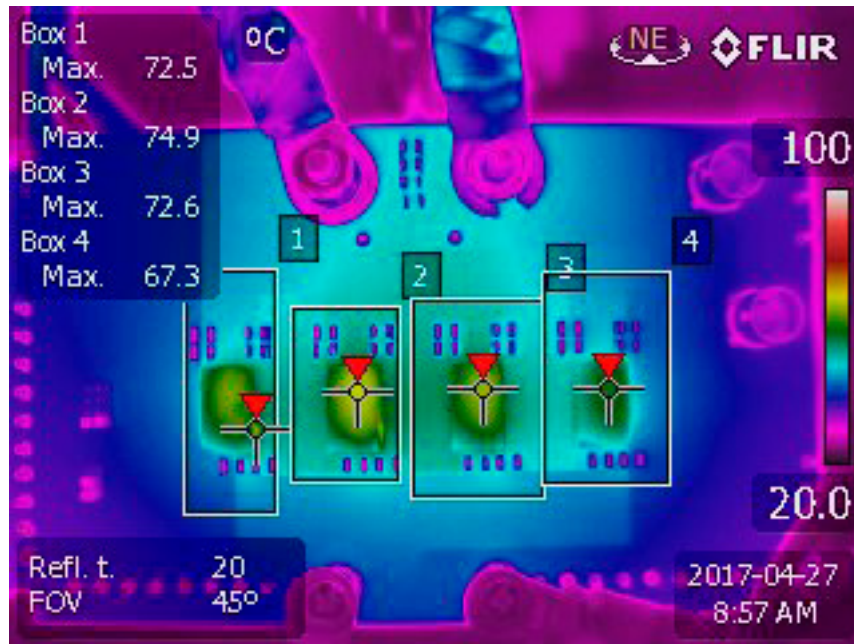


Figure 4. Thermal Capture at 12V<sub>IN</sub>, 1.0V<sub>OUT</sub>, 120A (T<sub>A</sub> = 25°C, 400LFM Airflow and No Heat Sink)

# DEMO MANUAL DC2616A-D

## PARTS LIST

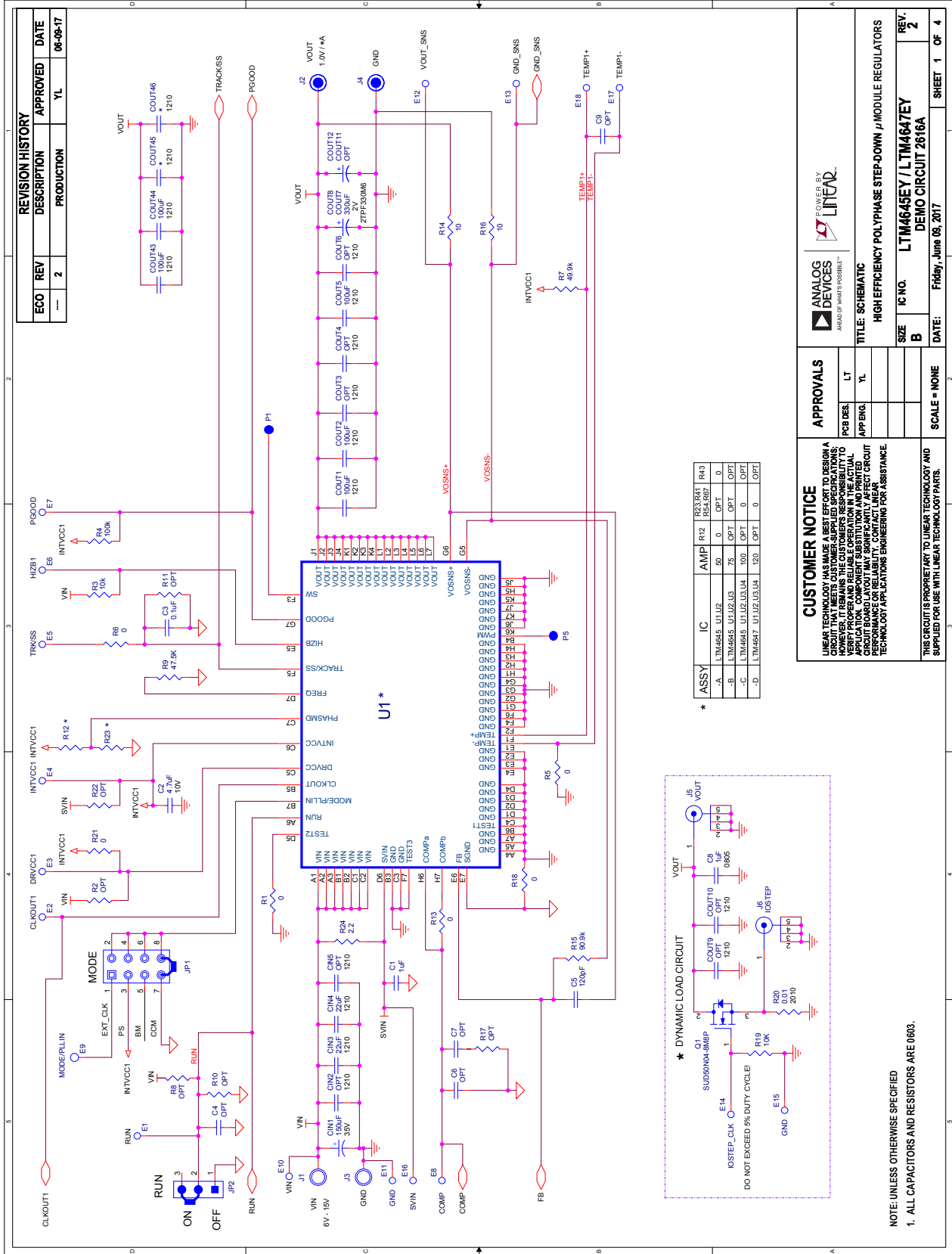
| ITEM                               | QTY | REFERENCE   | PART DESCRIPTION   | MANUFACTURER/PART NUMBER   |
|------------------------------------|-----|---|--|--|
| <b>Required Circuit Components</b> |     |   |  |  |
| 1                                  | 4   | C1, C12, C19, C22   | CAP., 1 $\mu$ F, X7R, 50V, 10%, 0603                           | TAIYO YUDEN, UMK107AB7105KA-T  |
| 2                                  | 16  | COUT1, COUT2, COUT5, COUT14, COUT15, COUT21, COUT24, COUT25, COUT31, COUT34, COUT35, COUT41, COUT43, COUT44, COUT45, COUT46 | CAP., 100 $\mu$ F, X5R, 6.3V, 20%, 1210                        | MURATA, GRM32ER60J107ME20L   |
| 3                                  | 1   | CIN1  | CAP., 150 $\mu$ F, ALUM., 35V, 20%, 10x10.5mm, SMD, HVH Series | SUN ELECTRONIC INDUSTRIES CORP, 35HVH150M  |
| 4                                  | 3   | C2, C11, C18, C21   | CAP., 4.7 $\mu$ F, X5R, 10V, 10%, 0603                         | AVX, 0603ZD475KAT2A<br>TAIYO YUDEN, LMK107BJ475KA-T<br>TDK, C1608X5R1A475K080AC        |
| 5                                  | 1   | C3  | CAP., 0.1 $\mu$ F, X7R, 16V, 10%, 0603                         | AVX, 0603YC104KAT2A<br>NIC, NMC0603X7R104K16TRPF                                       |
| 6                                  | 8   | CIN3, CIN4, CIN7, CIN8, CIN12, CIN13, CIN17, CIN18  | CAP., 22 $\mu$ F, X5R, 25V, 20%, 1210                          | AVX, 12103D226MAT2A<br>MURATA, GRM32ER61E226ME15L                                      |
| 7                                  | 1   | C5  | CAP., 120pF, X7R, 50V, 10%, 0603                               | YAGEO, CC0603KRX7R9BB121   |
| 8                                  | 8   | COUT7, COUT8, COUT13, COUT19, COUT23, COUT29, COUT33, COUT39  | CAP., 330 $\mu$ F, TANT, 2V, 20%, 7343, D2E                    | PANASONIC, 2TPF330M6   |
| 9                                  | 1   | C8  | CAP., 1 $\mu$ F, X7R, 50V, 10%, 0805                           | MURATA, GRM21BR71H105KA12L<br>TAIYO YUDEN, UMK212B7105KG-T<br>YAGEO, CC0805KKX7R9BB105 |
| 10                                 | 5   | R3, R19, R46, R59, R72  | RES., 10k, 1%, 1/10W, 0603, AEC-Q200                           | KOA SPEER, RK73H1JTTD1002F<br>PANASONIC, ERJ3EKF1002V<br>VISHAY, CRCW060310K0FKEA      |
| 11                                 | 1   | R4  | RES., 100k, 1%, 1/10W, 0603                                    | NIC, NRC06F1003TRF<br>PANASONIC, ERJ3EKF1003V<br>VISHAY, CRCW0603100KFEA               |
| 12                                 | 4   | R7, R26, R48, R61   | RES., 49.9k, 1%, 1/10W, 0603                                   | VISHAY, CRCW060349K9FKEA<br>YAGEO, RC0603FR-0749K9L                                    |
| 13                                 | 4   | R9, R44, R57, R70   | RES., 47.5k, 1%, 1/10W, 0603                                   | VISHAY, CRCW060347K5FKEA<br>YAGEO, RC0603FR-0747K5L                                    |
| 14                                 | 2   | R14, R16  | RES., 10 $\Omega$ S, 5%, 1/10W, 0603                           | NIC, NRC06J100TRF<br>VISHAY, CRCW060310R0JNEA  |
| 15                                 | 1   | R15   | RES., 90.9k, 1%, 1/10W, 0603, AEC-Q200                         | KOA SPEER, RK73H1JTTD9092F<br>PANASONIC, ERJ3EKF9092V<br>VISHAY, CRCW060390K9FKEA      |
| 16                                 | 1   | R20   | RES., 0.01 $\Omega$ , 1%, 1/2W, 2010, SENSE, AEC-Q200          | VISHAY, WSL2010R0100FEA  |
| 17                                 | 1   | R24   | RES., 2.2 $\Omega$ S, 5%, 1/10W, 0603, AEC-Q200                | VISHAY, CRCW06032R20JNEA   |
| 18                                 | 4   | U1, U2, U3, U4  | IC, SINGLE 30A DC/DC $\mu$ Module REG., BGA-77 (15x9x5.01mm)   | ANALOG DEVICES, LTM4647EY#PBF  |

## PARTS LIST

| ITEM  | QTY | REFERENCE   | PART DESCRIPTION   | MANUFACTURER/PART NUMBER                                     |
|---|-----|---|--|--|
| <b>Additional Demo Board Circuit Components</b> |     |   |  |  |
| 1   | 1   | Q1  | XSTR., MOSFET, N-CH, 40V, TO-252 (DPAK)                    | VISHAY, SUD50N04-8M8P-4GE3                                   |
| 2   | 25  | R1, R5, R6, R13, R18, R21, R23, R27, R28, R36, R38, R41, R45, R49, R50, R51, R52, R54, R58, R62, R63, R64, R65, R67, R71  | RES., 0Ω, 1/10W, 0603                                      | NIC, NRC06ZOTRF<br>VISHAY, CRCW060300000Z0EA                 |
| 3   | 0   | U4 (OPT)  | IC., OPTION, BGA-77  |  |
| 4   | 0   | R2, R8, R10, R11, R12, R17, R22, R23, R39, R41, R42, R43, R53, R54, R55, R56, R66, R67, R68, R69 (OPT)  | RES., OPTION, 0603   |  |
| 5   | 0   | COU11, COU12, COU17, COU18, COU27, COU28, COU37, COU38 (OPT)  | CAP., OPTION, D3L  |  |
| 6   | 0   | C4, C6, C7, C9, C17, C20, C23, C24, C25, C26 (OPT)  | CAP., OPTION, 0603   |  |
| 7   | 0   | CIN2, CIN5, CIN6, CIN9, CIN11, CIN14, CIN16, CIN19, COU3, COU4, COU6, COU9, COU10, COU16, COU20, COU22, COU26, COU30, COU32, COU36, COU40, COU42 (OPT)                    | CAP., OPTION, 1210   |  |
| 8   | 0   | COU33, COU39 (OPT)  | CAP., OPTION, D2E  |  |
| <b>Hardware: For Demo Board Only</b>            |     |   |  |  |
| 1   | 36  | E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19, E20, E21, E22, E23, E24, E25, E26, E27, E28, E29, E30, E31, E32, E33, E34, E35, E36 | TEST POINT, TURRET, 0.064, MTG. HOLE                       | MILL-MAX, 2308-2-00-80-00-00-07-0                            |
| 2   | 1   | JP1   | CONN., HDR, MALE, 2x4, 2mm, THT STR                        | SULLINS CONNECTOR SOLUTIONS, NRPN042PAEN-RC                  |
| 3   | 2   | J1, J3  | CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE      | KEYSTONE, 575-4  |
| 4   | 2   | J2, J4  | WASHER, FLAT, STEEL, ZINC PLATE, OD: 0.436 [11.1]          | KEYSTONE, 4703   |
| 5   | 2   | J2, J4  | STUD, FASTENER, #10-32                                     | PENNENGINEERING, KFH-032-10<br>PENNENGINEERING, KFH-032-10ET |
| 6   | 4   | J2, J4  | NUT, HEX, STEEL, ZINC PLATE, 10-32                         | KEYSTONE, 4705   |
| 7   | 2   | J2, J4  | RING, LUG, CRIMP, #10, NON-INSULATED, SOLDERLESS TERMINALS | KEYSTONE, 8205   |
| 8   | 1   | JP2   | CONN., HDR., MALE, 1x3, 2mm, THT, STR                      | SULLINS CONNECTOR SOLUTIONS, NRPN031PAEN-RC                  |
| 9   | 2   | J5, J6  | CONN., RF, BNC, RCPT, THT, STR, 5-PIN                      | AMPHENOL CONNEX, 112404                                      |
| 10  | 4   | MH1, MH2, MH3, MH4  | STANDOFF, NYLON, SNAP-ON, 0.50                             | KEYSTONE, 8833   |
| 11  | 2   | XJP1, XJP2  | CONN., SHUNT, FEMALE, 2 POS, 2mm                           | SAMTEC, 2SN-BK-G   |

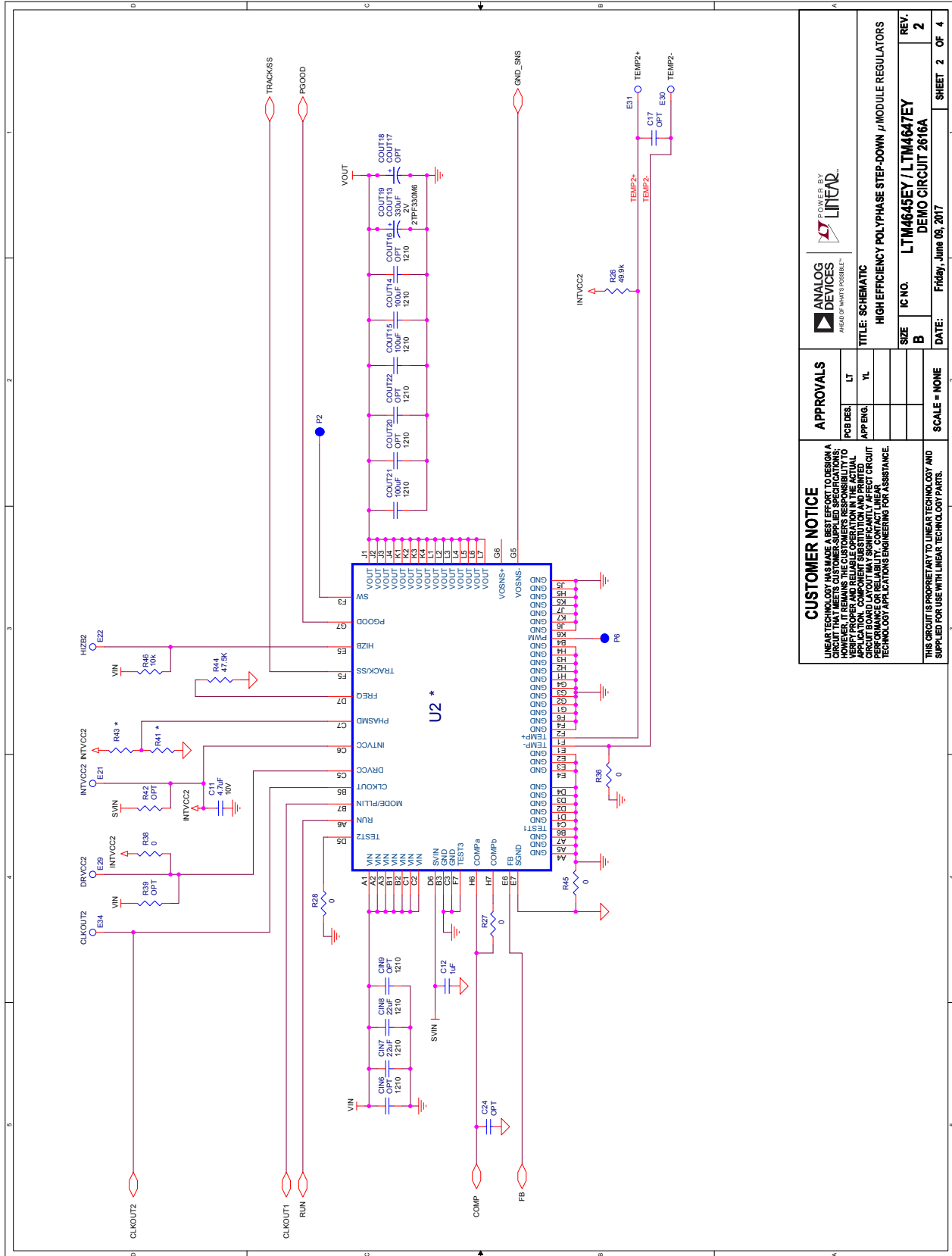
# DEMO MANUAL DC2616A-D

## SCHEMATIC DIAGRAM





## SCHEMATIC DIAGRAM



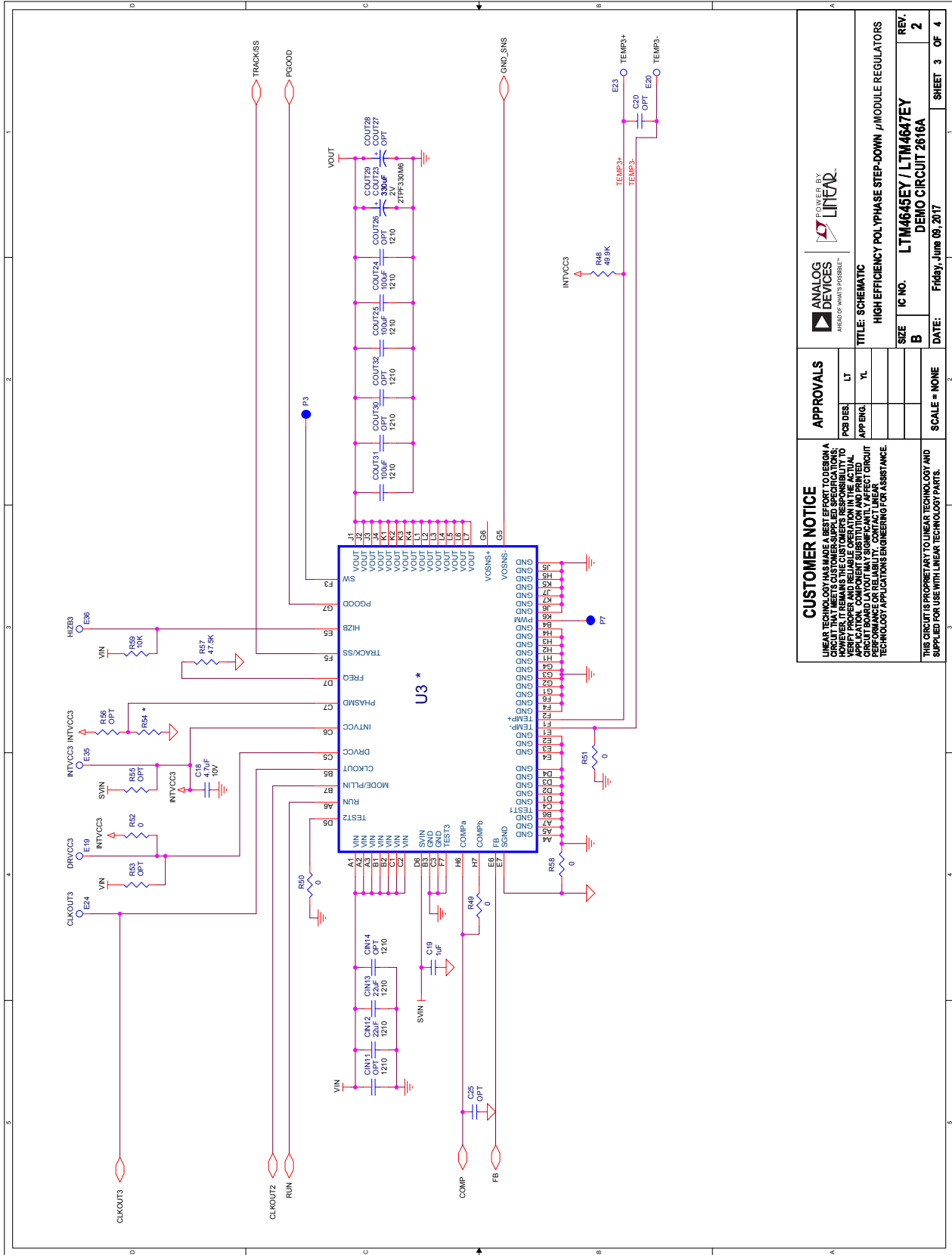
|                  |    |  |                             |
|------------------|----|--|-----------------------------|
|                  |    |  |                             |
| <b>APPROVALS</b> |    | <b>TITLE: SCHEMATIC</b>  |                             |
| PB DES.          | LT | <b>HIGH EFFICIENCY POLYPHASE STEP-DOWN μ-MODULE REGULATORS</b> |                             |
| APPNG.           | YL | <b>IC NO. LTM4645EY / LTM4647EY</b>                            |                             |
|                  |    | <b>DEMO CIRCUIT 2616A</b>                                      |                             |
|                  |    | SCALE = NONE   | REV. 2                      |
|                  |    |  | DATE: Friday, June 09, 2017 |
|                  |    |  | SHEET 2 OF 4                |

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# DEMO MANUAL DC2616A-D

## SCHEMATIC DIAGRAM

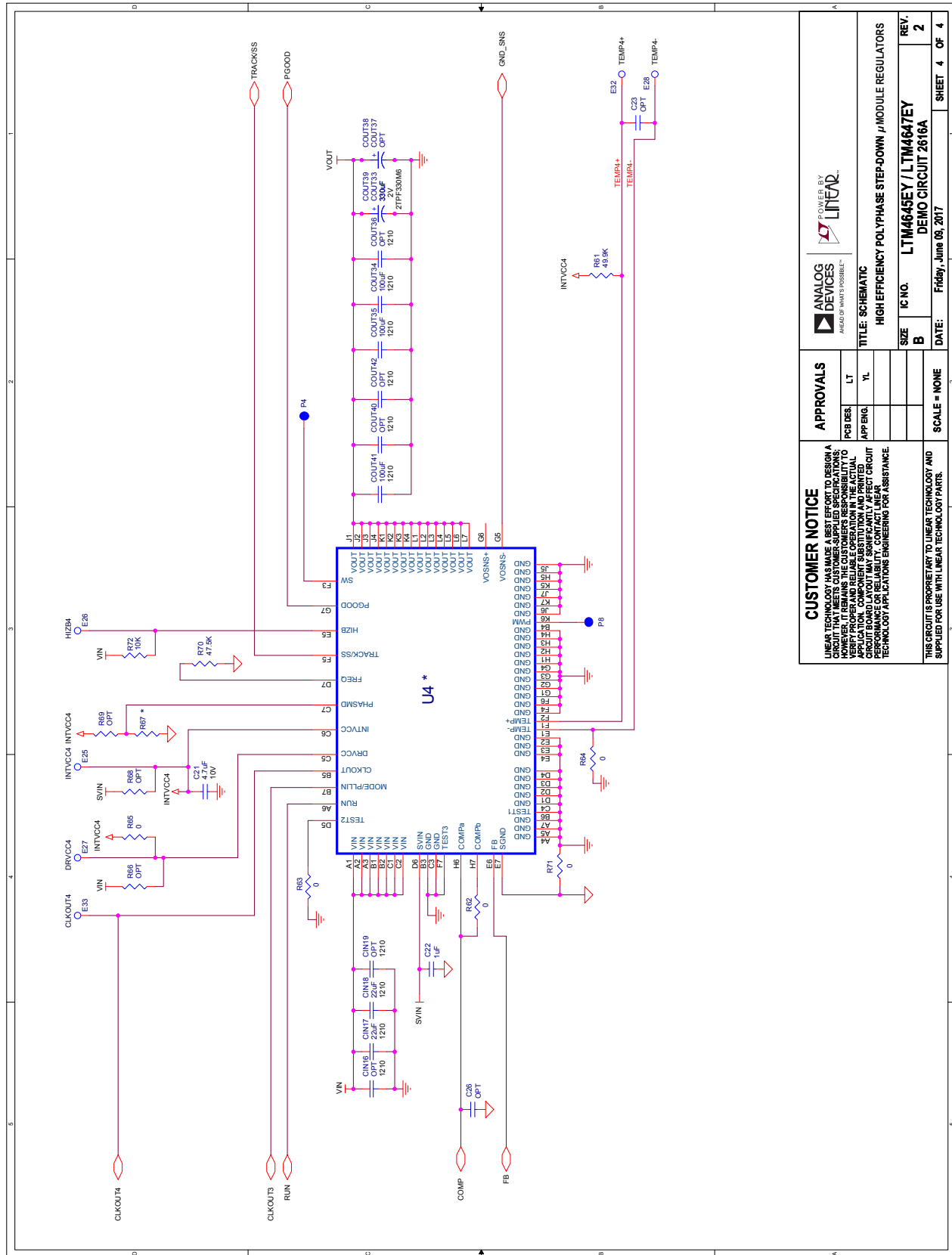


|   |  |   |  |
|---|--|---|--|
|   |  |   |  |
| TITLE: SCHEMATIC<br>HIGH EFFICIENCY POLY-PHASE STEP-DOWN μMODULE REGULATORS |  |   |  |
| SIZE: B   |  | IC NO.: LTM4645EY / LTM4647EY<br>DEMO CIRCUIT 2616A |  |
| SCALE: NONE   |  | DATE: Friday, June 09, 2017                         |  |
| SHEET: 3 OF 4   |  | REV: 2  |  |

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## SCHEMATIC DIAGRAM



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|   |          |  |                        |
|---|----------|--|------------------------|
|   |          |  |                        |
| TITLE: SCHEMATIC<br>HIGH EFFICIENCY POLYPHASE STEP-DOWN $\mu$ MODULE REGULATORS |          | IC NO. LTM4645EY / LTM4647EY<br>DEMO CIRCUIT 2616A |                        |
| APPROVALS<br>PDES. _____<br>APPNG. _____  | LT<br>YL | SIZE B<br>SCALE = NONE                             | REV. 2<br>SHEET 4 OF 4 |
| DATE: Friday, June 09, 2017   |          | DATE: Friday, June 09, 2017                        |                        |



## 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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