

# LTM4693

## 2.6V - 5.5V Input to 1.8V - 5V Output, Ultrathin 2A Buck-Boost $\mu$ Module Regulator

### DESCRIPTION

Demonstration circuit DC3016A is a buck-boost power supply featuring the [LTM<sup>®</sup>4693](#), ultrathin, highly efficient, 2A buck-boost  $\mu$ Module<sup>®</sup> regulator. The LTM4693 regulates an output voltage above, below, or equal to the input voltage. This demonstration circuit is designed to have an input voltage from 2.6V to 5.5V with selectable 1.8V, 2.5V, 3.3V, and 5V output voltage up to 2A load. Derating may be necessary for specific  $V_{IN}$ ,  $V_{OUT}$ , and thermal conditions.

This demo board includes a mode selector that allows the converter to run in CCM or Burst Mode<sup>®</sup> operation. Synchronization to an external clock is also possible. The switching frequency can be adjusted from 1MHz to 4MHz by a resistor. And the soft-start period is programmable by an external capacitor. The LTM4693 data sheet gives a complete description of these functions, operation, and application information. The data sheet must be read in conjunction with this quick start guide for demo circuit 3016A.

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

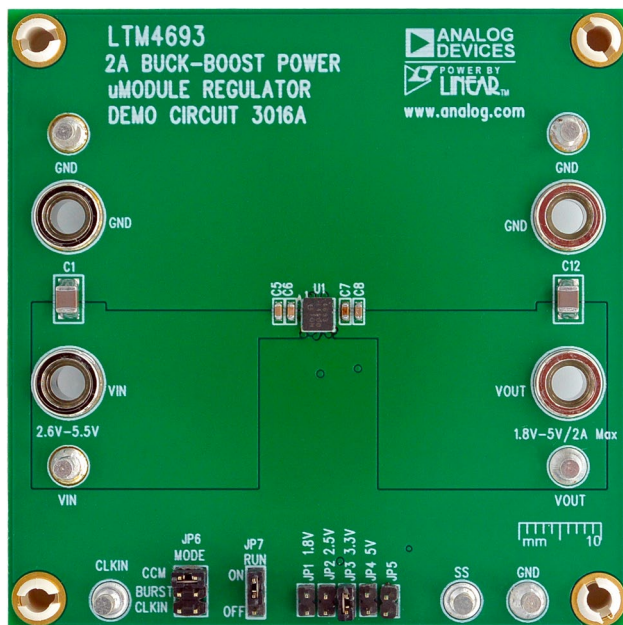
All registered trademarks and trademarks are the property of their respective owners.

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

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{IN}$	Input Supply Range	Continuous Operation, Free Air	2.6		5.5	V
$V_{OUT}$	Output Voltage	Jumper Place: 1.8V	1.75	1.8	1.85	V
		Jumper Place: 2.5V	2.4	2.5	2.6	V
		Jumper Place: 3.3V	3.2	3.3	3.4	V
		Jumper Place: 5V	4.9	5	5.1	V
$I_{OUT}$	Output Current	When $V_{IN} \geq V_{OUT}$			2	A
		When $V_{IN} < V_{OUT}$			1	A
$f_{sw}$	Switching Frequency			2200		kHz
$P_{OUT}/P_{IN}$	Efficiency See Figure 3 through Figure 6 for More Information	$V_{IN} = 3.3V, V_{OUT} = 1.8V, I_{OUT} = 2A$		86		%
		$V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{OUT} = 2A$		90.5		%
		$V_{IN} = 3.3V, V_{OUT} = 3.3V, I_{OUT} = 2A$		92.4		%
		$V_{IN} = 3.3V, V_{OUT} = 5V, I_{OUT} = 1A$		92.3		%

## BOARD PHOTO

Top View



## QUICK START PROCEDURE

Demonstration circuit 3016A is easy to set up to evaluate the performance of the LTM4693. Refer to Figure 1 for the proper measurement equipment setup and follow the procedure below:

NOTE: When measuring the output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the VIN or VOUT and GND terminals or directly across the relevant capacitor. See Figure 2 for the proper scope probe technique.

1. Place jumpers in the following positions:

JP6(MODE)    CCM

JP7(RUN)    ON

2. Set the output voltage by placing the respective jumper:

JP1	JP2	JP3	JP4
1.8V	2.5V	3.3V	5V

3. With power off, connect the input power supply to VIN and GND. With power off, connect loads from VOUT to GND.

4. Turn on the power at the input.

NOTE: Make sure that the input voltage does not exceed 5.5V.

5. Check for the proper output voltages.

When JP1 is selected,  $V_{OUT} = 1.75V$  to  $1.85V$

When JP2 is selected,  $V_{OUT} = 2.4V$  to  $2.6V$

When JP3 is selected,  $V_{OUT} = 3.2V$  to  $3.4V$

When JP4 is selected,  $V_{OUT} = 4.9V$  to  $5.1V$

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

6. Once the proper output voltages are established, adjust the loads within the operating ranges, and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.

7. To adjust the switching frequency, turn off the power supply, and modify R1 and R7.

**QUICK START PROCEDURE**

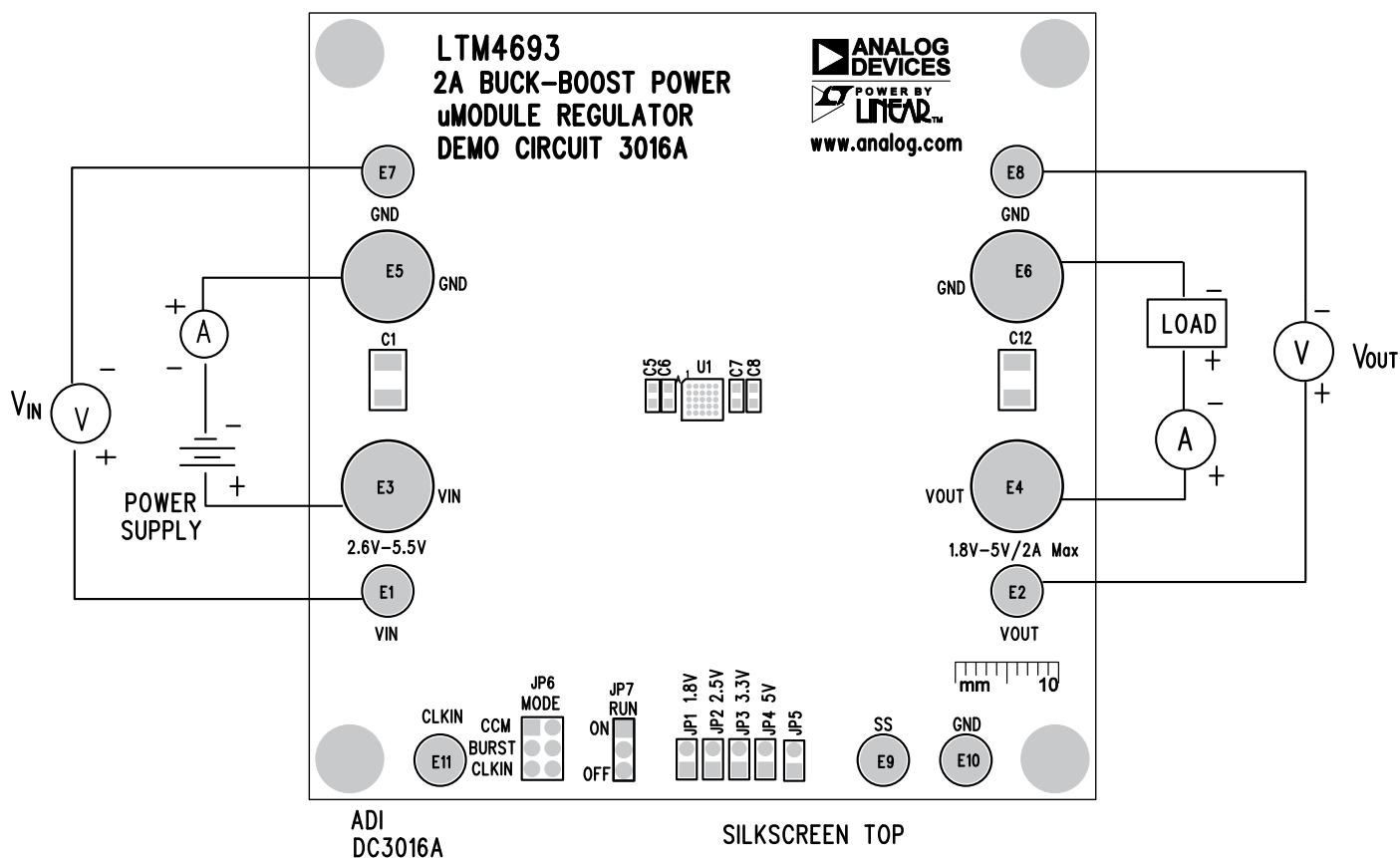


Figure 1. Test Setup Drawing for DC3016A

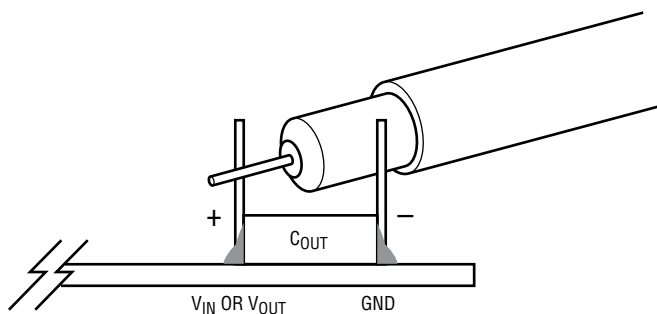


Figure 2. Proper Measurement Equipment Setup

## QUICK START PROCEDURE

### Mode Selection and Frequency Synchronization

The Demonstration circuit 3016A's Mode selector allows the converter to run in CCM operation, Burst Mode, or synchronize to an external clock source by changing the position of JP6. For synchronizing to an external clock source, apply the external clock from CLKIN turret to GND. Refer to the data sheet for more details.

### Rail Tracking

Demonstration circuit 3016A is configured for an on-board soft-start circuit. The soft-start ramp rate can be adjusted by changing the value of C14. Refer to the data sheet for more details.

### Bode Plot Measurement

Demonstration circuit 3016A provides the auxiliary circuits for bode plot measurement. R6 as the bottom resistor of voltage divider needs to be changed for different output voltage. The default value of R6 is for 5V<sub>OUT</sub>. R10 and R12 are one tenth of the top resistor and bottom resistor of voltage divider. And C18 should be 10 times as feed-forward capacitor C13. The perturbation signal should be injected between R9 and GND, then measure the bode plot at the symmetrical points (between the middle point of R6 and R9, and the middle point of R10 and R12).

## TYPICAL TEST RESULTS

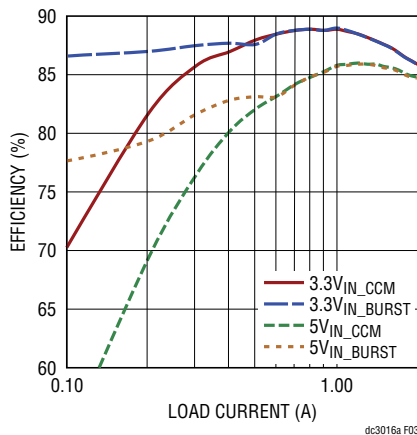


Figure 3. Measured Efficiency ( $V_{OUT} = 1.8V$ ,  $f_{SW} = 2.2MHz$ )

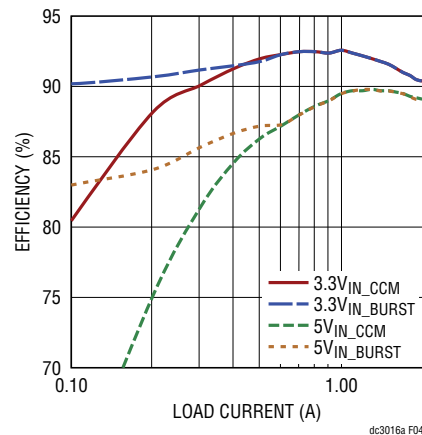


Figure 4. Measured Efficiency ( $V_{OUT} = 2.5V$ ,  $f_{SW} = 2.2MHz$ )

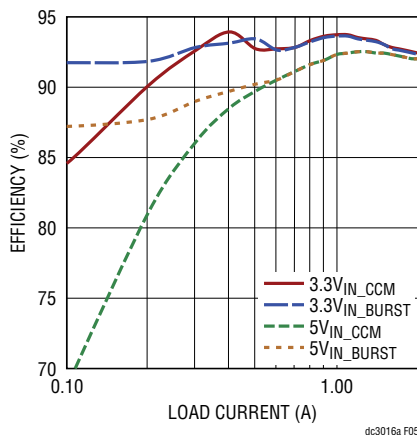


Figure 5. Measured Efficiency ( $V_{OUT} = 3.3V$ ,  $f_{SW} = 2.2MHz$ )

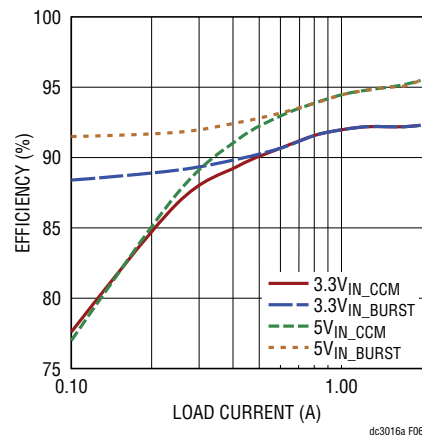
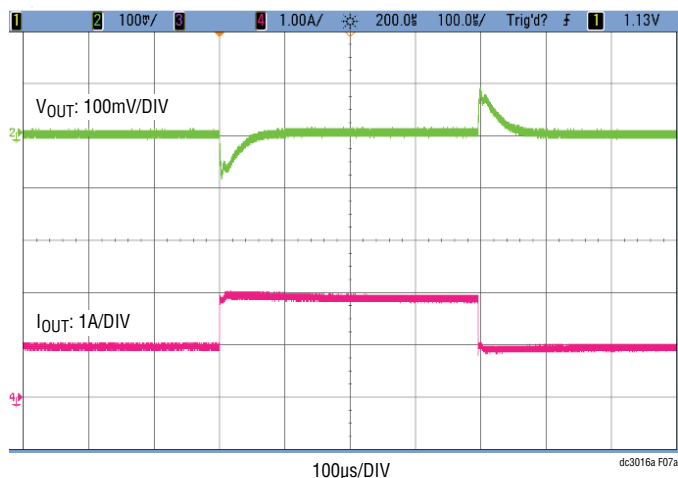
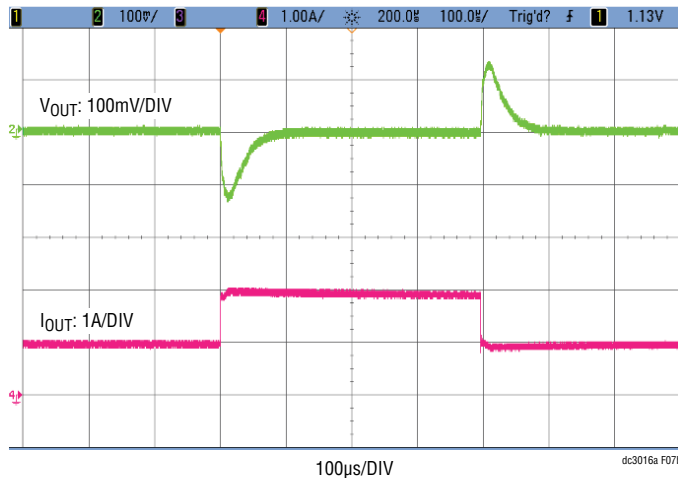


Figure 6. Measured Efficiency ( $V_{OUT} = 5V$ ,  $f_{SW} = 2.2MHz$ )

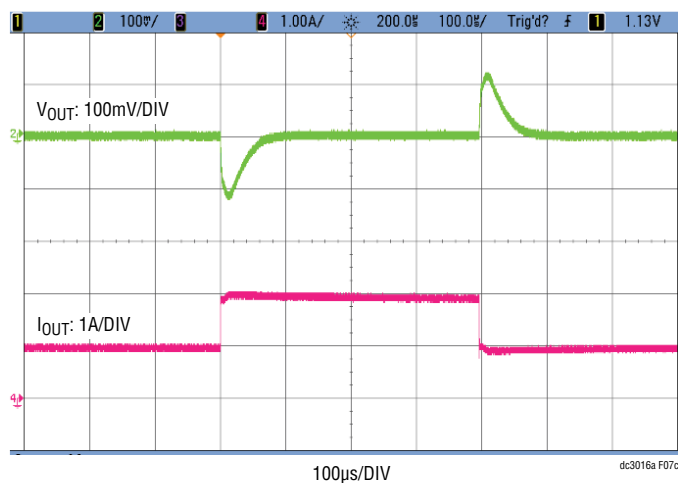
TYPICAL TEST RESULTS



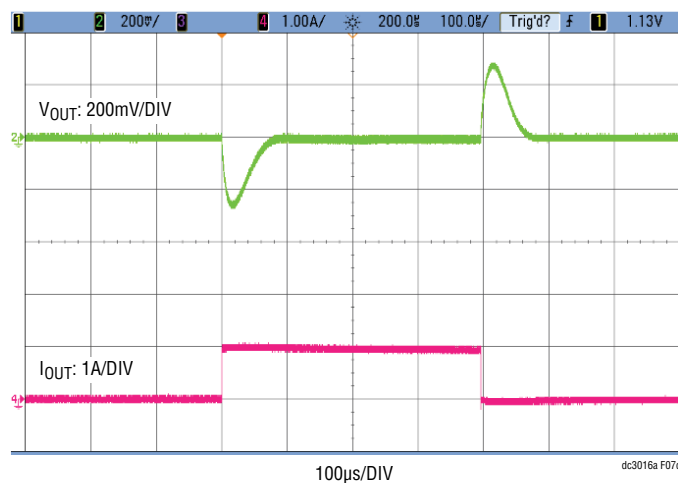
(7a)  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.8V$ , 1A-2A-1A Load Transient



(7b)  $V_{IN} = 3.3V$ ,  $V_{OUT} = 3.3V$ , 1A-2A-1A Load Transient



(7c)  $V_{IN} = 5V$ ,  $V_{OUT} = 3.3V$ , 1A-2A-1A Load Transient



(7d)  $V_{IN} = 3.3V$ ,  $V_{OUT} = 5V$ , 0A-1A-0A Load Transient

Figure 7. Transient Response Waveform

## TYPICAL TEST RESULTS

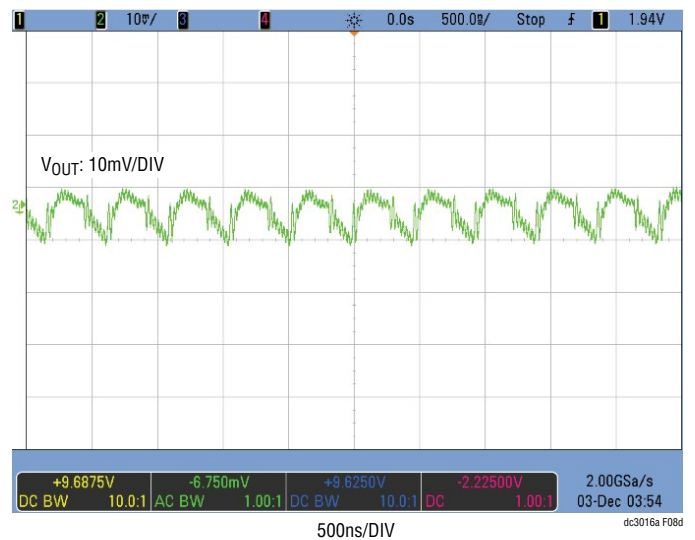
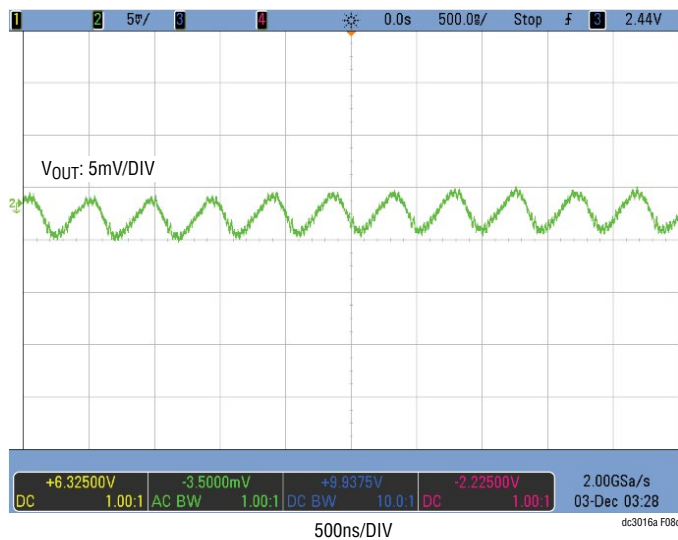
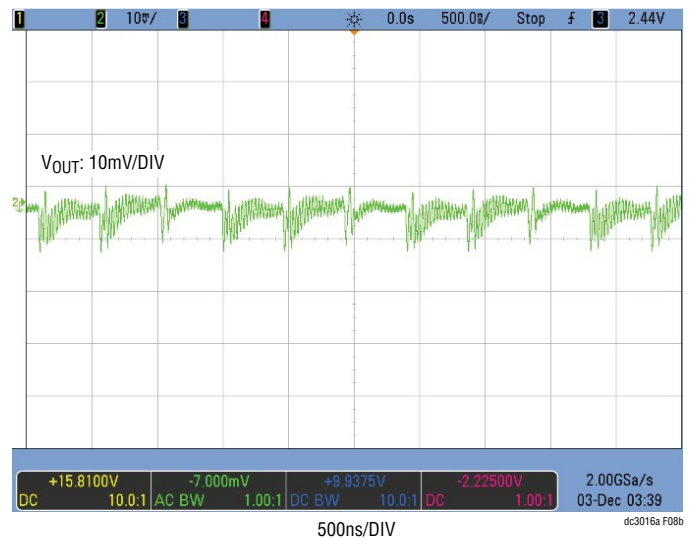
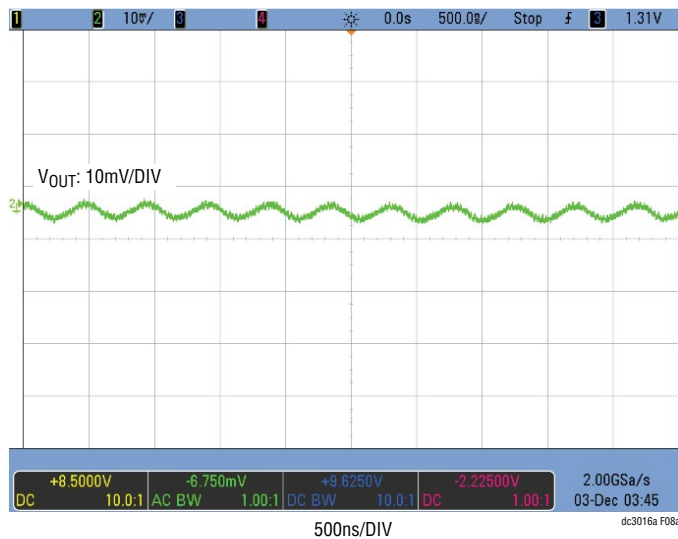
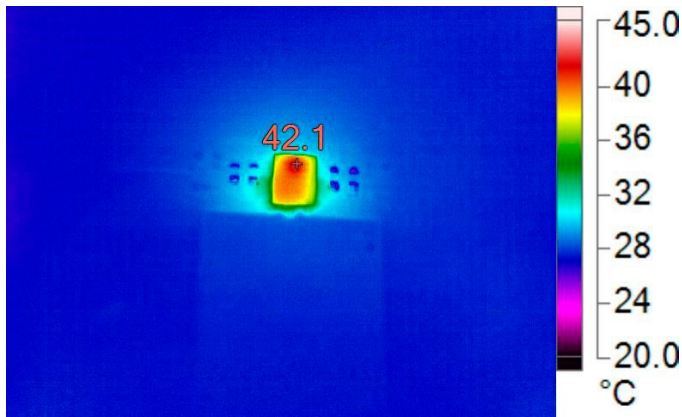


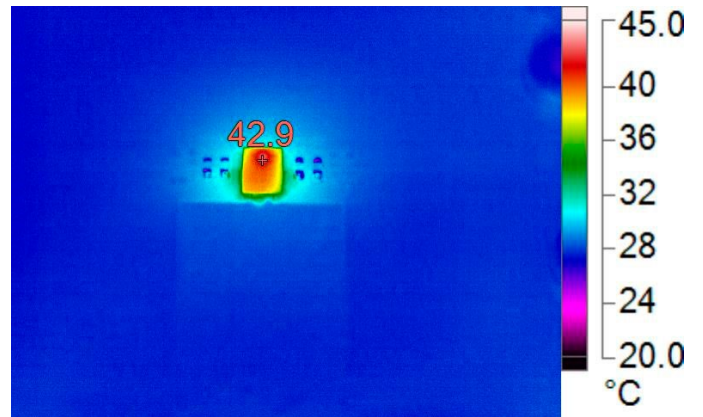
Figure 8. Measured Output Voltage Ripple (20MHz BW, CCM)



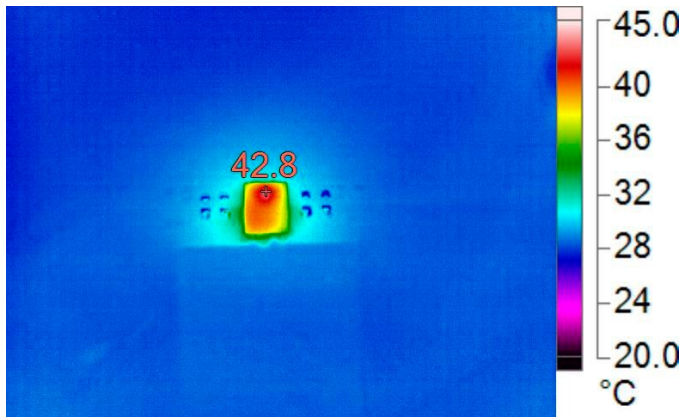
**TYPICAL TEST RESULTS**



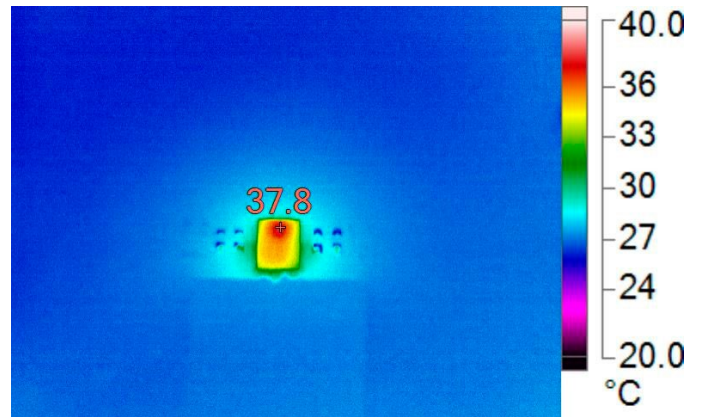
(9a)  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.8V$ ,  $I_{OUT} = 2A$



(9b)  $V_{IN} = 3.3V$ ,  $V_{OUT} = 3.3V$ ,  $I_{OUT} = 2A$



(9c)  $V_{IN} = 5V$ ,  $V_{OUT} = 3.3V$ ,  $I_{OUT} = 2A$



(9d)  $V_{IN} = 3.3V$ ,  $V_{OUT} = 5V$ ,  $I_{OUT} = 1A$

AIRFLOW	HEATSINK	AMBIENT (°C)
Natural Convection	None	25

Figure 9. Thermal Images

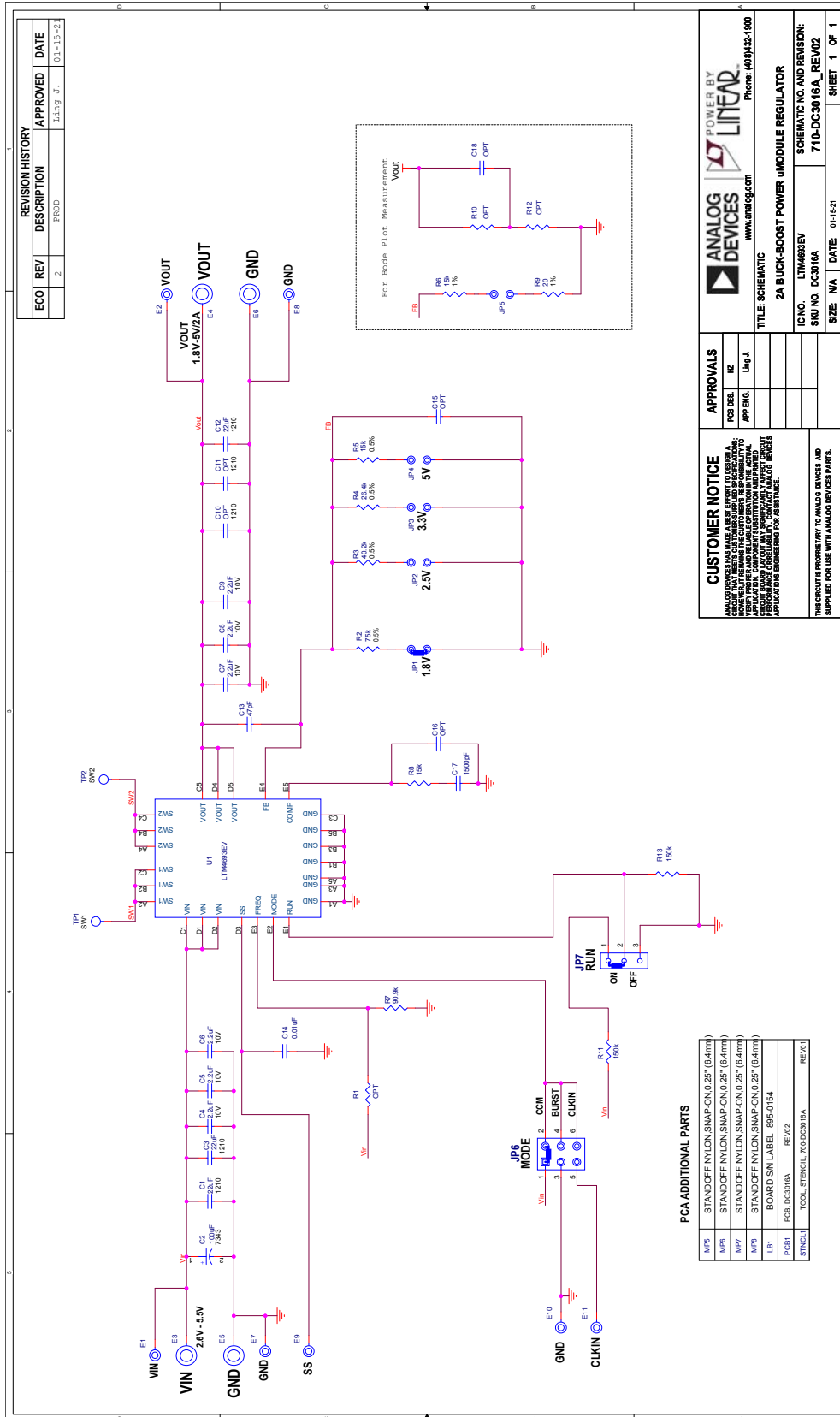
# DEMO MANUAL DC3016A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	3	C1, C3, C12	CAP, 22 $\mu$ F, X5R, 25V, 20%, 1210	AVX, 12103D226MAT2A
2	1	C2	CAP, 100 $\mu$ F, TANT. POSCAP, 20V, 20%, 7343, 55m $\Omega$ , TQC, NO SUBS. ALLOWED	PANASONIC, 20TQC100MYF
3	6	C4-C9	CAP, 2.2 $\mu$ F, X7R, 10V, 10%, 0603	MURATA, GRM188R71A225KE15D
4	1	C13	CAP, 47pF, X7R, 50V, 10%, 0603	AVX, 06035C470KAT2A
5	1	C14	CAP, 0.01 $\mu$ F, X7R, 50V, 10%, 0603	AVX, 06035C103KAT2A
6	1	C17	CAP, 1500pF, X7R, 50V, 10%, 0603	AVX, 06035C152KAT2A
7	1	R2	RES., 75k, 0.5%, 1/5W, 0603	PANASONIC, ERJ-PB3D7502V
8	1	R3	RES., 40.2k, 0.5%, 1/16W, 0603, METAL THIN FILM	SUSUMU, RR0816P-4022-D-59C
9	1	R4	RES., 26.4k, 0.5%, 1/10W, 0603, THIN FILM	YAGEO, RT0603DRE0726K4L
10	1	R5	RES., 15k, 0.5%, 1/10W, 0603	VISHAY, CRCW060326K4FKEA
11	1	R6	RES., 15k, 1%, 1/10W, 0603	NIC, NRC06F1502TRF
12	1	R7	RES., 90.9k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060390K9FKEA
13	1	R8	RES., 15k, 5%, 1/10W, 0603	YAGEO, RC0603JR-0715KL
14	1	R9	RES., 20 $\Omega$ , 1%, 1/10W, 0603	YAGEO, RC0603FR-0720RL
15	1	R11	RES., 150k, 1%, 1/10W, 0603	PANASONIC, ERJ3EKF1503V
16	1	R13	RES., 150k, 5%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3GEYJ154V
17	2	TP1, TP2	TESTPOINT, PCB COPPER FEATURE	N/A, N/A
18	1	U1	IC, BUCK BOOST POWER $\mu$ MODULE, 25-PIN LGA	ANALOG DEVICES, LTM4693EV#PBF
<b>Additional Demo Board Circuit Components</b>				
1	0	C10, C11	CAP, OPTION, 1210	
2	0	C15, C16, C18	CAP, OPTION, 0603	
3	0	R1, R10, R12	RES., OPTION, 0603	
<b>Hardware: For Demo Board Only</b>				
1	7	E1, E2, E7-E11	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	4	E3-E6	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
3	5	JP1-JP5	CONN., HDR, MALE, 1x2, 2mm, VERT, ST, THT	SULLINS CONNECTOR SOLUTIONS, NRPN021PAEN-RC
4	1	JP6	CONN., HDR, MALE, 2x3, 2mm, VERT, ST, THT	SULLINS CONNECTOR SOLUTIONS, NRPN032PAEN-RC
5	1	JP7	CONN., HDR, MALE, 1x3, 2mm, VERT, ST, THT, NO SUBS. ALLOWED	SAMTEC, TMM-103-02-L-S
6	4	MP5-MP8	STANDOFF, NYLON, SNAP-ON, 0.25" (6.4mm)	KEYSTONE, 8831
7	3	XJP1-XJP3	CONN., SHUNT, FEMALE, 2-POS, 2mm	SAMTEC, 2SN-BK-G



SCHEMATIC DIAGRAM



REVISION HISTORY		
ECO	REV	DESCRIPTION
	2	PROD
		APPROVED DATE
		Lieng J., 01-15-21

**ANALOG DEVICES** POWER BY **LINEAR**  
www.analog.com Phone: (603) 332-1900

**TITLE: SCHEMATIC**  
2A BUCK-BOOST POWER iMODULE REGULATOR

**IC NO.** LTM693EY **SCHEMATIC NO. AND REVISION:** 710-DC3016A\_REV02  
**SIZE:** N/A **DATE:** 01-15-21 **SHEET** 1 OF 1

**APPROVALS**

POB DES	RZ
APP ENCL	Ung J.

**CUSTOMER NOTICE**  
ANALOG DEVICES HAS A BEST EFFORT TO DESIGN A CIRCUIT WITH CUSTOMER USES IN MIND. HOWEVER, THE USER MUST VERIFY THE CIRCUIT'S PERFORMANCE IN THE ACTUAL APPLICATION. ANALOG DEVICES ASSUMES NO LIABILITY FOR ANY DAMAGE TO PROPERTY OR PERSONS ARISING FROM THE USE OF THIS CIRCUIT. ANALOG DEVICES ASSUMES NO LIABILITY FOR ANY DAMAGE TO PROPERTY OR PERSONS ARISING FROM THE USE OF THIS CIRCUIT. ANALOG DEVICES ASSUMES NO LIABILITY FOR ANY DAMAGE TO PROPERTY OR PERSONS ARISING FROM THE USE OF THIS CIRCUIT.

**THIS CIRCUIT IS PROPRIETARY TO ANALOG DEVICES AND SUPPLIED FOR USE WITH ANALOG DEVICES PARTS.**

**PCA ADDITIONAL PARTS**

MPS	STANDOFF, NYLON, SNAP-ON, 0.25" (6.4mm)
MP6	STANDOFF, NYLON, SNAP-ON, 0.25" (6.4mm)
MP7	STANDOFF, NYLON, SNAP-ON, 0.25" (6.4mm)
MP8	STANDOFF, NYLON, SNAP-ON, 0.25" (6.4mm)
L81	BOARD, S/N LABEL, 885-C7154
PCB1	PCB, DC3016A, REV02
STNCL1	TOOL, STENCIL, 700-DC3016A, REV01





## 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.