LTM4660
High Density Hybrid Step-Down Synchronous Converter

DESCRIPTION

Demonstration circuit 2879A is a high efficiency, high power density hybrid converter. It can deliver 12V/25A with an input voltage from 36V to 60V (up to 65V during transients). This demo board features the LTM®4660, which uses an architecture that merges soft-switching switched capacitor topology with a traditional step-down converter to provide superior efficiency compared to the traditional switching architectures. It offers a high efficiency/high density and cost effective solution for nonisolated intermediate bus applications in power distribution, datacom and telecom.

Due to its current mode control architecture, multiple LTM4660s can be operated in a parallel, multiphase configuration with excellent current sharing and low output voltage ripple to enable much higher power applications. Other benefits include low EMI emissions due to a soft-switched front end and reduced MOSFET stress.

The LTM4660 design eliminates the inrush current typically associated with switched capacitor circuits by pre-balancing the capacitors on start-up. The LTM4660 also monitors system voltage, current and temperature for faults. It stops switching and pulls the $\overline{\text{FAULT}}$ pin low when a fault condition occurs. An onboard timer can be set for appropriate restart/retry times.

Additional features include ±1.5% output voltage accuracy over temperature, a clock output for multiphase operation, a power good output signal, short-circuit protection, monotonic output voltage start-up, optional external reference, undervoltage lockout and internal charge balance circuitry.

The LTM4660 data sheet must be used in conjunction with this demo board manual.

Design files for this circuit board are available.

BOARD PHOTO

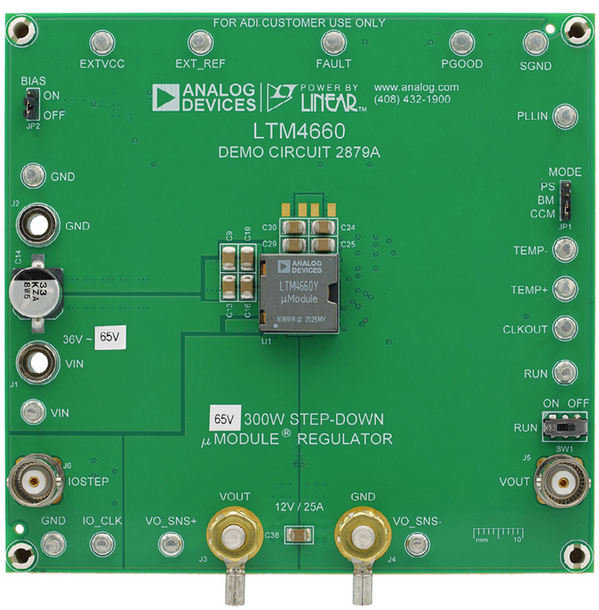


Figure 1. LTM4660/DC2879A Demo Circuit

PERFORMANCE SUMMARY Specifications are at T_A = 25°C

PARAMETER	CONDITION	MIN	TYP	MAX	VALUE
Input Voltage Range		36		60	V
Output Voltage, V_{OUT}	V_{IN} = 36V to 60V, I_{OUT} = 0A to 25A			12	V
Maximum Output Current, I_{OUT}	V_{IN} = 36V to 60V, V_{OUT} = 12V			25	A
Typical Efficiency	V_{IN} = 48V, V_{OUT} = 12V, I_{OUT} = 25A		96.6		%
Peak Efficiency	V_{IN} = 48V, V_{OUT} = 12V		97.0		%
Default Switching Frequency (at Start-Up)			430		kHz

QUICK START PROCEDURE

Demonstration circuit 2879A is easy to set up to evaluate the performance of the LTM4660. Refer to Figure 2 for the proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input power supply to VIN (36V to 60V) and GND (input return).
2. Connect the output load between VOUT and GND (Initial load: no load). Refer to Figure 2.
3. Connect the DVMs to the input and output.
4. Check the default jumper/switch position: SW1 (RUN): OFF.
5. Turn on the input power supply and adjust voltage to 48V.

   NOTE: Make sure that the input voltage does not exceed 60V.
6. Turn on the switches: SW1: ON.
7. Check for the proper output voltages from VO_SNS$^+$ to VO_SNS$^-$.
8. Once the proper output voltage is established, adjust the load within the operating range and measure the efficiency, output ripple voltage and other parameters.
9. After completing all tests, adjust the load to 0A, power off the input power supply.

Notes

1. When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 3 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (–) terminals of an output capacitor. The probe's ground ring needs to touch the (–) lead and the probe tip needs to touch the (+) lead.
2. When doing the load step test with the onboard dynamic load circuit, please make sure the load step-up pulse duty cycle does not exceed 2% and the pulse duration is less than 500µs so that the temperature of the MOSFETs Q11, Q12 in the dynamic load circuit stay in the safe region. Instead of using the onboard dynamic load circuit, an electric load can also be used for the load step test, which does not have the 2% max duty cycle limit for the load step.
3. The $EXTV_{CC}$ pin is connected by default to V_{OUT}, through a jumper R3. Remove R3 before applying external voltage to $EXTV_{CC}$ pin.
4. Due to the feature of the controller inside LTM4660, it is normal to see increased switching frequency after long-time running, as higher temperature leads to higher switching frequency.

QUICK START PROCEDURE

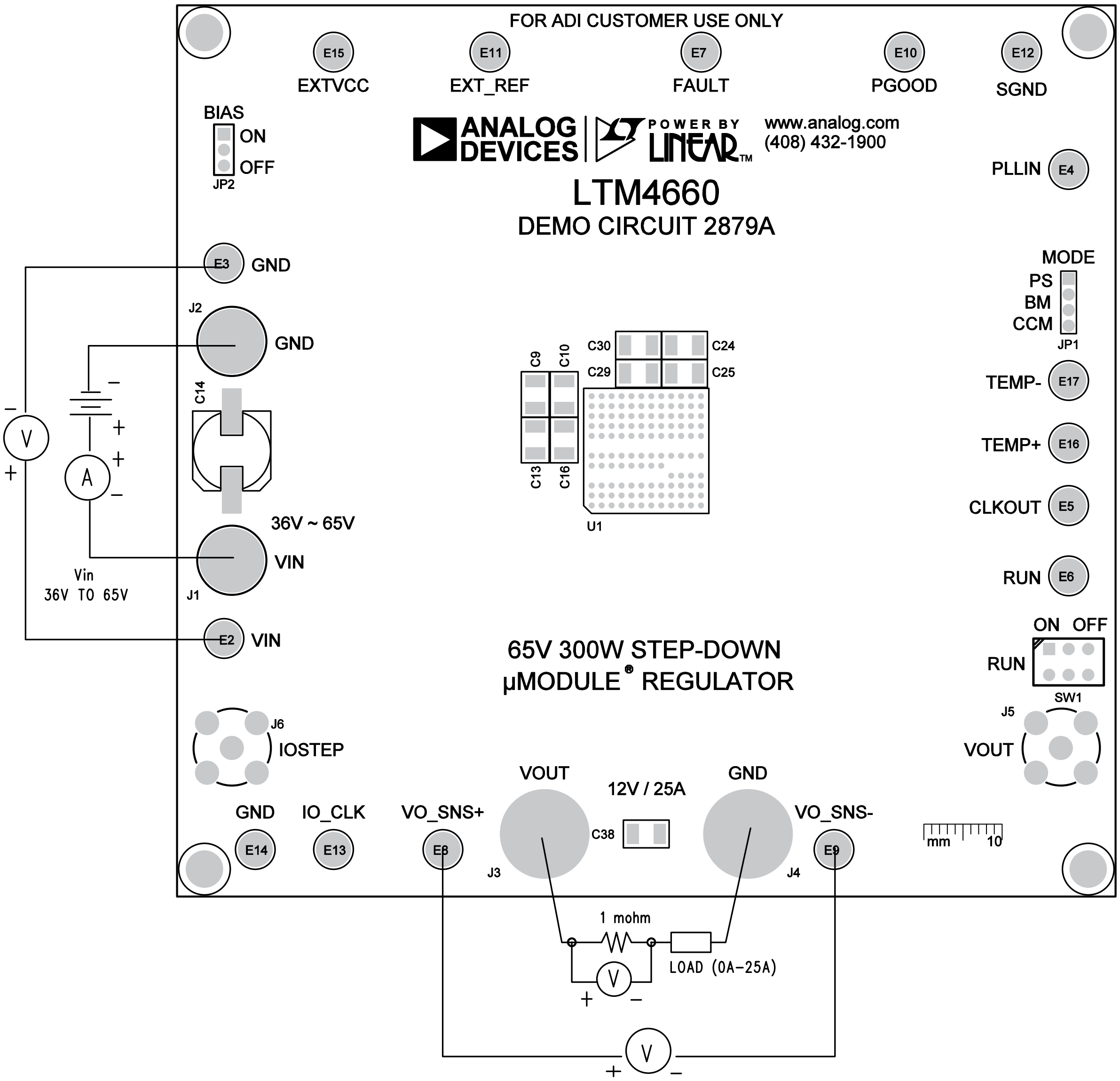


Figure 2. Proper Measurement Equipment Setup

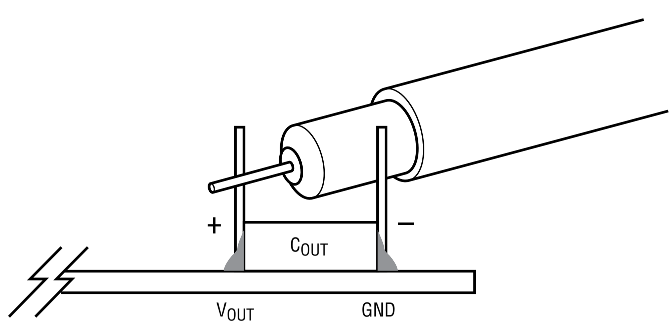


Figure 3. Measuring Output Voltage Ripple

QUICK START PROCEDURE

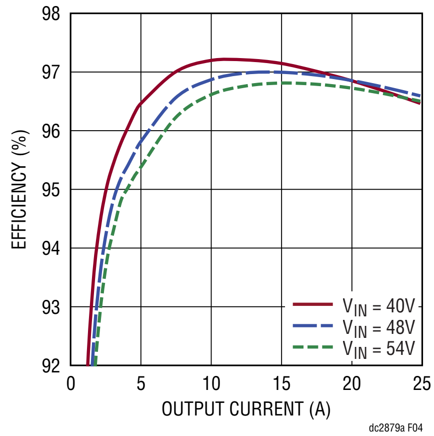


Figure 4. Efficiency vs Load Current at V_{OUT} = 12V, f_{SW} = 430kHz

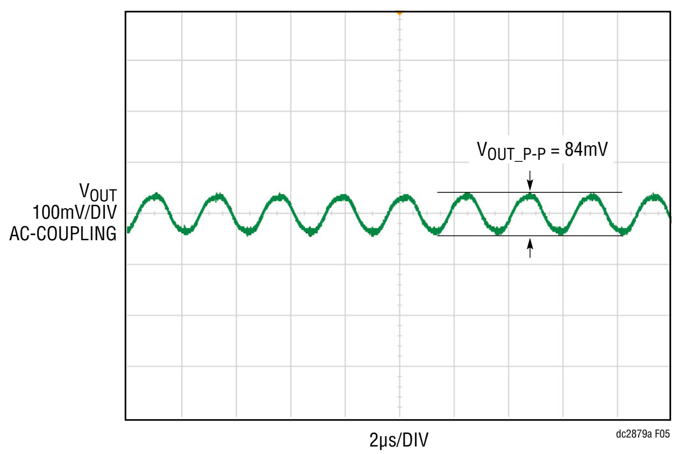


Figure 5. Output Voltage Ripple at V_{IN} = 48V, V_{OUT} = 12V, I_{OUT} = 25A, f_{SW} = 430kHz

QUICK START PROCEDURE

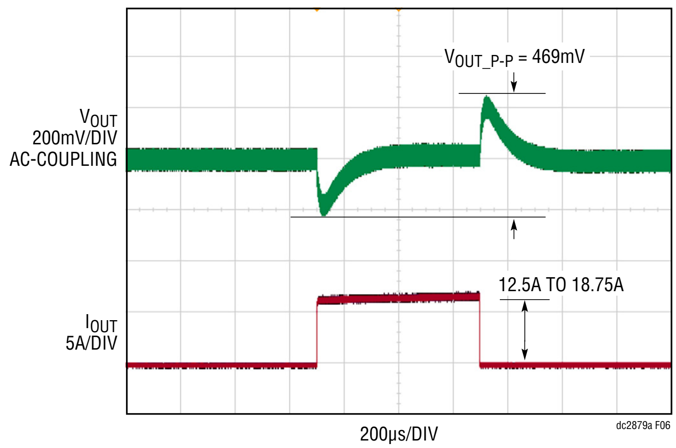


Figure 6. Load Step at V_{IN} = 48V, V_{OUT} = 12V, f_{SW} = 430kHz

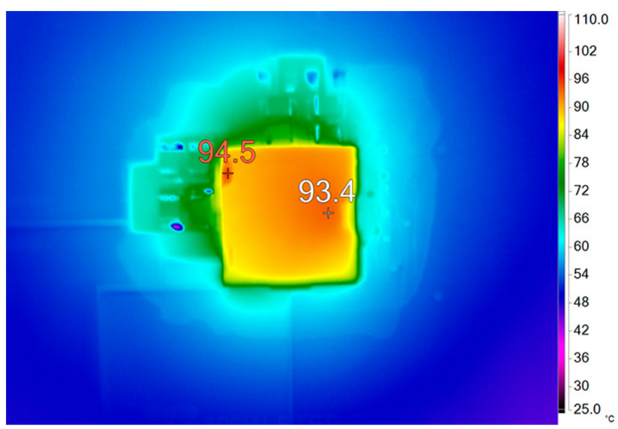


Figure 7. Thermal Performance V_{IN} = 48V, V_{OUT} = 12V, I_{OUT} = 25A, f_{SW} = 480kHz, T_A = 23°C, No Heatsink, No Airflow

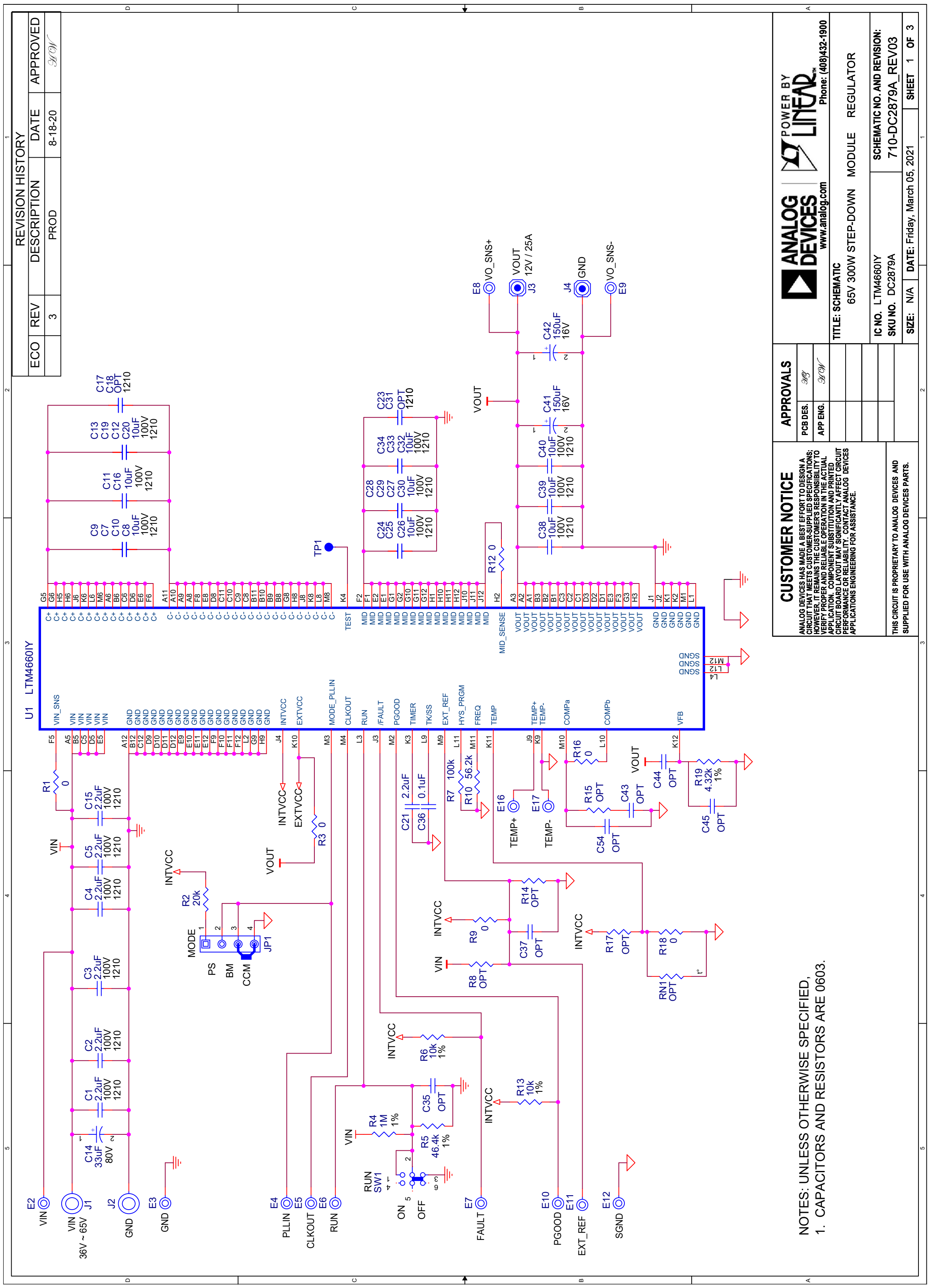
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	8	C1, C2, C3, C4, C5, C15, C46, C47	CAP., 2.2µF, X7R, 100V, 10%, 1210	AVX 12101C225KAT2A TDK C3225X7R2A225K230AB MURATA GRM32DR72A225KA12K MURATA GRM32DR72A225KA12L
2	23	C7, C8, C9, C10, C11, C12, C13, C16, C19, C20, C24, C25, C26, C27, C28, C29, C30, C32, C33, C34, C38, C39, C40	CAP., 10µF, X7S, 100V, 10%, 1210, NO SUBS. ALLOWED	MURATA GRM32EC72A106KE05L
3	1	C14	CAP., 33µF, ALUM. ELECT., 80V, 20%, 10×10.2mm SMD, RADIAL, AEC-Q200	PANASONIC EEHZA1K330P
4	1	C21	CAP., 2.2µF, X7S, 25V, 10%, 0603	MURATA GRM188C71E225KE11D
5	1	C36	CAP., 0.1µF, X7S, 100V, 10%, 0603	TAIYO YUDEN HMK107C7104KA-T TDK C1608X7S2A104K080AB
6	2	C41, C42	CAP., 150µF, ALUM./OS-CON, 16V, 20%, 8×6.9mm SMD, RADIAL	PANASONIC 16SVPC150M
7	2	C49, C50	CAP., 22µF, X5R, 25V, 10%, 1210	KEMET C1210C226K3PACTU MURATA GRM32ER61E226KE15K MURATA GRM32ER61E226KE15L SAMSUNG CL32A226KAJNNNE TAIYO YUDEN TMK325BJ226KM-P AVX 12103D226KAT2A TAIYO YUDEN TMK325BJ226KM-T
8	1	C51	CAP., 0.047µF, X7R, 25V, 10%, 0603	NIC NMC0603X7R473K25TRPF AVX 06033C473KAT2A
9	1	C52	CAP., 220pF, C0G, 50V, 5%, 0603	AVX 06035A221JAT2A MURATA GRM1885C1H221JA01D WURTH ELEKTRONIK 885012006059
10	1	C53	CAP., 1µF, X7R, 25V, 10%, 0603, AEC-Q200	MURATA GCM188R71E105KA64D TAIYO YUDEN TMK107AB7105KAHT TDK CGA3E1X7R1E105K080AC
11	1	L3	IND., 68µH, PWR, SHIELDED, 20%, 0.62A, 0.42Ω, 6mm × 6mm SMD	COILCRAFT LPS6225-683MRB COILCRAFT LPS6225-683MRC
12	2	Q11, Q12	XSTR., MOSFET, N-CH, 40V, TO-252 (DPAK)	VISHAY SUD50N04-8M8P-4GE3
13	6	R1, R3, R9, R12, R16, R18	RES., AEC-Q200, 0Ω, 1/10W, 0603	VISHAY CRCW06030000Z0EA VISHAY CRCW06030000Z0EB NIC NRC06Z0TRF
14	2	R2, R22	RES., AEC-Q200, 20k, 5%, 1/10W, 0603	NIC NRC06J203TRF VISHAY CRCW060320K0JNEA PANASONIC ERJ3GEYJ203V
15	1	R4	RES., AEC-Q200, 1M, 1%, 1/10W, 0603	NIC NRC06F1004TRF PANASONIC ERJ3EKF1004V VISHAY CRCW06031M00FKEA
16	1	R5	RES., 46.4k, 1%, 1/10W, 0603	NIC NRC06F4642TRF VISHAY CRCW060346K4FKEA YAGEO RC0603FR-0746K4L
17	3	R6, R13, R24	RES., AEC-Q200, 10k, 1%, 1/10W, 0603	VISHAY CRCW060310K0FKEA KOA SPEER RK73H1JTTD1002F PANASONIC ERJ3EKF1002V
18	1	R7	RES., 100k, 1%, 1/10W, 0603	VISHAY CRCW0603100KFKEA NIC NRC06F1003TRF PANASONIC ERJ3EKF1003V

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
19	1	R10	RES., 56.2k, 1%, 1/10W, 0603, AEC-Q200	NIC NRC06F5622TRF PANASONIC ERJ3EKF5622V VISHAY CRCW060356K2FKEA
20	1	R19	RES., AEC-Q200, 4.32k, 1%, 1/10W, 0603	VISHAY CRCW06034K32FKEA NIC NRC06F4321TRF PANASONIC ERJ3EKF4321V
21	1	R21	RES., AEC-Q200, 182k, 1%, 1/10W, 0603	PANASONIC ERJ3EKF1823V VISHAY CRCW0603182KFKEA
22	1	R23	RES., 80.6k, 1%, 1/10W, 0603	VISHAY CRCW060380K6FKEA NIC NRC06F8062TRF YAGEO RC0603FR-0780K6L
23	1	R25	RES., 0.1Ω, 1%, 1W, 2010	VISHAY WSL2010R1000FEA18
24	1	U1	IC, HYBRID STEP-DOWN NON-ISOLATED µModule® BUS CONVERTER	ANALOG DEVICES LTM4660IY#PBF
25	1	U2	IC, SYNCHRONOUS STEP-DOWN CONVERTER	ANALOG DEVICES LTC3630AEMSE#PBF ANALOG DEVICESLTC3630AEMSE#TRPBF
Additional Demo Board Circuit Components				
1	0	C17, C18, C23, C31	CAP., OPTION, 1210	
2	0	C35, C37, C43, C44, C45, C48, C54	CAP., OPTION, 0603	
3	0	R8, R14, R15, R17, R20	RES., OPTION, 0603	
4	0	RN1	THERMISTOR, OPTION, 0603	
Hardware: For Demo Board Only				
1	16	E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E16, E17	TEST POINT, TURRET, 0.094", MTG. HOLE	MILL-MAX 2501-2-00-80-00-00-07-0
2	2	J1, J2	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE	KEYSTONE 575-4
3	2	J3, J4	STUD, FASTENER, #10-32	PENN ENGINEERING KFH-032-10ET
4	2	J5, J6	CONN., RF, BNC, RCPT JACK, 5-PIN, STR, THT, 50Ω	AMPHENOL RF 112404
5	2	JLRE1, JLRE2	RING, LUG, CRIMP, #10, NON-INSULATED, SOLDERLESS TERMINALS	KEYSTONE 8205
6	4	JNE1, JNE2, JNE3, JNE4	NUT, HEX, #10-32, BRASS	PENCOM NU1132
7	1	JP1	CONN., HDR, MALE, 1×4, 2mm, STR, THT	WURTH ELEKTRONIK 62000411121
8	1	JP2	CONN., HDR, MALE, 1×3, 2mm, THT, STR, NO SUBS. ALLOWED	WURTH ELEKTRONIK 62000311121
9	2	JWE1, JWE2	WASHER, #10, LOCK, EXT, TIN FINISH	PENCOM WA4526
10	1	LB1	LABEL SPEC, DEMO BOARD SERIAL NUMBER	BRADY THT-96-717-10
11	4	MH1, MH2, MH3, MH4	STANDOFF, NYLON, SNAP-ON, 0.625"	KEYSTONE 8834
12	1	PCB1	PCB, DC2879A	PHASE 3600-DC2879A
13	1	STNCL1	TOOL, STENCIL, DC2879A	ANALOG DEVICES 830-DC2879A
14	1	SW1	SWITCH, SLIDE, DPDT, 0.3A, 6VDC, PTH	C&K JS202011CQN
15	2	XJP1, XJP2	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK 60800213421

SCHEMATIC DIAGRAM



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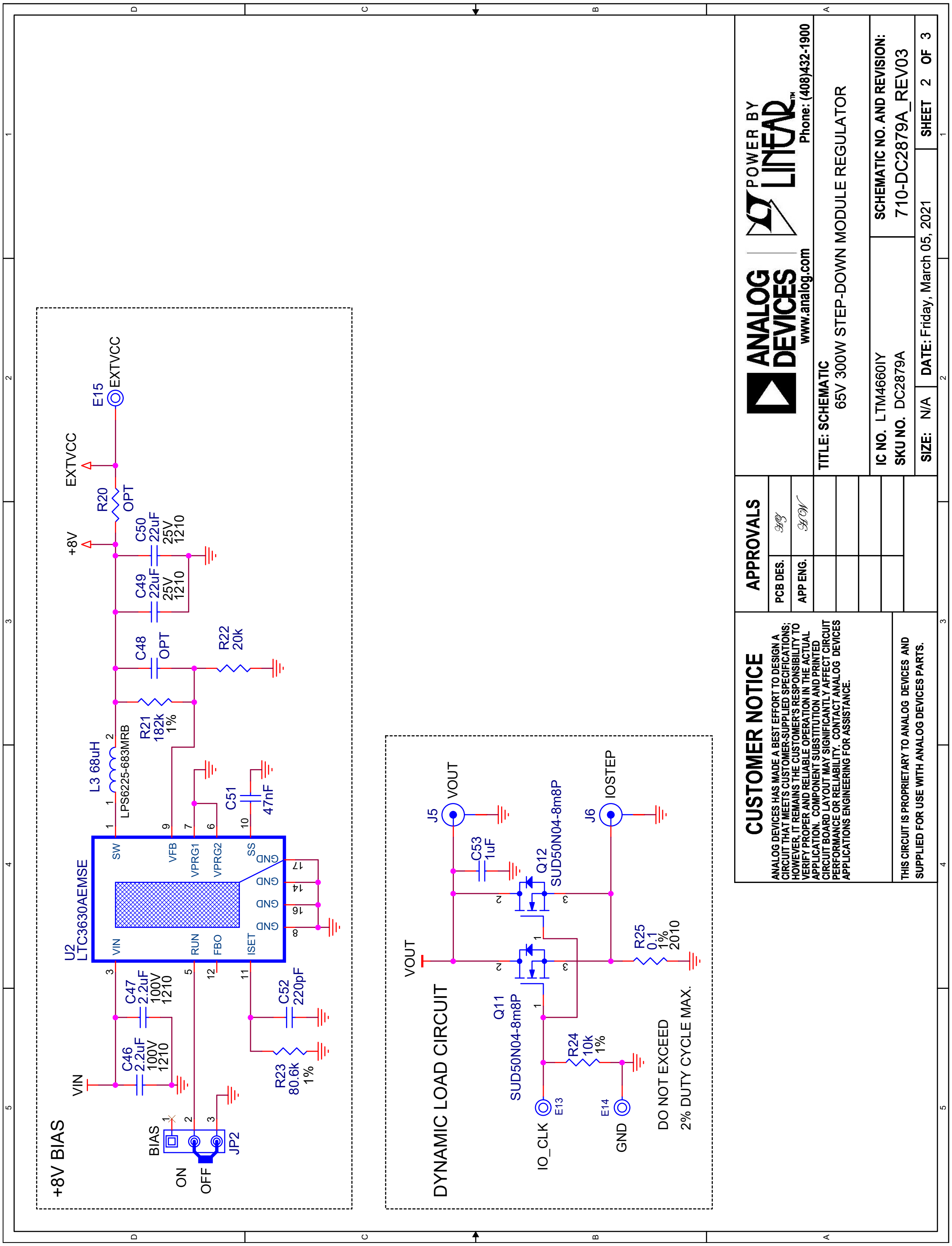

Rev. 0

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.

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