# LTC3372EUK
# 4-Channel 8A Configurable Buck Plus Low $I_Q$ High Voltage Buck Supply

## DESCRIPTION

Demonstration circuit 2419A features the LTC®3372 in a multi-output step-down converter. The controller portion of the LTC3372 drives a high output voltage (HV) buck converter which has an input voltage range of 6V to 60V. Its output voltage ($V_{OUT\_HV}$) is nominally 5V but can be configured for either 5V or 3.3V with the $V_{OUTPRG}$ pin. $V_{OUT\_HV}$ supplies power to the configurable buck regulator. This regulator provides four low voltage (LV) outputs labelled $V_{OUT1-4}$. These outputs are 1.2V/2A, 1.8V/2A, 2.5V/2A and 3.3V/2A respectively. When $V_{OUT\_HV}$ is configured for 5V, it can supply 6A to the external loads with full load on $V_{OUT1-4}$. With no load on $V_{OUT1-4}$, $V_{OUT\_HV}$ can supply 10A to the external loads. See Figure 3 for the Block Diagram.

The LV buck regulator consists of eight power stages that can be arranged in up to four channels. The LV regulator on the DC2419A is setup for four channels of two power stages each. With modifications, the LV buck regulator can be setup for eight different configurations. See the LV Regulator Configuration section for more details.

If $V_{OUT\_HV}$ is programmed for 3.3V, then $V_{OUT4}$ which provides 3.3V/2A will be in dropout. This rail will require an external input voltage to stay in regulation. See the LV Regulator Configuration section for more details.

The LV rails operate at 2MHz and the HV converter operates at one-sixth this frequency or 333kHz. The high frequency of the LV rails allows the use of 4mm × 4mm inductors. The power stage for the HV converter consists of 60V avalanche rated MOSFETs and a 2.2µH 10mm × 10mm inductor. A 4mΩ discrete sense resistor is used to sense current.

The low $I_Q$ current of the LTC3372 provides high efficiency at light loads. When the $V_{OUT\_HV}$ is supplying the nominal 5V, its Burst Mode® efficiency with 1mA load is 90.3% for a 12V input, see Figure 9. When the HV converter is off, it only draws 27µA from a 12V input.

Other features of the board include:

- Selectable light load operating modes of:
  - FCM
  - Pulse-skipping (HV) and Burst Mode operation (LV)
  - Burst Mode operation
- PLLIN pin to synchronize the LV regulators over a 1MHz to 3MHz range (166kHz to 500kHz for the HV converter)
- Watch dog circuit
- TEMP pin to monitor the junction temperature of the LTC3372
- PGOOD pin for the HV converter and $\overline{RST}$ pin for the LV regulators

The LTC3372 data sheet provides a complete description of the IC operation and application information. The data sheet must be read in conjunction with the quick start guide.

**Design files for this circuit board are available at http://www.analog.com/DC2419A**

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## PERFORMANCE SUMMARY Specifications are at $T_A = 25°C$

**Table 1. Performance Summary for the HV Converter ($T_A = 25°C$), No Airflow**

| PARAMETER | CONDITION | VALUE |
|---|---|---|
| Minimum Input Voltage ($V_{IN}$) | | 6V |
| Maximum Input Voltage ($V_{IN}$) | | 60V |
| Output Voltage ($V_{OUT\_HV}$) | $I_{OUT\_HV}$ = 0A to 10A, No load on $V_{OUT1-4}$<br>$V_{OUTPRG}$ Tied High | 5V ± 2% |
| Output Voltage ($V_{OUT\_HV}$) | $I_{OUT\_HV}$ = 0A to 10A, No load on $V_{OUT1-4}$<br>$V_{OUTPRG}$ Tied Low | 3.3V ± 2% |
| $I_{OUT(MAX)}$ for $V_{OUT\_HV}$ | $V_{IN}$ = 6V to 60V, $V_{OUT\_HV}$ = 5V or 3.3V<br>No Load on $V_{OUT1-4}$ | 10A |
| Nominal Switching Frequency | | 333kHz |
| Efficiency<br>See Figures 7 to 10 | $V_{OUT\_HV}$ = 5V, $V_{IN}$ = 12V, $I_{OUT\_HV}$ = 10A<br>$V_{OUT\_HV}$ = 5V, $V_{IN}$ = 48V, $I_{OUT\_HV}$ = 10A | 94.6% Typical<br>90.6% Typical |

**Table 2. Performance Summary for the LV Regulators ($T_A = 25°C$), No Airflow**

| PARAMETER | CONDITION | VALUE |
|---|---|---|
| Minimum Input Voltage ($V_{IN\_LV}$)* | | 2.25V |
| Maximum Input Voltage ($V_{IN\_LV}$)* | | 5.5V |
| Output Voltage $V_{OUT1}$ | $I_{OUT1}$ = 0A to 2A, $V_{IN\_LV}$ = 5V or 3.3V | 1.2V ± 1% |
| Output Voltage $V_{OUT2}$ | $I_{OUT2}$ = 0A to 2A, $V_{IN\_LV}$ = 5V or 3.3V | 1.8V ± 2% |
| Output Voltage $V_{OUT3}$ | $I_{OUT3}$ = 0A to 2A, $V_{IN\_LV}$ = 5V or 3.3V | 2.5V ± 3% |
| Output Voltage $V_{OUT4}$ | $I_{OUT4}$ = 0A to 2A, $V_{IN\_LV}$ = 5V Only | 3.3V ± 3% |
| Nominal Switching Frequency | | 2MHz |
| Efficiency<br>See Figures 11 to 14 | $V_{OUT1}$ = 1.2V, $I_{OUT1}$ = 2A, $V_{IN\_LV}$ = 5V | 79.7% Typical |
| | $V_{OUT2}$ = 1.8V, $I_{OUT2}$ = 2A, $V_{IN\_LV}$ = 5V | 84.7% Typical |
| | $V_{OUT3}$ = 2.5V, $I_{OUT3}$ = 2A, $V_{IN\_LV}$ = 5V | 88.0% Typical |
| | $V_{OUT4}$ = 3.3V, $I_{OUT4}$ = 2A, $V_{IN\_LV}$ = 5V | 90.4% Typical |

*$V_{IN\_LV}$ and $V_{OUT\_HV}$ share the same net on the demo board.

## QUICK START PROCEDURE

The evaluation setup for demonstration circuit 2419A is straight forward. Refer to the diagram shown in Figure 1.

Next, follow the procedure below:

1) With power off, connect the input supply, load and meters as shown in Figure 1. Preset the loads to 0A and $V_{IN}$ supply to be 0V.
2) Place the RUN jumper in the ON position and EN1 to EN4 in the off position. Make sure $V_{OUTPRG}$ is in the 5V position and the PULLUP PWR jumper is in the $INTV_{CC}$ position.
3) Set the input voltage to 12V.
4) Check $V_{OUT\_HV}$. The output voltage should be within the regulation limits shown in the performance summary table for the HV converter.
5) Apply 10A load and re-measure $V_{OUT\_HV}$. It should be within the same regulation limits.
6) Make sure the PULLUP PWR jumper is in the $INTV_{CC}$ position. This will ensure the EN pins for the LV regulators can be pulled high for the steps that follow.

## QUICK START PROCEDURE

7) Place EN1 in the ON position.

8) Measure $V_{OUT1}$. It should be within the regulation limits shown in the performance summary table for the low voltage regulators.

9) Apply 2A load to $V_{OUT1}$. It should be within the same regulation limits.

10) Repeat steps 7 to 9 for $V_{OUT2-4}$.

11) With 2A load each on $V_{OUT1-4}$ and 6A load on $V_{OUT\_HV}$, measure the input current flowing into $V_{IN}$ at an input voltage of 12V. It should be less than 4.58A.

12) After the basic performance has been verified, the other aspects of performance can be measured and observed.

## OUTPUT RIPPLE MEASUREMENT

When measuring the output voltage or input voltage ripple, be sure to place the probe directly across an output or input capacitor. Figure 2 shows one example. Leads are soldered to either side of the capacitor. The probe's ground ring makes contact with the return lead and the probe tip makes contact with the other lead.

## AIRFLOW REQUIREMENTS

When $V_{OUT\_HV}$ is 5V, the demo board can operate with no airflow at room temperature ambient with full load on all outputs for input voltages up to 60V.

When $V_{OUT\_HV}$ is 3.3V, airflow will be required with full load on all outputs and high input voltages due to losses in the $INTV_{CC}$ LDO. Here are some guidelines to follow:

$V_{IN}$ = 12V: no airflow

$V_{IN}$ = 36V: 200 LFM airflow

$V_{IN}$ = 48V: 400 LFM airflow

## LV REGULATOR CONFIGURATION

The LV regulator section consists of eight power stages labeled A to H which can be arranged in up to four channels. Each stage consists of a PMOS top FET and NMOS bottom FET and can supply 1A each. The stages are paralleled by tying their input voltages together and SW nodes together. When paralleled, the combined stages can supply N x 1A, where N is the number of parallel stages. Up to four stages can be paralleled.

The LV regulators on the demo board are setup for the 2-2-2-2 configuration. 2-2-2-2 means four channels with two stages each. As indicated, the switch nodes are tied in pairs: SWA and B, SWC and D, SWE and F and SWG and H. Modifying the LV regulation section involves these steps:

1) Cutting and jumping the SW traces. The SW pairs mentioned above are all separable. A SW trace in one pair can be tied to a SW trace in another pair by making a cut and jump. Use 28 AWG or similar size wire. Make the cuts and jumps close to the SW pins. To facilitate this, openings in the solder mask were placed over the SW traces next to the SW pins.

2) Setting the configuration bits. Pins C1 to C3 are the configuration bits. By tying these pins high or low, different configurations can be programmed. Refer to Table 1 in the data sheet for the complete list of configurations.

## LV REGULATOR CONFIGURATION

3) If a channel is not used, then tie its FB pin and EN pin to ground. Also remove the inductor.

The $V_{IN}$ pin for each stage is tied to the output of the HV converter with 0mΩ jumpers.

Figure 4 and Figure 5 show how to setup the board for two different configurations.

Refer to the Applications Information section of the data sheet for guidance on selecting the output capacitors and inductors when adding or removing a power stage to or from a channel.

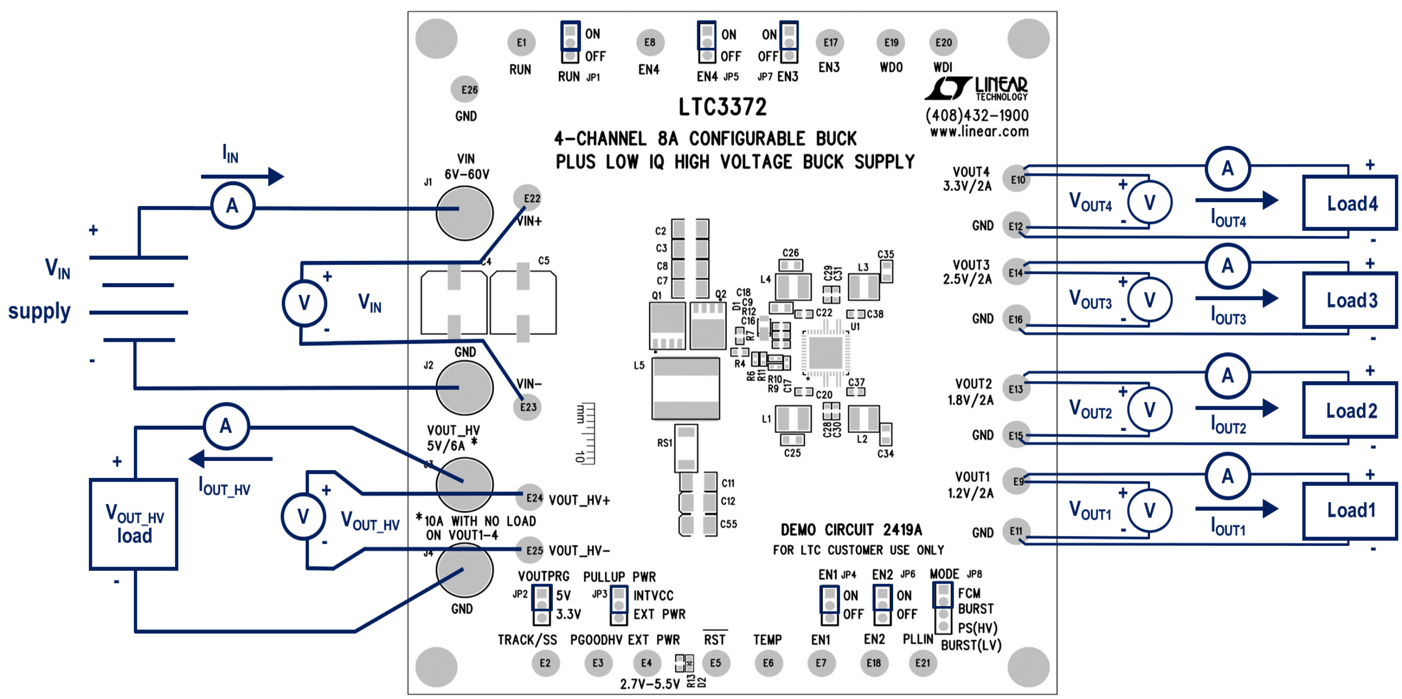
For a few cases an external supply may be required for the LV regulators. This could happen for the following reasons:

- The HV converter is fed from a supply which does not have sufficient power.
- An external load is drawing too much current from the HV converter.
- A LV regulator needs more headroom.

To supply a LV regulator channel with an external supply, follow these steps:

- Remove the 0mΩ copper jumper tying $V_{IN\_LV}$ to the channel's input pins. $V_{IN\_LV}$ and $V_{OUT\_HV}$ share the same net.
- Place a small bulk capacitor from the input to ground for damping.
- Connect the external supply across this capacitor.

See Figure 6 for more details




NOTE: FOR ACCURATE EFFICIENCY MEASUREMENTS OF THE LV RAILS, MONITOR THEIR OUTPUT VOLTAGE AND INPUT VOLTAGE AT THE FOLLOWING POINTS

| CHANNEL #1: | CHANNEL #2: | CHANNEL #3: | CHANNEL #4: |
|---|---|---|---|
| $V_{OUT1}$: C25 | $V_{OUT2}$: C34 | $V_{OUT3}$: C35 | $V_{OUT4}$: C26 |
| $V_{INAB}$: C20 OR C28 | $V_{INC}$, $V_{IND}$: C30 OR C37 | $V_{INE}$, $V_{INF}$: C38 OR C31 | $V_{ING}$, $V_{INH}$: C29 AND C22 |

DC2419a F01

**Figure 1. Proper Measurement Setup of the DC2419A**

# QUICK START PROCEDURE

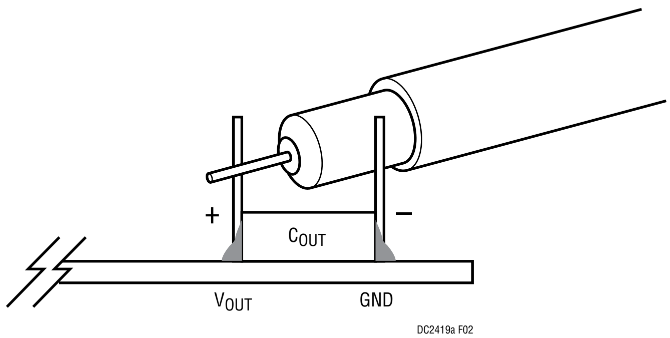



**Figure 2. Measuring Output Voltage Ripple**

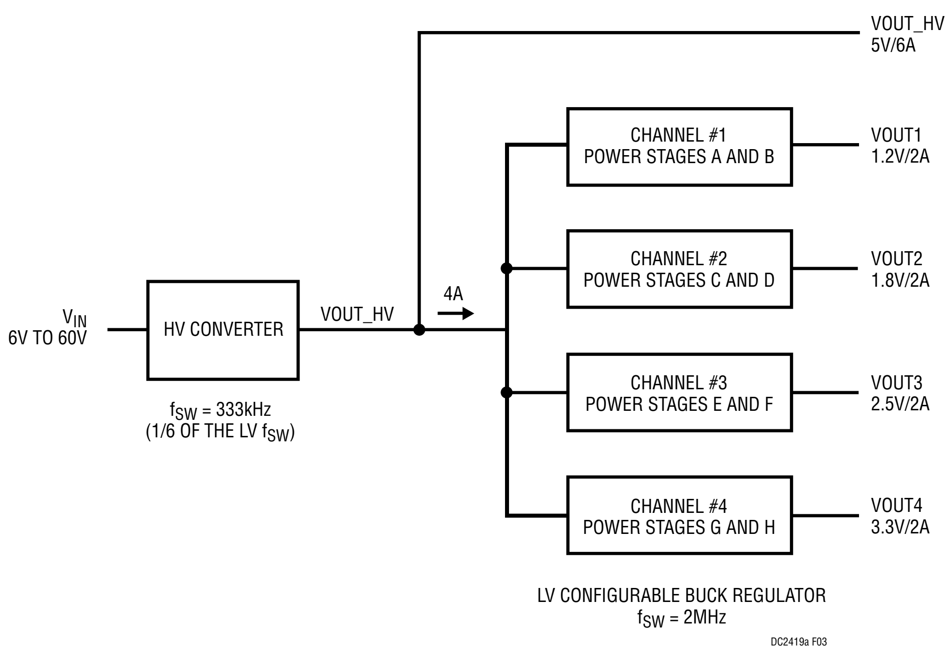
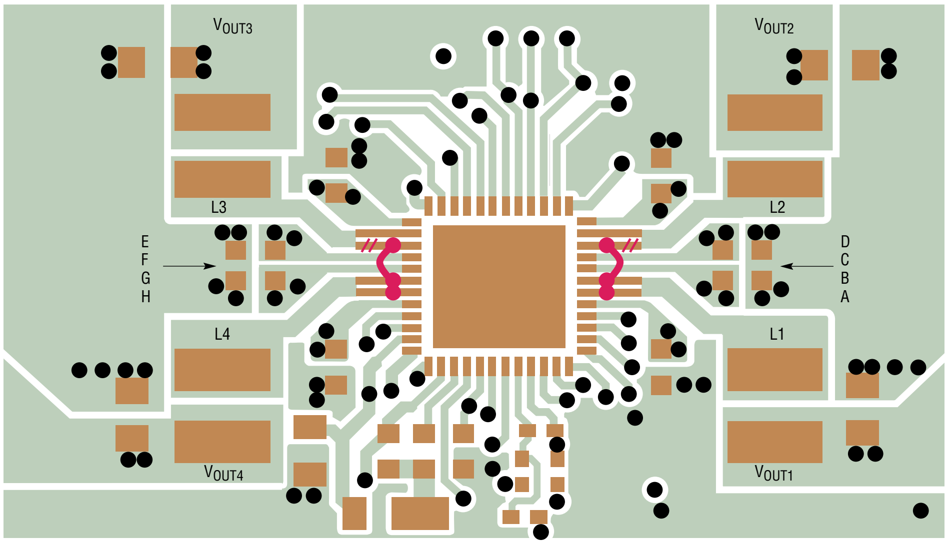
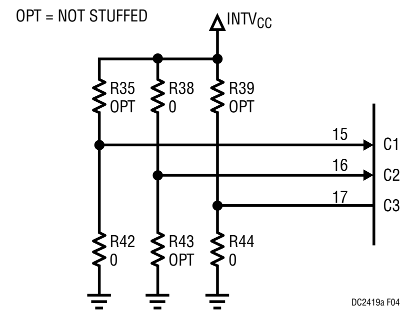



**Figure 3. DC2419A Block Diagram**

# QUICK START PROCEDURE

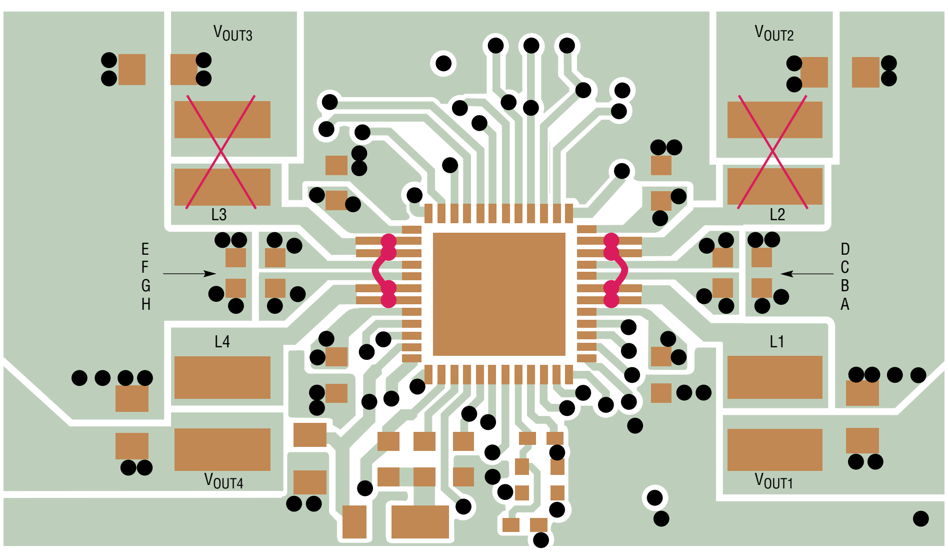


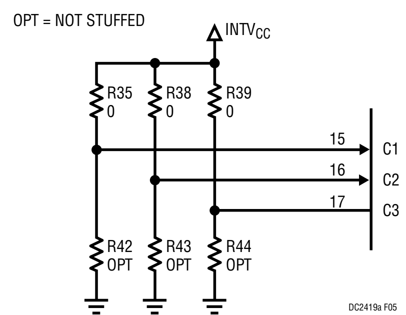

// = CUT

WITH THIS CONFIGURATION, CHANNELS 1 AND 4 PROVIDE 3A OUTPUTS WHILE CHANNELS 2 AND 3 PROVIDE 1A OUTPUTS. THE FOOTPRINTS OF L1 AND L4 CAN BE STUFFED WITH 5mm × 5mm INDUCTORS TO ALLOW HIGHER CURRENT DEVICES TO BE USED. ORIGINAL DESIGN USES 4mm × 4mm INDUCTORS.

**Figure 4. DC2419A Setup for the ABC-D-E-FGH Configuration**



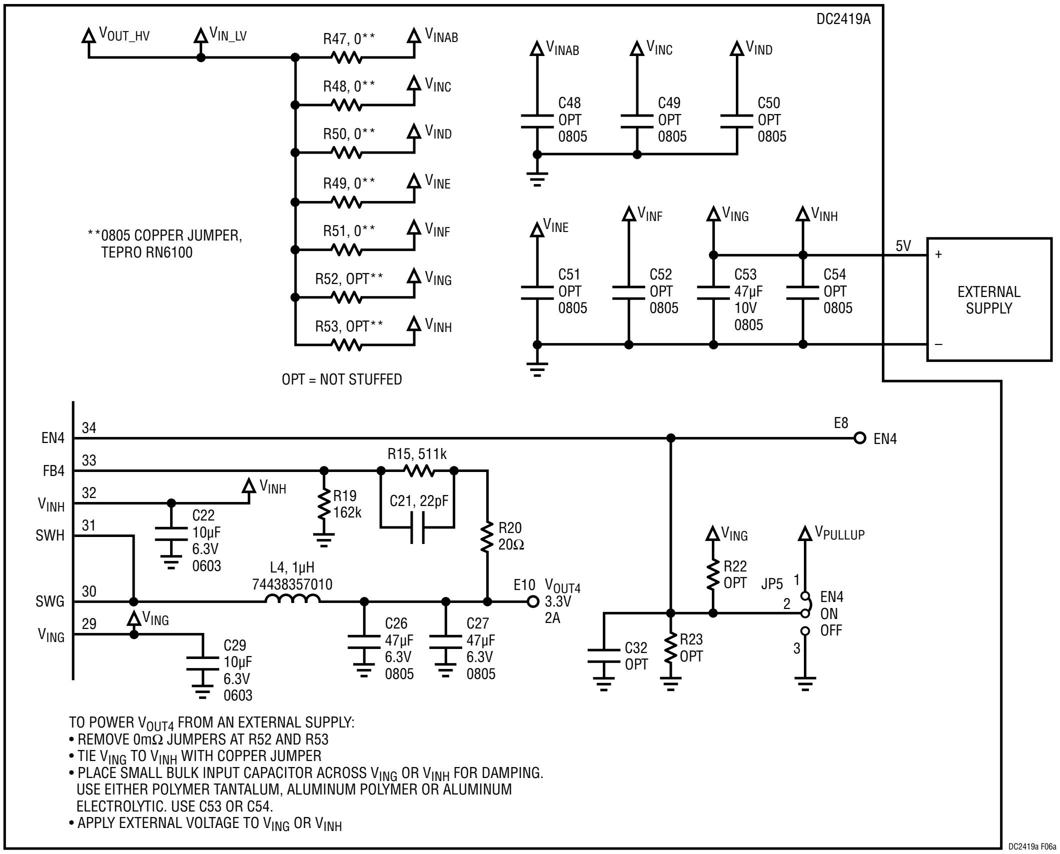

NOTE:
TIE THE EN AND FB PINS OF CHANNELS 2 AND 3 TO GND SINCE THEY ARE NOT BEING USED.



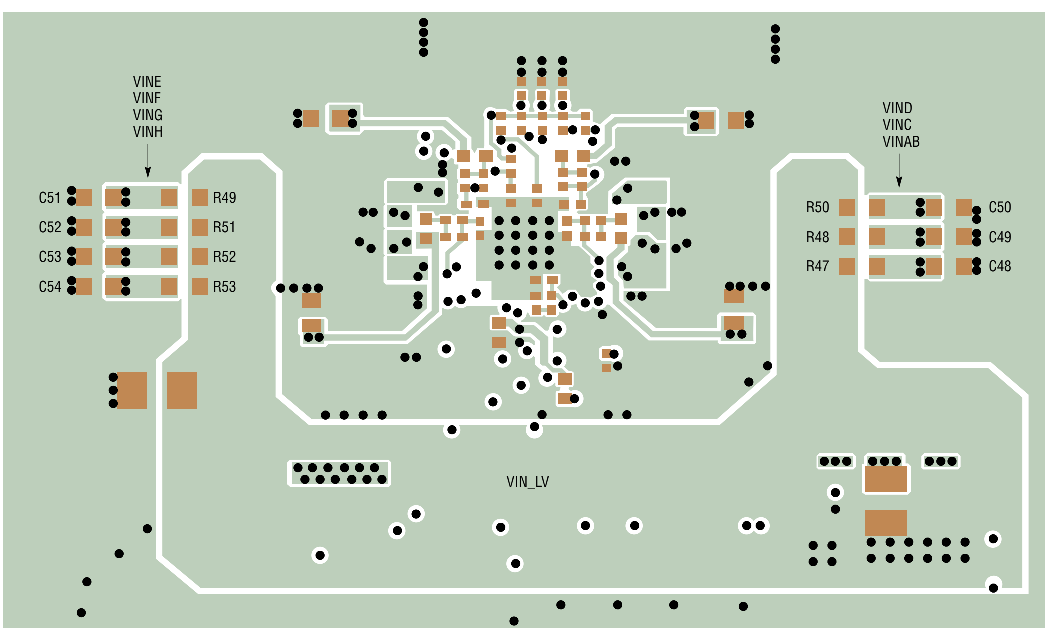

WITH THIS CONFIGURATION, BOTH CHANNELS 1 AND 4 PROVIDE 4A OUTPUTS. CHANNELS 2 AND 3 ARE NOT USED. THE FOOTPRINTS OF L1 AND L4 CAN BE STUFFED WITH 5mm × 5mm INDUCTORS TO ALLOW HIGHER CURRENT DEVICES TO BE USED. ORIGINAL DESIGN USES 4mm × 4mm INDUCTORS.

**Figure 5. DC2419A Setup for the ABCD- EFGH Configuration**

## QUICK START PROCEDURE



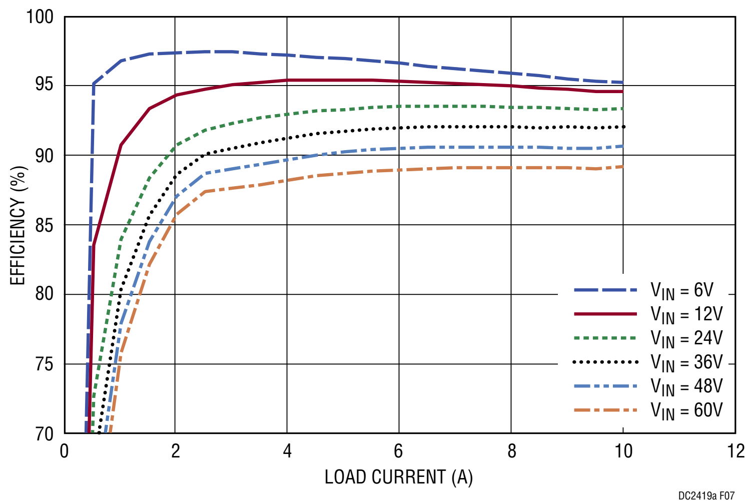

**(a) Example: Supplying the 3.3V, 2A Rail with an External Voltage**




**(b) Location of the $V_{IN\_LV}$ Jumpers and the Optional LV Input Capacitors**

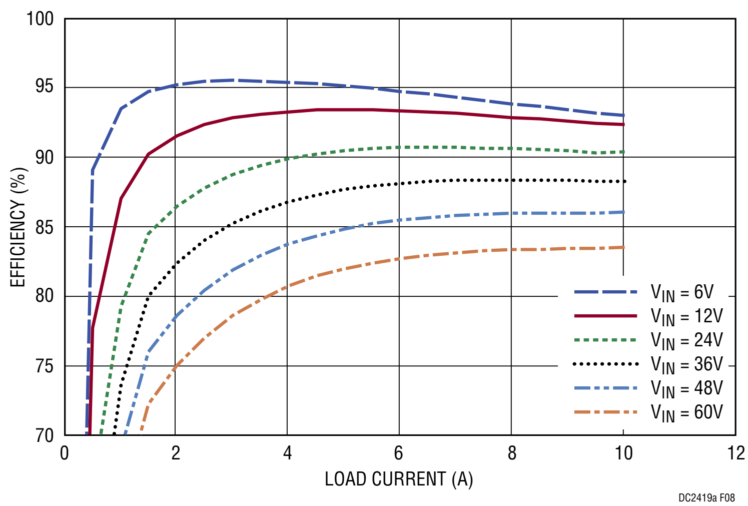
**Figure 6. How to Connect an External Supply to the Input of a LV Rail**

# QUICK START PROCEDURE




L: COILCRAFT XAL1010-222ME (2.2µH, 2.55mΩ TYP)
TOP FET: RJK0651DPB
BOTTOM FET: RJK0652DPB
$f_{SW}$: 330kHz
$R_{SENSE}$: 4mΩ
LV REGULATORS DISABLED

**Figure 7. Efficiency of the HV Converter in FCM, $V_{OUT\_HV}$ = 5V**




L: COILCRAFT XAL1010-222ME (2.2µH, 2.55mΩ TYP)
TOP FET: RJK0651DPB
BOTTOM FET: RJK0652DPB
$f_{SW}$: 330kHz
$R_{SENSE}$: 4mΩ
LV REGULATORS DISABLED

**Figure 8. Efficiency of the HV Converter in FCM, $V_{OUT\_HV}$ = 3.3V**

# QUICK START PROCEDURE

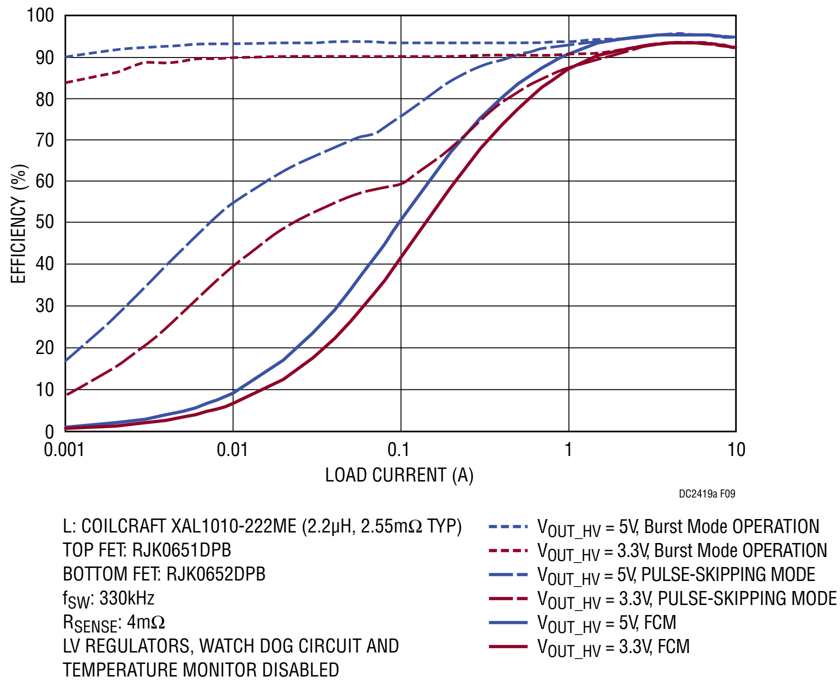



**Figure 9. Efficiency of the HV Converter in FCM, Pulse-Skipping and Burst Mode Operation, $V_{IN}$ = 12V**

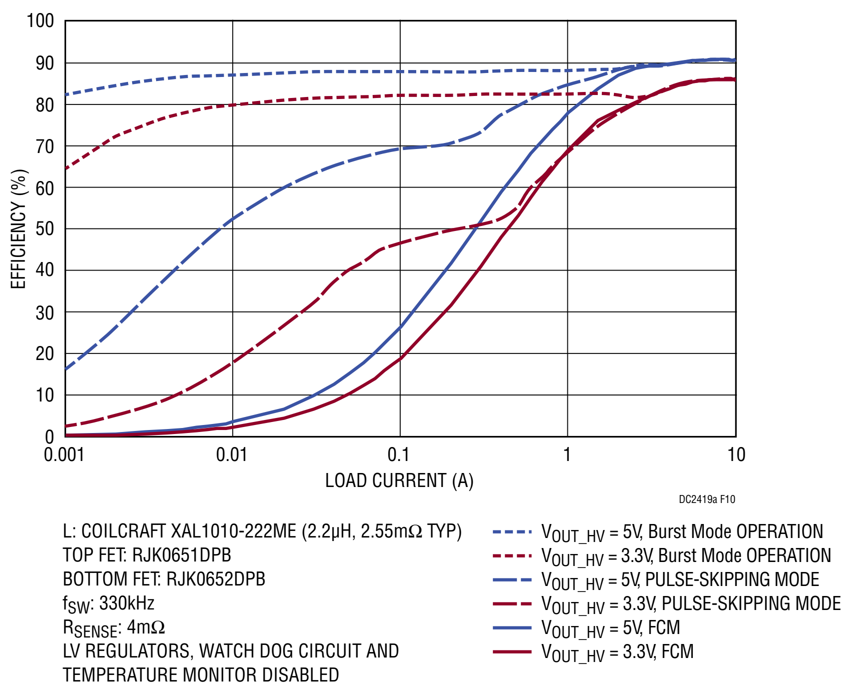



**Figure 10. Efficiency of the HV Converter in FCM, Pulse-Skipping and Burst Mode Operation, $V_{IN}$ = 48V**

## QUICK START PROCEDURE

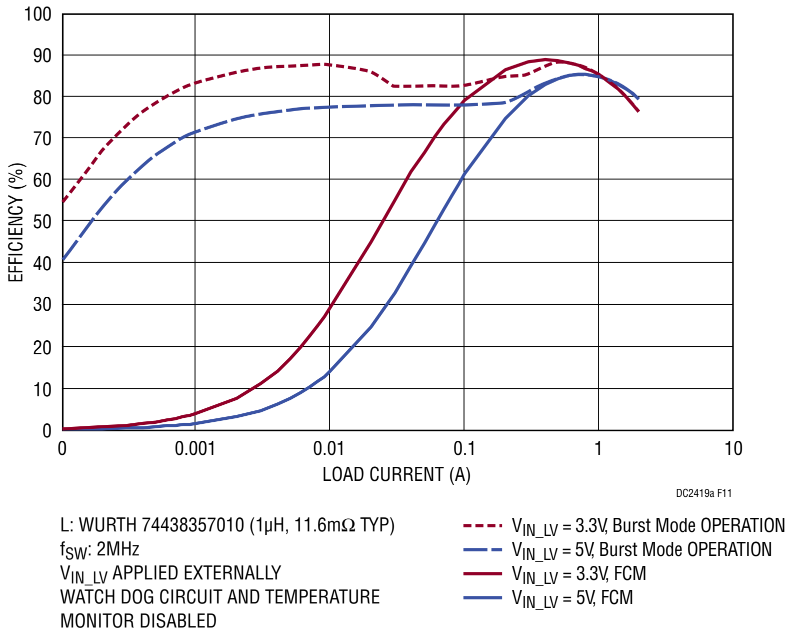



**Figure 11. Efficiency of the 1.2V, 2A LV Rail ($V_{OUT1}$)**

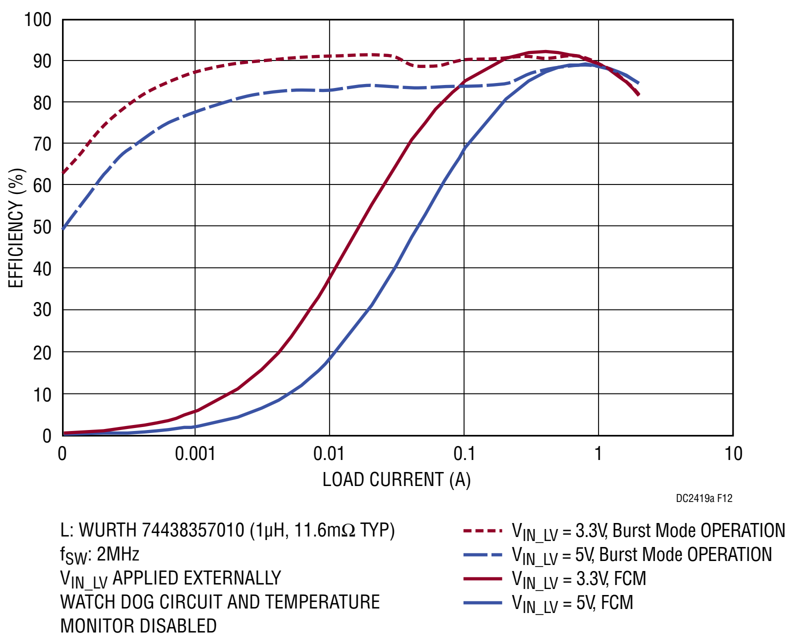



**Figure 12. Efficiency of the 1.8V, 2A LV Rail ($V_{OUT2}$)**

## QUICK START PROCEDURE

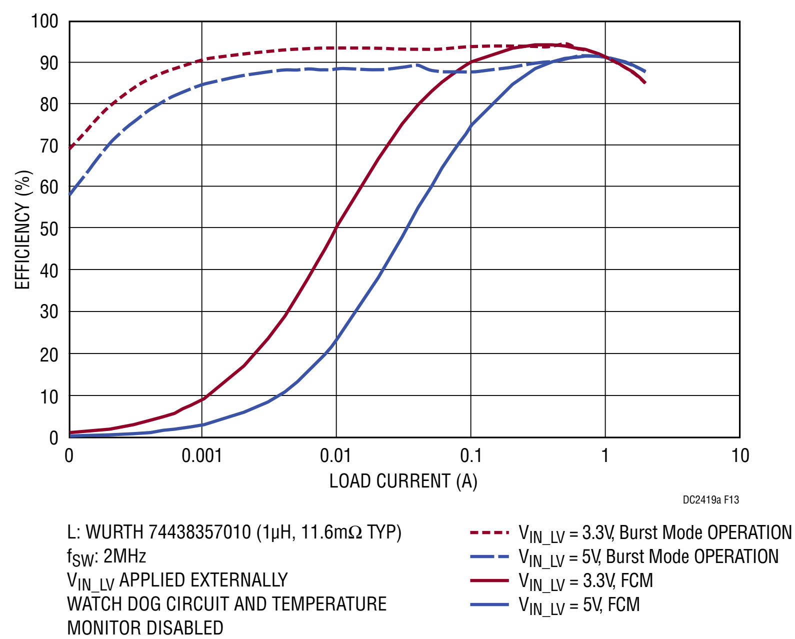



**Figure 13. Efficiency of the 2.5V, 2A LV Rail ($V_{OUT3}$)**

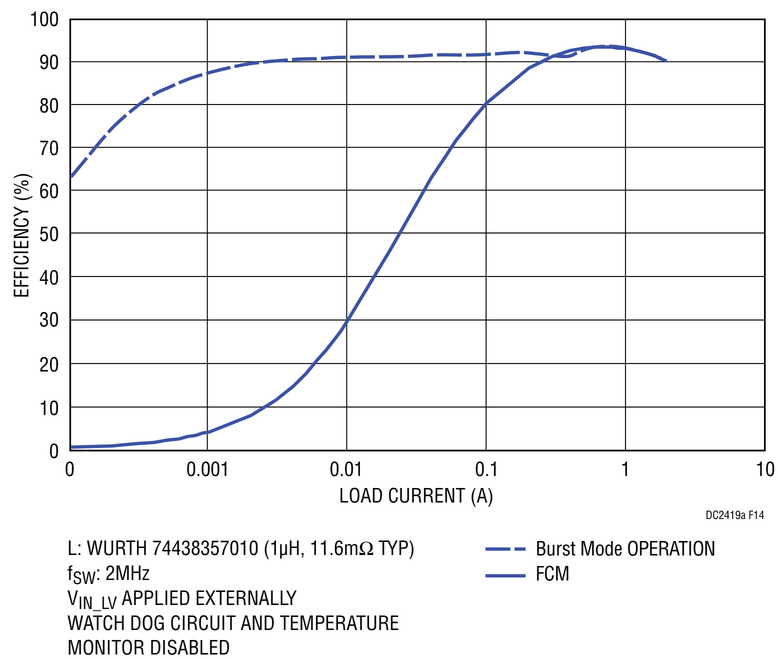
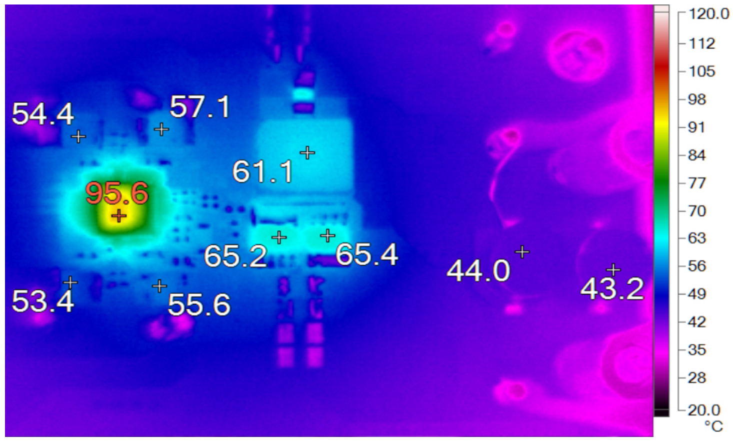


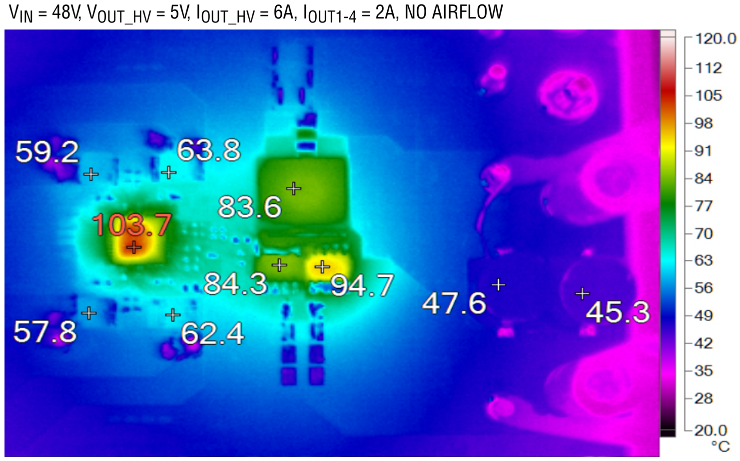

**Figure 14. Efficiency of the 3.3V, 2A LV Rail ($V_{OUT4}$), $V_{IN\_LU}$ = 5V**

## QUICK START PROCEDURE

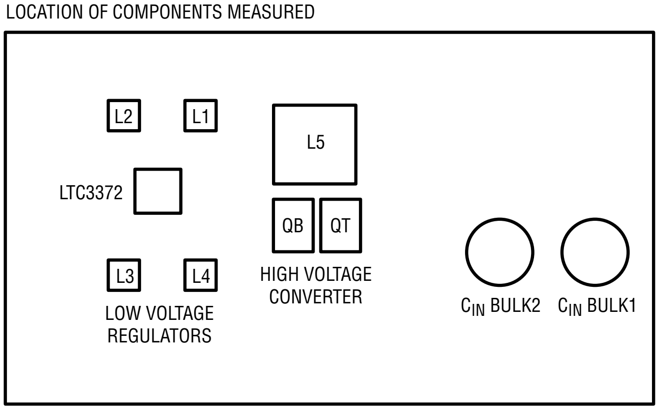
$V_{IN}$ = 12V, $V_{OUT\_HV}$ = 5V, $I_{OUT\_HV}$ = 6A, $I_{OUT1-4}$ = 2A, NO AIRFLOW




$V_{IN}$ = 48V, $V_{OUT\_HV}$ = 5V, $I_{OUT\_HV}$ = 6A, $I_{OUT1-4}$ = 2A, NO AIRFLOW




LOCATION OF COMPONENTS MEASURED




DC2419 F015

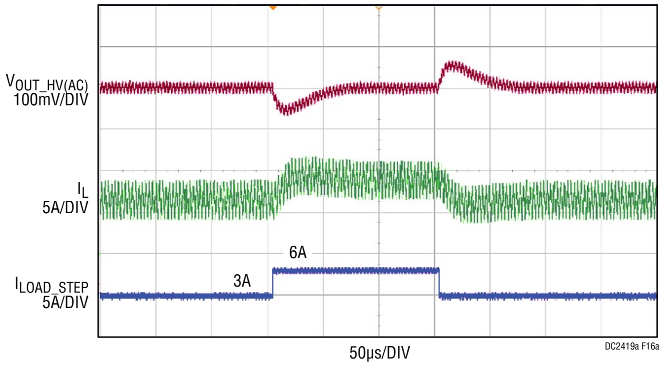
CIRCUIT COMPONENTS AND SETUP

LV REGULATORS:
$V_{OUT1-4}$: 1.2V/2A, 1.8V/2A, 2.5V/2A, 3.3V/2A
L1-4: WURTH 74438357010 (1µH, 11.6mΩ TYP)
$f_{SW}$: 2MHz

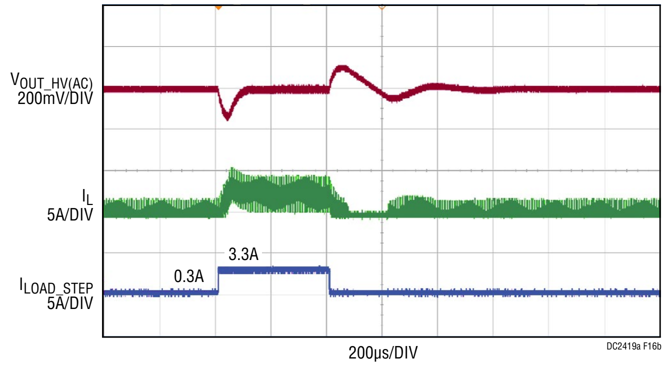
HV CONVERTER:
L5: COILCRAFT XAL1010-222ME (2.2µH, 2.55mΩ TYP)
TOP FET: RJK0651DPB
BOTTOM FET: RJK0652DPB
$f_{SW}$: 330kHz
$R_{SENSE}$:4mΩ

**Figure 15. Thermal Image of the DC2419A Demo Board with Full Load on All Rails**

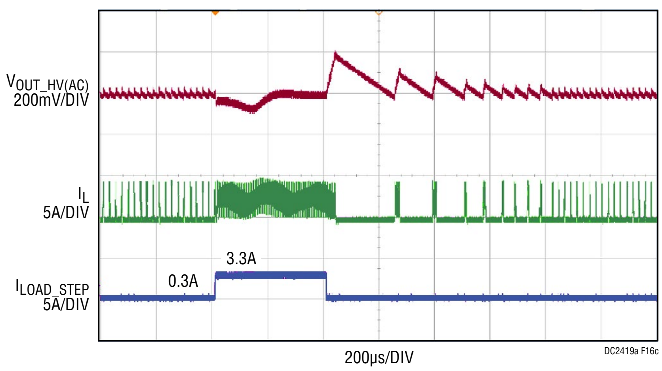
# QUICK START PROCEDURE




**(a) 3A to 6A Load Step Response, 2A Load Each on $V_{OUT1-4}$, FCM**




**(b) 0.3A to 3.3A Load Step Response, No Load on $V_{OUT1-4}$, Pulse-Skipping Mode**




**(c) 0.3A to 3.3A Load Step Response, No Load on $V_{OUT1-4}$, Burst Mode Operation**

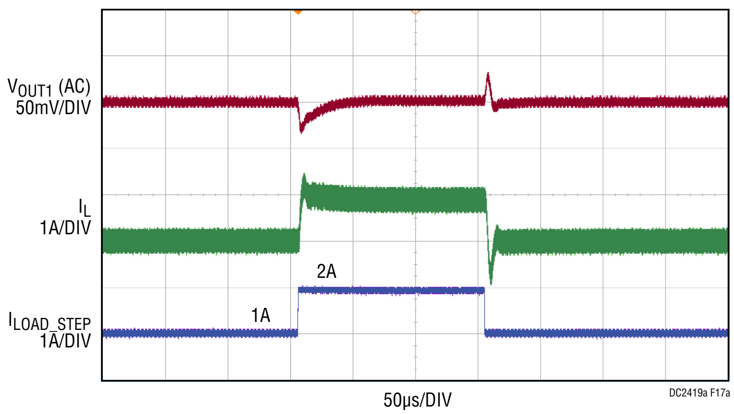
$C_{OUT(BULK)}$: 2x T520B157M006ATE025
(150µF, 6.3V, 25mΩ)

$C_{OUT(CER)}$: TMK325ABJ476MM-T
(47µF, 25V, X5R, 1210)

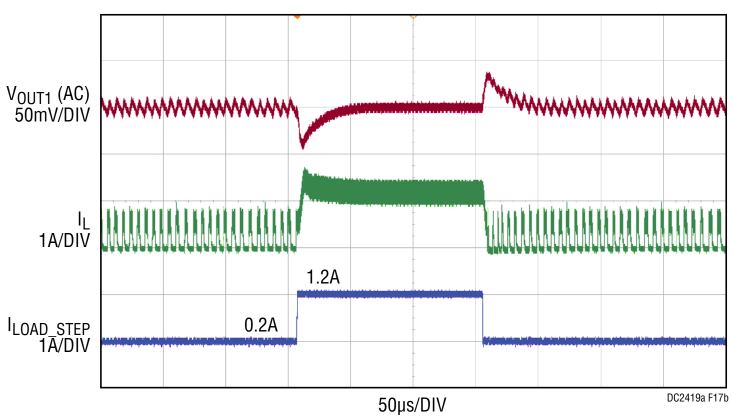
$f_{SW}$: 330kHz

**Figure 16. Load Step Response of the HV Converter ($V_{OUT\_HV}$), $V_{OUT\_HV}$ = 5V, $V_{IN}$ = 12V**

## QUICK START PROCEDURE




**(a) 1A to 2A Load Step Response, FCM**




**(b) 0.2A to 1.2A Load Step Response, Burst Mode Operation**

$C_{OUT}$: 2× GRM21BR60J476ME15L
(47µF, 6.3V, X5R, 0805)

$f_{SW}$: 2MHz

**Figure 17. Load Step Response of the LV 1.2V, 2A Regulator ($V_{OUT1}$), $V_{IN\_LV}$ = 5V**

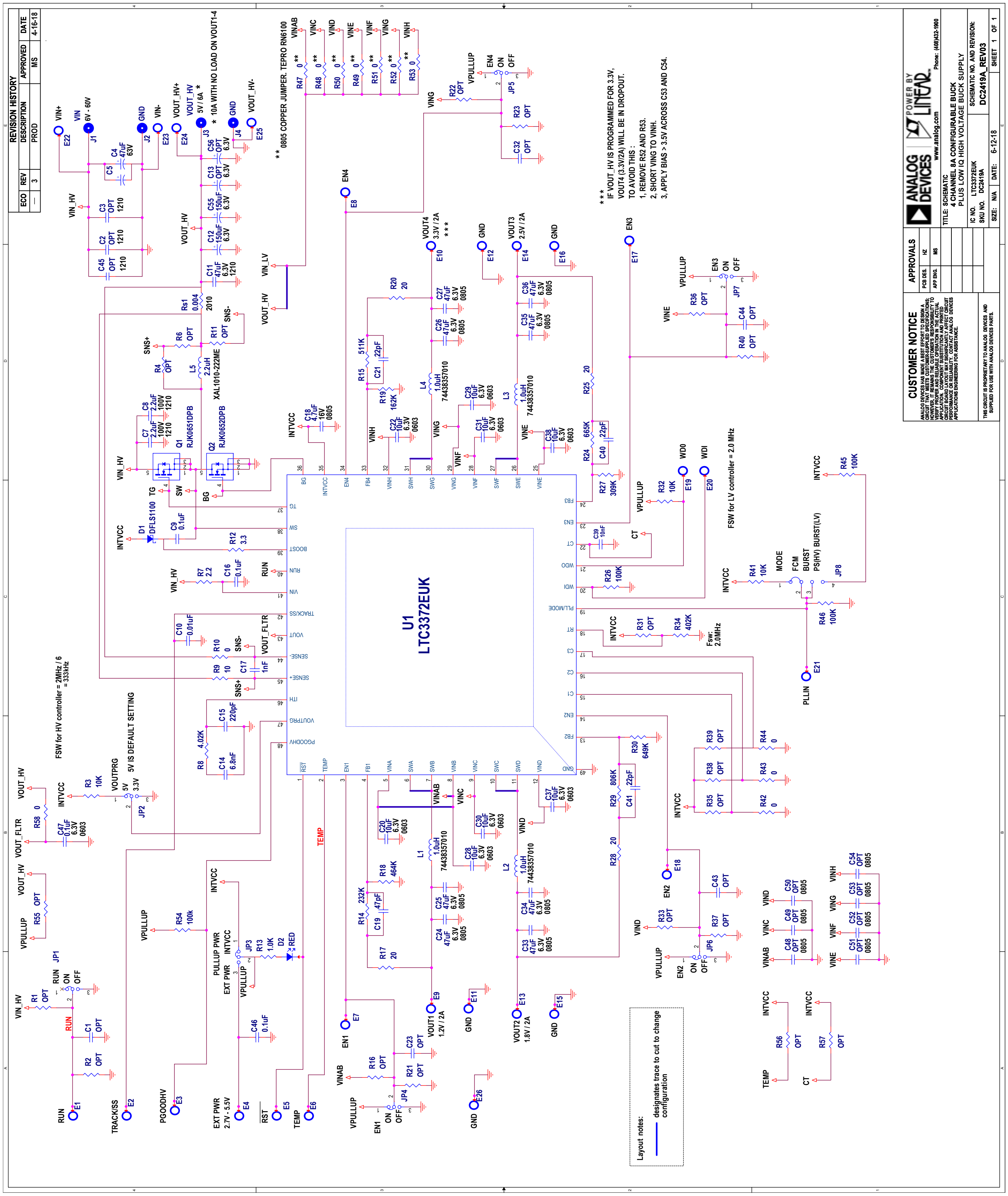
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components** | | | | |
| 1 | 1 | C10 | CAP, 0.01µF 10% 25V X7R 0402 | MURATA, GRM155R71E103KA01J |
| 2 | 1 | C39 | CAP, 0.01µF 10% 50V X7R 0402 | MURATA, GRM155R71H103KA88D |
| 3 | 3 | C9, C16, C46 | CAP, 0.1µF 10% 100V X7R 0603 | MURATA, GRM188R72A104KA35D |
| 4 | 1 | C17 | CAP, 1000pF 5% 50V NP0 0402 | MURATA, GRM1555C1H102JA01D |
| 5 | 9 | C20, C22, C28 TO C31, C37, C38, C47 | CAP, 10µF 20% 16V X5R 0603 | MURATA, GRM188R61C106MA73D |
| 6 | 2 | C7, C8 | CAP, 2.2µF 10% 100V X7R 1210 | MURATA, GRM32ER72A225KA35L |
| 7 | 1 | C15 | CAP, 220pF 5% 25V NPO 0402 | YAGEO, CC0402JRNPO8BN221 |
| 8 | 3 | C21, C40, C41 | CAP, 22pF 5% 50V NPO 0402 | MURATA, GRM1555C1H220JA01D |
| 9 | 2 | C12, C55 | CAP, 3528 150µF 6.3V POLY TANT | KEMET, T520B157M006ATE025 |
| 10 | 1 | C18 | CAP, 4.7µF 10% 25V X5R 0805 | MURATA, GRM21BR61E475KA12L |
| 11 | 1 | C19 | CAP, 47pF 5% 50V NPO 0402 | MURATA, GRM1555C1H470JA01D |
| 12 | 1 | C11 | CAP, 47µF 20% 1210 25V X5R | TAIYO YUDEN, TMK325ABJ476MM-T |
| 13 | 8 | C24 TO C27, C33 TO C36 | CAP, 47µF 20% 6.3V X5R 0805 | MURATA, GRM21BR60J476ME15L |
| 14 | 2 | C4, C5 | CAP, 47µF 63V, 30mW, 2.1A RMS | SUNCON ELEC, 63HVH47M |
| 15 | 1 | C14 | CAP, 6800pF 10% 50V X7R 0402 | YAGEO, AC0402KRX7R9BB682 |
| 16 | 1 | D1 | DIODE, SCHOTTKY 100V | DIODES INC, DFLS1100-7 |
| 17 | 1 | U1 | IC LTC3372EUK | ADI, LTC3372EUK#PBF |
| 18 | 4 | L1 TO L4 | IND, 1µH 7.4A 13.5mW | WURTH ELEKTRONIK, 74438357010 |
| 19 | 1 | L5 | IND, 2.2µH 32.0A 2.55mW | COILCRAFT, XAL1010-222MEB |
| 20 | 6 | R47 TO R53 | JUMPER, 0mW 0805 | TEPRO, RN61 |
| 21 | 1 | Q1 | MOSFET, N-CH 60V 25A LFPAK | RENESAS, RJK0651DPB-00#J5 |
| 22 | 1 | Q2 | MOSFET, N-CH 60V 35A LFPAK | RENESAS, RJK0652DPB-00#J5 |
| 23 | 4 | R10, R42, R43, R44 | RES, 0W, 0402 | VISHAY, CRCW04020000Z0ED |
| 24 | 1 | R58 | RES, 0W, 0603 | VISHAY, CRCW06030000Z0EA |
| 25 | 4 | R54, R26, R45, R46 | RES, 100k 1% 0603 | VISHAY, CRCW0603100KFKEA |
| 26 | 3 | R3, R32, R41 | RES, 10k 5% 0603 | VISHAY, CRCW060310K0JNEA |
| 27 | 1 | R9 | RES, 10W, 5% 0402 | VISHAY, CRCW040210R0JNED |
| 28 | 1 | R19 | RES, 162k 1% 0402 | VISHAY, CRCW0402162KFKED |
| 29 | 1 | R7 | RES, 2.2W 1% 0603 | VISHAY, CRCW06032R20FKEA |
| 30 | 1 | RS1 | RES, 2010 4mW 1% 1W | VISHAY, WSL20104L000FEA |
| 31 | 4 | R17, R28, R20, R25 | RES, 20W 1% 0603 | VISHAY, CRCW060320R0FKEA |
| 32 | 1 | R14 | RES, 232k 1% 0402 | VISHAY, CRCW0402232KFKED |
| 33 | 1 | R12 | RES, 3.3W 1% 0603 | VISHAY, CRCW06033R30FKEA |
| 34 | 1 | R27 | RES, 309k 1% 0402 | VISHAY, CRCW0402309KFKED |
| 35 | 1 | R8 | RES, 4.02k, 1% 0402 | VISHAY, CRCW04024K02FKED |
| 36 | 1 | R34 | RES, 402k 1% 0402 | VISHAY, CRCW0402402KFKED |
| 37 | 1 | R18 | RES, 464k 1% 0402 | VISHAY, CRCW0402464KFKED |
| 38 | 1 | R15 | RES, 511k 1% 0402 | VISHAY, CRCW0402511KFKED |
| 39 | 1 | R30 | RES, 649k 1% 0402 | VISHAY, CRCW0402649KFKED |
| 40 | 1 | R24 | RES, 66k 1% 0402 | VISHAY, CRCW0402665KFKED |
| 41 | 1 | R29 | RES, 806K 1% 0402 | VISHAY, CRCW0402806KFKED |

# PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Additional Demo Board Circuit Components** | | | | |
| 1 | 0 | C1, C23, C32, C43, C44 | CAP, 0402 OPT | |
| 2 | 0 | C48 TO C54 | CAP, 0805 OPT | |
| 3 | 0 | C2, C3 | CAP, 1210 OPT | |
| 4 | 0 | C13, C56 | CAP, 3528 OPT | |
| 5 | 1 | D2 | LED, RED | WURTH ELEKTRONIK, 150060RS75000 |
| 6 | 1 | R13 | RES, 1k 1% 0603 | VISHAY, CRCW06031K00FKEA |
| 7 | 0 | R1, R2, R4, R6, R11, R16, R21, R22, R23, R31, R33, R35 TO R40, R55 TO R57 | RES, OPTIONAL | |
| **Hardware: For Demo Board Only** | | | | |
| 1 | 7 | JP1 TO JP7 | HEADER, SINGLE ROW 3PIN | WURTH ELEKTRONIK 62000311121 |
| 2 | 1 | JP8 | HEADER, SINGLE ROW 4PIN | WURTH ELEKTRONIK 62000411121 |
| 3 | 4 | J1, J2, J3, J4 | JACK, BANANA | KEYSTONE, 575-4 |
| 4 | 8 | XJP1 TO XJP8 | SHUNT | WURTH ELEKTRONIK 60800213421 |
| 5 | 4 | | STANDOFF, NYLON, SNAP-ON, 0.375" | WURTH ELEKTRONIK 702933000 |
| 6 | 26 | E1 TO E26 | TURRET | MILL MAX 2501-2-00-80-00-00-07-0 |

# SCHEMATIC DIAGRAM





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