

# LTC7819 Low I<sub>Q</sub>, Triple Output Synchronous Step-Down Supply

## DESCRIPTION

Demonstration circuit 2897A is a low I<sub>Q</sub>, triple output, synchronous step-down supply featuring the **LTC®7819**. The circuit is optimized for high efficiency. It provides outputs of 3.3V at 12A, 8.5V at 10A and 5.0V at 12A over an input voltage range of 10V to 36V with a switching frequency of 380kHz. Each rail uses a 3mΩ sense resistor to sense the current and provides optional footprints for DCR sensing. Typical applications include automotive, transportation, industrial, military and avionics systems.

Features of the DC2897A include pin selectable light load operating modes of forced continuous mode,

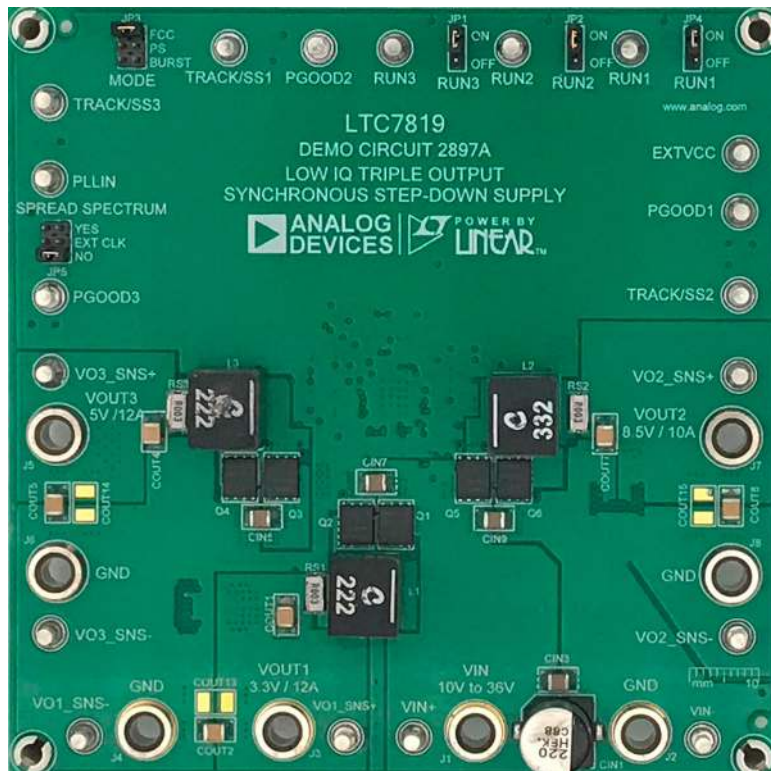
pulse-skipping and Burst Mode® operation. Optional spread spectrum modulation to reduce EMI, a PLLIN pin to synchronize to an external clock, optional DCR sensing footprints, an EXT<sub>VCC</sub> pin to reduce losses in the controller and optional footprints to parallel two or three channels.

The LTC7819 data sheet provides a complete description of the part, operational details, and applications information. DC2897A must be read in conjunction with the data sheet.

**Design files for this circuit board are available.**

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## BOARD PHOTO



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

| PARAMETER                               | CONDITIONS   | MIN | TYP  | MAX | UNITS |
|---|--|-----|------|-----|-------|
| Input Voltage Range                     |  | 10  |      | 36  | V     |
| Output Voltage #1, $V_{OUT1}$           | $V_{IN} = 10\text{V to } 36\text{V}$ , $I_{OUT1} = 0\text{A} - 12\text{A}$ |     | 3.3  |     | V     |
| Output Voltage #2, $V_{OUT2}$           | $V_{IN} = 10\text{V to } 36\text{V}$ , $I_{OUT2} = 0\text{A} - 10\text{A}$ |     | 8.5  |     | V     |
| Output Voltage #3, $V_{OUT3}$           | $V_{IN} = 10\text{V to } 36\text{V}$ , $I_{OUT3} = 0\text{A} - 12\text{A}$ |     | 5.0  |     | V     |
| Maximum Output Current, $I_{OUT1}$      | $V_{IN} = 10\text{V to } 36\text{V}$ , $V_{OUT1} = 3.3\text{V}$            |     | 12   |     | A     |
| Maximum Output Current, $I_{OUT2}$      | $V_{IN} = 10\text{V to } 36\text{V}$ , $V_{OUT2} = 8.5\text{V}$            |     | 10   |     | A     |
| Maximum Output Current, $I_{OUT3}$      | $V_{IN} = 10\text{V to } 36\text{V}$ , $V_{OUT3} = 5.0\text{V}$            |     | 12   |     | A     |
| Switching Frequency                     |  |     | 380  |     | kHz   |
| Efficiency ( $f_{SW} = 380\text{kHz}$ ) | $V_{IN} = 12\text{V}$ , $V_{OUT1} = 3.3\text{V}$ , $I_{OUT1} = 12\text{A}$ |     | 94.9 |     | %     |
|   | $V_{IN} = 12\text{V}$ , $V_{OUT2} = 8.5\text{V}$ , $I_{OUT2} = 10\text{A}$ |     | 97.9 |     | %     |
|   | $V_{IN} = 12\text{V}$ , $V_{OUT3} = 5.0\text{V}$ , $I_{OUT3} = 12\text{A}$ |     | 96.4 |     | %     |

### QUICK START PROCEDURE

Demonstration circuit 2897A is easy to setup for evaluating the LTC7819. Please refer to Figure 1 for the proper measurement equipment setup and follow the procedure below.

1. Connect the input power supply to  $V_{IN}$  (10V – 36V) and GND (input return).
2. Preset the load for each output to 0A and the input supply to 0V.
3. Place jumpers in the following positions:
 

|             |                 |     |
|-------------|-----------------|-----|
| <b>JP4:</b> | RUN1            | ON  |
| <b>JP2:</b> | RUN2            | ON  |
| <b>JP1:</b> | RUN3            | ON  |
| <b>JP3:</b> | MODE            | FCC |
| <b>JP5:</b> | SPREAD SPECTRUM | NO  |
4. Set the input voltage to within the specified range and check  $V_{OUT1}$ ,  $V_{OUT2}$  and  $V_{OUT3}$ .
5. Once the proper output voltages have been confirmed, observe the output voltage ripple, efficiency, and other parameters.

#### LIGHT LOAD OPERATION, SYNCHRONIZATION TO AN EXTERNAL CLOCK AND SPREAD SPECTRUM

To synchronize the LTC7819 to an external clock, place the SPREAD SPECTRUM jumper (JP5) in the EXT CLK position and apply an external clock between the PLLIN turret and GND. The phase-lockable frequency range is 100kHz to 3MHz. The low clock level should be 0.5V or lower and the high clock level should be 2.2V or higher. For spread spectrum, place the jumper in the YES position. With spread spectrum enabled, the frequency will be modulated between 100% and 120% of the programmed frequency (380kHz to 456kHz). This will help reduce the peak emission levels. To allow the converter to free run at its programmed frequency (380kHz), place the jumper in the NO position which is the default setting.

Demonstration circuit 2897A can be programmed to operate in either forced continuous conduction mode (FCC), pulse-skipping mode (PS) or Burst Mode operation (BURST) at no load or light load with JP3. Forced continuous mode (default setting) provides the cleanest output voltage ripple. Pulse-skipping mode provides higher efficiency at light load, but the output voltage ripple is less regular. Burst Mode operation provides the highest light load efficiency, but the output voltage ripple is the least regular and highest of the three modes.

## QUICK START PROCEDURE

### OPTIONAL DCR SENSING

Demonstration circuit 2897A has optional footprints for DCR sensing. The benefit of DCR sensing is a lower parts count and high efficiency but at the expense of a less accurate current sensing and current limit. To implement DCR sensing refer to Table 1 and the Applications Information section of the data sheet. Be sure to stuff a 0mΩ copper shunt or a short, thick piece of copper at RS1, RS2 and/or RS3.

### EXTV<sub>CC</sub> BIAS OPTION

The EXTV<sub>CC</sub> pin of the LTC7819 on the standard demo board is connected to the 5V output (VOUT3) to reduce the losses in the controller and improve efficiency. If necessary, the EXTV<sub>CC</sub> pin can be tied to an external supply by following these steps:

1. Remove the 0Ω jumper at R20.
2. Connect a DC voltage from the EXTV<sub>CC</sub> turret to a GND turret. The DC voltage should be between 5V and 30V.

### PARALLELING CHANNELS

For higher power, two or more channels of demonstration circuit 2897A can be paralleled. Given that the channels operate 120 degrees out of phase with each other, paralleling channels provides the benefit of ripple current cancelation in the output and input capacitors. This in turn provides lower output voltage and input voltage ripple. Another benefit of interleaved channels is a faster load step response. When paralleling phases channel 1 is always the master and channels 2 and 3 are slaves. In addition, each phase should have the same inductor, sense resistor—if used and MOSFETs. Detailed instructions are below:

#### Parallel Channel 1 with Channel 2:

- Stuff 0Ω jumpers at R11, R12 and R15.
- Stuff a 0mΩ jumper or short, thick piece of copper at R19.

#### Parallel Channel 1 with Channel 3:

- Stuff 0Ω jumpers at R10, R13 and R14.
- Stuff a 0mΩ jumper or short, thick piece of copper at R18.

#### Parallel Channel 1 with Channel 2 and Channel 3:

- Stuff 0Ω jumpers at R11, R10, R12, R13, R15 and R14.
- Stuff a 0mΩ jumper or short, thick piece of copper at R19 and R18.

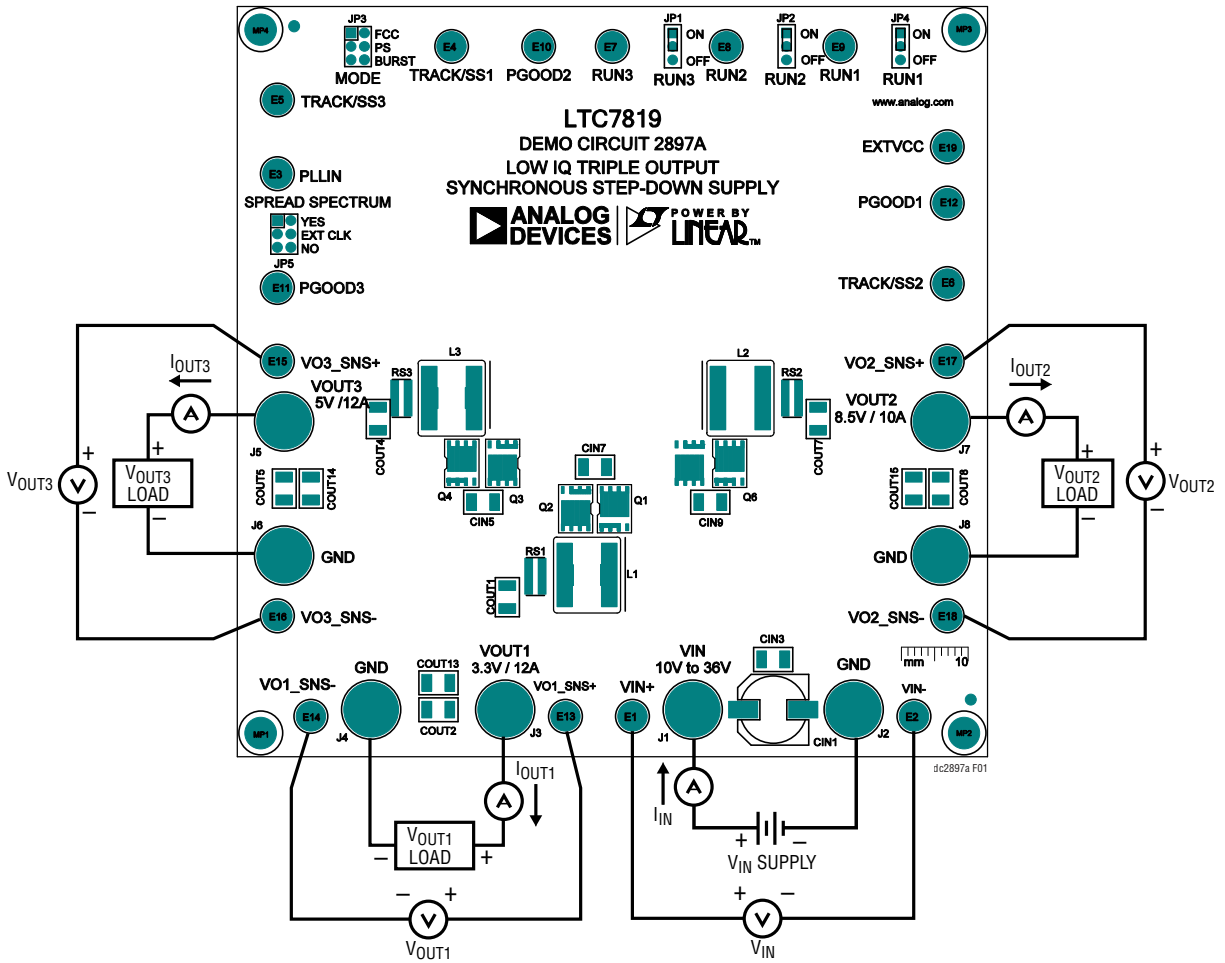
### Notes

1. When measuring the output voltage 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 the output or input capacitor. The probe's ground ring needs to contact the (–) lead and the probe tip needs to contact the (+) lead.
2. When powering the board, first connect the input supply to the demo board as written above. Next, turn-on the input supply. Do not hot plug. This could cause large input voltage transients that may damage the converter, especially at high V<sub>IN</sub>.
3. When using electronic loads which are rated to provide full current with a voltage of 0V, make sure the load is off before turning off the rail. Otherwise, the load could pull V<sub>OUT</sub> below ground. This may damage the converter.

Table 1. Optional Inductor DCR Sensing

| CONFIGURATION    | CHANNEL 1 | RS1    | R30  | R29  | C14                 | R45  | R47  | R61  |
|------------------|-----------|--------|------|------|---------------------|------|------|------|
|                  | CHANNEL 2 | RS2    | R52  | R54  | C56                 | R50  | R49  | R46  |
|                  | CHANNEL 3 | RS3    | R40  | R39  | C15                 | R51  | R53  | R62  |
| RSENSE (DEFAULT) |           | 3mΩ    | 0Ω   | 0Ω   | 1nF                 | Open | Open | Open |
| DCR SENSING      |           | 0mΩ Cu | Open | Open | Refer to Data Sheet |      |      | 0Ω   |

### QUICK START PROCEDURE



NOTE FOR ACCURATE EFFICIENCY MEASUREMENTS:  
 MONITOR  $V_{OUT1}$ ,  $V_{OUT2}$  AND  $V_{OUT3}$  ACROSS  $C_{OUT1}$ ,  $C_{OUT7}$  AND  $C_{OUT4}$ , RESPECTIVELY.  
 MONITOR  $V_{IN}$  ACROSS EITHER  $C_{IN7}$  (CH1),  $C_{IN9}$  (CH2) OR  $C_{IN5}$  (CH3).

Figure 1. Proper Measurement Equipment Setup

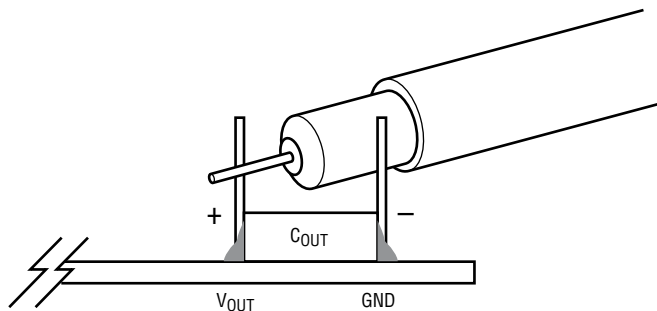
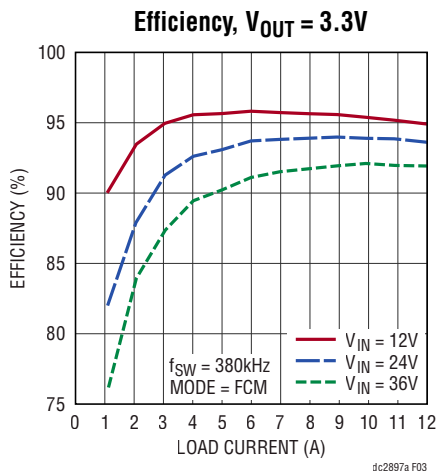
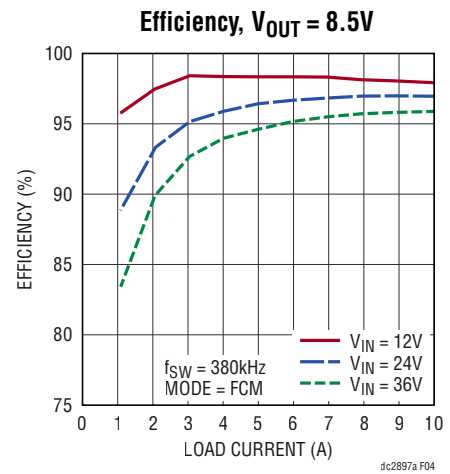


Figure 2. How to Measure the Output or Input Voltage Ripple

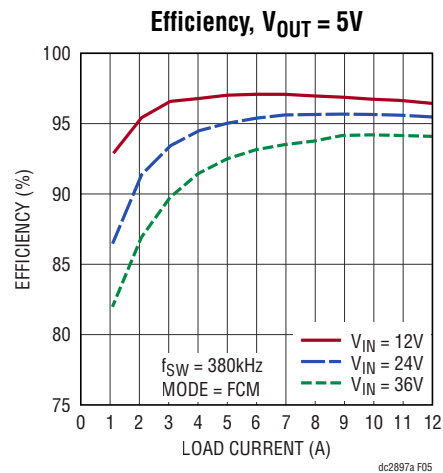
## QUICK START PROCEDURE



**Figure 3. Efficiency of the 3.3V/12A Rail ( $V_{OUT1}$ ) Over the Input Voltage Range, the Other Two Rails Were Disabled, No Voltage Was Applied to the  $EXTV_{CC}$  Pin and the PGOOD Pull-Ups Were Removed**



**Figure 4. Efficiency of the 8.5V/10A Rail ( $V_{OUT2}$ ) Over the Input Voltage Range, the Other Two Rails Were Disabled, No Voltage Was Applied to the  $EXTV_{CC}$  Pin and the PGOOD Pull-Ups Were Removed**



**Figure 5. Efficiency of the 5V/12A Rail ( $V_{OUT3}$ ) Over the Input Voltage Range, the Other Two Rails Were Disabled, the 5V Output was Tied to the  $EXTV_{CC}$  Pin and the PGOOD Pull-Ups Were Removed**

### QUICK START PROCEDURE

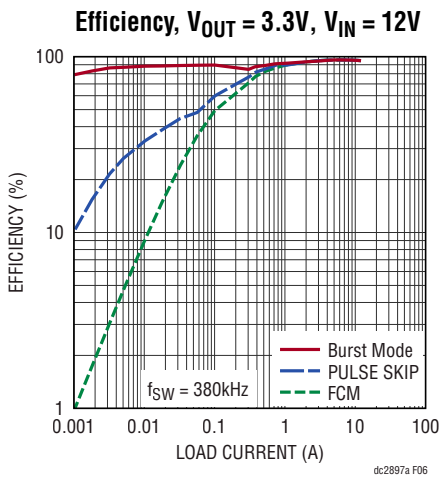


Figure 6. Efficiency of the 3.3V/12A Rail ( $V_{OUT1}$ ) at  $12V_{IN}$  for the Three Light Load Operating Modes, the Other Two Rails Were Disabled, No Voltage Was Applied to the  $EXTV_{CC}$  Pin and the PGOOD Pull-Ups Were Removed

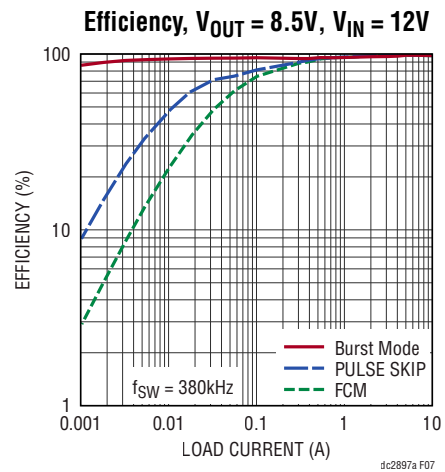


Figure 7. Efficiency of the 8.5V/10A Rail ( $V_{OUT2}$ ) at  $12V_{IN}$  for the Three Light Load Operating Modes, the Other Two Rails Were Disabled, No Voltage Was Applied to the  $EXTV_{CC}$  Pin and the PGOOD Pull-Ups Were Removed

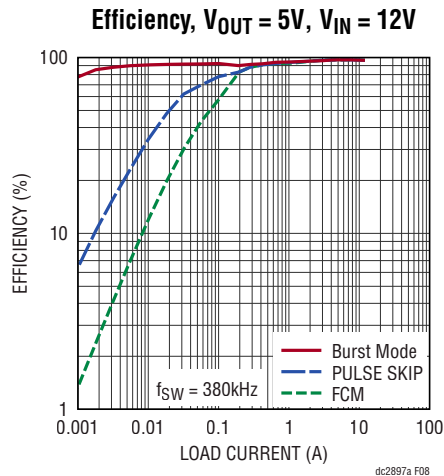


Figure 8. Efficiency of the 5V/12A Rail ( $V_{OUT3}$ ) for the Three Light Load Operating Modes, the Other Two Rails Were Disabled, the 5V Output Was Tied to the  $EXTV_{CC}$  Pin and the PGOOD Pull-Ups Were Removed

## QUICK START PROCEDURE

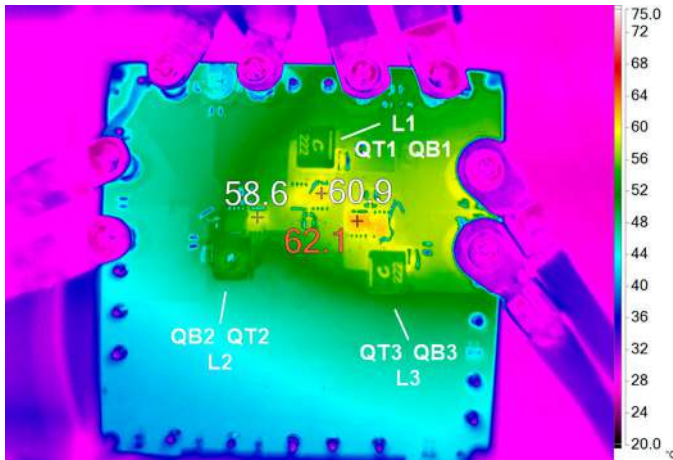


Figure 9. Thermal Image with Full Load on Each Rail at  $12V_{IN}$ ,  $f_{SW} = 380kHz$ , No Airflow,  $T_A = 23^\circ C$ , Markers Show the Hot Spot for Each Channel

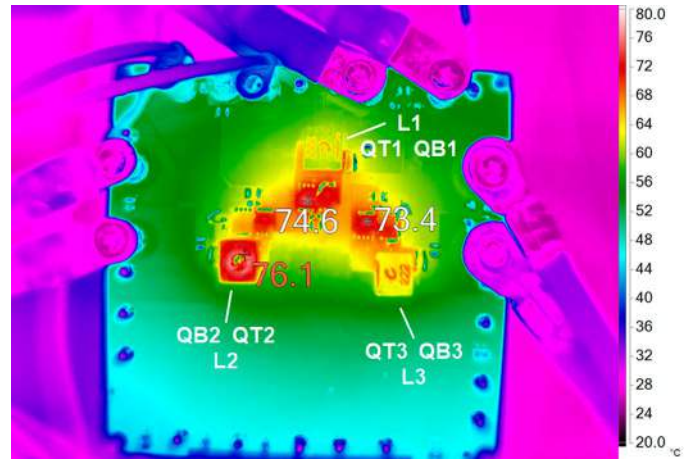


Figure 10. Thermal Image with Full Load on Each Rail at  $36V_{IN}$ ,  $f_{SW} = 380kHz$ , No Airflow,  $T_A = 23^\circ C$ , Markers Show the Hot Spot for Each Channel

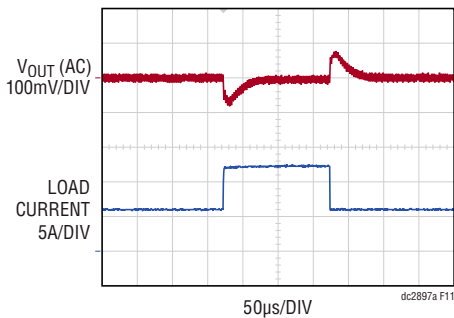


Figure 11. 50% to 100% Load Step Response of the 3.3V/12A Rail ( $V_{OUT1}$ )

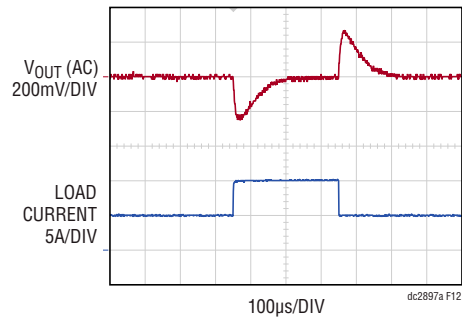


Figure 12. 50% to 100% Load Step Response of the 8.5V/10A Rail ( $V_{OUT2}$ )

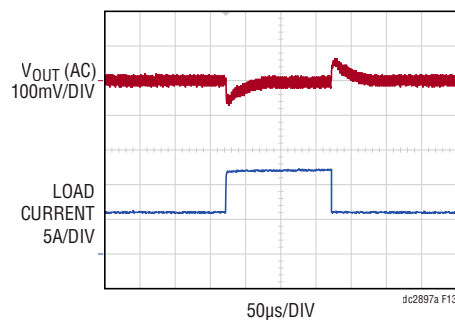


Figure 13. 50% to 100% Load Step Response of the 5.0V/12A Rail ( $V_{OUT3}$ )

# DEMO MANUAL

## DC2897A

### PARTS LIST

| ITEM                               | QTY | REFERENCE   | PART DESCRIPTION  | MANUFACTURER/PART NUMBER  |
|------------------------------------|-----|---|---|---|
| <b>Required Circuit Components</b> |     |   |   |   |
| 1                                  | 5   | C1, C14, C15, C43, C56  | CAP., 1000pF, C0G, 50V, 10%, 0603                                       | AVX, 06035A102KAT2A   |
| 2                                  | 1   | C11   | CAP., 4.7μF, X5R, 10V, 10%, 0805  | KEMET, C0805C475K8PACTU<br>MURATA, GRM21BR61A475KA73L<br>SAMSUNG, CL21A475KPFNNNF<br>TDK, C2012X5R1A475K125AA |
| 3                                  | 8   | C2, C4, C20, C21, C47, C52, C61, C74                                      | CAP., 0.1μF, X7R, 50V, 10%, 0603  | AVX, 06035C104KAT2A<br>KEMET, C0603C104K5RAC7867; C0603C104K5RACTU<br>TDK, C1608X7R1H104K080AA                |
| 4                                  | 1   | C41   | CAP., 2200pF, X7R, 50V, 10%, 0603                                       | AVX, 06035C222KAT2A<br>MURATA, GRM188R71H222KA01D<br>SAMSUNG, CL10B222KB8NFNC                                 |
| 5                                  | 2   | C42, C44  | CAP., 47pF, X7R, 50V, 10%, 0603   | AVX, 06035C470KAT2A<br>KEMET, C0603C470K5RACTU  |
| 6                                  | 1   | C53   | CAP., 0.01μF, C0G, 50V, 5%, 0603  | MURATA, GRM1885C1H103JA01D<br>TDK, C1608COG1H103J080AA  |
| 7                                  | 1   | C54   | CAP., 220pF, X7R, 50V, 10%, 0603  | AVX, 06035C221KAT2A<br>KEMET, C0603C221K5RACTU<br>NIC, NMC0603X7R221K50TRPF                                   |
| 8                                  | 2   | C69, C70  | CAP., 1μF, X7R, 10V, 10%, 0603  | AVX, 0603ZC105KAT2A<br>KEMET, C0603C105K8RACTU<br>MURATA, GRM188R71A105KA61D<br>TDK, C1608X7R1A105K080AC      |
| 9                                  | 1   | CIN1  | CAP., 220μF, ALUM ELECT, 50V, 20%, 10mm × 10.2mm, RADIAL, SMD, AEC-Q200 | PANASONIC, EEFK1H221GP<br>CORNELL DUBILIER, AFK227M50G24T-F   |
| 10                                 | 8   | CIN3, CIN4, CIN5, CIN6, CIN7, CIN8, CIN9, CIN10                           | CAP., 4.7μF, X7R, 50V, 10%, 1210  | AVX, 12105C475KAT2A<br>KEMET, C1210C475K5RACTU<br>MURATA, GRM32ER71H475KA88L<br>YAGEO, CC1210KKX7R9BB475      |
| 11                                 | 6   | COUT1, COUT2, COUT4, COUT5, COUT7, COUT8                                  | CAP., 47μF, X7R, 10V, 10%, 1210   | AVX, 1210ZC476KAT2A<br>MURATA, GRM32ER71A476KE15L<br>TAIYO YUDEN, LMK325B7476KM-PR; LMK325B7476KM-TR          |
| 12                                 | 2   | COUT10, COUT11  | CAP., 470μF, TANT, POSCAP, 6.3V, 20%, 7343, 10mΩ, TCF                   | PANASONIC, 6TCF470MAH   |
| 13                                 | 1   | COUT12  | CAP., 150μF, TANT, POSCAP, 10V, 20%, 7343, D3L                          | PANASONIC, 10TPF150ML   |
| 14                                 | 3   | D1, D2, D6  | DIODE, SCHOTTKY, 100V, 1A, POWERDI-123, AEC-Q101                        | DIODES INC., DFLS1100Q-7  |
| 15                                 | 2   | L1, L3  | IND., 2.2μH, PWR., 20%, 11.8mm × 10.5mm SMD, AEC-Q200                   | COILCRAFT, XAL1010-222MEB; XAL1010-222MED   |
| 16                                 | 1   | L2  | IND., 3.3μH, PWR., 20%, 25A, 4.10mΩ, 11.8mm × 10.5mm, XAL1010, AEC-Q200 | COILCRAFT, XAL1010-332MEB; XAL1010-332MED   |
| 17                                 | 3   | Q1, Q3, Q5  | XSTR., MOSFET, N-CH, 40V, 59A, TDSO8-8 FL                               | INFINEON, BSC059N04LS6; BSC059N04LS6ATMA1   |
| 18                                 | 3   | Q2, Q4, Q6  | XSTR., MOSFET, N-CH, 40V, 100A, TDSO8-8 FL                              | INFINEON, BSC022N04LS6; BSC022N04LS6ATMA1   |
| 19                                 | 16  | R1, R3, R4, R5, R9, R25, R27, R29, R30, R39, R40, R44, R52, R54, R83, R84 | RES., 0Ω, 1/10W, 0603, AEC-Q200   | VISHAY, CRCW06030000Z0EA; CRCW06030000Z0EB<br>NIC, NRC06ZOTRF   |



## PARTS LIST

| ITEM | QTY | REFERENCE         | PART DESCRIPTION  | MANUFACTURER/PART NUMBER  |
|------|-----|-------------------|---|---|
| 20   | 1   | R20               | RES., 0 $\Omega$ , 1/4W, 1206, AEC-Q200   | VISHAY, CRCW12060000Z0EA<br>PANASONIC, ERJ8GEY0R00V<br>NIC, NRC12ZOTRF  |
| 21   | 3   | R26, R38, R55     | RES., 1M, 1%, 1/10W, 0603, AEC-Q200   | NIC, NRC06F1004TRF<br>PANASONIC, ERJ3EKF1004V<br>VISHAY, CRCW06031M00FKEA   |
| 22   | 1   | R31               | RES., 10k, 1%, 1/10W, 0603, AEC-Q200  | PANASONIC, ERJ3EKF1002V<br>VISHAY, CRCW060310K0FKEA; CRCW060310K0FKEB<br>KOA SPEER, RK73H1JTDD1002F                         |
| 23   | 2   | R33, R35          | RES., 20k, 1%, 1/10W, 0603  | NIC, NRC06F2002TRF<br>VISHAY, CRCW060320K0FKEA<br>PANASONIC, ERJ3EKF2002V<br>YAGEO, RC0603FR-0720KL                         |
| 24   | 1   | R43               | RES., 105k, 1%, 1/10W, 0603, AEC-Q200   | VISHAY, CRCW0603105KFKEA<br>NIC, NRC06F1053TRF  |
| 25   | 1   | R57               | RES., 133k, 1%, 1/10W, 0603   | BOURNS, CR0603-FX-1333ELF<br>YAGEO, RC0603FR-07133KL  |
| 26   | 1   | R58               | RES., 13.7k, 1%, 1/10W, 0603,<br>AEC-Q200   | VISHAY, CRCW060313K7FKEA<br>PANASONIC, ERJ3EKF1372V   |
| 27   | 1   | R6                | RES., 1k, 5%, 1/10W, 0603, AEC-Q200   | PANASONIC, ERJ3GEYJ102V   |
| 28   | 1   | R60               | RES., 4.99k, 1%, 1/10W, 0603  | PANASONIC, ERJ3EKF4991V<br>YAGEO, RC0603FR-074K99L  |
| 29   | 4   | R7, R34, R37, R63 | RES., 100k, 1%, 1/10W, 0603, AEC-Q200   | VISHAY, CRCW0603100KFKEA<br>NIC, NRC06F1003TRF<br>PANASONIC, ERJ3EKF1003V   |
| 30   | 3   | R8, R36, R59      | RES., 10 $\Omega$ , 1%, 1/10W, 0603   | VISHAY, CRCW060310R0FKEA<br>NIC, NRC06F10R0TRF<br>PANASONIC, ERJ3EKF10R0V<br>ROHM, MCR03EZPFX10R0<br>YAGEO, RC0603FR-0710RL |
| 31   | 3   | RS1, RS2, RS3     | RES., 0.003, 0 $\Omega$ , 1%, 2W, 2010 LONG-<br>SIDE TERM, METAL, SENSE, AEC-Q200 | SUSUMU, KRL5025E-C-R003-F-T1  |
| 32   | 1   | U1                | IC, SYN. STEP-DOWN CONVERTER,<br>40-PIN QFN                                       | ANALOG DEVICES, LTC7819RUJ#PBF; LTC7819RUJ#TRPBF  |

### Additional Circuit Components

|   |   |   |   |  |
|---|---|---|---|--|
| 1 | 0 | C38, C48, C60, C62, C63,<br>C64, C65, C66, C67, C68,<br>C71, C72, C73   | CAP., OPTION, 0603                        |  |
| 2 | 0 | CIN2  | CAP., OPTION, ALUM. ELECT., SMD           |  |
| 3 | 0 | COU13, COU14, COU15   | CAP., OPTION, 1210                        |  |
| 4 | 0 | COU3, COU6, COU9  | CAP., OPTION, 7343                        |  |
| 5 | 0 | Q7, Q10, Q11, Q12, Q13, Q14   | XSTR., OPTION, MOSFET N-CH,<br>PG-TDSON-8 |  |
| 6 | 0 | R18, R19  | RES., OPTION, 2010                        |  |
| 7 | 0 | R2, R10, R11, R12, R13,<br>R14, R15, R21, R22, R23,<br>R28, R32, R41, R42, R45,<br>R46, R47, R49, R50, R51,<br>R53, R56, R61, R62 | RES., OPTION, 0603                        |  |

# DEMO MANUAL

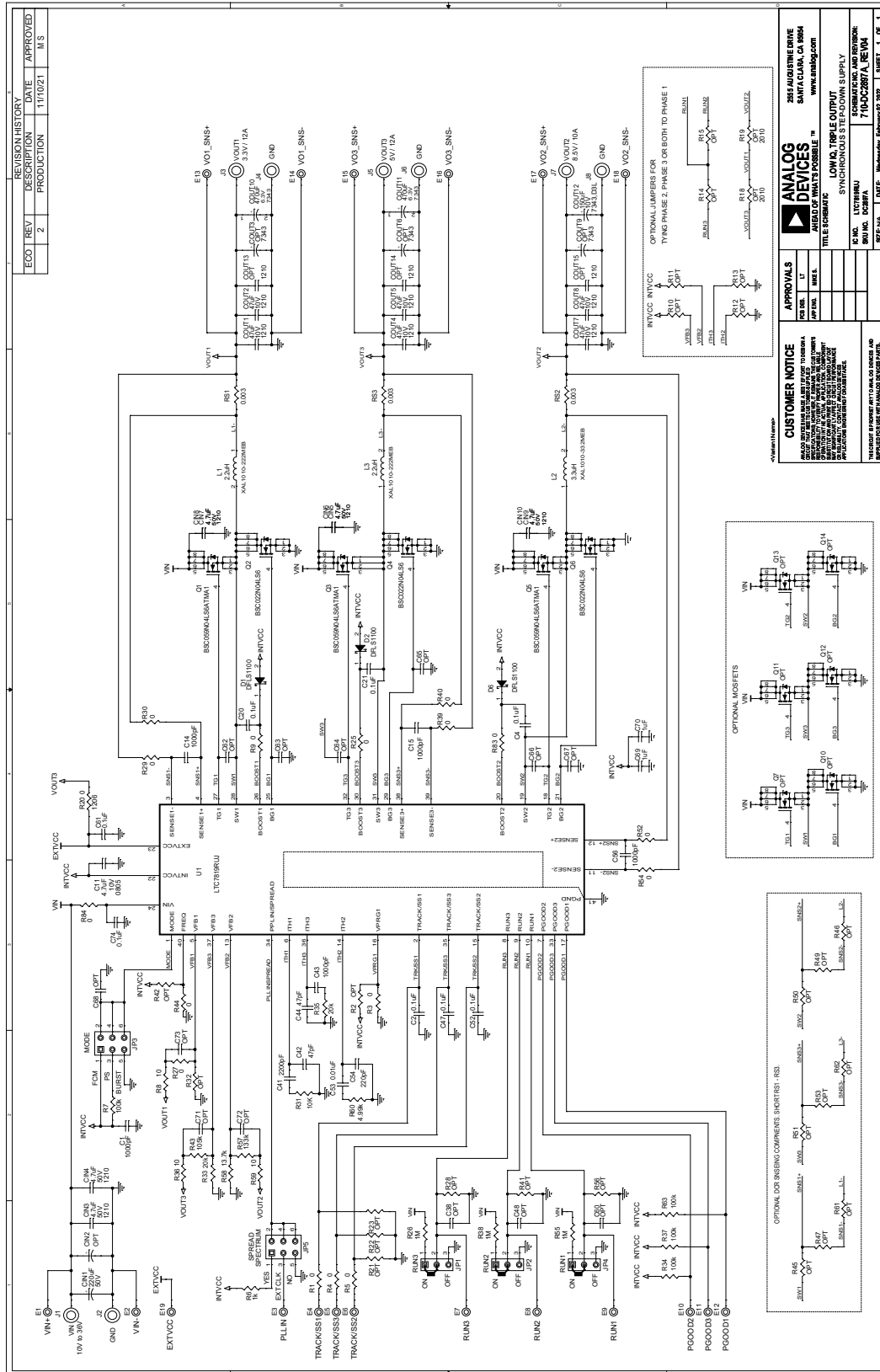
## DC2897A

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### PARTS LIST

| ITEM                                 | QTY | REFERENCE  | PART DESCRIPTION  | MANUFACTURER/PART NUMBER          |
|--------------------------------------|-----|--|---|-----------------------------------|
| <b>Hardware: For Demo Board Only</b> |     |  |   |                                   |
| 1                                    | 19  | E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19 | TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK          | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 2                                    | 8   | J1, J2, J3, J4, J5, J6, J7, J8   | CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218" | KEYSTONE, 575-4                   |
| 3                                    | 3   | JP1, JP2, JP4  | CONN., HDR, MALE, 1x3, 2mm, VERT, ST, THT, NO SUBS. ALLOWED   | WURTH ELEKTRONIK, 62000311121     |
| 4                                    | 2   | JP3, JP5   | CONN., HDR, MALE, 2x3, 2mm, VERT, ST, THT                     | WURTH ELEKTRONIK, 62000621121     |
| 5                                    | 8   | MP1, MP2, MP3, MP4, MP5, MP6, MP7, MP8   | STANDOFF, NYLON, SNAP-ON, 0.625" (5/8"), 15.9mm               | KEYSTONE, 8834                    |
| 6                                    | 3   | XJP1, XJP2, XJP4   | CONN., SHUNT, FEMALE, 2-POS, 2mm                              | WURTH ELEKTRONIK, 60800213421     |

## SCHEMATIC DIAGRAM





### 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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