

LTC3871

High Power PolyPhase® Bi-Directional Supply/Charger

DESCRIPTION

Demonstration circuit 2348A is a high power high efficiency bi-directional synchronous buck or boost converter featuring the LTC®3871 and is available in two versions. The DC2348A-A operates with two each LTC3871 devices with four phases and the DC2348A-B utilizes one LTC3871 device with two phases.

When operating in buck mode, this demo circuit has an input voltage range of 30V to 75V and produces a 12V output. When operating in boost mode, the input voltage is from 10V to 13V and produces a 48V output voltage.

Both boards have a switch that allows the converter to run in either buck or boost mode. A DC voltage source can be connected to the SETCUR turret to set the average inductor current in each phase of the converter. Both boards also utilize a mode jumper to select forced continuous conduction mode, buck-mode only pulse-skipping or full pulse-skipping mode for buck and boost.

Synchronization to an external clock (frequency range 100 kHz to 300 kHz) is also possible on these boards.

The demo circuit senses inductor current with a sense resistor. An optional DCR sense circuit utilizes the inductor's DCR as the current sensing element further saving cost, footprint and improving efficiency.

The LTC3871 data sheet gives a complete description of the part's operation and application information and must be read in conjunction with this quick start guide.

Design files for this circuit board are available at
<http://www.linear.com/demo/DC2348A>

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PERFORMANCE SUMMARY

DC2348A-A (4-Phase) Buck Mode

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V _{HIGH}	Supply Range		30		75	V
V _{LOW}	Output Voltage		11.8	12	12.2	V
Output Current					60	A
f _{SW}	Operating Frequency			110		kHz
	Efficiency	48V to 12V at 60A		97.5		%

Boost Mode

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V _{LOW}	Supply Range		10		13	V
V _{HIGH}	Output Voltage		47	48	49	V
Output Current					15	A
f _{SW}	Operating Frequency			110		kHz
	Efficiency	12V to 48V at 15A		97		%

DEMO MANUAL

DC2348A-A/DC2348A-B

PERFORMANCE SUMMARY

DC2348-B (2-Phase) Buck Mode

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V _{HIGH}	Supply Range		30		75	V
V _{LOW}	Output Voltage		11.8	12	12.2	V
Output Current					30	A
f _{SW}	Operating Frequency			110		kHz
	Efficiency	48V to 12V at 30A		97		%

Boost Mode

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V _{LOW}	Supply Range		10		13	V
V _{HIGH}	Output Voltage		47	48	49	V
Output Current					7.5	A
f _{SW}	Operating Frequency			110		kHz
	Efficiency	12V to 48V at 7.5A		97		%

QUICK START PROCEDURE

Demonstration circuit DC2348A has voltage regulation (CV) and current regulation (CC) modes that can be evaluated. Refer to Figure 1 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 input or output voltage ripple by touching the probe tip directly across the V_{HIGH} or V_{LOW} and GND terminals or directly across relevant capacitor. See Figure 2 for proper scope probe technique.

For CV (constant voltage) buck mode (V_{HIGH} is the input and V_{LOW} is the output):

1. Place jumpers in the following positions:

JP1	ILIM	OPEN
JP2	PHASE1	OPEN
JP3	MODE	FCM
JP4	RUN	OFF
JP6	PHASE2	GND
S1	BUCK/BOOST	BUCK

2. With the power off, connect the input power supply to V_{HIGH} and GND. Connect the load to V_{LOW} and GND. The load current should be less than 60A for DC2348A-A and less than 30A for DC2348A-B.

3. Connect the SETCUR turret according to the BUCK/BOOST setting:

Buck: SETCUR = V5 (JP1 pin 2)

Boost: SETCUR = GND

4. Turn on the power at the input.

NOTE: Make sure that the input voltage is between 30V and 75V.

5. Change the JP4 to ON position.

6. Check for the proper output voltage (V_{LOW} = 11.8V to 12.2V).

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.

dc2348aabf

QUICK START PROCEDURE

8. Disconnect the load from the DC2348A and then turn off the input power.

For CV boost mode (V_{LOW} is the input and V_{HIGH} is the output).

9. Change the S1 position from BUCK to BOOST.

10. Connect the input power supply to V_{LOW} and GND. Connect the load to V_{HIGH} and GND. The load current should be less than 15A for DC2348A-A and less than 7.5A for DC2348A-B.

11. Turn on the input power.

NOTE: Make sure that the input voltage is between 10V and 13V.

Check for the proper output voltage ($V_{HIGH}=47V$ to $49V$).

12. Once the proper output voltage is established, adjust the load within the operating range and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

For CC (constant current) mode operation:

1. Use the same afore mentioned jumpers setting.
2. An electronic load active in CV (constant voltage) mode is required as the current-sinking device. Set the electronic load voltage to below 11V or below 46V for buck or boost mode respectively.

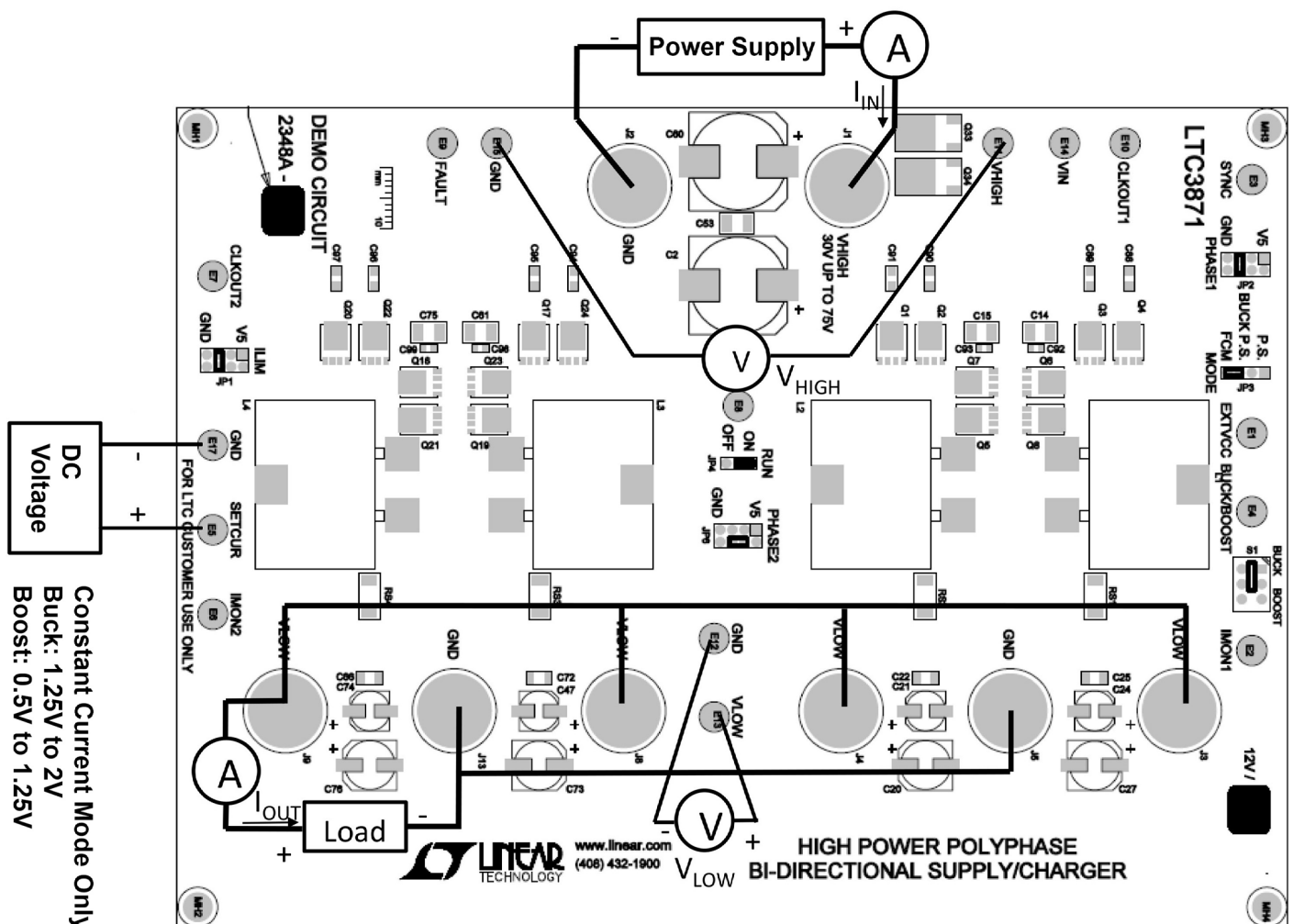


Figure 1. Proper Measurement Equipment Setup (Buck Mode)

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DEMO MANUAL

DC2348A-A/DC2348A-B

QUICK START PROCEDURE

- With the power off, connect the input power supply and the load according to the BUCK/BOOST setting:

	POWER SUPPLY	ELECTRONIC LOAD
BUCK	VHIGH	VLOW
BOOST	VLOW	VHIGH

- Connect a DC voltage source between the SETCUR and GND turrets. Set the initial DC voltage to 1.25V. The valid SETCUR voltage range is 1.25V to 2V for BUCK mode and 1.25V to 0.5V for BOOST mode. Turn on the power and then change the JP4 to ON position.

NOTE: Watch closely for the load current, which is proportional to the SETCUR voltage. At SETCUR = 1.25V the load current may or may not be zero, depending upon the different ILIM settings.

- Observe the IMON1 or IMON2 turret voltage. It should be equal to the SETCUR voltage until the ILIM-set current limit is hit.

- Adjust the SETCUR back to 1.25V. Change the JP4 to OFF position. Turn off the input power.

For battery charging applications, SETCUR can be programmed dynamically on-the-fly to set the charging currents to the batteries in either BUCK or BOOST mode. The BUCK/BOOST mode can also be set dynamically: Toggle the S1 switch to the middle position and drive the BUCK turret by a signal generator.

BUCK: 5V

BOOST: 0V

NOTE (Constant Current Mode Only): When doing the bidirectional current transition tests, both VHIGH and VLOW sides need a power supply and an electronic load which is active in the CV mode. In this case, the electronic load functions like a battery which is being charged. Make sure the power supply voltages are always below the same side electronic load voltages. See Figure 3 for proper equipment setup.

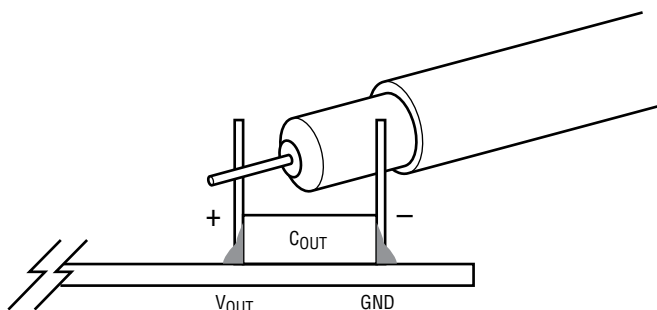


Figure 2. Measuring Input or Output Ripple Across Terminals or Directly Across Bulk Capacitor

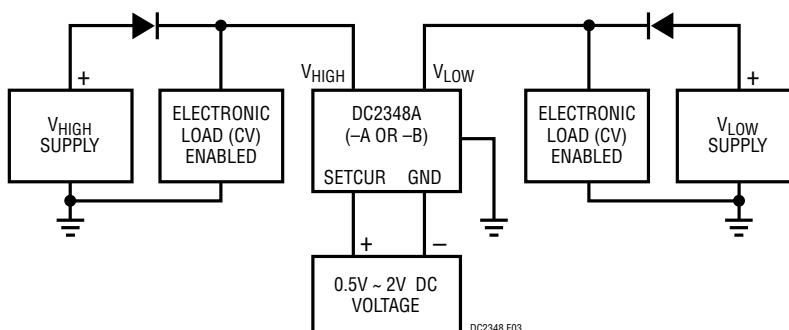


Figure 3. Proper Equipment Setup For Bidirectional Current Transition Tests (DC2348A in CC Mode)

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OPTIONAL INDUCTOR DCR CURRENT SENSING

Demonstration circuit 2348A provides an optional circuit for Inductor DCR current sensing. Inductor DCR current sensing uses the DCR of the inductor to sense the inductor current instead of discrete sense resistors. The advantages of DCR sensing are lower cost, reduced board space and higher efficiency, but the disadvantage is a less accurate

current limit. If DCR sensing is used, be sure to select an inductor with sufficiently high saturation current or use an iron powder type material.

Refer to Table 2 for Optional Inductor DCR Current Sensing setup and to the data sheet for more details.

Table 2. Optional Inductor DCR Current Sensing

Configuration	CHANNEL1	RS1	R39	R26	C32
	CHANNEL2	RS2	R40	R25	C33
	CHANNEL3	RS3	R43	R79	C34
	CHANNEL4	RS4	R49	R54	C35
Current Sense Resistor (Default)	REF SCH		REF SCH	OPEN	OPEN
Inductor DCR Current Sensing	0Ω Copper		OPEN	Calculated Value from Data Sheet	

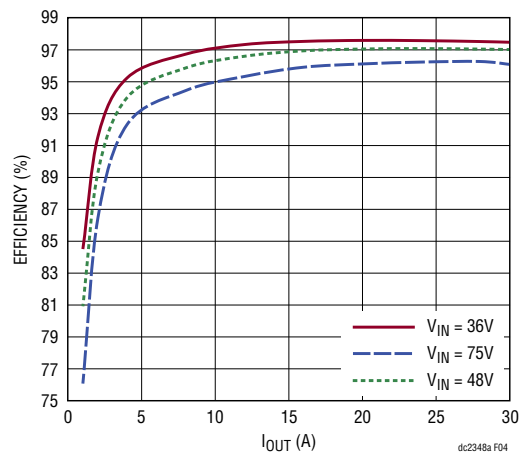


Figure 4. DC2348A-B Buck Mode Typical Efficiency vs Load Current

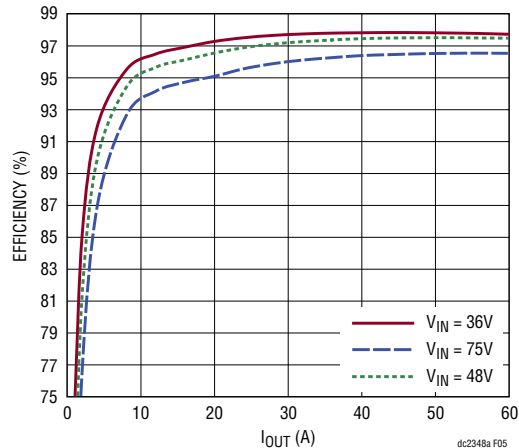


Figure 5. DC2348A-A Buck Mode Typical Efficiency vs Load Current

OPTIONAL INDUCTOR DCR CURRENT SENSING

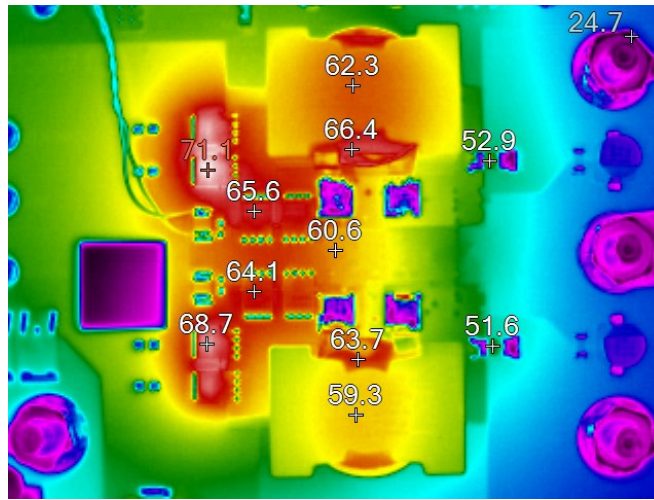


Figure 6. DC2348A-B Thermal Image, $V_{HIGH} = 75V$, $V_{LOW} = 12V$, $I_{OUT} = 30A$, Free Air, $T_A = 25^\circ C$

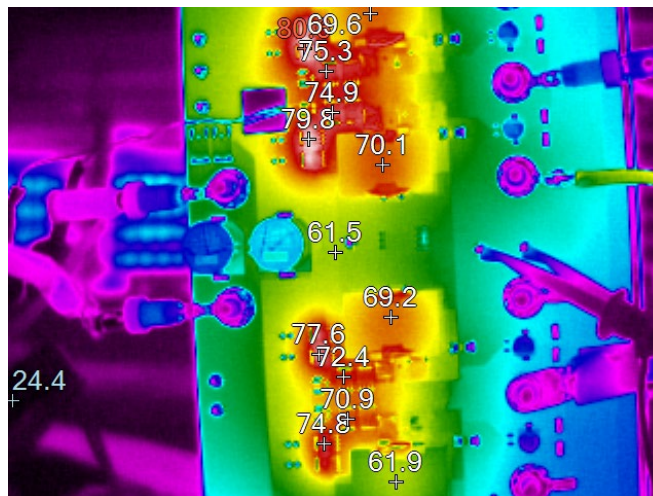


Figure 7. DC2348A-A Thermal Image, $V_{HIGH} = 75V$, $V_{LOW} = 12V$, $I_{OUT} = 60A$, Free Air, $T_A = 25^\circ C$

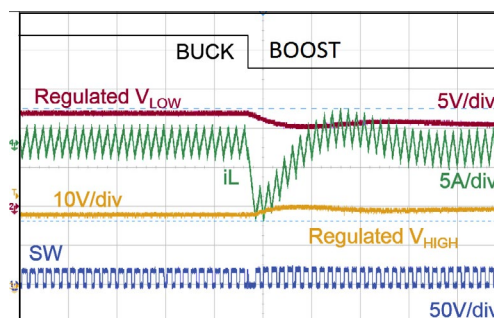


Figure 8. Mode Transition from Buck to Boost

DEMO MANUAL

DC2348A-A/DC2348A-B

PARTS LIST DC2348A-A

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	10	C1, C14, C15, C16, C19, C53, C54, C55, C61, C75	CAP, 1210 2.2 μ F 10% 100V X7R	AVX 12101C225KAT2A
2	2	C2, C60	CAP, 100 μ F 20% 100V ELEC	SUN ELECT. 100CE100KXT
3	4	C3, C4, C70, C100	CAP, 33 μ F 20% 80V ELEC	PANASONIC EEE-FK1K330P
4	1	C5	CAP, 0603 47pF 10% 50V C0G	AVX 06035A470KAT2A
5	2	C6, C9	CAP, 0603 10nF 10% 100V X7R	AVX 06031C103KAT2A
6	2	C7, C39, C58	CAP, 0603 100nF 10% 50V X7R	AVX 06035C104KAT2A
7	8	C8, C13, C28, C29, C45, C46, C48, C63	CAP, 0603 0.22 μ F 10% 25V X5R	AVX 06033D224KAT2A
8	5	C10, C31, C51, C64, C107	CAP, 0805 4.7 μ F 10% 16V X7R	AVX 0805YC475KAT2A
9	3	C11, C62, C65	CAP, 0603 100pF 10% 100V NPO	AVX 06031A101KAT2A
10	2	C12, C67	CAP, 0603 10pF 10% 100V C0G	AVX 06031A100KAT2A
11	6	C18, C23, C59, C71, C105, C106	CAP, 0603 1 μ F 10% 25V X7R	MURATA GRM188R71E105KA12D
12	4	C21, C24, C47, C74	CAP, 100 μ F 20% 25V ALUM	PANASONIC EEHZA1E101XP
13	4	C22, C25, C66, C72	CAP, 1206 10 μ F 10% 25V X7R	MURATA GRM31CR71E106KA12L
14	4	D1, D2, D3, D4	DIODE, SCHOTTKY, RECTIFIER	DIODES INC. DFLS1100-7
15	4	L1, L2, L3, L4	IND, 10 μ H	WURTH 7443641000
16	8	Q1, Q2, Q3, Q4, Q17, Q20, Q22, Q24	XSTR, MOSFET N-CH 80V 100A TDSO-8	INFINEON BSC117N08NS5
17	8	Q5, Q6, Q7, Q8, Q18, Q19, Q21, Q23	XSTR, MOSFET N-CH 80V 100A TDSO-8	INFINEON BSC040N08NS5
18	2	Q33, Q34	XSTR, SIPMOS, P-CHANNEL	VISHAY SUD50P08-25L
19	4	RS1, RS2, RS3, RS4	RES, 2010 0.001 Ω 1% 1W	VISHAY WSL20101L000FEA18
20	1	R1	RES, 0603 649k Ω 1% 1/10W	VISHAY CRCW0603649KFKEA
21	1	R2	RES, 0603 243k Ω 1% 1/10W	VISHAY CRCW0603243KFKEA
22	1	R3	RES, 0603 200k Ω 1% 0.1W	VISHAY CRCW0603200KFKEA
23	23	R4, R12, R14, R21, R24, R30, R33, R34, R35, R39, R40, R43, R49, R67, R72, R80, R82, R85, R86, R87, R88, R89, R90	RES, 0603 0 Ω JUMPER	VISHAY CRCW06030000Z0EA
24	1	R5	RES, 0603 69.8k Ω 1% 0.1W	VISHAY CRCW060369K8FKEA
25	1	R6	RES, 0603 12.7k Ω 1% 1/10W	VISHAY CRCW060312K7FKEA
26	8	R7, R8, R9, R17, R27, R36, R46, R48	RES, 0603 10k Ω 1% 1/10W	VISHAY CRCW060310K0FKEA
27	1	R10	RES, 0603 3.01k Ω 1% 1/10W	VISHAY CRCW06033K01FKEA
28	1	R11	RES, 0603 4.53k Ω 1% 1/10W	VISHAY CRCW06034K53FKEA
29	2	R13, R47	RES, 0603 20k Ω 1% 1/10W	VISHAY CRCW060320K0FKEA
30	1	R15	RES, 0603 110k Ω 1% 1/10W	VISHAY CRCW0603110KFKEA
31	1	R16	RES, 0805 499k Ω 1% 1/8W	VISHAY CRCW0805499KFKEA
32	1	R18	RES, 0603 100k Ω 5% 1/10W	VISHAY CRCW0603100KJNEA
33	1	R22	RES, 0603 90.9k Ω 1% 1/10W	VISHAY CRCW060390K9FKEA
34	2	R23, R81	RES, 0603 10 Ω 1% 1/10W	VISHAY CRCW060310R0FKEA
35	2	R29, R78	RES, 1206 2.2 Ω 1% 1/4W	VISHAY CRCW12062R20FKEA
36	4	R31, R32, R53, R65	RES, 0603 4.99k Ω 1% 0.1W	VISHAY CRCW06034K99FKEA
37	4	R38, R41, R42, R50	RES, 0603 300 Ω 1% 0.1W	VISHAY CRCW0603300RFKEA
38	2	R44, R51	RES, 0603 34k Ω 1% 0.1W	VISHAY CRCW060334K0FKEA

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DEMO MANUAL

DC2348A-A/DC2348A-B

PARTS LIST DC2348A-A

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
39	2	R83, R84	RES, 2512 0 Ω JUMPER	VISHAY CRCW25120000Z0EG
40	2	U1, U2	IC, HIGH POWER BiDIRECTIONAL SUPPLY	LINEAR TECH LTC3871HLXE#PBF

Additional Demo Board Circuit Components

1	0	C20, C27, C73, C76	CAP, ALUM OPTION	OPTION
2	0	C30, C32, C33, C34, C35, C92, C93, C98, C99, C101, C102, C103, C104	CAP, 0603 OPTION	OPTION
3	0	C88, C89, C90, C91, C94, C95, C96, C97, C108, C109, C110, C111, C112, C113, C114, C115	CAP, 0805 OPTION	OPTION
4	0	L1, L2, L3, L4 - ALTERNATE	IND, 10 μ H	COILCRAFT SER2918H-103
5	0	Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q25, Q26, Q27, Q28, Q29, Q30, Q31, Q32	XSTR, MOSFET OPTION	INFINEON IPD60N10S4-12 OPTION
6	0	R19, R20	RES, 0603 OPTION	OPTION
7	0	R25, R26, R54, R79	RES, 1206 OPTION	OPTION

Hardware: For Demo Board Only

1	16	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, E15, E17	TURRET	MIIL-MAX 2501-2-00-80-00-00-07-0
2	3	JP1, JP2, JP6	HEADER, 4PIN, DBL ROW 2mm	WURTH ELEKTRONIK 62000821121
3	1	JP3	HEADER, 4PIN, 2mm	WURTH ELEKTRONIK 62000411121
4	1	JP4	HEADER, 2mm, 3PIN	WURTH ELEKTRONIK 62000311121
6	8	J1, J2, J3, J4, J5, J8, J9, J13	STUD, TESTPIN	PEM KFH-032-10
7	8		LUG RING, #10	KEYSTONE 8205
8	16		NUT, BRASS 10-32	ANY #10-32
9	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE 8834
10	8		WASHER, #10 TIN PLATED BRASS	ANY #10 EXT BZ TN
11	1	S1	SWITCH, SUBMINATURE, SLIDE, SPDT	C&K-COMPONENTS JS202011CQN
12	5	XJP1, XJP3, XJP4, XJP6, XJP7	SHUNT, 2mm	WURTH ELEKTRONIK 60800213421

PARTS LIST DC2348A-B

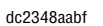
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	5	C1, C14, C15, C16, C19	CAP, 1210 2.2μF 10% 100V X7R	AVX 12101C225KAT2A
2	1	C2	CAP, 100μF 20% 100V ELEC	SUN ELECT. 100CE100KXT
3	2	C3, C4	CAP, 33μF 20% 80V ELEC	PANASONIC EEE-FK1K330P
4	1	C5	CAP, 0603 47pF 10% 50V C0G	AVX 06035A470KAT2A
5	2	C6, C9	CAP, 0603 10nF 10% 100V X7R	AVX 06031C103KAT2A
6	2	C7, C39	CAP, 0603 100nF 10% 50V X7R	AVX 06035C104KAT2A
7	4	C8, C13, C28, C29	CAP, 0603 0.22μF 10% 25V X5R	AVX 06033D224KAT2A
8	2	C10, C31	CAP, 0805 4.7μF 10% 16V X7R	AVX 0805YC475KAT2A
9	1	C11	CAP, 0603 100pF 10% 100V NPO	AVX 06031A101KAT2A
10	1	C12	CAP, 0603 10pF 10% 100V C0G	AVX 06031A100KAT2A
11	3	C18, C23, C105	CAP, 0603 1μF 10% 25V X7R	MURATA GRM188R71E105KA12D
12	2	C21, C24	CAP, 100μF 20% 25V ALUM	PANASONIC EEHZA1E101XP
13	2	C22, C25	CAP, 1206 10μF 10% 25V X7R	MURATA GRM31CR71E106KA12L
14	2	D1, D2	DIODE, SCHOTTKY, RECTIFIER	DIODES INC. DFLS1100-7
15	2	L1, L2	IND, 10μH	WURTH 7443641000
16	4	Q1, Q2, Q3, Q4	XSTR, MOSFET N-CH 80V 100A TDSO-8	INFINEON BSC117N08NS5
17	4	Q5, Q6, Q7, Q8	XSTR, MOSFET N-CH 80V 100A TDSO-8	INFINEON BSC040N08NS5
18	2	Q33, Q34	XSTR, SIPMOS, P-CHANNEL	VISHAY SUD50P08-25L
19	2	RS1, RS2	RES, 2010 0.001Ω 1% 1W	VISHAY WSL20101L000FEA18
20	1	R1	RES, 0603 649kΩ 1% 1/10W	VISHAY CRCW0603649KFKEA
21	1	R2	RES, 0603 243kΩ 1% 1/10W	VISHAY CRCW0603243KFKEA
22	1	R3	RES, 0603 200kΩ 1% 0.1W	VISHAY CRCW0603200KFKEA
23	11	R4, R12, R14, R21, R24, R30, R33, R34, R35, R39, R40	RES, 0603 0Ω JUMPER	VISHAY CRCW06030000Z0EA
24	1	R5	RES, 0603 69.8kΩ 1% 0.1W	VISHAY CRCW060369K8FKEA
25	1	R6	RES, 0603 12.7kΩ 1% 1/10W	VISHAY CRCW060312K7FKEA
26	6	R7, R8, R9, R17, R27, R36	RES, 0603 10kΩ 1% 1/10W	VISHAY CRCW060310K0FKEA
27	1	R10	RES, 0603 3.01kΩ 1% 1/10W	VISHAY CRCW06033K01FKEA
28	1	R11	RES, 0603 4.53kΩ 1% 1/10W	VISHAY CRCW06034K53FKEA
29	1	R13	RES, 0603 20kΩ 1% 1/10W	VISHAY CRCW060320K0FKEA
30	1	R15	RES, 0603 110kΩ 1% 1/10W	VISHAY CRCW0603110KFKEA
31	1	R16	RES, 0805 499kΩ 1% 1/8W	VISHAY CRCW0805499KFKEA
32	1	R18	RES, 0603 100kΩ 5% 1/10W	VISHAY CRCW0603100KJNEA
33	1	R22	RES, 0603 90.9kΩ 1% 1/10W	VISHAY CRCW060390K9FKEA
34	1	R23	RES, 0603 10Ω 1% 1/10W	VISHAY CRCW060310R0FKEA
35	1	R29	RES, 1206 2.2Ω 1% 1/4W	VISHAY CRCW12062R20FKEA
36	2	R31, R32	RES, 0603 4.99kΩ 1% 0.1W	VISHAY CRCW06034K99FKEA
37	1	R44	RES, 0603 34kΩ 1% 0.1W	VISHAY CRCW060334K0FKEA
38	2	R38, R41	RES, 0603 300Ω 1% 0.1W	VISHAY CRCW0603300RFKEA
39	2	R83, R84	RES, 2512 0Ω JUMPER	VISHAY CRCW25120000Z0EG
40	1	U1	IC, HIGH POWER BiDIRECTIONAL SUPPLY	LINEAR TECH LTC3871HLXE#PBF

DEMO MANUAL

DC2348A-A/DC2348A-B

PARTS LIST DC2348A-B

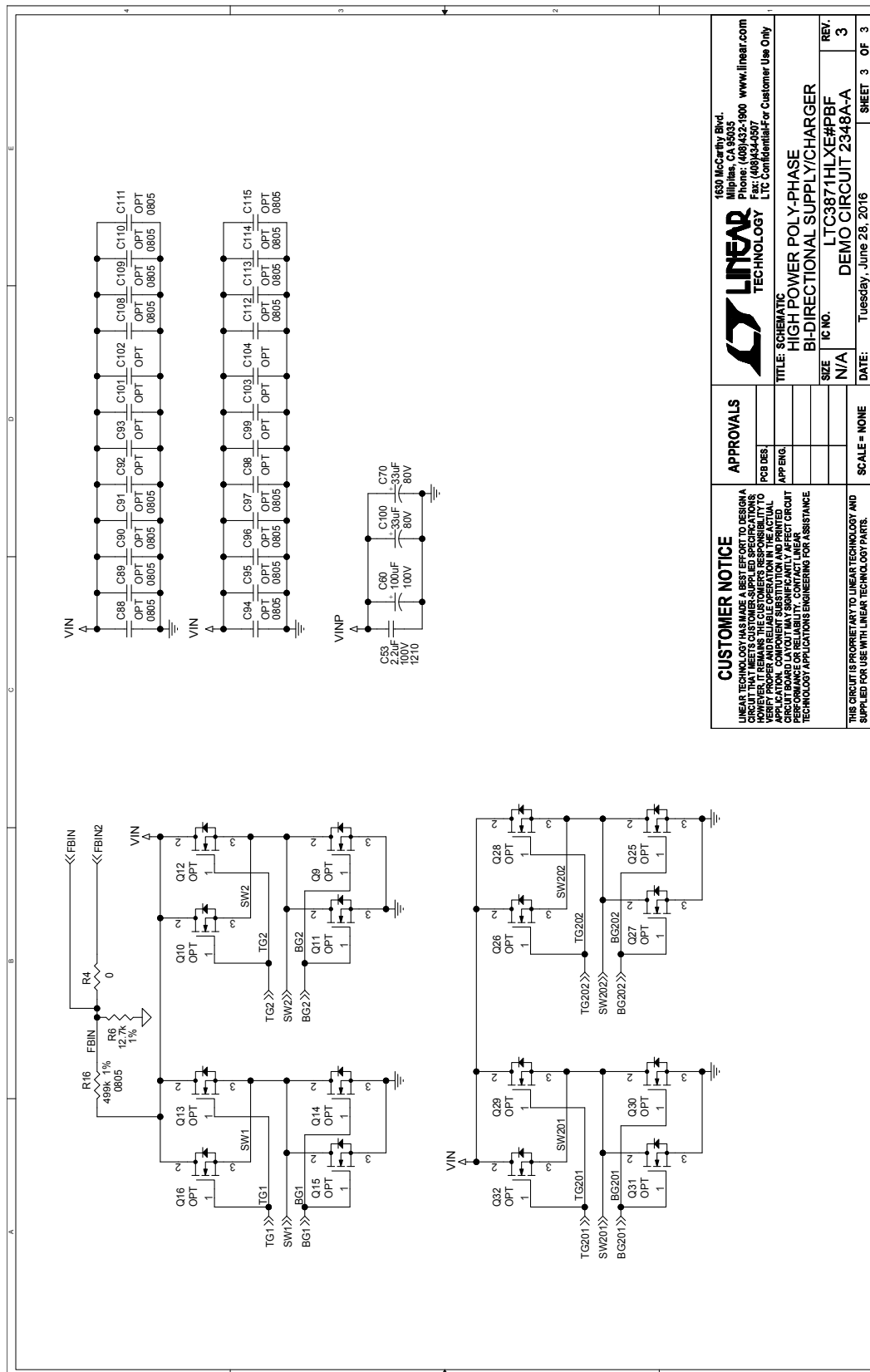
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Circuit Components				
1	0	C20, C27	CAP, ALUM OPTION	OPTION
2	0	C30, C32, C33, C92, C93, C101, C102	CAP, 0603 OPTION	OPTION
3	0	C88, C89, C90, C91, C108, C109, C110, C111	CAP, 0805 OPTION	OPTION
4	0	L1, L2 - ALTERNATE	IND, 10 μ H	COILCRAFT SER2918H-103
5	0	Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16	XSTR, MOSFET OPTION	INFINEON IPD60N10S4-12 OPTION
6	0	R19, R20	RES, 0603 OPTION	OPTION
7	0	R25, R26	RES, 1206 OPTION	OPTION
8	1	S1	SWITCH, SUBMINATURE, SLIDE, SPDT	C&K-COMPONENTS JS202011CQN
9	4	XJP1, XJP4, XJP6, XJP7	SHUNT, 2mm	WURTH ELEKTRONIK 60800213421
Hardware: For Demo Board Only				
1	13	E1, E2, E3, E4, E5, E8, E9, E10, E11, E12, E13, E14, E15	TURRET	MIIL-MAX 2501-2-00-80-00-00-07-0
2	2	JP1, JP2	HEADER, 4PIN, DBL ROW 2mm	WURTH ELEKTRONIK 62000821121
3	1	JP3	HEADER, 4PIN, 2mm	WURTH ELEKTRONIK 62000411121
4	1	JP4	HEADER, 2mm, 3PIN	WURTH ELEKTRONIK 62000311121
5	5	J1, J2, J3, J4, J5	STUD, TESTPIN	PEM KFH-032-10
6	5		LUG RING, #10	KEYSTONE 8205
7	10		NUT, BRASS 10-32	ANY #10-32
8	5		WASHER, #10 TIN PLATED BRASS	ANY #10 EXT BZ TN
9	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE 8834



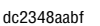
SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



DEMO MANUAL

DC2348A-A/DC2348A-B

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

Mailing Address:

Linear Technology
1630 McCarthy Blvd.
Milpitas, CA 95035

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