

# LTC7106 and LTM4636 7-Bit DAC with PMBus Controlled Step-Down $\mu$ Module Regulator

## DESCRIPTION

Demonstration circuit 2830A features the [LTM®4636EY](#), a 40A high efficiency, switch mode step-down  $\mu$ Module® regulator which is controlled by the [LTC®7106EDDB](#), a precision, bidirectional, 7-Bit current DAC with PMBus interface. The LTC7106 is used to adjust the output voltage of the LTM4636 by way of the PMBus. The LTM4636's input voltage range is from 4.7V to 15V and the output voltage range is from 0.6V to 3.3V. De-rating is necessary for certain VIN, VOUT, frequency and thermal conditions. The LTC7106 requires an input voltage from 2.5V to 5.5V and on DC2830A it's powered directly from the DC1613A dongle. The LTC7106 provides three ranges of IDAC output current: Nominal Range ( $-64\mu\text{A}$  to  $63\mu\text{A}$ ), Range High ( $-256\mu\text{A}$  to  $252\mu\text{A}$ ) and Range Low ( $-16\mu\text{A}$  to  $15.75\mu\text{A}$ ). The nominal range is optimized with the highest accuracy.

It is recommended that users design the resistor divider using the nominal range of the IDAC setting.

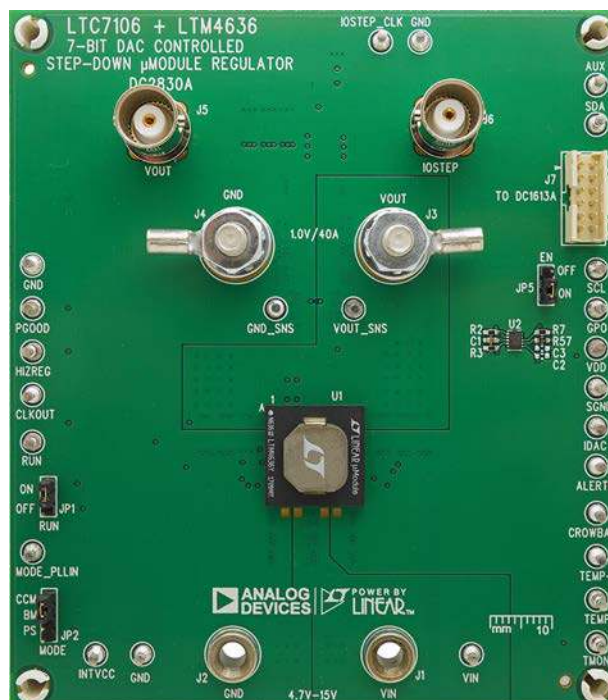
To explore the power system management features of the LTC7106, download the GUI software [LTpowerPlay®](#) onto your PC and use ADI's I<sup>2</sup>C/SMBus/PMBus Dongle DC1613A to connect to the board. LTpowerPlay allows the user to reconfigure the part on-the-fly, view IDAC current value and fault status.

The LTM4636 and LTC7106 data sheets must be read in conjunction with this demo manual prior to working on or modifying demo circuit DC2830A.

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

All registered trademarks and trademarks are the property of their respective owners.

## BOARD PHOTO



# DEMO MANUAL DC2830A

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

IC	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
LTM4636	Input Voltage Range		4.7		15	V
	Output Voltages			$1.0 \pm 2.3\%$		V
	Maximum Continuous Output Current	De-rating is necessary for certain operating conditions. See data sheet for details.		40		A <sub>DC</sub>
	Operating Frequency			350		kHz
	Efficiency	$V_{IN} = 12\text{V}, V_{OUT} = 1.0\text{V}, I_{OUT} = 40\text{A}$			87.1	%
	Load Transient	$V_{IN} = 12\text{V}, V_{OUT} = 1.0\text{V}, I_{STEP} = 30\text{A to } 40\text{A}$			49	mV
LTC7106	I <sub>DAC</sub> Operation Voltage		0.4		2.0	V
	Output Current Range	Nominal, LSB = 1 $\mu\text{A}$	-64		63	$\mu\text{A}$
		Range High, LSB = 4 $\mu\text{A}$	-256		252	$\mu\text{A}$
		Range Low, LSB = 0.25 $\mu\text{A}$	-16		15.75	$\mu\text{A}$
I <sub>DAC</sub> Accuracy	Nominal Range	-1.5		0.8	%	

## QUICK START PROCEDURE

Demonstration circuit 2830A makes it easy to use the LTC7106 to adjust the LTM4636 output voltage. This demo manual will focus on the evaluation of LTC7106. For the LTM4636 evaluation procedure, please refer to the DC2230A-A demo manual on the Analog Devices website. Please refer to Figure 1 for proper demo board setup with PC and follow the procedure below:

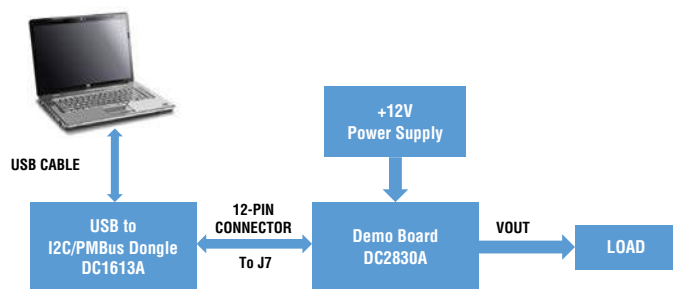


Figure 1. Demo Setup with PC of DC2830A

- Place jumpers in the following positions for a typical application:

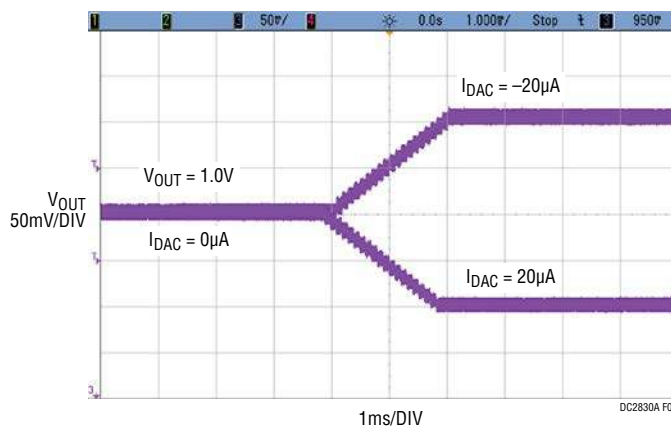
MODE (JP2)	RUN (JP1)	EN (JP5)
CCM	ON	OFF

- 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.
- Turn on the power supply at the input. The output voltage should be  $1.0\text{V} \pm 2.3\%$  (0.977V to 1.023V).
- Vary the input voltage from 4.7V to 15V and vary the load current from 0A to 40A. Observe the output voltage regulation, ripple voltage, efficiency, and other parameters.
- Once the proper output voltage is established on the LTM4636 output, place the EN jumper (JP5) in the ON position to enable the LTC7106.

## QUICK START PROCEDURE

- Open the LTpowerPlay software and adjust the IDAC current value of the LTC7106. Monitor the regulator's output voltage as IDAC is changing. See LTpowerPlay Quick Start session for details.
- The output voltage will change by the following equation, where  $R_{FB1}$  is the top resistor of the voltage divider and  $I_{DAC}$  is the programmed bidirectional current of the LTC7106. In the LTM4636,  $R_{FB1}$  is 4.99k inside the module. Therefore, the user can simply choose  $I_{DAC}$  value accordingly to achieve the desired  $V_{OUT}$  adjustment. See Figure 2 for a typical  $V_{OUT}$  waveform with  $\pm 20\mu A$   $I_{DAC}$ .

$$\Delta V_{OUT} = -I_{DAC} \cdot R_{FB1}$$



**Figure 2. Typical Margin High and Margin Low Waveforms of LTM4636 by LTC7106**

## LTpowerPlay SOFTWARE GUI

LTpowerPlay is a powerful Windows based development environment that supports Linear Technology power system management ICs, including the LTC3880, LTC3883, LTC3882, LTC3815, 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 utilizes the DC1613A USB-to-SMBus controller to communicate with one of many potential targets, including the LTC7106's DC2830A demo system, or a customer board. The soft-

ware 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://www.analog.com/en/design-center/ltpower-play.html>.

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

## LTpowerPlay SOFTWARE GUI

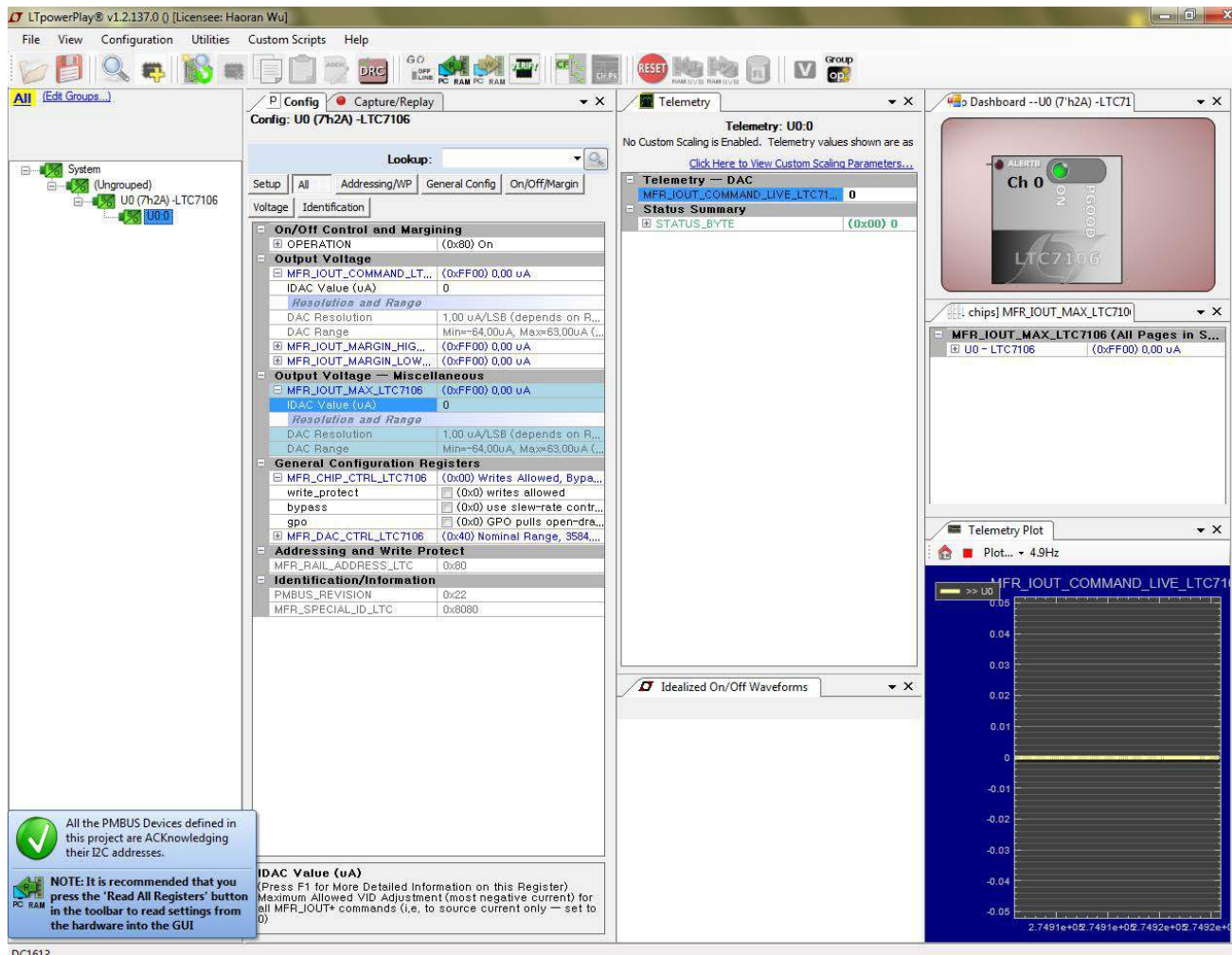
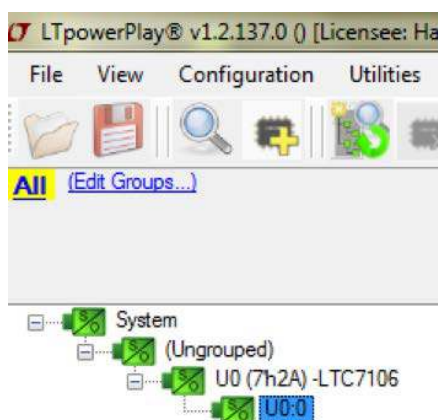


Figure 3. LTpowerPlay Main Interface for LTC7106

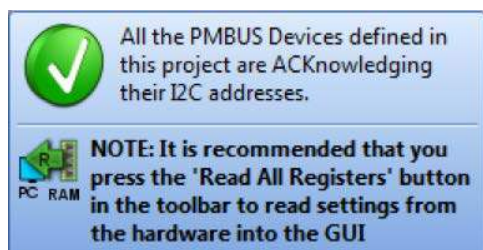
## LTpowerPlay QUICK START PROCEDURE

The following procedure describes how to use LTpowerPlay to monitor and change the settings of LTC7106.

1. Download and install the LTpowerPlay GUI:
  - <http://www.analog.com/en/design-center/ltpower-play.html>
2. Launch the LTpowerPlay GUI.
  - a. The GUI should automatically identify the DC2830A. The system tree on the left-hand side should look like this:



- b. A blue message box shows for a few seconds in the lower left-hand corner, confirming that the LTC7106 is communicating:



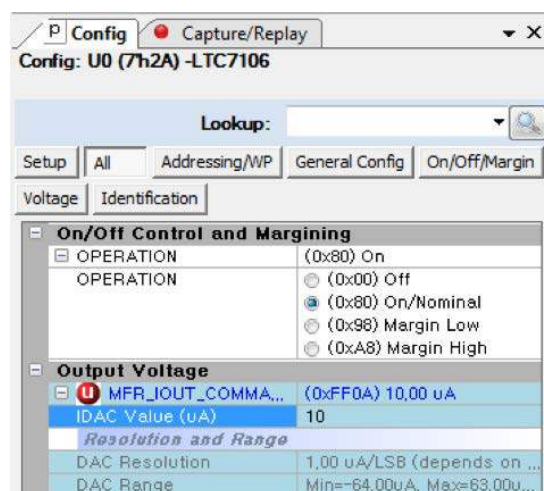
- c. In the Toolbar, click the “R” icon (RAM to PC) to read the RAM from the LTC7106.



This reads the configuration from the RAM of LTC7106 and loads it into the GUI. When first powering on, you should read IDAC current at zero (high impedance IDAC) due to the LTC7106’s internal power-on reset circuitry until a valid write takes place. The IDAC current value can be plotted in real time, shown in the following screenshot (at zero when first powering on):



- d. If you want to change the IDAC current to 10µA for example, in the Config tab, type “10” in the MFR\_IOUT\_COMMAND\_LTC7106:



Then, click the “W” icon (PC to RAM) to write these register values to the LTC7106.

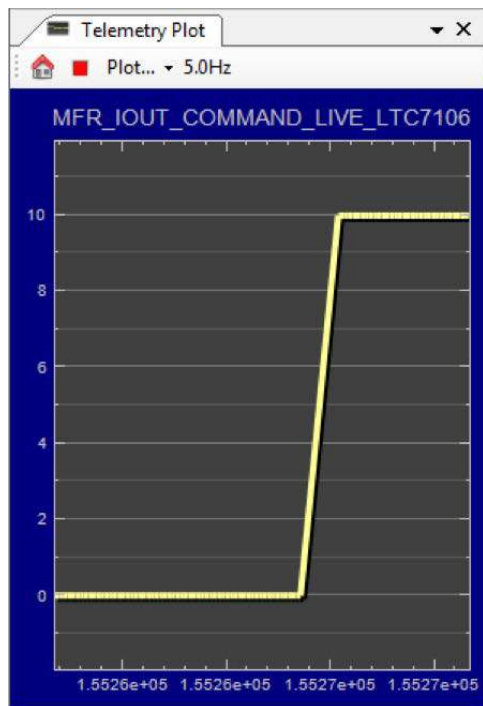


## LTpowerPlay QUICK START PROCEDURE

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



In the Telemetry Plot, you will see IDAC current value change to the commanding value:



- e. If you want to change the IDAC current to a negative value (meaning sinking current), you need to change the MFR\_IOUT\_MAX\_LTC7106 to a negative value first (see data sheet for more details).

Output Voltage — Miscellaneous	
MFR_IOUT_MAX_LTC7106 (0xFF40)	-64,00 uA
IDAC Value (uA)	-64
<i>Resolution and Range</i>	
DAC Resolution	1,00 uA/LSB (depends on ...
DAC Range	Min=-64,00uA, Max=63,00u...

- f. You can also change IDAC range between Nominal, Low and High Range, as well as the Time Per Step in LTpowerPlay, as shown in the following picture.

MFR_DAC_CTRL_LTC7...	(0x9A) High Range, 96,0 us/step
IDAC Range	<input type="radio"/> (2'b 00) Low Range (0,25uA/step) <input type="radio"/> (2'b 01) Nominal (1,0uA/step) <input checked="" type="radio"/> (2'b 10) High Range (4,0uA/step)
Time Per Step	(6'h 1A) 96,0 us/step

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	1	C1	CAP, 1 $\mu$ F, X5R, 10V, 10%, 0603	AVX, 0603ZD105KAT2A
2	1	C14	CAP, 3300pF, X7R, 50V, 10%, 0603	MURATA, GRM188R71H332KA01D
3	1	C15	CAP, 150pF, X7R, 50V, 10%, 0603	AVX, 06035C151KAT2A
4	1	C18	CAP, 2200pF, X7R, 25V, 10%, 0603	AVX, 06033C222KAT2A
5	2	C19, C25	CAP, 0.1 $\mu$ F, X5R, 16V, 10%, 0603	AVX, 0603YD104KAT2A
6	1	C22	CAP, 4.7 $\mu$ F, X5R, 10V, 10%, 0603	TAIYO YUDEN, LMK107BJ475KA-T
7	1	C23	CAP, 1 $\mu$ F, X5R, 25V, 10%, 0603	TAIYO YUDEN, TMK107BJ105KA-T
8	1	C24	CAP, 22 $\mu$ F, X5R, 6.3V, 20%, 0805	MURATA, GRM21BR60J226ME39L
9	1	CIN1	CAP, 180 $\mu$ F, ALUM. POLY., 25V, 20%, 8x12mm SMD, E12	PANASONIC, 25SVPF180M
10	6	CIN4-CIN9	CAP, 22 $\mu$ F, X5R, 16V, 20%, 1210	MURATA, GRM32ER61C226ME20L
11	11	COU1-COU4, COU6, COU7, COU10-COU12, COU15, COU16	CAP, 330 $\mu$ F, X5R, 4V, 20%, 1210	MURATA, GRM32ER60G337ME05L
12	4	COU8, COU9, COU13, COU14	CAP, 680 $\mu$ F, TANT, POLYMER, 4V, 20%, 7343	PANASONIC, 4TPF680MAH
13	1	Q1	XSTR., MOSFET, N-CH, 40V, TO-252 (DPAK)	VISHAY, SUD50N04-8M8P-4GE3
14	7	R2, R3, R7, R11, R12, R16, R54	RES., 10k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060310K0FKEA
15	1	R9	RES., 7.5k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06037K50FKEA
16	3	R17, R33, R57	RES., 0 $\Omega$ , 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EA
17	1	R18	RES., 15k, 1%, 1/10W, 0603	YAGEO, RC0603FR-0715KL
18	1	R22	RES., 23.7k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060323K7FKEA
19	2	R25, R32	RES., 10 $\Omega$ , 1%, 1/10W, 0603	VISHAY, CRCW060310R0FKEA
20	1	R35	RES., 2.2 $\Omega$ , 5%, 1/8W, 0805, AEC-Q200	VISHAY, CRCW08052R20JNEA
21	1	R40	RES., 34.8k, 1%, 1/10W, 0603	VISHAY, CRCW060334K8FKEA
22	1	R55	RES., 0.01 $\Omega$ , 1%, 1/2W, 2010, SENSE, AEC-Q200	VISHAY, WSL2010R0100FEA
23	1	U1	IC, 40A DC/DC MODULE REGULATOR, BGA-144	ANALOG DEVICES, LTM4636EY#PBF
24	1	U2	IC, 7-BIT CURRENT DAC WITH PMBus, DFN-10	ANALOG DEVICES, LTC7106EDDB#PBF
<b>Additional Demo Board Circuit Components</b>				
1	0	C2, C3, C16	CAP, OPTION, 0603	
2	0	R8, R15, R19, R21, R23, R38	RES., OPTION, 0603	

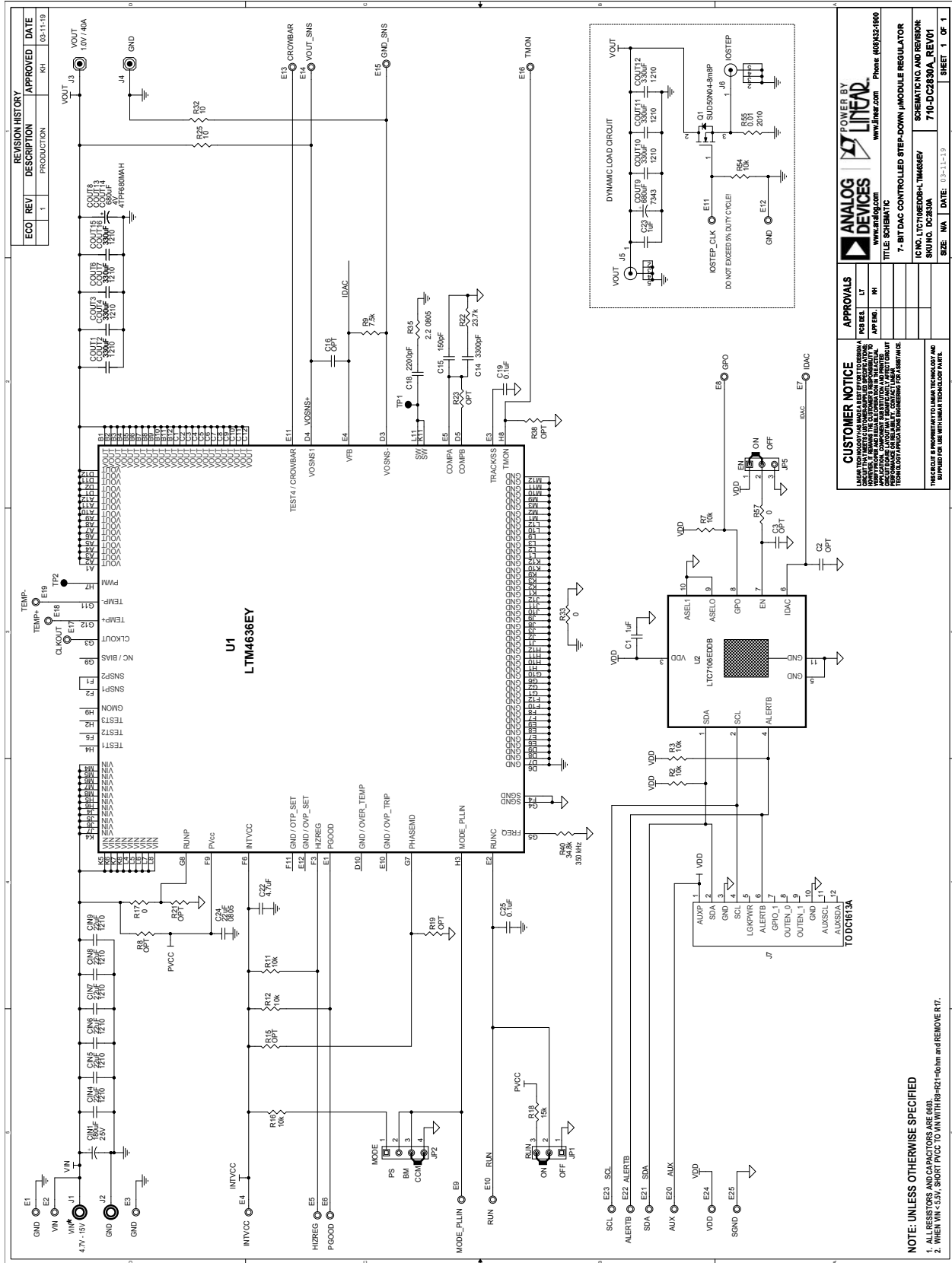
# DEMO MANUAL DC2830A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Hardware: For Demo Board Only</b>				
1	25	E1-E25	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THICK	MILL-MAX, 2308-2-00-80-00-00-07-0
2	2	J1, J2	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
3	2	J3, J4	STUD, FASTENER, #10-32	PENNENGINEERING, KFH-032-10ET
4	2	J5, J6	CONN., RF, BNC, RCPT JACK, 5-PIN, STR, THT, 50Ω	AMPHENOL RF, 112404
5	1	J7	CONN., SHROUDED HDR, MALE, 2x6, 2mm, VERT, STR, THT	FCI, 98414-G06-12ULF
6	2	JP1, JP5	CONN., HDR., MALE, 1x3, 2mm, VERT, STR, THT	SULLINS CONNECTOR SOLUTIONS, NRPNO31PAEN-RC
7	1	JP2	CONN., HDR., MALE, 1x4, 2mm, THT, STR	SULLINS CONNECTOR SOLUTIONS, NRPNO41PAEN-RC
8	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.625"	KEYSTONE, 8834
9	4	MP5-MP8	NUT, HEX, STEEL, ZINC PLATE, 10-32	KEYSTONE, 4705
10	4	MP9, MP10, MP13, MP14	WASHER, FLAT, STEEL, ZINC PLATE, OD: 0.436 [11.1]	KEYSTONE, 4703
11	2	MP11, MP12	RING, LUG, CRIMP, #10, NON-INSULATED, SOLDERLESS TERMINALS	KEYSTONE, 8205
12	2	MP15, MP16	WASHER, #10, LOCK, EXT, TIN FINISH	PENCOM, WA4526
13	3	XJP1, XJP2, XJP5	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.

## Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.