

# Dual Output Step-Down DC/DC Controller with Power System Management

## DESCRIPTION

Demonstration circuit 1936A is a high current, high efficiency, polyphase synchronous buck converter featuring the **LTC3882EUJ**, a dual output polyphase voltage mode controller. The LTC3882 has the PMBus interface and power system management functions.

The DC1936A uses 6mm × 6mm DrMOS as the power stage. The input range of this board is from 7V to 14V, and the output voltage can be programmed from 0.8V to 1.8V. The DC1936A provides two outputs, with each output capable of 1V/30A. The DC1936A has optional discrete driver (LTC4449EDCB) and MOSFET footprints for high input voltage applications up to 38V. The DC1936A also has an on-board dynamic load circuit, which makes it easy for the customer to evaluate the transient performances.

The DC1936A powers up to default settings and produces power based on configuration resistors or with its non-volatile memory without the need for any serial bus communication. This allows easy evaluation of the DC/DC converter. To fully explore the extensive power system

management features of the parts, download the GUI software LTpowerPlay™ onto your PC and use LTC's I<sup>2</sup>C/SMBus/PMBus Dongle DC1613A to connect to the board. LTpowerPlay allows the user to reconfigure the part on the fly and store the configuration settings within its onboard EEPROM, along with viewing telemetry parameters that include voltage, current, temperature and fault status.

### GUI Download

The software can be downloaded from:

<http://www.linear.com/ltpowerplay>

For more details and instructions of LTpowerPlay, please refer to LTpowerPlay for LTC3880 Quick Start Guide. The LTC3882 operation in LTpowerPlay is similar to that of the LTC3880.

**Design files for this circuit board are available at**  
<http://www.linear.com/demo/DC1936A>

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## PERFORMANCE SUMMARY Specifications are at T<sub>A</sub> = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>IN</sub>	Input Supply Range		7	12	14	V
V <sub>OUT0,1</sub>	Output Voltage Range	I <sub>OUT</sub> = 0A TO 30A, V <sub>IN</sub> = 7V to 14V	0.8	1	1.8*	V
I <sub>OUT0,1</sub>	Output Current Range		0		30	A
f <sub>SW</sub>	Factory Default Switching			500		kHz
EFF	Peak Efficiency	V <sub>IN</sub> = 12V, V <sub>OUT0</sub> = 1V, See Figure 4		90.4		%
LOAD TRANSIENT	Output Voltage Peak-to-Peak Spike During Load Transient	V <sub>IN</sub> = 12V, V <sub>OUT0</sub> = 1V, I <sub>STEP</sub> = 0A – 7.5A			30	mV

\*Note: The DC1936A uses 4V-rated low ESR PosCAP (Part No. 4TPF470ML) as output capacitors for optimized load transient performance. If >3.6V V<sub>OUT</sub> is needed, 6.3V-rated output capacitors should be used.

## QUICK START PROCEDURE

Demonstration circuit 1936A makes it easy to set up to evaluate the performances of the LTC3882. Refer to Figure 2 for proper measurement equipment setup and follow the procedure below:

NOTE: When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the output voltage ripple by touching the probe tip directly across the C10/C45. See Figure 3 for proper scope probe technique.

1. Make sure jumpers are in the following positions:

JUMPER	POSITION	FUNCTION
JP1	C	GPIO0B to GPIO1B
JP2	NC	RUN0 to RUN1
JP3	ON	5V Bias for DrMOS
JP4	ON	Bias Supply for $V_{CC}$ of the LTC3882
JP5	OFF	Write Protection

2. With power off, connect the input power supply to  $V_{IN}$  and GND. Connect active load to the output.

3. Make sure RUN switch (SW3 and SW4) is OFF.

4. Turn on the power at the input.

NOTE. Make sure that the input voltage does not exceed 16V.

5. Turn on RUN switch as desired.
6. Check for the correct output voltage from E6 to E7 for CH0 and from E8 to E9 for CH1.  $V_{OUT} = 1V \pm 0.5\%$  (0.995V ~ 1.005V)

NOTE: If there is no output, temporarily disconnect the load to make sure that the load is not set too high.

7. Once the proper output voltage is established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage, efficiency and other parameters.
8. Connect the dongle and control the output voltages from the GUI. See LTpowerPlay QUICK START session for details.

### Connecting a PC to DC1936A

You can use a PC to reconfigure the power management features of the LTC3882 such as: nominal  $V_{OUT}$ , margin set points, OV/UV limits, temperature fault limits, sequencing parameters, the fault log, fault responses, GPIO and other functionality. The DC1613A dongle may be plugged in regardless of whether or not  $V_{IN}$  is present. Dongle can be hot-plugged.

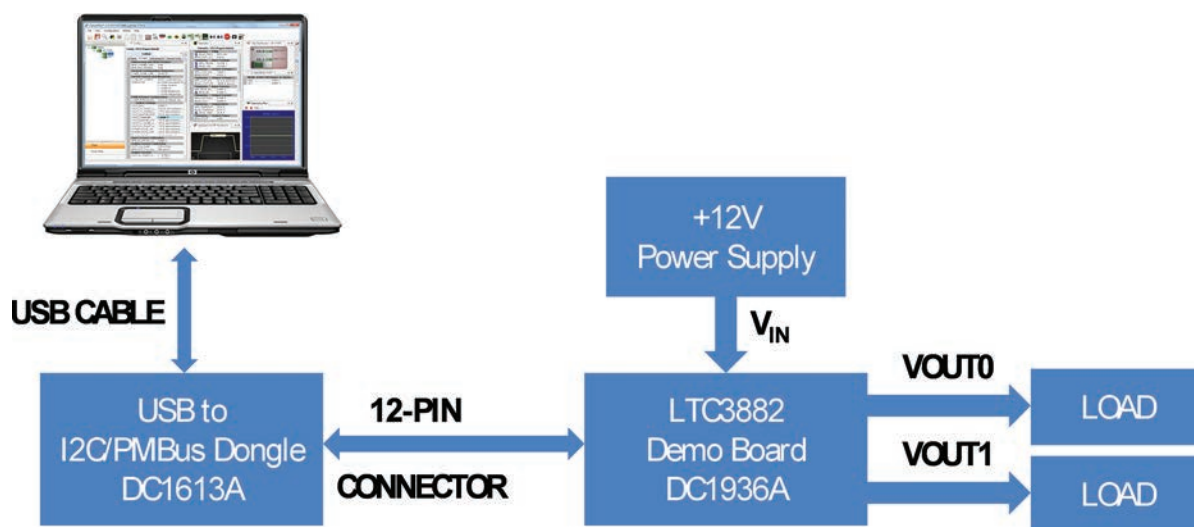


Figure 1. Demo Setup with PC

## QUICK START PROCEDURE

### Measuring Efficiency for DC1936A (See Figure 2)

To accurately measure efficiency of any configuration, do the following:

- Set JP3 and JP4 to OFF position to disable the auxiliary circuits.
- Turn on one channel only.
- Apply external 5V from E21 to E22 as the driver supply for DrMOS.
- Apply external 5V from E5 to E29 as  $V_{CC}$  for LTC3882.

- Measure  $V_{IN}$  across the input ceramic capacitor (C6 for CH1, C39 for CH0). Measure  $V_{OUT}$  across the output ceramic capacitor (C45 for CH1, C10 for CH0).

- The efficiency is calculated as:

$$\text{Efficiency} = \frac{V_{OUT} \cdot I_{OUT}}{V_{IN} \cdot I_{IN} + V_{DR} \cdot I_{DR} + V_{CC} \cdot I_{CC}} \cdot 100\%$$

### Measuring Output Ripple Voltage

An accurate ripple measurement may be performed by using the configuration across C10 as shown in Figure 3.

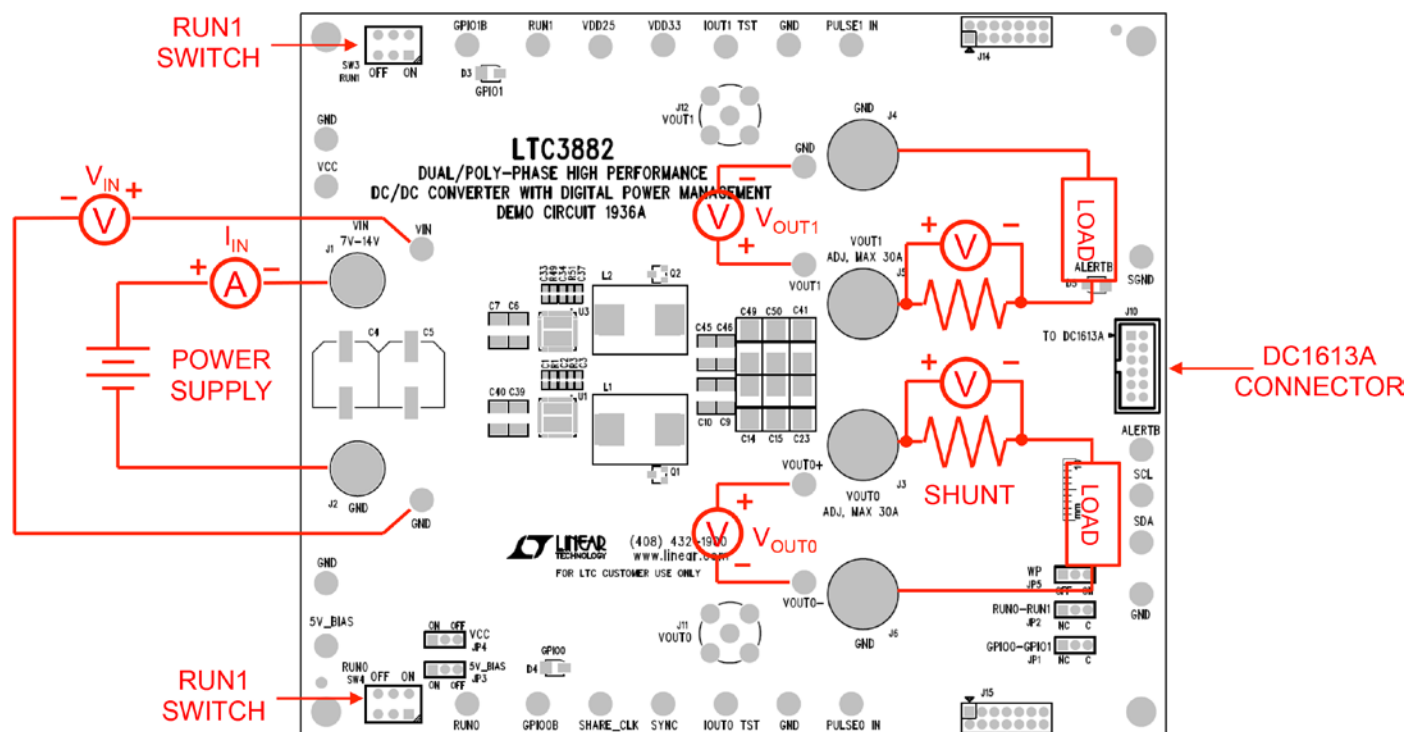


Figure 2. Power Test Setup for DC1936A

## QUICK START PROCEDURE

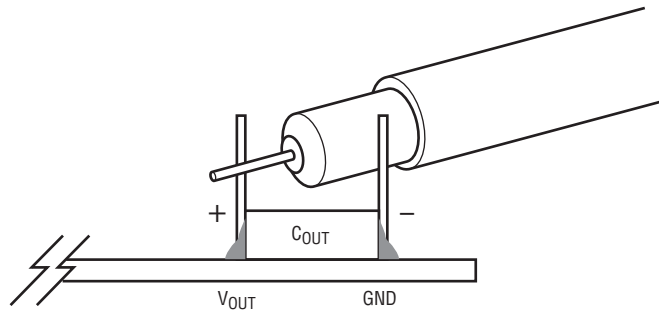


Figure 3. Measuring Output Voltage Ripple

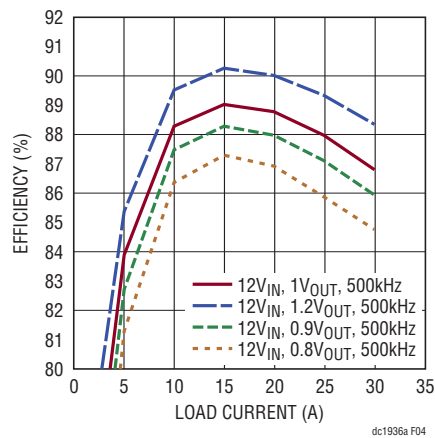


Figure 4. Typical Efficiency Curves of DC1936A,  $V_{IN} = 12V$ ,  $f_{SW} = 500kHz$ , Single Phase

## QUICK START PROCEDURE

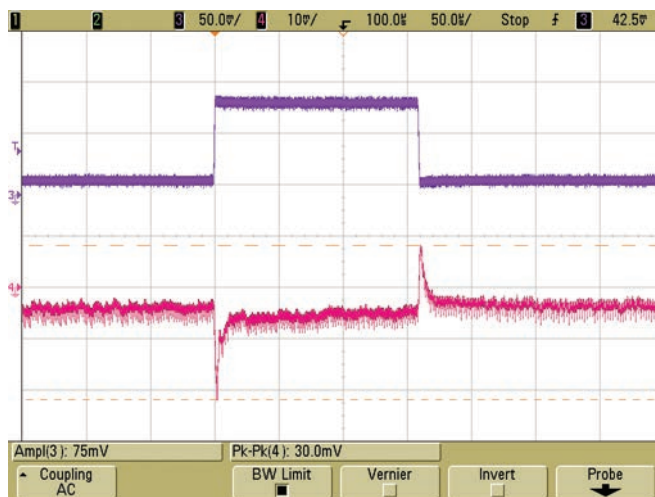


Figure 5. Load Transient Waveform of DC1936A,  $V_{IN} = 12V$ ,  $V_{OUT0} = 1V$ ,  $f_{SW} = 500kHz$ , 0% to 25% Load Step

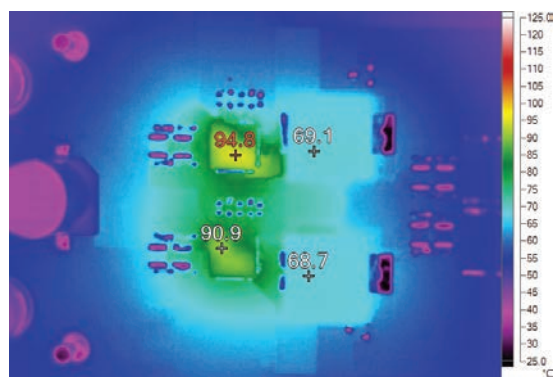


Figure 6. Thermal Picture of DC1936A,  $V_{IN} = 12V$ ,  $V_{OUT0} = V_{OUT1} = 1V$ ,  $I_{OUT0} = I_{OUT1} = 30A$ ,  $f_{SW} = 500kHz$ , No Airflow,  $T_A = 25^\circ C$

## LTpowerPlay SOFTWARE GUI

LTpowerPlay is a powerful Windows based development environment that supports Linear Technology power system management ICs, including the LTC3880, LTC3883, LTC3882, LTC2974 and LTC2978. The software supports a variety of different tasks. You can use LTpowerPlay to evaluate Linear Technology ICs by connecting to a demo board system. LTpowerPlay can also be used in an offline mode (with no hardware present) in order to build a multichip configuration file that can be saved and reloaded at a later time. LTpowerPlay provides unprecedented diagnostic and debug features. It becomes a valuable diagnostic tool during board bring-up to program or tweak the power

management scheme in a system, or to diagnose power issues when bringing up rails. LTpowerPlay utilizes the DC1613A USB-to-SMBus controller to communicate with one of many potential targets, including the LTC3882's DC1936A demo system, or a customer board. The software also provides an automatic update feature to keep the software current with the latest set of device drivers and documentation. The LTpowerPlay software can be downloaded from: <http://linear.com/ltpowerplay>

To access technical support documents for LTC Digital Power Products visit Help. View online help on the LTpowerPlay menu.

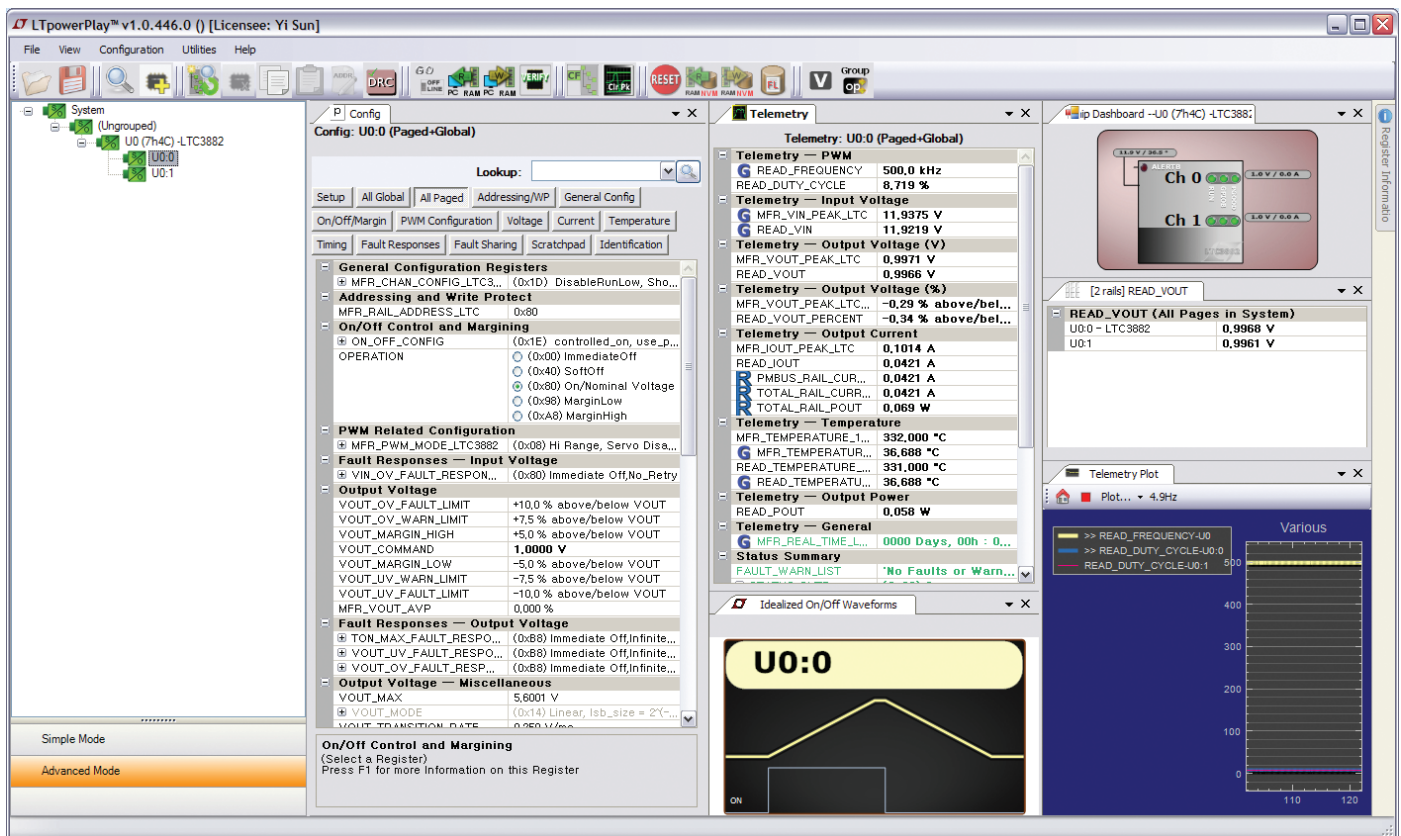


Figure 7. LTpowerPlay Main Interface

## LTpowerPlay QUICK START PROCEDURE

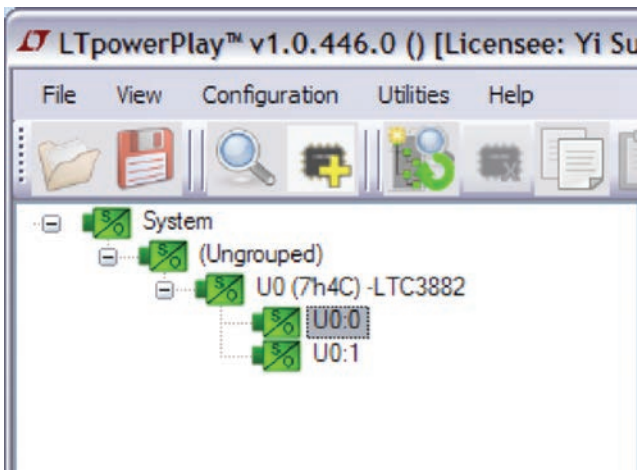
The following procedure describes how to use LTpowerPlay to monitor and change the settings of LTC3882.

1. Download and install the LTpowerPlay GUI:

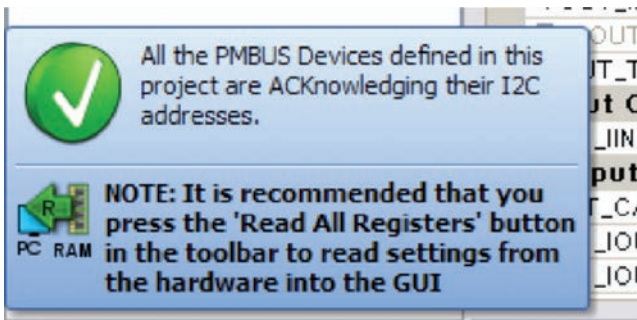
<http://linear.com/ltpowerplay>

2. Launch the LTpowerPlay GUI.

- a. The GUI should automatically identify the DC1936A. The system tree on the left hand side should look like this:



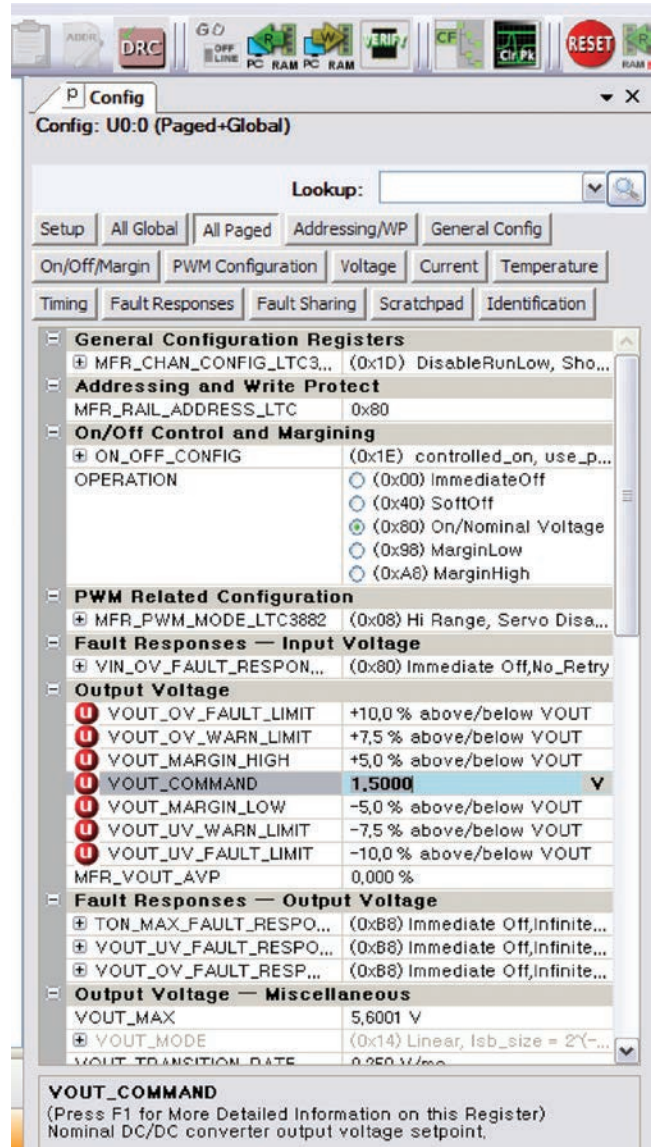
- b. A green message box shows for a few seconds in the lower left hand corner, confirming that the LTC3882 is communicating:



- c. In the Toolbar, click the R (RAM to PC) icon to read the RAM from the LTC3882. This reads the configuration from the RAM of LTC3882 and loads it into the GUI.



- d. If you want to change the output voltage to a different value, like 1.5V. In the Config tab, type in 1.5 in the VOUT\_COMMAND box, like this:

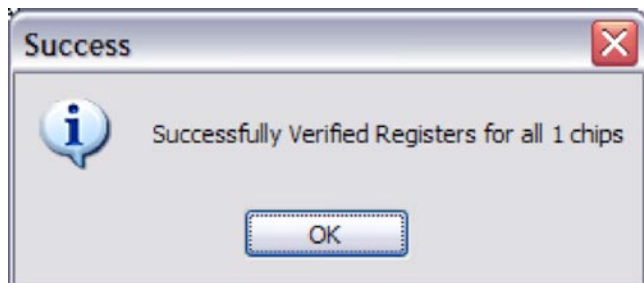


Then, click the W (PC to RAM) icon to write these register values to the LTC3882. After finishing this step, you will see the output voltage will change to 1.5V.



## LTpowerPlay QUICK START PROCEDURE

If the write is successful, you will see the following message:



e. You can save the changes into the NVM. In the tool bar, click RAM to NVM button, as following



f. Save the demo board configuration to a (\*.proj) file. Click the Save icon and save the file. Name it whatever you want.

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	4	C6, C7, C39, C40	CAP., X5R 22µF 25V 10% 1210	AVX, 12103D226KAT2A
2	5	C1, C3, C17, C33, C37	CAP., X7R 1µF 16V 10% 0603	AVX, 0603YC105KAT2A
3	2	C25, C32	CAP., X7R 3.3nF 25V 10% 0603	AVX, 06033C332KAT2A
4	2	C26, C31	CAP., X7R 330pF 16V 0603	AVX, 0603YC331KAT2A
5	1	C59	CAP., X7R 1µF 16V 10% 1206	AVX, 1206YC105KAT2A
6	3	C2, C16, C34	CAP., X5R 2.2µF 16V 10% 0603	TDK, C1608X5R1C225K
7	2	C27, C30	CAP., NPO 33pF 50V 5% 0603	AVX, 06035A330JAT2A
8	2	C4, C5	CAP., OS-CON, 330µF, 16V, 20%, F12	PANASONIC, 16SVP330M
9	3	C8, C54, C67	CAP., X7R 0.1µF 50V 10% 0603	AVX, 06035C104KAT2A
10	8	C9-C12, C45-C48	CAP., X5R 100µF 6.3V 1210	AVX, 12106D107MAT2A
11	6	C14, C15, C23, C41, C49, C50	CAP., POSCAP, 470µF, 4V, D3L SIZE	PANASONIC, 4TPF470ML
12	1	C18	CAP., X5R 4.7µF 25V 0805	TAIYO YUDEN, TMK212ABJ475KG-T
13	2	C24, C66	CAP., X7R 0.22µF 25V 10% 0603	TDK, C1608X7R1E224K
14	2	C61, C62	CAP., X7R 2.2µF 6.3V 10% 0805	MURATA, GRM21BR70J225KA01L
15	6	C28, C29, C38, C51, C64, C65	CAP., X7R 0.01µF 50V 10% 0603	AVX, 06035C103KAT2A
16	2	L1, L2	INDUCTOR, SMT POWER IND. 0.22µH	PULSE, PA0515.221NLT
17	2	Q1, Q2	TRANS GP SS PNP 40V SOT-23	ON SEMI., MMBT3906LT1G
18	13	R1, R21, R26-R28, R43, R44, R48, R49, R64, R68, R105, R45	RES., CHIP 0Ω, 0603	VISHAY, CRCW06030000Z0EA
19	4	R3, R51, R69, R104	RES., CHIP, 10Ω, 5%, 0603	VISHAY, CRCW060310R0JKEA
20	1	R31	RES., CHIP, 17.4k, 1%, 0603	VISHAY, CRCW060317K4FKEA
21	1	R32	RES., CHIP, 16.2k, 1%, 0603	VISHAY, CRCW060316K2FKEA
22	2	R29, R36	RES., CHIP, 357Ω, 1%, 0603	VISHAY, CRCW0603357RFKEA
23	2	R5, R54	RES., CHIP, 1Ω, 1%, 0603	NIC, NRC06F1R00TRF
24	2	R30, R33, R6, R13-R18, R56, R61, R72, R73, R86, R87, R88, R89	RES., CHIP, 10k, 5%, 0603	VISHAY, CRCW060310K0JKEA



## PARTS LIST

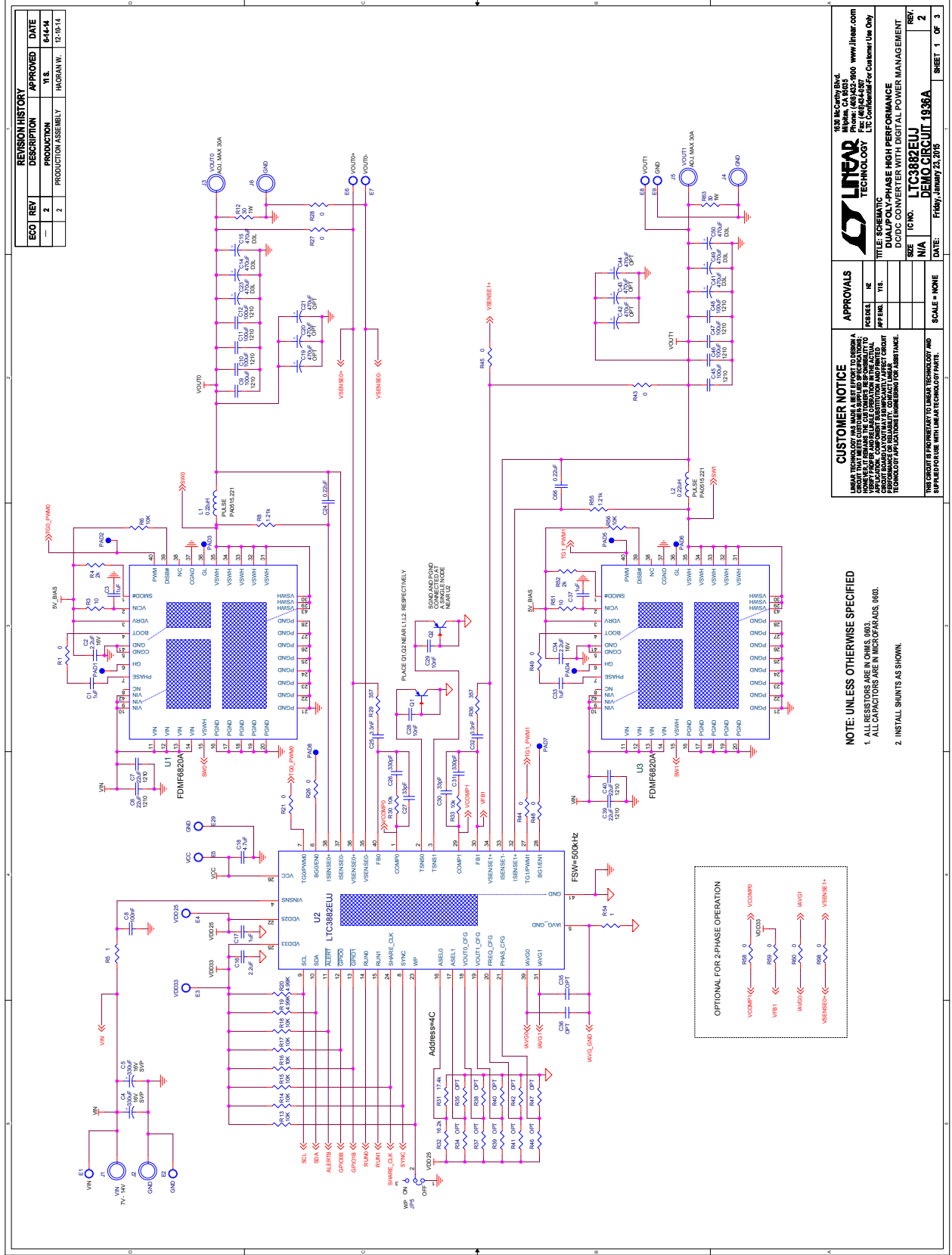
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
25	2	U1, U3	IC, HIGH FREQUENCY DrMOS MOUDLE	FAIRCHILD, FDMF6820A
26	1	U2	IC, LTC3882EUJ, QFN 6mm x 6mm	LINEAR TECH., LTC3882EUJ#10BJ-2PBF-ES
27	1	U4	IC, 24LC025-I/ST, SOIC	MICROCHIP, 24LC025-I/ST
<b>Additional Demo Board Circuit Components</b>				
1	0	CIN1, CIN2, CIN3, CIN4 OPT	CAP., X5R 22 $\mu$ F 25V 10% 1210	AVX, 12103D226KAT2A
2	2	C35, C36 OPT	CAP., X7R 47pF 5% 50V 0603 OPT	
3	2	C60, C63	CAP., X5R 10 $\mu$ F 35V 1206	TAIYO YUDEN, GMK316BJ106ML-T
4	0	C55, C56, C57, C58, C19, C20, C21, C42, C43, C44 OPT	CAP., 0603	
5	0	D1, D2 OPT	DIODE, SCHOTTKY, SOD-323	
6	1	D6	DIODE, SCHOTTKY, SOD-323	CENTRAL SEMI., CMDSH-3TR
7	2	D3, D4	LED, 0603 GREEN	WURTH ELEKTRONIK, 150060GS75000
8	1	D5	LED, 0603 RED	WURTH ELEKTRONIK, 150060SS75000
9	0	D7, D8	DIODE, SOD-323	
10	2	Q11, Q12	MOSFET SPEED SRS 30V 30A LPAK	RENESAS, RJK0305DPB-00#J0
11	0	Q3, Q4, Q5, Q6 OPT	MOSFET SPEED SRS 30V 30A LPAK	RENESAS, RJK0305DPB-00#J0
12	0	Q7, Q8, Q9, Q10 OPT	MOSFET JET SERIES 30V 45A LPAK	RENESAS, RJK0330DPB-00#J0
13	2	Q13, Q14	MOSFET P-CH 20V 0.58A SOT-23	VISHAY, TP0101K-T1-E3
14	2	Q15, Q16	MOSFET N-CH 60V 115MA SOT-23	FAIRCHILD, 2N7002
15	2	SW1, SW2	CONNECTOR, SUB MINIATURE SLIDE SWITCHES	C&K., JS202011CQN
16	0	R34, R35, R37-R42, R82-R85, R101, R102, R46, R47, R58, R59, R60, R66, R71, R98, R65, R70, R76, R77, R67, R103, R107 OPT	RES., CHIP, 0603	
17	2	R8, R55	RES., CHIP, 1.21k, 1%, 0603	VISHAY, CRCW06031K21FKEA
18	2	R12, R63	RES., CHIP, 30 $\Omega$ , 1%, 2512	VISHAY, CRCW251230R0FKEG
19	1	R62	RES., CHIP, 15.8k, 1%, 0603	VISHAY, CRCW060315K8FKEA
20	4	R79, R80, R19, R20	RES., CHIP, 4.99k, 1%, 0603	NIC, NRC06F4991TRF
21	2	R90, R91	RES., CHIP, 6.19k, 1%, 0603	VISHAY, CRCW06036K19FKEA
22	2	R92, R93	RES., CHIP, 0.01 $\Omega$ , 1%, 2010	VISHAY WSL2010R0100FEA
23	4	R94, R95, R4, R52	RES., CHIP, 2k, 1%, 0603	VISHAY, CRCW06032K00FKEA
24	2	R96, R97	RES., CHIP, 200 $\Omega$ , 1%, 0603	VISHAY, CRCW0603200RFKEA
25	2	R57, R99	RES., CHIP, 50 $\Omega$ , 1%, 0603	VISHAY, CRCW060350R0FKEA
26	1	R100	RES., CHIP, 127 $\Omega$ , 1%, 0603	VISHAY, CRCW0603127RFKEA
27	0	U5, U6 OPT	N-CHANNEL MOSFET DRIVER, LTC4449IDCB	
28	1	U7	IC, LT3029IMSE, MSOP, 16 PIN	LINEAR TECH., LT3029IMSE#PBF

# DEMO MANUAL DC1936A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Hardware: For Demo Board Only</b>				
1	29	E1-E29	TESTPOINT, TURRET, 0.094"	MILL-MAX, 2501-2-00-80-00-00-07-0
2	2	J1, J2	JACK, BANANA	KEYSTONE, 575-4
3	4	J3-J6	STUD, TEST PIN	PEM KFH-032-10
4	8	J3-J6 (X2)	NUT, BRASS 10-32	ANY #10-32
5	4	J3-J6	RING, LUG #10	KEYSTONE, 8205, #10
6	4	J3-J6	WASHER, TIN PLATED BRASS	ANY #10
7	1	J14	CONN RECEPT 2MM DUAL R/A 14POS (F)	SULLINS, NPPN072FJFN-RC
8	1	J15	HEADER 14POS 2MM R/A GOLD (M)	MOLEX, 87760-1416
9	1	J10	CONN HEADER 12POS 2MM STR DL PCB	FCI 98414-G06-12ULF
10	5	JP1-JP5	0.079 SINGLE ROW HEADER, 3 PIN	SULLIN, NRPN031PAEN-RC
11	5	JP1-JP5	SHUNT	SAMTEC, 2SN-BK-G
12	2	J11, J12	CONN, BNC, 5 PINS	CONNEX, 112404
13	2	SW1, SW2	CONNECTOR, SUB MINIATURE SLIDE SWITCHES	C&K., JS202011CQN

SCHEMATIC DIAGRAM



REVISION HISTORY		
ECO#	REV	DATE
—	2	12-16-14
DESCRIPTION		APPROVED
PRODUCTION		Y1 S.
PRODUCTION ASSEMBLY		HAGMAN W.

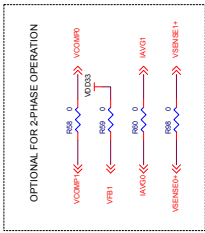
APPROVALS	
DESIGN	IK
APP ENG	YH
SCALE	NONE
DATE	Friday, January 23, 2015
SHEET	1 OF 3

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Folsom, CA 95630  
Tel: 916.444.2300  
Fax: 916.444.2307  
www.linear.com

**TITLE: SCHEMATIC**  
**DC/DC CONVERTER WITH DIGITAL POWER MANAGEMENT**  
**IC#0: LTC3882EUJ**  
**DEMO CIRCUIT 1936A**

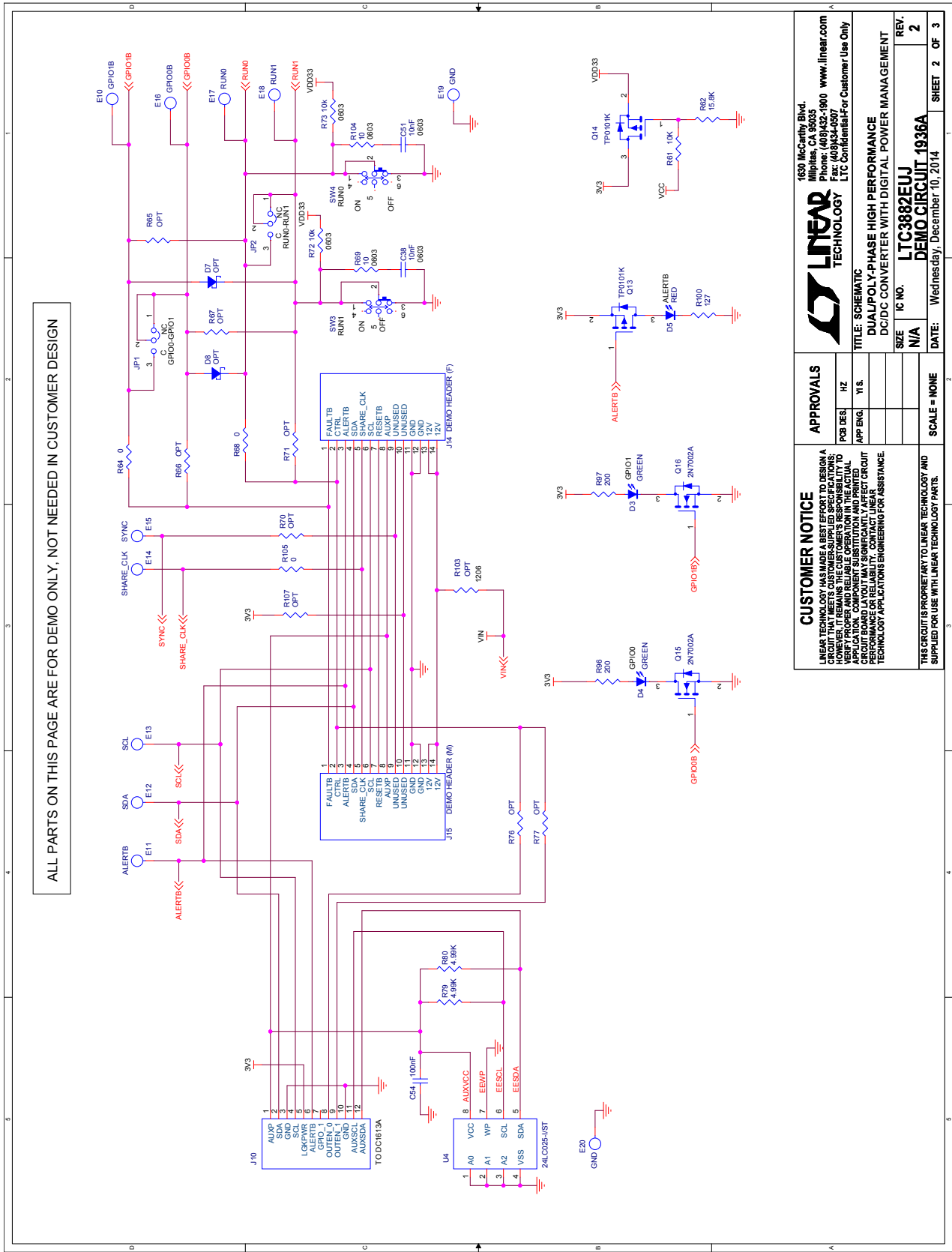
**NOTE: UNLESS OTHERWISE SPECIFIED**  
1. ALL RESISTORS ARE IN OHMS (Ω) UNLESS OTHERWISE SPECIFIED.  
2. INSTALL SHUNTS AS SHOWN.



# DEMO MANUAL DC1936A

## SCHEMATIC DIAGRAM

ALL PARTS ON THIS PAGE ARE FOR DEMO ONLY, NOT NEEDED IN CUSTOMER DESIGN



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**APPROVALS**

POB DES	HZ
APP ENG	YI.S.

SCALE = NONE

**LINEAR TECHNOLOGY**

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Milpitas, CA 95035  
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Fax: (408)434-0097  
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**TITLE: SCHEMATIC**

**DUAL/POLY-PHASE HIGH PERFORMANCE DC/DC CONVERTER WITH DIGITAL POWER MANAGEMENT**

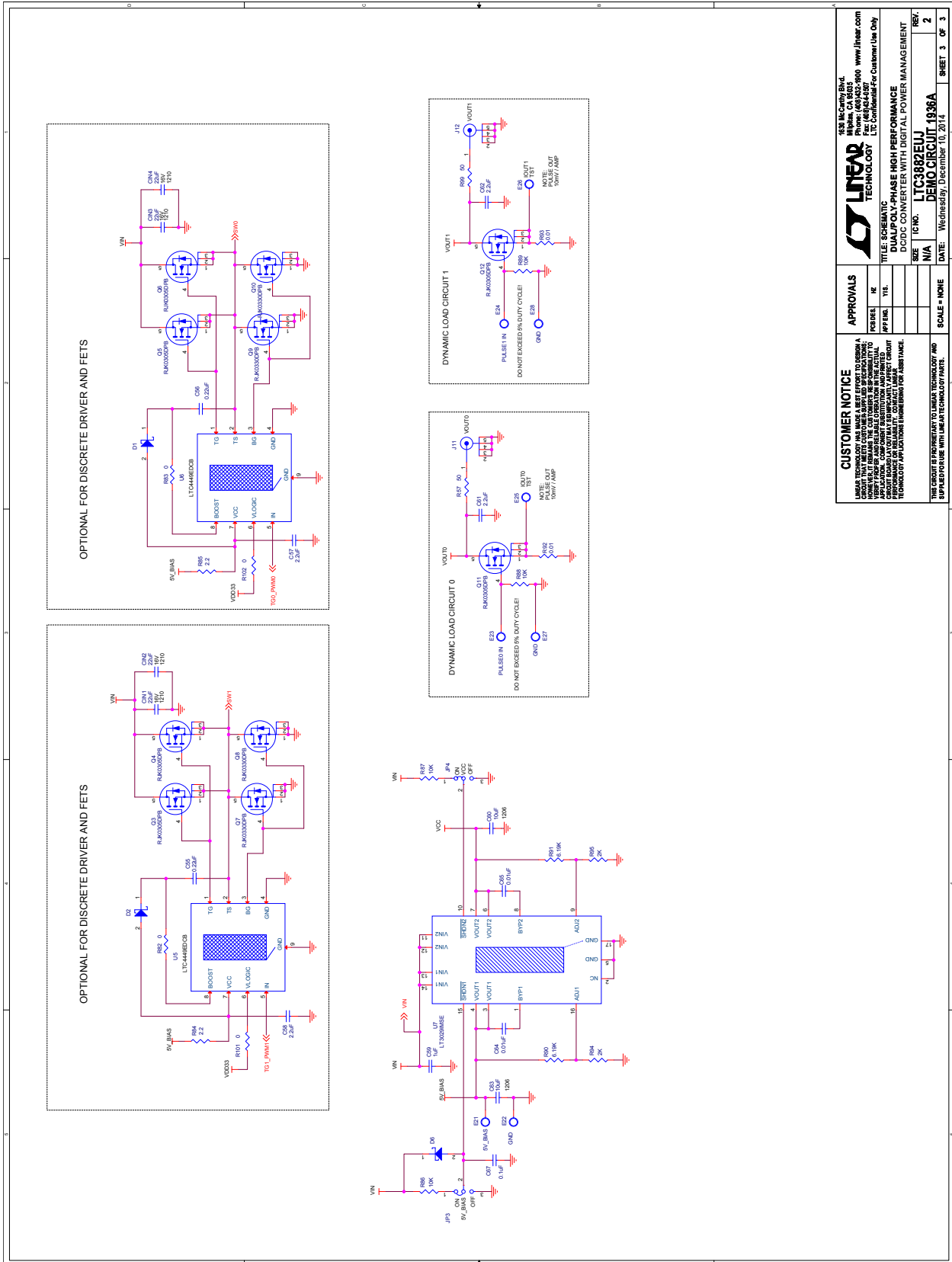
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IC NO: **LTC3882EUI**

DATE: Wednesday, December 10, 2014

SHEET 2 OF 3

SCHEMATIC DIAGRAM



# DEMO MANUAL DC1936A

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## DEMONSTRATION BOARD IMPORTANT NOTICE

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

This demonstration board (DEMO BOARD) kit being sold or provided by Linear Technology is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not provided by LTC for commercial use. As such, the DEMO BOARD herein may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to product safety measures typically found in finished commercial goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may or may not meet the technical requirements of the directive, or other regulations.

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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**Please read the DEMO BOARD manual prior to handling the product.** Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged.**

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

Mailing Address:

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