

High Current, Dual Output Synchronous Buck Converter

DESCRIPTION

Demonstration circuits [DC1997A-A/DC1997A-B](#) are dual output synchronous buck converters featuring the [LTC[®]3838EUHF-1/LTC3838EUHF-2](#). Both assemblies provide two outputs of 1.5V/20A and 1.2V/20A over an input voltage range of 4.5V to 14V at a switching frequency of 300kHz.

Applications requiring the output to be adjusted with an external reference can be implemented with the DC1997A-B assembly. Such applications include adaptive voltage scaling optimization (AVSO) where the processor voltage is adjusted to achieve optimal efficiency, wide output voltage applications controlled by a DAC, or margining. The 2nd channel of the DC1997A-B assembly is regulated to an onboard 1.2V reference in the default setup. The same reference can be set from 0.8V to 1.5V with a potentiometer or the 2nd channel can regulate to a source external to the board. The 1st channel on the DC1997A-B assembly and both channels on the DC1997A-A version are regulated to the internal reference.

The entire converter, excluding the bulk input and output capacitors, fits within a 1.5in² area on the board. The high density is a result of the compact, 2-sided drop-in layout and the use of dual channel FETs.

Additional features of this demo board include:

- Remote sensing for each output.
- PLLIN and CLKOUT pins.
- PGOOD, RUN and TRK/SS pins for each output.
- Optional resistors to tie the two outputs together.
- Optional footprint for discrete single channel FETs for higher output current.
- Optional footprints to implement DTR (detect transient) to reduce overshoot following a load release.

Design files for this circuit board are available at <http://www.linear.com/demo>

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PERFORMANCE SUMMARY Specifications are at T_A = 25°C, No Airflow

| PARAMETER | CONDITION | VALUE |
|---|--|---------------|
| Minimum Input Voltage | | 4.5V |
| Maximum Input Voltage | | 14V |
| Output Voltage V _{OUT1} | I _{OUT1} = 0A to 20A, V _{IN} = 4.5V to 14V | 1.5V ± 2% |
| Output Voltage V _{OUT2} | I _{OUT2} = 0A to 20A, V _{IN} = 4.5V to 14V | 1.2V ± 2% |
| V _{OUT1} Maximum Output Current, I _{OUT1} | V _{IN} = 4.5V to 14V, V _{OUT1} = 1.5V | 20A |
| V _{OUT2} Maximum Output Current, I _{OUT2} | V _{IN} = 4.5V to 14V, V _{OUT2} = 1.2V | 20A |
| Nominal Switching Frequency | | 300kHz |
| Efficiency (Measured on DC1997A-B Assembly) See Figure 2 | V _{OUT1} = 1.5V, I _{OUT1} = 20A, V _{IN} = 12V | 90.4% Typical |
| | V _{OUT2} = 1.2V, I _{OUT2} = 20A, V _{IN} = 12V | 88.8% Typical |

DEMO MANUAL

DC1997A-A/DC1997A-B

QUICK START PROCEDURE

Demonstration circuit DC1997A-A/DC1997A-B is easy to set up to evaluate the performance of the LTC3838EUHF-1/LTC3838EUHF-2. Please refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input supply, load and meters as shown in Figure 1. Preset the load to 0A and VIN supply to be 0V. For both assemblies, place the jumpers in the following positions:

| | | |
|-----|------|-----|
| JP4 | RUN1 | ON |
| JP1 | RUN2 | ON |
| JP2 | MODE | FCM |

The DC1997A-B assembly has additional jumpers for the reference circuit. Place these jumpers in the following positions:

| | | |
|-----|-----------|-------|
| JP5 | ON BD REF | FIXED |
| JP6 | REF | ON BD |

2. Adjust the input voltage to be between 4.5V and 14V. V_{OUT1} should be $1.5V \pm 2\%$. V_{OUT2} should be $1.2V \pm 2\%$.
3. Next, apply 20A load to each output and re-measure V_{OUT} .
4. Once the DC regulation is confirmed, observe the output voltage ripple, load step response, efficiency and other parameters.

Note 1: Use the BNC connectors labeled V_{OUT1} or V_{OUT2} to measure the output volt-age ripple.

Note 2: Do not connect load from the VO1_SNS+ turret to the VO1_SNS- turret or from the VO2_SNS+ turret to the VO2_SNS- turret. This could damage the converter. Only apply load across the stud connectors on the edge of the board.

Reference Circuit for Channel 2 of DC1997A-B Assembly

Channel 2 of the DC1997A-B assembly is configured by default to regulate to the fixed 1.2V reference generated by the LT[®]6650 reference circuit. If desired, this reference can be set with a potentiometer, or an external source such as a DAC or another source. See the following instructions to set the board for either:

Adjusting the Onboard Reference:

1. Remove power from the input of the board.
2. Place these jumpers in the following positions:

| | | |
|-----|-----------|-------|
| JP5 | ON BD REF | ADJ |
| JP6 | REF | ON BD |

3. Apply power to the input of the board.
4. Adjust reference with potentiometer at R52.

Connecting a Reference External to the Board:

1. Remove power from the input of the board.
2. Place JP6 in the EXT position.
3. Connect the external reference between the EXTREF2+ and EXTREF2- turrets.
4. Apply power to the input of the board.
5. Turn-on the external reference.

Note 3: For accurate efficiency measurements in DCM at light load at V_{IN} greater than 5V, remove R51 and apply an external reference to the board as mentioned above.

Single Output/Dual Phase Operation

A single output/dual phase converter may be preferred for higher output current applications. The optional components required to tie the phases together are found on the top middle of the first sheet. To tie the two outputs together, make the following modifications:

1. Tie the two VOUT shapes together with a piece of copper at the edge of the board where the copper is exposed.
2. Tie the VOUT SENSE1+ pin to INTVCC with a 0 Ω jumper at R8. This will tie ITH1 to ITH2 inside the chip.
3. Tie RUN1 to RUN2 by stuffing a 0 Ω jumper at R15.
4. If DTR is implemented, then stuff 0 Ω jumper at R9 to tie the two DTR pins together.

QUICK START PROCEDURE

Dynamic Load Circuit (Optional)

Demonstration circuit DC1997A-A/DC1997A-B provides a simple load-step circuit consisting of a MOSFET and sense resistor for each rail. To apply a load step, follow the steps below.

1. Pre-set the amplitude of a pulse generator to 0.0V and the duty cycle to 5% or less.
2. Connect the scope to the VOUT BNC connectors for the rail under test with a coax cable. To monitor the load-step current, connect the scope probe across the ISTEP+/- turrets for that rail.

3. Connect the output of the pulse generator to the PULSE turret for the rail under test and connect the return to the adjacent GND turret.
4. With the converter running, slowly increase the amplitude of the pulse generator output to provide the desired load step pulse height. The scaling for the load step signal is 5mV/Amp.

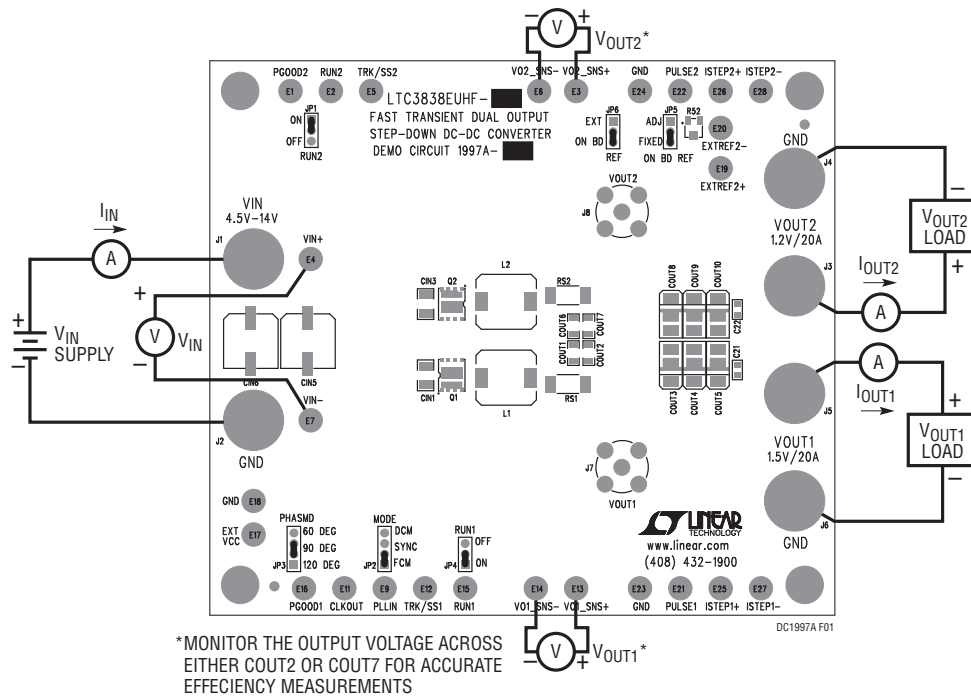


Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE

LTC3838-2 1.5V/20A and 1.2V/20A Converter

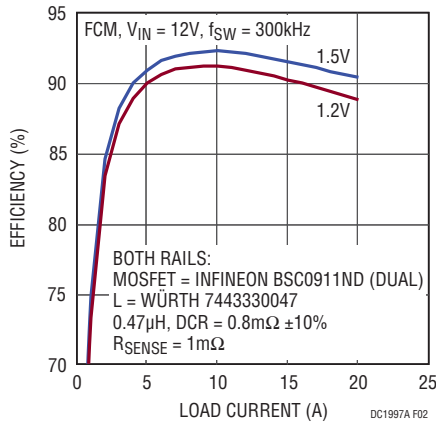


Figure 2. Efficiency Curves for the 1.5V Rail and 1.2V Rail of the DC1997A-B Assembly in FCM at $V_{IN} = 12V$

LTC3838-2 1.5V/20A and 1.2V/20A Converter

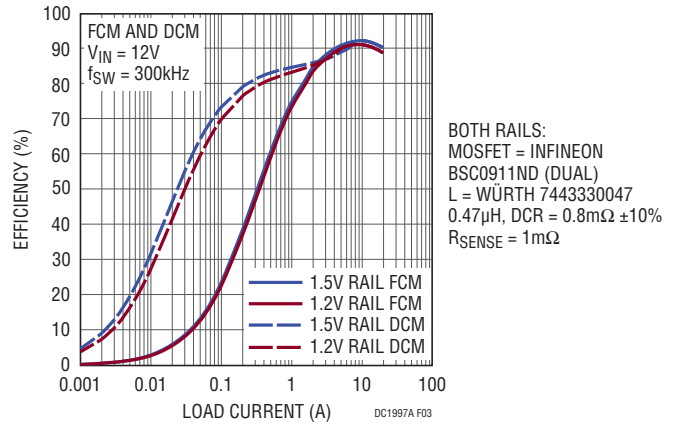


Figure 3. Efficiency Curves for the 1.5V Rail and 1.2V Rail of the DC1997A-B Assembly in FCM and DCM at $V_{IN} = 12V$

VOUT2 of the LTC3838-2 Demo Board Adjusted with External Reference

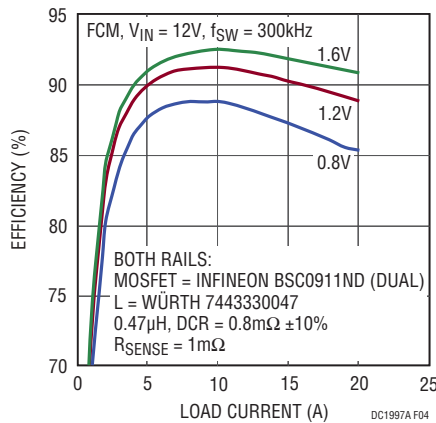


Figure 4. Efficiency Curves for VOUT2 on the DC1997A-B Assembly at Different Output Voltage Settings

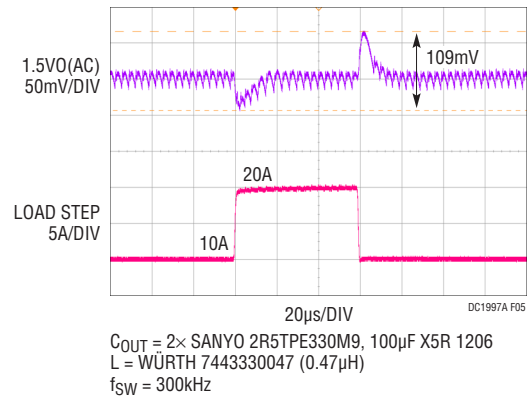


Figure 5. 50% to 100% to 50% Load Step Response of the 1.5V Rail on the DC1997A-A Assembly

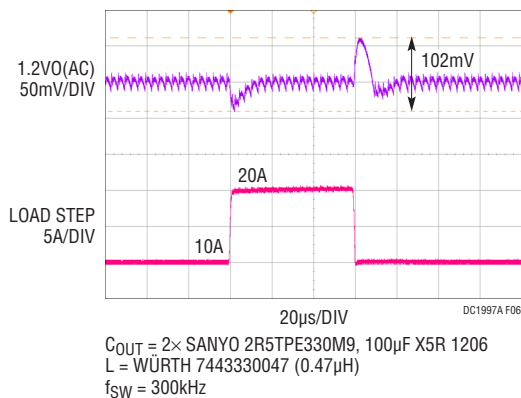


Figure 6. 50% to 100% to 50% Load Step Response of the 1.2V Rail on the DC1997A-A Assembly

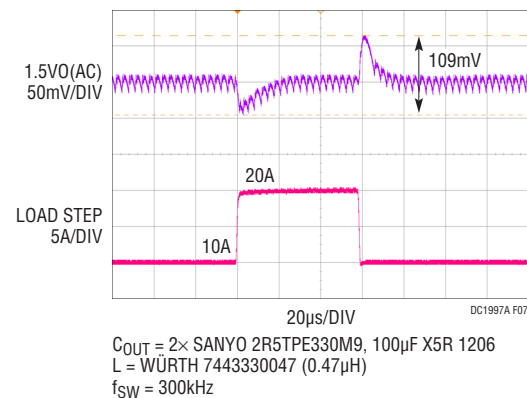


Figure 7. 50% to 100% to 50% Load Step Response of the 1.5V Rail on the DC1997A-B Assembly

QUICK START PROCEDURE

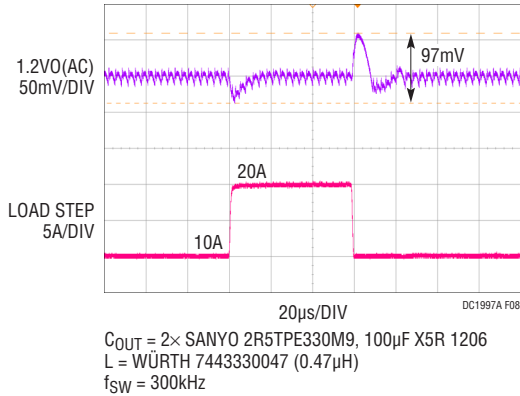


Figure 8. 50% to 100% to 50% Load Step Response of the 1.2V Rail on the DC1997A-B Assembly

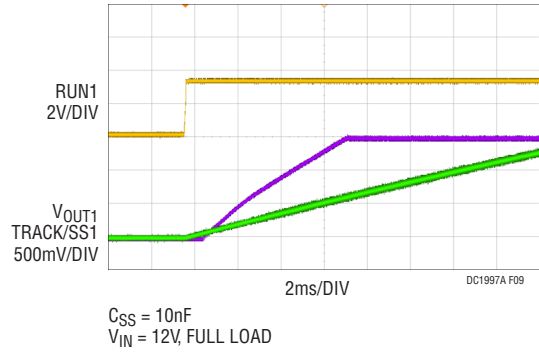


Figure 9. Turn-On of the 1.5V Rail of the DC1997A-A Assembly. RUN Pin Released from Ground

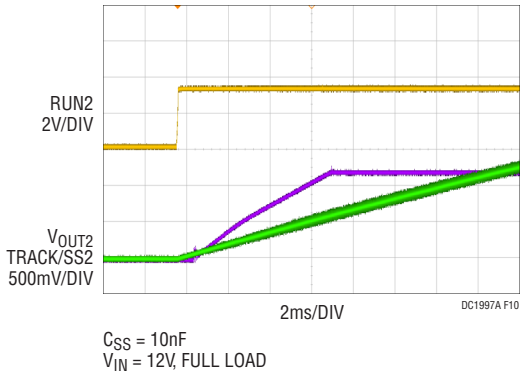


Figure 10. Turn-On of the 1.2V Rail of the DC1997A-A Assembly. RUN Pin Released from Ground

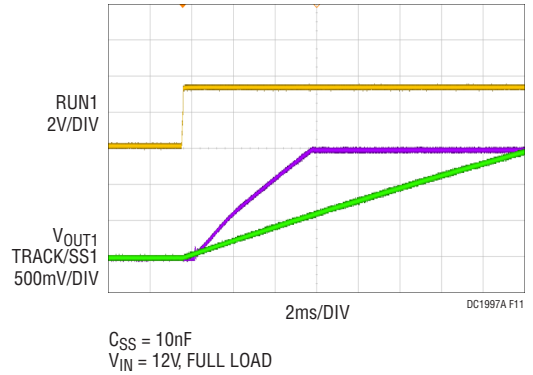


Figure 11. Turn-On of the 1.5V Rail of the DC1997A-B Assembly. RUN Pin Released from Ground

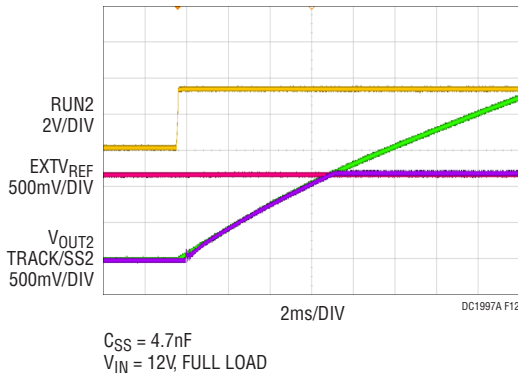


Figure 12. Turn-On of the 1.2V Rail of the DC1997A-B Assembly. RUN Pin Released from Ground

DEMO MANUAL

DC1997A-A/DC1997A-B

PARTS LIST-DC1997A-A

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|------------------------------------|-----|---|------------------------------|----------------------------|
| Required Circuit Components | | | | |
| 1 | 1 | C12 | CAP X7R 470pF 16V 5% 0603 | AVX 0603YC471JAT2A |
| 2 | 2 | C21, C22 | CAP X5R 10µF 16V,10% 0805 | MURATA GRM21BR61C106KE15L |
| 3 | 2 | C3, C16 | CAP NPO 1000pF 25V 5% 0603 | AVX 06033A102JAT2A |
| 4 | 3 | C4, C10, C14 | CAP X5R 0.1µF 16V 10% 0603 | AVX 0603YD104KAT2A |
| 5 | 2 | C5, C11 | CAP NPO 47pF 16V 5% 0603 | AVX,0603YA470JAT2A |
| 6 | 1 | C6 | CAP X7R 330pF 16V 0603 | AVX 0603YC331JAT2A |
| 7 | 2 | C7, C13 | CAP X5R 0.01µF 16V 10% 0603 | AVX 0603YD103KAT2A |
| 8 | 1 | C8 | CAP X5R 4.7µF 16V,10% 0805 | AVX 0805YD475KAT2A |
| 9 | 2 | C9, C18 | CAP X5R 1µF 16V,10% 0603 | AVX 0603YD105KAT2A |
| 10 | 4 | CIN1, CIN2, CIN3, CIN4 | CAP X5R 22µF 16V 1210 | AVX 1210YD226MAT2A |
| 11 | 1 | CIN6 | CAP 180µF 16V SVP-F8 | SANYO 16SVP180MX |
| 12 | 4 | COUT1, COUT2, COUT6, COUT7 | CAP X5R 100µF 6.3V 20% 1206 | MURATA GRM31CR60J107ME39L |
| 13 | 4 | COUT4, COUT5, COUT9, COUT10 | CAP 330µF 2.5V SIZE 7343 | SANYO 2R5TPE330M9 |
| 14 | 2 | D1, D2 | DIODE SCHOTTKY SOD-323 | CENTRAL SEMI. CMDSH-4E TR |
| 15 | 2 | L1, L2 | IND 0.47µH 0.8mΩ DCR | WÜRTH 7443330047 |
| 16 | 2 | Q1, Q2 | MOSFET 5mm x 6mm POWER STAGE | INFINEON BSC0911ND |
| 17 | 2 | R13, R45 | RES 100k 1% 0603 | VISHAY CRCW0603100KFKEA |
| 18 | 6 | R2, R11, R19, R44, R4, R12 | RES 10k 1% 0603 | VISHAY CRCW060310K0FKEA |
| 19 | 1 | R27 | RES CHIP 11k 1% 0603 | VISHAY CRCW060311K0FKEA |
| 20 | 2 | R29, R31 | RES 2.2Ω 1% 0603 | VISHAY CRCW06032R20FKEA |
| 21 | 1 | R30 | RES 133k 1% 0603 | VISHAY CRCW0603133KFKEA |
| 22 | 2 | R32, R40 | RES 15k 1% 0603 | VISHAY CRCW060315K0FKEA |
| 23 | 12 | R5, R17, R21, R23, R25, R35, R38, R41, R42, R50, R14, R24 | RES 0Ω,0603 | VISHAY CRCW06030000Z0EA |
| 24 | 4 | R6, R7, R46, R48 | RES 10Ω 1% 0603 | VISHAY CRCW060310R0FKED |
| 25 | 2 | RS1, RS2 | RES 0.001Ω 1W 1% 2512 | VISHAY WSL25121L000FEA |
| 26 | 1 | U1 | LTC3838EUHF-1 QFN 38-LEAD | LINEAR TECH. LTC3838EUHF-1 |

PARTS LIST-DC1997A-A

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|--------------------------------------|-----|---|-----------------------------|--------------------------|
| Additional Circuit Components | | | | |
| 1 | 0 | C1, C2, C15, C17, C19, C23, C24 | CAP 0603 | OPT |
| 2 | 0 | C20 | CAP 0805 | OPT |
| 3 | 0 | CIN5 | CAP SVP-F8 | OPT |
| 4 | 0 | CIN7-CIN12 | CAP OPT 1210 | OPT |
| 5 | 0 | COU3, COU8, COU11-COU14 | CAP OPT 7343 | OPT |
| 6 | 0 | D3 | DIODE SOD-323 | OPT |
| 7 | 0 | E19, E20 | TESTPOINT TURRET 0.095" | OPT |
| 8 | 0 | JP5, JP6 | HEADER OPT 2MM SINGLE 3-PIN | OPT |
| 9 | 2 | Q11, Q12 | MOSFET N-CH 30V TO-252 | FAIRCHILD FDD8874 |
| 10 | 0 | Q3-Q10 | MOSFET LPAK | OPT |
| 11 | 0 | R1, R3, R8, R9, R10, R15, R16, R18, R20, R22, R26, R28, R33, R34, R36, R37, R39, R43, R47, R49, R63 | RES 0603 | OPT |
| 12 | 0 | R51, R53, R54, R59, R60, R61, R62 | RES 0603 | OPT |
| 13 | 0 | R52 | RES POT-3313J-1 | OPT |
| 14 | 2 | R55, R56 | RES 10k 1% 0603 | VISHAY CRCW060310K0FKEA |
| 15 | 2 | R57, R58 | RES 0.005Ω 1/2W 1% 2010 | VISHAY WSL20105L000FEA |
| 16 | 0 | U2 | LT6650HS5 SOT23-5 | OPT |
| Hardware | | | | |
| 1 | 6 | J1-J6 | STUD TEST PIN | PEM KFH-032-10 |
| 2 | 12 | J1-J6 | NUT BRASS #10-32 | ANY |
| 3 | 6 | J1-J6 | RING LUG #10 | KEYSTONE 8205 |
| 4 | 6 | J1-J6 | WASHER TIN PLATED BRASS | ANY |
| 5 | 2 | J7, J8 | CONN BNC 5 PINS | CONNEX 112404 |
| 6 | 2 | JP1, JP4 | HEADER 2MM SINGLE 3-PIN | SAMTEC TMM-103-02-L-S |
| 7 | 2 | JP2, JP3 | HEADER 2MM SINGLE 4-PIN | SAMTEC TMM-104-02-L-S |
| 8 | 4 | XJP1-XJP4 | SHUNT | SAMTEC 2SN-BK-G |

DEMO MANUAL

DC1997A-A/DC1997A-B

PARTS LIST-DC1997A-B

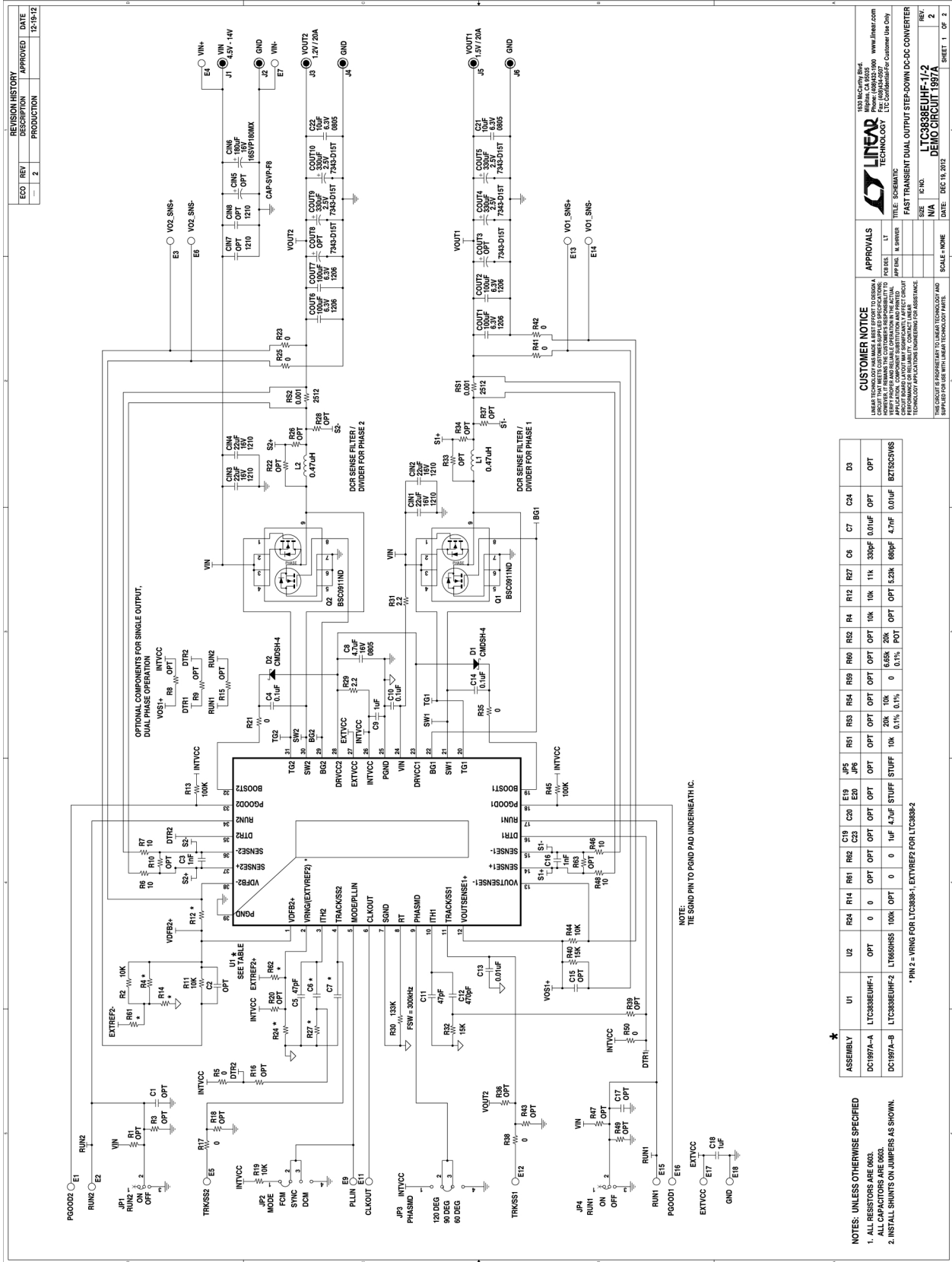
| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|------------------------------------|-----|--|------------------------------|----------------------------|
| Required Circuit Components | | | | |
| 1 | 1 | C12 | CAP X7R 470pF 16V 5% 0603 | AVX 0603YC471JAT2A |
| 2 | 2 | C21, C22 | CAP X5R 10µF 16V 10% 0805 | MURATA GRM21BR61C106KE15L |
| 3 | 2 | C3, C16 | CAP NPO 1000pF 25V 5% 0603 | AVX 06033A102JAT2A |
| 4 | 3 | C4, C10, C14 | CAP X5R 0.1µF 16V 10% 0603 | AVX 0603YD104KAT2A |
| 5 | 2 | C5, C11 | CAP NPO 47pF 16V 5% 0603 | AVX,0603YA470JAT2A |
| 6 | 1 | C6 | CAP NPO 680pF 16V 0603 | AVX 0603YC681JAT2A |
| 7 | 1 | C13 | CAP X5R 0.01µF 16V 10% 0603 | AVX 0603YD103KAT2A |
| 8 | 1 | C7 | CAP X7R 4.7nF 10V 0603 | AVX 0603ZC472JAT2A |
| 9 | 1 | C8 | CAP X5R 4.7µF 16V,10% 0805 | AVX 0805YD475KAT2A |
| 10 | 2 | C9, C18 | CAP X5R 1µF 16V,10% 0603 | AVX 0603YD105KAT2A |
| 11 | 4 | CIN1, CIN2, CIN3, CIN4 | CAP X5R 22µF 16V 1210 | AVX 1210YD226MAT2A |
| 12 | 1 | CIN6 | CAP 180µF 16V SVP-F8 | SANYO 16SVP180MX |
| 13 | 4 | COU1, COU2, COU6, COU7 | CAP X5R 100µF 6.3V 20% 1206 | MURATA GRM31CR60J107ME39L |
| 14 | 4 | COU4, COU5, COU9, COU10 | CAP 330µF 2.5V SIZE 7343 | SANYO 2R5TPE330M9 |
| 15 | 2 | D1, D2 | DIODE SCHOTTKY SOD-323 | CENTRAL SEMI. CMDSH-4E TR |
| 16 | 2 | L1, L2 | IND 0.47µH 0.8mΩ DCR | WÜRTH 7443330047 |
| 17 | 2 | Q1, Q2 | MOSFET 5mm x 6mm POWER STAGE | INFINEON BSC0911ND |
| 18 | 3 | R13, R24, R45 | RES 100k 1% 0603 | VISHAY CRCW0603100KFKEA |
| 19 | 4 | R2, R11, R19, R44 | RES 10k 1% 0603 | VISHAY CRCW060310K0FKEA |
| 20 | 1 | R27 | RES CHIP 5.23k 1% 0603 | VISHAY CRCW06035K23FKEA |
| 21 | 2 | R29, R31 | RES 2.2Ω 1% 0603 | VISHAY CRCW06032R20FKEA |
| 22 | 1 | R30 | RES 133k 1% 0603 | VISHAY CRCW0603133KFKEA |
| 23 | 2 | R32, R40 | RES 15k 1% 0603 | VISHAY CRCW060315K0FKEA |
| 24 | 13 | R5, R17, R21, R23, R25, R35, R38, R41, R42, R50, R59, R61, R62 | RES 0Ω, 0603 | VISHAY CRCW06030000Z0EA |
| 25 | 4 | R6, R7, R46, R48 | RES 10Ω 1% 0603 | VISHAY CRCW060310R0FKED |
| 26 | 2 | RS1, RS2 | RES 0.001Ω 1W 1% 2512 | VISHAY WSL25121L000FEA |
| 27 | 1 | U1 | LTC3838EUHF-2 QFN 38-LEAD | LINEAR TECH. LTC3838EUHF-2 |

PARTS LIST-DC1997A-B

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|--------------------------------------|-----|---|-------------------------------------|----------------------------------|
| Additional Circuit Components | | | | |
| 1 | 0 | C1, C2, C15, C17 | CAP 0603 | OPT |
| 2 | 1 | C19 | CAP X5R 1 μ F 16V 0603 | AVX 0603YD105KAT2A |
| 3 | 1 | C20 | CAP X5R 4.7 μ F 16V 0805 | AVX 0805YD475KAT2A |
| 4 | 1 | C23 | CAP X5R 1 μ F 16V 0603 | AVX 0603YD105KAT2A |
| 5 | 1 | C24 | CAP X5R 0.01 μ F 16V 0603 | AVX 0603YD103KAT2A |
| 6 | 0 | CIN5 | CAP SVP-F8 | OPT |
| 7 | 0 | CIN7-CIN12 | CAP OPT 1210 | OPT |
| 8 | 0 | COU3, COU8, COU11-COU14 | CAP OPT 7343 | OPT |
| 9 | 1 | D3 | DIODE BZT52C5V6S 5.6V ZENER SOD-323 | DIODES BZT52C5V6S-7-F |
| 10 | 2 | Q11, Q12 | MOSFET N-CH 30V TO-252 | FAIRCHILD FDD8874 |
| 11 | 0 | Q3-Q10 (OPT) | MOSFET LFPAK | OPT |
| 12 | 0 | R1, R3, R8, R9, R10, R15, R16, R18, R20, R22, R26, R28, R33, R34, R36, R37, R39, R43, R47, R49, R63 | RES 0603 | OPT |
| 13 | 0 | R4, R12, R14 | RES 0603 | OPT |
| 14 | 1 | R51 | RES CHIP 10k 1% 0603 | VISHAY CRCW060310K0FKEA |
| 15 | 1 | R52 | RES POT 20k 1% POT-3313J-1 | BOURN 3313J-1-203E |
| 16 | 1 | R53 | RES 20k 0.1% 0603 | VISHAY PTN0603E2002BST1 |
| 17 | 1 | R54 | RES 10k 0.1% 0603 | VISHAY PTN0603E1002BSTS |
| 18 | 2 | R55, R56 | RES 10k 1% 0603 | VISHAY CRCW060310K0FKEA |
| 19 | 2 | R57, R58 | RES 0.005 Ω 1/2W 1% 2010 | VISHAY WSL20105L000FEA |
| 20 | 1 | R60 | RES CHIP 6.65k 0.1% 0603 | VISHAY PTN0603E6651BSTS |
| 21 | 1 | U2 | LT6650HS5 SOT23-5 | LINEAR TECH. LT6650HS5 |
| Hardware | | | | |
| 1 | 2 | E19, E20 | TESTPOINT TURRET 0.095" | MILL-MAX 2501-2-00-80-00-00-07-0 |
| 2 | 26 | E1-E7, E9, E11-E28 | TESTPOINT TURRET 0.095" | MILL-MAX 2501-2-00-80-00-00-07-0 |
| 3 | 6 | J1-J6 | STUD TEST PIN | PEM KFH-032-10 |
| 4 | 6 | J1-J6 | NUT BRASS #10-32 | ANY |
| 5 | 6 | J1-J6 | RING LUG #10 | KEYSTONE 8205 |
| 6 | 12 | J1-J6 | WASHER TIN PLATED BRASS | ANY |
| 7 | 2 | J7, J8 | CONN BNC 5 PINS | CONNEX 112404 |
| 8 | 2 | JP1, JP4 | HEADER 2MM SINGLE 3-PIN | SAMTEC TMM-103-02-L-S |
| 9 | 2 | JP2, JP3 | HEADER 2MM SINGLE 4-PIN | SAMTEC TMM-104-02-L-S |
| 10 | 2 | JP5, JP6 | HEADER 2MM SINGLE 3-PIN | SAMTEC TMM-103-02-L-S |
| 11 | 1 | XJP1-XJP4 | SHUNT | SAMTEC 2SN-BK-G |
| 12 | 1 | XJP5,XJP6 | SHUNT | SAMTEC 2SN-BK-G |

DEMO MANUAL DC1997A-A/DC1997A-B

SCHEMATIC DIAGRAM



DEMO MANUAL

DC1997A-A/DC1997A-B

DEMONSTRATION BOARD IMPORTANT NOTICE

Linear Technology Corporation (LTC) provides the enclosed product(s) under the following **AS IS** conditions:

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If this evaluation kit does not meet the specifications recited in the DEMO BOARD manual the kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY THE SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.**

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