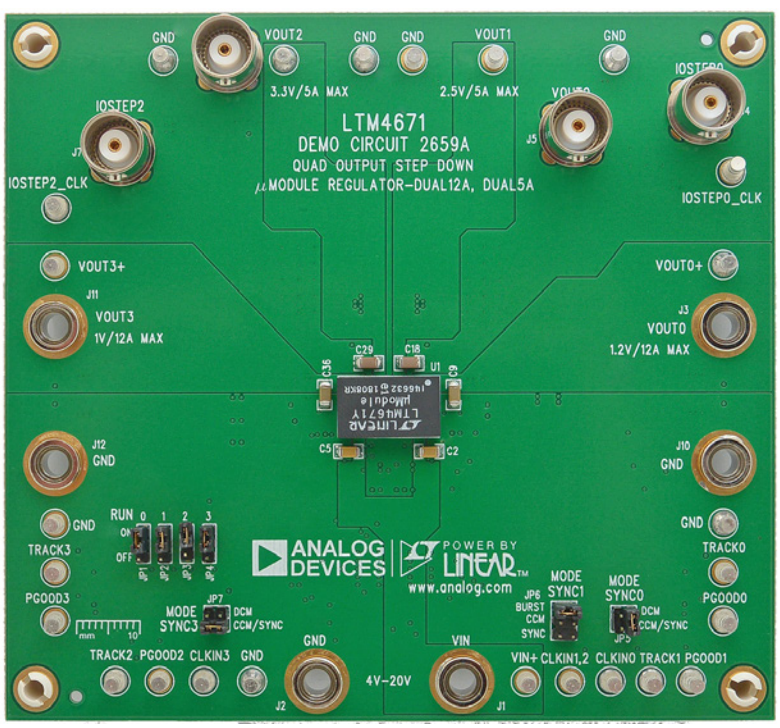
LTM4671
Quad Output (Dual 12A, Dual 5A) Step-Down µModule Regulator

DESCRIPTION

Demonstration circuit 2659A features the LTM®4671 µModule® regulator, a high performance high efficiency four output step-down regulator. The LTM4671EY has an operating input voltage range of 3.6V to 20V providing up to 12A from each of its two higher current rails and up to 5A from each of its two lower current rails. The two higher current rails' output voltage is programmable from 0.6V to 3.3V while the two lower current rails' output voltage is programmable from 0.6V to 5.5V. High current rails can be paralleled together, and lower current rails can be paralleled together to satisfy higher rail current requirements. The LTM4671EY is a complete multi-output DC-DC point-of-load regulator in a thermally enhanced 16mm × 9.5mm × 4.82mm BGA package requiring only a few input and output capacitors. Output voltage tracking is made available by the TRACK/SS pins for supply rail sequencing. Temperature sensing options are included via the TSENSE and TMON pins. External clock synchronization is available through the CLKIN pins, CLKOUT pins provide for optional synchronization of additional module phases. The LTM4671 data sheet must be read in conjunction with this demo manual for working on or modifying demo circuit 2659A

Design files for this circuit board are available.

BOARD PHOTO



PERFORMANCE SUMMARY Specifications are at $T_A = 25°C$

PARAMETER	CONDITIONS/NOTES	VALUE
Input Voltage Range		3.6V – 20V
Output Voltage V_{OUT}	Jumper Selectable	$V_{OUT0} = 1.2V_{DC}$, $V_{OUT1} = 2.5V_{DC}$, $V_{OUT2} = 3.3V_{DC}$, $V_{OUT4} = 1V_{DC}$
Maximum Continuous Output Current per Phase	De-Rating is Necessary for Certain Operating Conditions. See Data Sheet for Details	$I_{OUT0MAX}$, $I_{OUT3MAX} = 12A_{DC}$ $I_{OUT1MAX}$, $I_{OUT2MAX} = 5A_{DC}$
Default Operating Frequency		600kHz (for V_{OUT0}, V_{OUT3}) 1MHz (for V_{OUT1}, V_{OUT2})
Efficiency	$V_{IN} = 12V$ $V_{OUT0} = 1.2V$, $I_{OUT} = 12A$ $V_{OUT0} = 3.3V$, $I_{OUT} = 5A$	See Figure 2 87.4% 91.6%

QUICK START PROCEDURE

Demonstration circuit 2659A is an easy way to evaluate the performance of the LTM4671EY. Please refer to Figure 1 for test setup connections and follow the procedure below.

1. With power off, place the jumpers in the following positions:

JP1	JP2	JP3	JP4	JP5	JP6	JP7
RUN0	RUN1	RUN2	RUN3	MODE0	MODE1	MODE3
ON	ON	ON	ON	CCM	CCM	CCM

2. Before connecting input supply, loads and meters, preset the input voltage supply to be between 4V to 20V. Preset the load currents to 0A.
3. With power off, connect the loads, input voltage supply and meters as shown in Figure 1.
4. Turn on input power supply. The output voltage meters for each phase should display the programmed output voltage ±2%.
5. Once the proper output voltages are established, adjust the load currents for each phase within the 0A–12A range for V_{OUT0} and V_{OUT3} outputs and within 0A–5A for V_{OUT1} and V_{OUT2} outputs. Observe each output's load regulation, efficiency, and other parameters. Output voltage ripples for each output should be measured across the furthest output capacitor with a BNC cable and oscilloscope. BNCs J5 and J9 are available for V_{OUT0} and V_{OUT2} ripple measurements, respectively.
6. To observe increased light load efficiency, for V_{OUT0} and V_{OUT3} place the MODE pin jumpers (JP5, JP7) in the DCM position, for V_{OUT1} and V_{OUT2} place the MODE pin jumper (JP6) in the BURST position.
7. For optional load transient testing on-board transient circuits are provided to measure transient responses on V_{OUT0} and V_{OUT2} outputs. Place a positive pulse signal between the IOSTEPx_CLK pin and GND pins. The pulse amplitude sets the load step current amplitude. The pulse width should be short (<1ms) and pulse duty cycle should be low (<15%) to limit the thermal stress on the load transient circuit. The load step response for V_{OUT0} and V_{OUT2} can be monitored with a BNC connected to J4 (10mV/A) and J7 (20mV/A), respectively.

QUICK START PROCEDURE

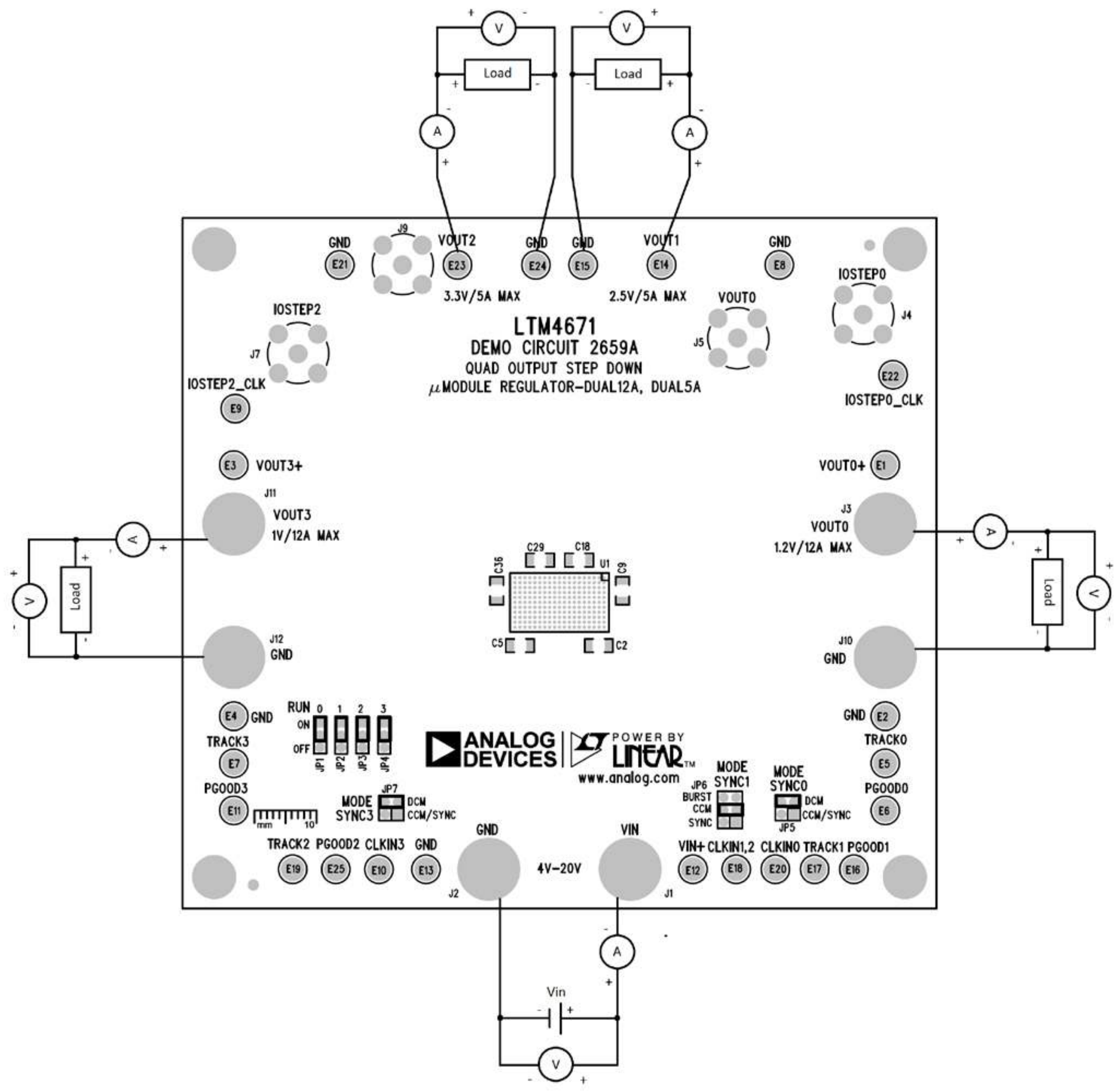
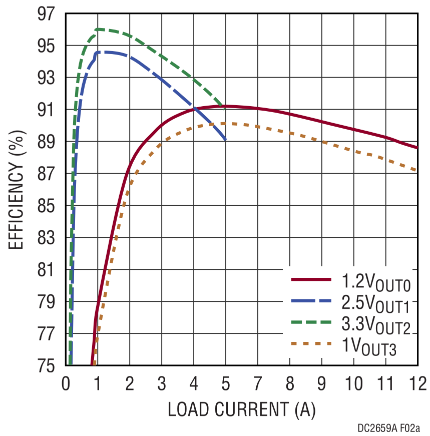
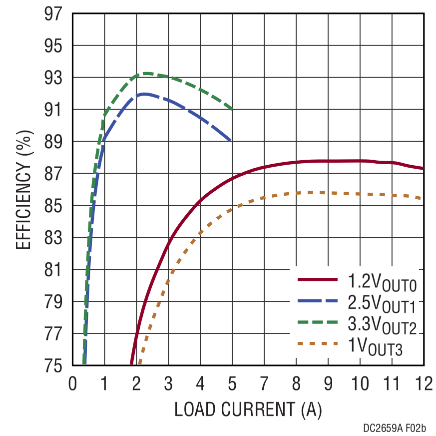


Figure 1. Test Setup of DC2659A

QUICK START PROCEDURE

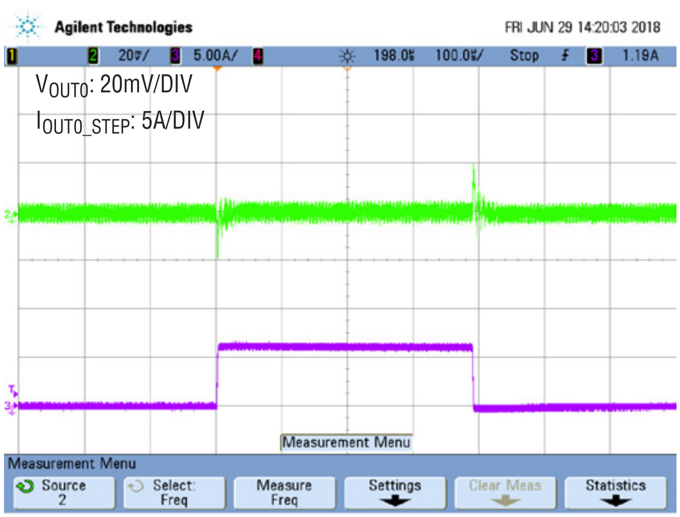


(a) $5V_{IN}$ CCM Efficiency

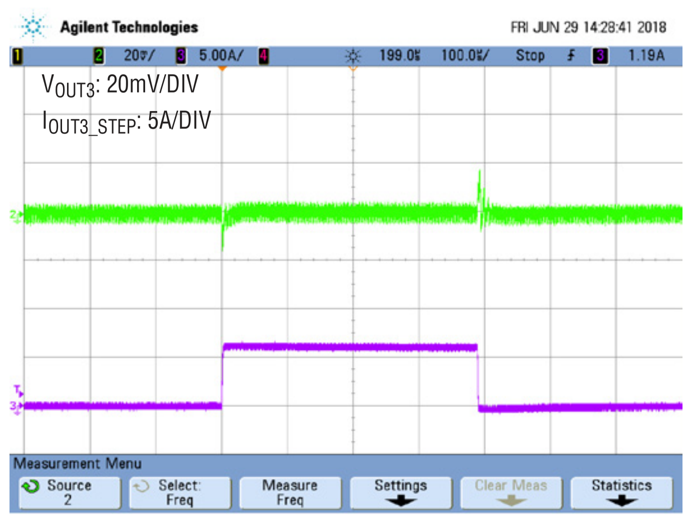


(b) $12V_{IN}$ CCM Efficiency

Figure 2. Measured Supply Efficiency at $5V_{IN}$ and $12V_{IN}$



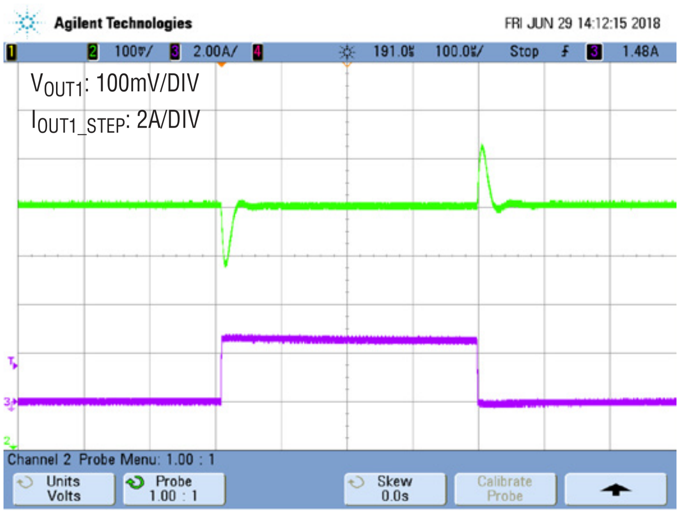
V_{IN} (V)	V_{OUT0} (V)	C_{OUT} CERAMIC
12	1.2	2 × 100µF/6.3V/Ceramic +1 × 330µF/6.3V/Bulk



V_{IN} (V)	V_{OUT3} (V)	C_{OUT} CERAMIC
12	1	2 × 100µF/6.3V/Ceramic +1 × 330µF/6.3V/Bulk

Figure 3. Measured V_{OUT0} = 1.2V and V_{OUT3} = 1V Load Transient Responses (6A Load Step)

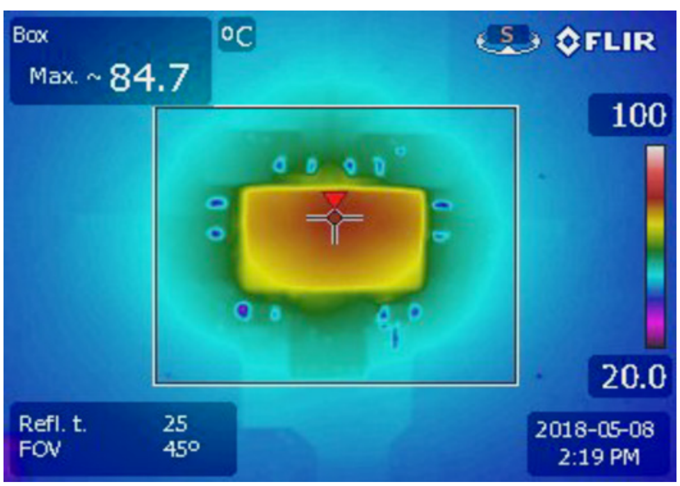
QUICK START PROCEDURE



V_{IN} (V)	V_{OUT1} (V)	C_{OUT} CERAMIC
12	2.5	2 × 47µF/6.3V/Ceramic +1 × 10µF/6.3V/Ceramic

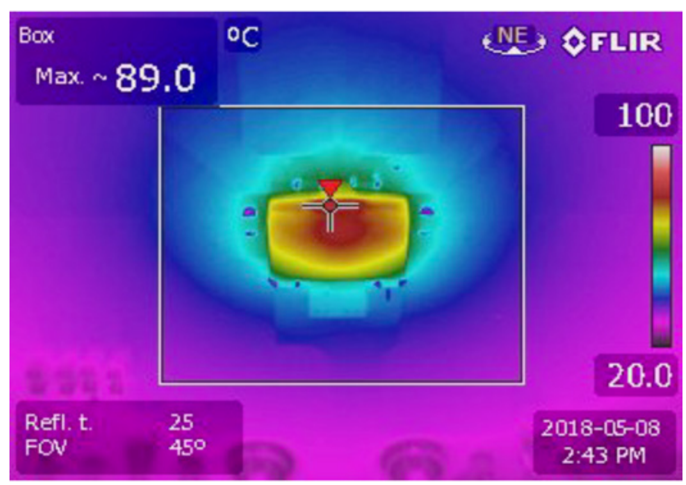
V_{IN} (V)	V_{OUT2} (V)	C_{OUT} CERAMIC
12	3.3	2 × 47µF/6.3V/Ceramic +1 × 10µF/6.3V/Ceramic

Figure 4. Measured V_{OUT1} = 2.5V and V_{OUT2} =3.3V Load Transient Responses (2.5A Load Step)



V_{IN} (V)	AIRFLOW	HEATSINK	AMBIENT (°C)
12	Natural Convection	None	23

CHANNEL	V_{OUT0}	V_{OUT1}	V_{OUT2}	V_{OUT3}
V_{OUT} (V)	1.2	2.5	3.3	1
I_{OUT} (A)	10	4	4	10



V_{IN} (V)	AIRFLOW	HEATSINK	AMBIENT (°C)
12	Forced Air 200LFM	None	23

CHANNEL	V_{OUT0}	V_{OUT1}	V_{OUT2}	V_{OUT3}
V_{OUT} (V)	1.2	2.5	3.3	1
I_{OUT} (A)	12	5	5	12

Figure 5. Measured Thermal Captures

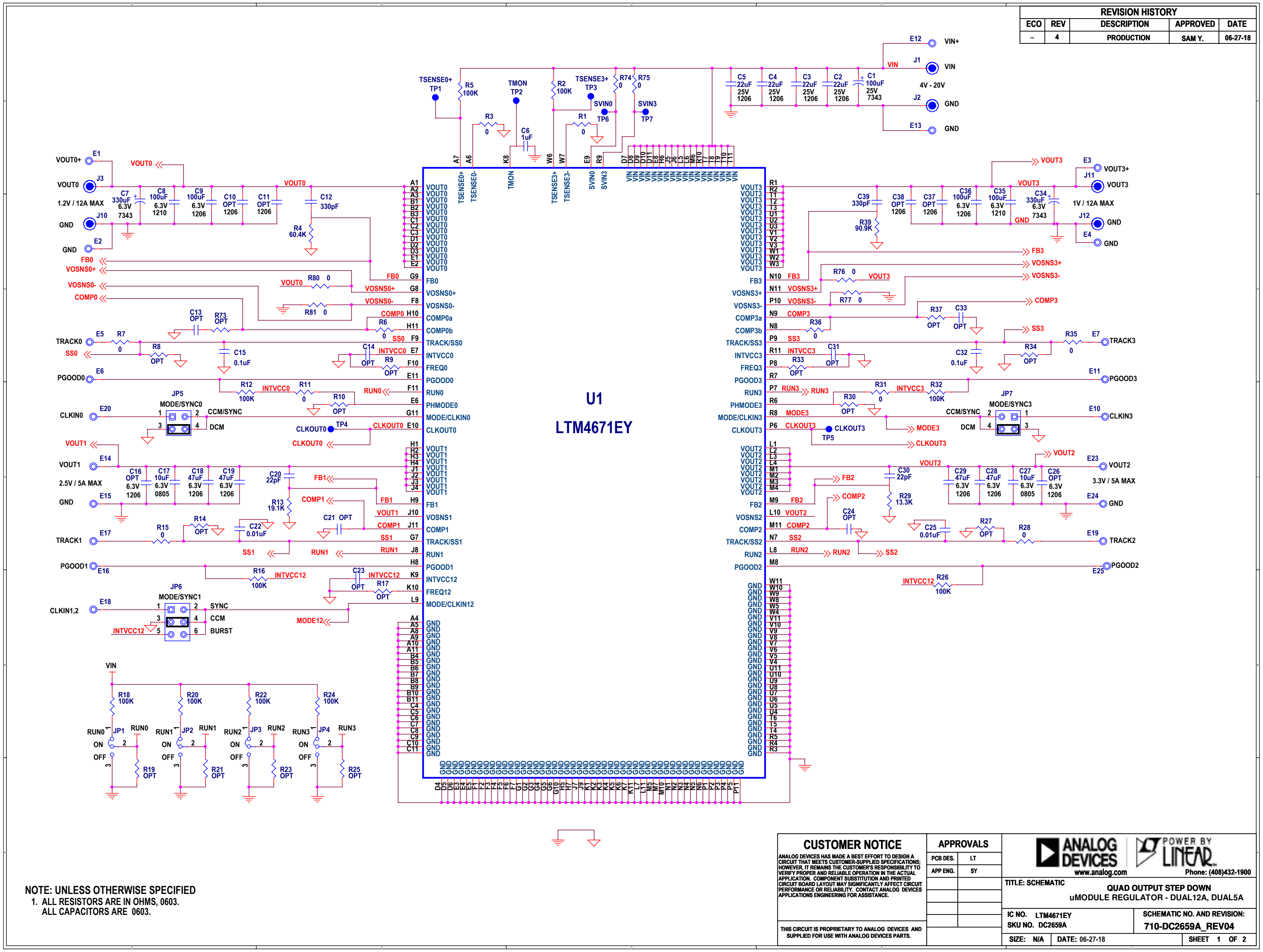
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	4	C2, C3, C4, C5	CAP., 22µF, X5R, 25V, 20%, 1206	MURATA, GRM31CR61E226ME15L
2	2	C8, C35	CAP., 100µF, X5R, 6.3V, 20%, 1210	TDK, C3225X5R0J107M250AC
3	2	C18, C28	CAP., 47µF, X5R, 16V, 20%, 1206	TDK, C3216X5R1C476M160AB
4	1	R4	RES., 60.4k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060360K4FKEA
5	1	R13	RES., 19.1k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060319K1FKEA
6	1	R29	RES., 13.3k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060313K3FKEA
7	1	R39	RES., 90.9k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060390K9FKEA
8	1	U1	IC, QUAD HIGH EFFICIENCY MODULE, BGA-16mm × 9.5mm × 4.72mm	ANALOG DEVICES., LTM4671EY#PBF
Additional Demo Board Circuit Components				
1	2	C7, C34	CAP., 330µF, ALUM. ELECT., 2.5V, 20%, 7343, 9mΩ, 6.3A	PANASONIC, EEFSX0E331ER
2	2	C9, C36	CAP., 100µF, X5R, 6.3V, 20%, 1206	TDK, C3216X5R0J107M160AB
3	2	C17, C27	CAP., 10µF, X5R, 16V, 10%, 0805	MURATA, GRM21BR61C106KE15L
4	2	C19, C29	CAP., 47µF, X5R, 16V, 20%, 1206	TDK, C3216X5R1C476M160AB
5	2	C20, C30	CAP., 22pF, C0G, 50V, 5%, 0603	MURATA, GRM1885C1H220JA01J
6	2	C12, C39	CAP., 330pF, C0G, 50V, 5%, 0603	MURATA, GRM1885C1H331JA01J
7	2	C15, C32	CAP., 0.1µF, X7R, 50V, 10%, 0603	TDK, C1608X7R1H104K080AA
8	1	C1	CAP., 100µF, TANT. POLY., 25V, 20%, 7343	KEMET, T521X107M025ATE060
9	1	C6	CAP., 1µF, X5R, 16V, 10%, 0603	MURATA, GRM188R61C105KA93D
10	2	C22, C25	CAP., 0.01µF, X7R, 50V, 10%, 0603	KEMET, C0603C103K5RACTU
11	4	C40, C43, C45, C47	CAP., 1µF, X7R, 16V, 20%, 0603	TDK, C1608X7R1C105M080AC
12	2	C42, C46	CAP., 1µF, X7R, 50V, 10%, 0805	MURATA, GRM21BR71H105KA12L
13	2	Q1, Q2	XSTR., MOSFET, N-CH, 40V, TO-252 (DPAK)	VISHAY, SUD50N04-8M8P-4GE3
14	16	R1, R3, R6, R7, R11, R15, R28, R31, R35, R36, R74, R75, R76, R77, R80, R81	RES., 0Ω, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EA
15	10	R2, R5, R12, R16, R26, R32, R18, R20, R22, R24	RES., 100k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW0603100KFKEA
16	4	R50, R51, R82, R83	RES., 1k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06031K00FKEA
17	2	R54, R69	RES., 10k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060310K0FKEA
18	1	R55	RES., 0.01, 1%, 1/2W, 2010, SENSE, AEC-Q200	VISHAY, WSL2010R0100FEA
19	1	R70	RES., 0.02, 1%, 1/2W, 2010, SENSE, AEC-Q200	VISHAY, WSL2010R0200FEA

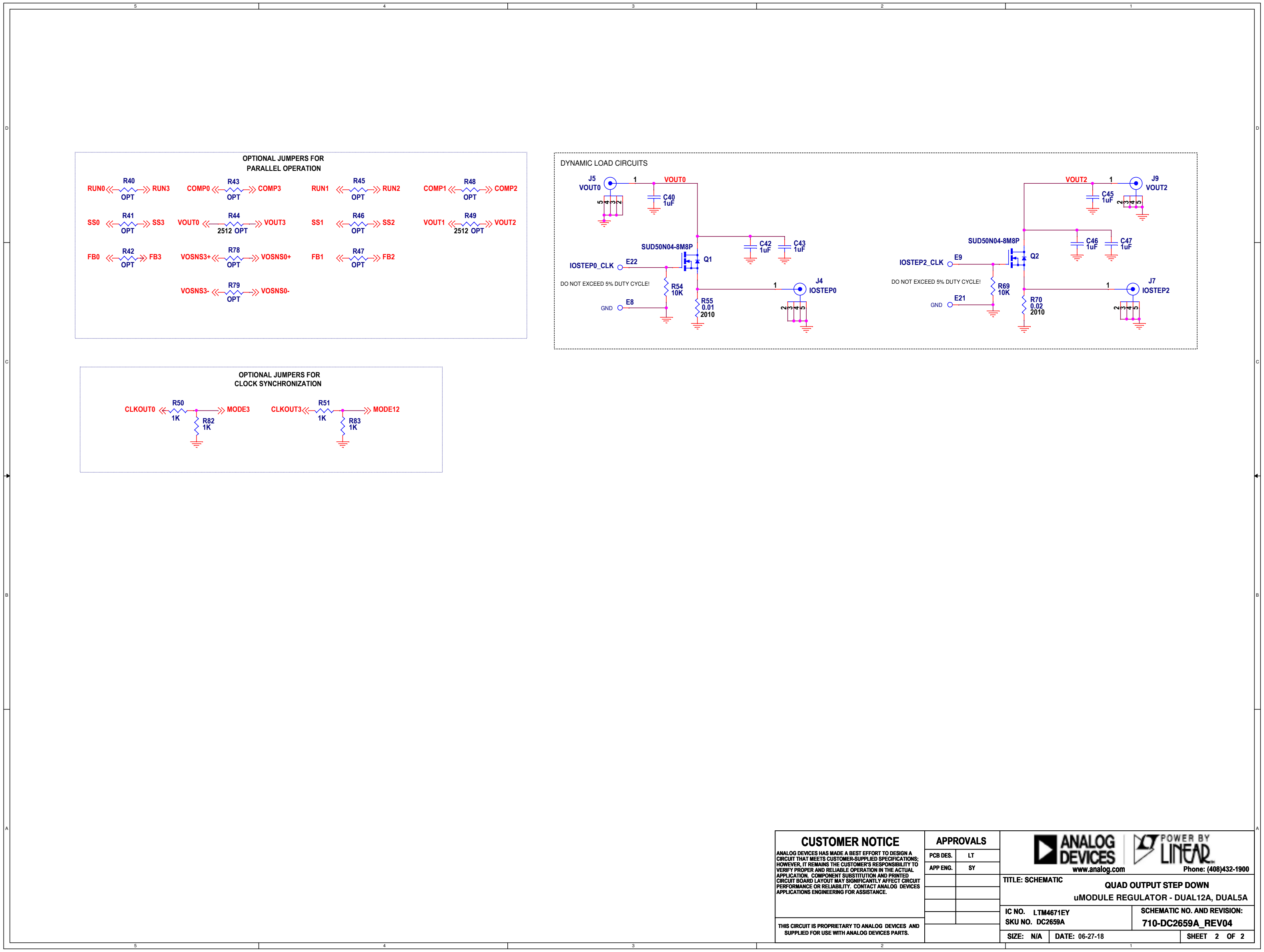
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Hardware				
1	25	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17, E18, E19, E20, E21, E22, E23, E24, E25	TEST POINT, TURRET, 0.094", MTG. HOLE	MILL-MAX, 2501-2-00-80-00-00-07-0
2	6	J1, J2, J3, J10, J11, J12	CONN.,BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE	KEYSTONE, 575-4
3	4	JP1, JP2, JP3, JP4	CONN., HDR, MALE, 1mm ×3mm × 2mm, VERT, STR, THT	WURTH ELEKTRONIK, 62000311121
4	4	J4, J5, J7, J9	CONN., RF, BNC, RCPT JACK, 5-PIN, STR, THT, 50Ω	AMPHENOL RF, 112404
5	2	JP5, JP7	CONN., HDR, MALE, 2mm × 2mm × 2mm, VERT, STR, THT	WURTH ELEKTRONIK, 62000421121
6	1	JP6	CONN., HDR, MALE, 2mm × 3mm × 2mm, VERT, STR, THT	WURTH ELEKTRONIK, 62000621121
7	4	MH1, MH2, MH3, MH4	STANDOFF, NYLON, SNAP-ON, 0.375"	KEYSTONE, 8832
8	7	XJP1, XJP2, XJP3, XJP4, XJP5, XJP6, XJP7	CONN., SHUNT, FEMALE, 2-POS,2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



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 NONINFRINGEMENT 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.