

LTC3892EFE-1

PolyPhase High V_{OUT}

Synchronous Buck Converter

DESCRIPTION

Demonstration circuit 2190A is a high output voltage, high efficiency synchronous PolyPhase[®] buck converter featuring the LTC[®]3892EFE-1. This demo circuit is available in two versions. The input voltage range of both versions is from 16V to 55V. The DC2190A-A is configured using two each LTC3892EFE-1 devices with 4-phase interleaving operation which provides a 12V/60A output, while the DC2190A-B is configured using one LTC3892EFE-1 device with 2-phase interleaving operation which provides a 12V/30A output.

Both boards have a mode selection jumper that allows the converter to run in forced CCM mode, pulse-skip mode or Burst Mode[®] operation. Synchronization to an external clock (frequency range 100kHz to 300kHz) is also possible on this board.

The demo circuit senses inductor current with a sense resistor but also has an optional DCR sense circuit that allows using the inductor's DCR as the current sensing element to save cost, footprint and improve efficiency.

The LTC3892EFE-1 data sheet gives a complete description of these parts, operation and application information and must be read in conjunction with this quick start guide for DC2190A.

Design files for this circuit board are available at
<http://www.linear.com/demo/DC2190A>

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PERFORMANCE SUMMARY

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

DC2190A-B

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	Input Supply Range		16		55	V
V_{OUT}	Output Voltage Range	$V_{IN} = 16\text{V to } 55\text{V}$, $I_{OUT} = 0\text{A to } 30\text{A}/2\text{-Phase}$	11.8	12	12.2	V
f_{SW}	Typical Free Running Switching Frequency			140		kHz
Efficiency	2-Phase Efficiency See Figure 3 for Efficiency Curves	$V_{IN} = 48\text{V}$, $V_{OUT1} = 12\text{V}$, $I_{OUT} = 30\text{A}$		97.2		%

DC2190A-A

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	Input Supply Range		16		55	V
V_{OUT}	Output Voltage Range	$V_{IN} = 16\text{V to } 55\text{V}$, $I_{OUT} = 0\text{A to } 60\text{A}/4\text{-Phase}$	11.8	12	12.2	V
f_{SW}	Typical Free Running Switching Frequency			140		kHz
Efficiency	4-Phase Efficiency See Figure 4 for Efficiency Curves	$V_{IN} = 48\text{V}$, $V_{OUT1} = 12\text{V}$, $I_{OUT} = 60\text{A}$		97.2		%

DEMO MANUAL

DC2190A-A/DC2190A-B

QUICK START PROCEDURE

Demonstration circuit DC2190A is easy to set up to evaluate the performance of the LTC3892-1. 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_{IN} or V_{OUT} and GND terminals or directly across relevant capacitor. See Figure 2 for proper scope probe technique.

1. Place jumpers in the following positions:

JP1: Int. SYNC

JP2: ON

JP3: Int. (DC2190A-A Only)

2. With power off, connect the input power supply to V_{IN} and GND. Connect the load to the output. The load current should be smaller than 60A for DC2190A-A and smaller than 30A for DC2190A-B.

3. Turn on the power at the input.

NOTE: Make sure that the input voltage is between 16V and 55V.

4. Check for the proper output voltages.

$V_{OUT} = 11.8V$ to $12.2V$

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

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

FREQUENCY SYNCHRONIZATION AND MODE SELECTION

The DC2190A's mode selector allows the converter to run in FCC operation, pulse-skip operation, Burst Mode or be synchronizing to an external clock by changing the position of JP1 and JP3.

For synchronizing to an external clock source, apply the external clock from SYNC turret to GND.

Refer to Table 1 and to the data sheet for more details.

Table 1. Mode Selection and Synchronizing Operation Options

CONFIGURATION	JP1	JP3 (DC2190A-A ONLY)
Forced Continuous Conduction Operation	Int. SYNC	Int.
Pulse-Skip Mode Operation	Ext. SYNC/ Pulse-Skip.	Ext./Pulse-Skip
Burst Mode Operation	Burst	Ext./Pulse-Skip
Synchronize to Ext. Clock (Ext. Clock Apply to SYNC Turret)	Ext. SYNC/ Pulse-Skip	Ext./Pulse-Skip

OPTIONAL INDUCTOR DCR CURRENT SENSING

Demonstration circuit 2190A 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.

POWER THE EXT V_{CC} FROM EXTERNAL SUPPLY

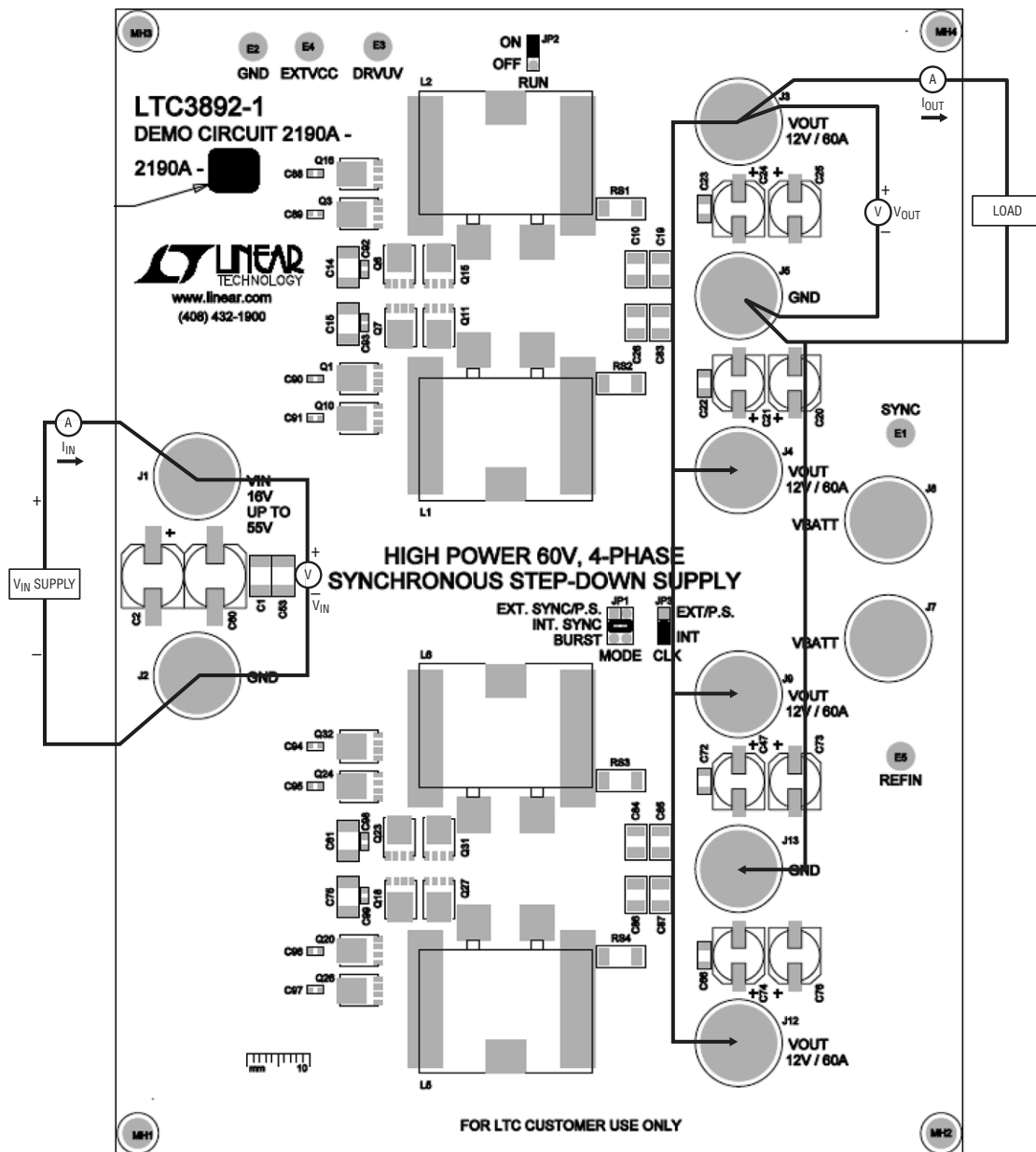
The DC2190A EXT V_{CC} turret is tied to the 12V V_{OUT} by default. To power the EXT V_{CC} from external supply:

1. Remove the R7.
2. Solder a 16V, 1 μ F MLCC between EXT V_{CC} and GND turret.
3. Apply a DC voltage (<14V) between the EXT V_{CC} and GND turret, after the input voltage is established. Ensure that $EXTV_{CC} \leq V_{IN}$.

QUICK START PROCEDURE

Table 2. Optional Inductor DCR Current Sensing

Configuration	CHANNEL1	RS1	R18	R20	C13	C29	R23	R26	R24
	CHANNEL2	RS2	R17	R19	C12	C28	R22	R25	R21
	CHANNEL3	RS3	R63	R64	C63	C45	R77	R79	R65
	CHANNEL4	RS4	R66	R67	C57	C48	R53	R54	R55
Current Sense Resistor (Default)		Ref. Sch.	Ref. Sch.	Ref. Sch.	Ref. Sch.	Open	Open	Open	Open
Inductor DCR Current Sensing		0Ω Copper	Open	Open	Ref. Sch.	Calculated Value from Data Sheet			0Ω



QUICK START PROCEDURE

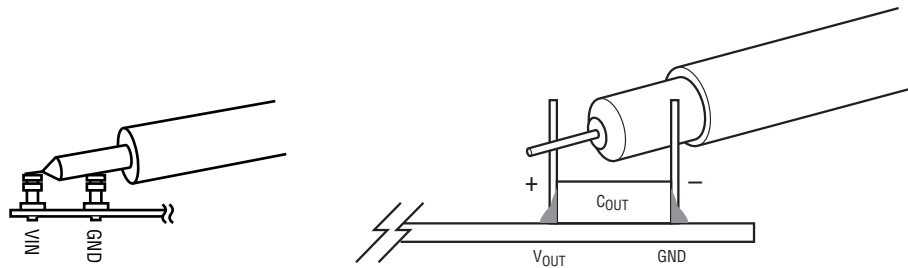
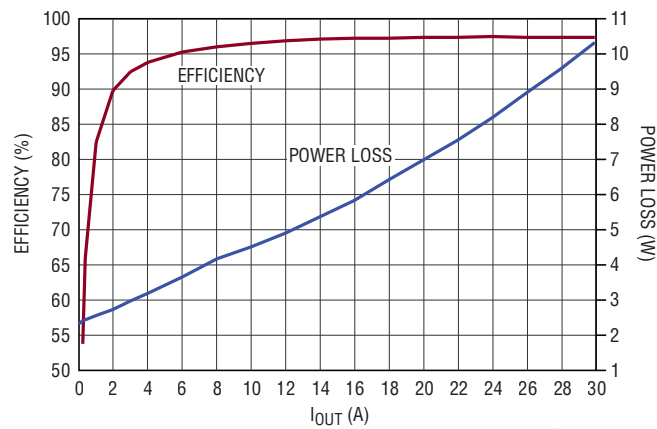
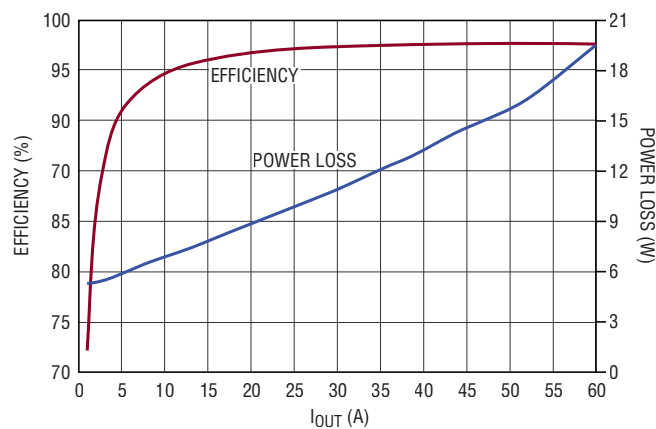


Figure 2. Measuring Input or Output Ripple Across Terminals or Directly Across Bulk Capacitor



DC2190A F03

Figure 3. Typical Efficiency vs Load Current (DC2190A-B, 2-Phase Solution, $V_{IN} = 48V$)



DC2190A F04

Figure 3. Typical Efficiency vs Load Current (DC2190A-A, 4-Phase Solution, $V_{IN} = 48V$)

DEMO MANUAL

DC2190A-A/DC2190A-B

PARTS LIST DC2190A-A

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2190A-A Required Circuit Components				
1	10	C1, C14, C15, C16, C17, C53, C54, C55, C61, C75	CAP, 1812 2.2μF 10% 100V X7R	TDK C4532X7R2A225K
2	2	C2, C60	CAP, 100μF 20% 63V ELEC	SUN ELECT. 63CE100KX
3	2	C3, C49	CAP, 0805 0.1μF 10% 100V X7R	TDK C2012X7R2A104K
4	2	C4, C64	CQP, 0805 4.7μF 10% 16V X7R	AVX, 0805YC475KAT2A
4	8	C5, C32, C33, C39, C67, C78, C79, C80	CAP, 0603 0.1μF 10% 50V X7R	TDK C1608X7R1H104K
6	1	C6	CAP, 0603 470pF 10% 50V X7R	MURATA GRM188R71H471KA01D
7	1	C7	CAP, 0603 10pF 5% 50V NPO	AVX, 06035A100JAT2A
8	3	C8, C46, C62	CAP, 0603 47pF 5% 100V NPO	AVX 06031A470JAT2A
9	2	C9, C34	CAP, 0603 10nF 10% 100V X7R	AVX, 06031C103KAT2A
10	2	C11, C68	CAP, 0603 0.1μF 10% 100V X7R	MURATA GRM188R72A104KA35D
11	4	C12, C13, C57, C63	CAP, 0603 2.2pF 10% 100V NPO	AVX, 06031A2R2KAT2A
12	4	C18, C27, C59, C71	CAP, 0603 1μF 10% 16V X7R	AVX, 0603YC105KAT2A
13	4	C20, C25, C73, C76	CAP, 150μF 20% 16V ALUM	PANASONIC 16SVPC150M
14	4	C22, C23, C66, C72	CAP, 1206 10μF 10% 16V X7R	AVX, 1206YC106KAT2A
15	4	C30, C31, C51, C58	CAP, 0603 0.22μF 10% 25V X5R	AVX 06033D224KAT2A
16	2	C35, C36	CAP, 0603 1nF 10% 25V X7R	AVX 06033C102KAT2A
17	1	C37	CAP, 0603 100pF 10% 100V NPO	AVX, 06031A101KAT2A
18	2	C40, C100	CAP, 33μF 20% 63V ELEC	SUN ELECT., 63HVB33M
19	1	C69	CAP, 0603 4.7nF 10% 25V X7R	AVX, 06033C472KAT2A
20	27	R7, R12, R16, R17, R18, R27, R28, R44, R45, R49, R51, R57, R60, R64, R67, R74, R76, R80, R81, C81, R82, C82, R83, R84, R85, R89, R90	RES, 0603 0Ω JUMPER	VISHAY CRCW06030000Z0EA
21	4	L1, L2, L5, L6	IND, 10μH	COILCRAFT SER2918H-103
22	8	Q1, Q2, Q3, Q4, Q17, Q20, Q22, Q24	XSTR, MOSFET N-CH 80V 100A TDSO8	INFINEON BSC123N08NS3 G
23	8	Q5, Q6, Q7, Q8, Q18, Q19, Q21, Q23	XSTR, MOSFET N-CH 80V 100A TDSO8	INFINEON BSC042NE7NS3
24	4	RS1, RS2, RS3, RS4	RES, 2010 0.003Ω 1% 1W	VISHAY WSL20103L000FEA18
25	2	R_PRG1, R_PRG	RES, 0603 29.4k 1% 1/10W	VISHAY, CRCW060329K4FKEA
26	2	R1, R62	RES. 1206 2.2Ω 1% 1/4W	VISHAY CRCW12062R20FKEA
27	1	R8	RES, 0603 100k 5% 1/10W	VISHAY CRCW0603100KJNEA
28	1	R9	RES, 0805 499k 1% 1/8W	VISHAY, CRCW0805499KFKEA
29	3	R10, R33, R37	RES, 0603 10Ω 1% 1/10W	VISHAY CRCW060310R0FKEA
30	1	R11	RES, 0603 35.7k 1% 1/10W	VISHAY CRCW060335K7FKEA
31	1	R14	RES, 0603 1.5k 1% 1/10W	VISHAY CRCW06031K50FKEA
32	4	R19, R20, R63, R66	RES, 0603 100Ω 5% 1/10W	VISHAY, CRCW0603100RJNEA
33	2	R30, R48	RES, 0603 90.9k 1% 1/10W	VISHAY CRCW060390K9FKEA
34	5	R32, R35, R38, R39, R40	RES, 0603 10k 1% 1/10W	VISHAY CRCW060310K0FKEA
35	4	R34, R43, R52, R86	RES, 2010 0.001Ω 1% 1W	VISHAY, WSL20101L000FEA18
36	2	R36, R41	RES, 0603 392k 1% 1/10W	VISHAY CRCW0603392KFKEA

DEMO MANUAL

DC2190A-A/DC2190A-B

PARTS LIST DC2190A-A

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
37	1	R42	RES, 0603 3.3k 5% 1/10W	VISHAY CRCW06033K30JNEA
38	2	U1, U4	IC, DUAL OUTPUT HIGH VOLTAGE STEP-DOWN CONVERTER	LINEAR TECH. LTC3892EFE-1#PBF
39	0	C70	CAP, 100μF 20% 63V ELEC OPTION	SUN ELECT., 63CE100KX OPTION

DC2190A-A Additional Demo Board Circuit Components

40	1	U2	IC, HIGH VOLTAGE BIDIRECTIONAL CURRENT SENSE AMP	LINEAR TECH. LT1999CS8-10#PBF
41	1	U5	IC, OP AMP, COMPARATOR AND REFERENCE	LINEAR TECH. LTC1541CMS8#PBF
42	1	U6	IC, DUAL AND QUAD, SINGLE SUPPLY, PRECISION OP AMPS	LINEAR TECH. LT2078CS8#PBF
43	1	U7	IC, LOW POWER DUAL COMPARATORS WITH REFERENCE	LINEAR TECH. LTC1843CS8#PBF
44	1	U8	IC, MULTIPHASE OSCILLATOR WITH SPREAD SPECTRUM FREQUENCY MODULATION	LINEAR TECH. LTC6902CMS#PBF
45	0	Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q25, Q26, Q27, Q28, Q29, Q30, Q31, Q32	XSTR, MOSFET OPTION	OPTION
46	1	Q33	XSTR, SMALL SIGNAL, NPN	DIODES INC. MMBT3904
47	0	Q34, R50, R59, R61	DO NOT STUFF	NONE
48	0	R2, R3, R4, R5, R13, R21, R22, R23, R24, R25, R26, R29, R31, R46, R53, R54, R55, R56, R65, R71, R72, R73, R77, R78, R79	RES, 0603 OPTION	OPTION
49	0	D1, D2, D3	DIODE, SCHOTTKY 30V, 100mA OPTION	CENTRAL SEMI CMDSH-3-TR OPTION
50	1	D4	DIODE, ZENER 5.1V	DIODES INC. MMSZ5231BS
51	0	L3, L4, L7, L8	IND, OPTION	OPTION
52	0	C28, C29, C45, C48, C50, C52, C56, C65, C77, C88, C89, C90, C91, C92, C93, C94, C95, C96, C97, C98, C99	CAP, 0603 OPTION	OPTION
53	0	C10, C19, C26, C38, C83, C84, C85, C86, C87	CAP, 1210 OPTION	OPTION
54	0	C21, C24, C41, C42, C43, C44, C47, C74	CAP, 150μF 20% 16V ALUM OPTION	PANASONIC 16SVPC150M OPTION
55	0	R47, R58	RES, 0603 10k 1% 1/10W OPTION	VISHAY CRCW060310K0FKEA OPTION

DC2190A-A Hardware

56	5	E1, E2, E3, E4, E5	TURRET	MIIL-MAX 2501-2-00-80-00-00-07-0
57	1	JP1	HEADER, 3-PIN, DBL ROW 2mm	SULLINS, NRPN032PAEN-RC
58	2	JP2, JP3	HEADER, 2mm, 3-PIN	SULLINS, NRPN031PAEN-RC
59	10	J1, J2, J3, J4, J5, J7, J8, J9, J12, J13	STUD, TESTPIN	PEM KFH-032-10
60	10		LUG RING, #10	KEYSTONE 8205
61	3	XJP1, XJP2, XJP3	SHUNT, 2mm	SAMTEC 2SN-BK-G
62	10		WASHER, #10 TIN PLATED BRASS	ANY #10 EXT BZ TN
63	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE_8831
64	20		NUT, BRASS 10-32	ANY #10-32

DEMO MANUAL

DC2190A-A/DC2190A-B

PARTS LIST DC2190A-B

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2190A-B Required Circuit Components				
1	5	C1, C14, C15, C16, C17	CAP, 1812 2.2μF 10% 100V X7R	TDK C4532X7R2A225K
2	1	C2	CAP, 100μF 20% 63V ELEC	SUN ELECT. 63CE100KX
3	1	C3	CAP, 0805 0.1μF 10% 100V X7R	TDK C2012X7R2A104K
4	1	C4	CQP, 0805 4.7μF 10% 16V X7R	AVX, 0805YC475KAT2A
5	7	C5, C32, C33, C39, C78, C79, C80	CAP, 0603 0.1μF 10% 50V X7R	TDK C1608X7R1H104K
6	1	C6	CAP, 0603 470pF 10% 50V X7R	MURATA GRM188R71H471KA01D
7	1	C7	CAP, 0603 15pF 5% 50V C0G	AVX 06035A150JAT4A
8	1	C8	CAP, 0603 47pF 5% 100V NPO	AVX 06031A470JAT2A
9	2	C9, C34	CAP, 0603 10nF 10% 100V X7R	AVX, 06031C103KAT2A
10	1	C11	CAP, 0603 0.1μF 10% 100V X7R	MURATA GRM188R72A104KA35D
11	2	C12, C13	CAP, 0603 2.2pF 10% 100V NPO	AVX, 06031A2R2KAT2A
12	2	C18, C27	CAP, 0603 1μF 10% 16V X7R	AVX, 0603YC105KAT2A
13	2	C20, C25	CAP, 150μF 20% 16V ALUM	PANASONIC 16SVPC150M
14	2	C22, C23	CAP, 1206 10μF 10% 16V X7R	AVX, 1206YC106KAT2A
15	2	C30, C31	CAP, 0603 0.22μF 10% 25V X5R	AVX 06033D224KAT2A
16	2	C35, C36	CAP, 0603 1nF 10% 25V X7R	AVX 06033C102KAT2A
17	1	C37	CAP, 0603 100pF 10% 100V NPO	AVX, 06031A101KAT2A
18	2	C40, C100	CAP, 33μF 20% 63V ELEC	SUN ELECT., 63HVH33M
19	1	C69	CAP, 0603 4.7nF 10% 25V X7R	AVX, 06033C472KAT2A
20	19	R7, R12, R16, R17, R18, R27, R28, R44, R45, R49, R81, C81, R82, C82, R83, R84, R85, R89, R90	RES, 0603 0Ω JUMPER	VISHAY CRCW06030000Z0EA
21	4	Q1, Q2, Q3, Q4	XSTR, MOSFET N-CH 80V 100A TDSO-8	INFINEON BSC123N08NS3G
22	4	Q5, Q6, Q7, Q8	XSTR, MOSFET N-CH 80V 100A TDSO-8	INFINEON BSC042NE7NS3
33	2	L1, L2	IND, 10μH	COILCRAFT SER2918H-103
24	2	RS1, RS2	RES, 2010 0.003Ω 1% 1W	VISHAY WSL20103L000FEA18
25	1	R_PRG	RES, 0603 29.4k 1% 1/10W	VISHAY, CRCW060329K4FKEA
26	1	R1	RES, 1206 2.2Ω 1% 1/4W	VISHAY CRCW12062R20FKEA
27	1	R8	RES, 0603 100k 5% 1/10W	VISHAY CRCW0603100KJNEA
28	1	R9	RES, 0805 499k 1% 1/8W	VISHAY, CRCW0805499KFKEA
29	3	R10, R33, R37	RES, 0603 10Ω 1% 1/10W	VISHAY CRCW060310R0FKEA
30	1	R11	RES, 0603 35.7k 1% 1/10W	VISHAY CRCW060335K7FKEA
31	1	R14	RES, 0603 4.02k 1% 1/10W	VISHAY CRCW06034K02FKEA
32	2	R19, R20	RES, 0603 100Ω 5% 1/10W	VISHAY, CRCW0603100RJNEA
33	1	R30	RES, 0603 90.9k 1% 1/10W	VISHAY CRCW060390K9FKEA
34	5	R32, R35, R38, R39, R40	RES, 0603 10k 1% 1/10W	VISHAY CRCW060310K0FKEA
35	4	R34, R43, R52, R86	RES, 2010 0.001Ω 1% 1W	VISHAY, WSL20101L000FEA18
36	2	R36, R41	RES, 0603 392k 1% 1/10W	VISHAY CRCW0603392KFKEA
37	1	R42	RES, 0603 3.3k 5% 1/10W	VISHAY CRCW06033K30JNEA
38	1	U1	IC, DUAL OUTPUT HIGH VOLTAGE STEP-DOWN CONVERTER	LINEAR TECH. LTC3892EFE-1#PBF

dc2190afa

DEMO MANUAL

DC2190A-A/DC2190A-B

PARTS LIST DC2190A-B

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2190A-B Additional Demo Board Circuit Components				
39	0	C10, C19, C26, C38, C83, C84, C85, C86, C87	CAP, 1210 OPTION	OPTION
40	0	C28, C29, C56, C77, C88, C89, C90, C91, C92, C93	CAP, 0603 OPTION	OPTION
41	0	L3, L4, L7, L8	IND, OPTION	OPTION
42	0	D1, D2, D3	DIODE, SCHOTTKY 30V, 100mA OPTION	CENTRAL SEMI CMDSH-3-TR OPTION
43	1	D4	DIODE, ZENER 5.1V	DIODES INC. MMSZ5231BS
44	0	C21, C24, C41, C42, C43, C44	CAP, 150µF 20% 16V ALUM OPTION	PANASONIC 16SVPC150M OPTION
45	0	Q9, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q25, Q26, Q27, Q28, Q29, Q30, Q31, Q32	XSTR, MOSFET OPTION	OPTION
46	1	Q33	XSTR, SMALL SIGNAL, NPN	DIODES INC. MMBT3904-7-F
47	0	Q34, R50, R59, R61	DO NOT STUFF	NONE
48	0	R2, R3, R4, R5, R13, R21, R22, R23, R24, R25, R26, R29, R31, R46	RES, 0603 OPTION	OPTION
49	0	R47, R58	RES, 0603 10k 1% 1/10W OPTION	VISHAY CRCW060310K0FKEA OPTION
50	1	U2	IC, HIGH VOLTAGE BIDIRECTIONAL CURRENT SENSE AMP	LINEAR TECH. LT1999CS8-10#PBF
51	1	U5	IC, MICROPOWER OP AMP, COMPARATOR AND REFERENCE	LINEAR TECH. LTC1541CMS8#PBF
52	1	U6	IC, DUAL AND QUAD, SINGLE SUPPLY, PRECISION OP AMPS	LINEAR TECH. LT2078CS8#PBF
53	1	U7	IC, LOW POWER DUAL COMPARATORS WITH REFERENCE	LINEAR TECH. LTC1843CS8#PBF
54	1	U8	IC, MULTIPHASE OSCILLATOR W/SPREAD SPECTRUM FREQUENCY MODULATION	LINEAR TECH. LTC6902CMS#PBF
DC2190A-B Hardware				
55	7		WASHER, #10 TIN PLATED BRASS	ANY #10 EXT BZ TN
56	2	XJP1, XJP2	SHUNT, 2mm	SAMTEC 2SN-BK-G
57	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE_8831
58	14		NUT, BRASS 10-32	ANY #10-32
59	5	E1, E2, E3, E4, E5	TURRET	MIIL-MAX 2501-2-00-80-00-00-07-0
60	1	JP1	HEADER, 3-PIN, DBL ROW 2mm	SULLINS, NRPN032PAEN-RC
61	1	JP2	HEADER, 2mm, 3-PIN	SULLINS, NRPN031PAEN-RC
62	7	J1, J2, J3, J4, J5, J7, J8	STUD, TESTPIN	PEM KFH-032-10
63	7		LUG RING, #10	KEYSTONE 8205

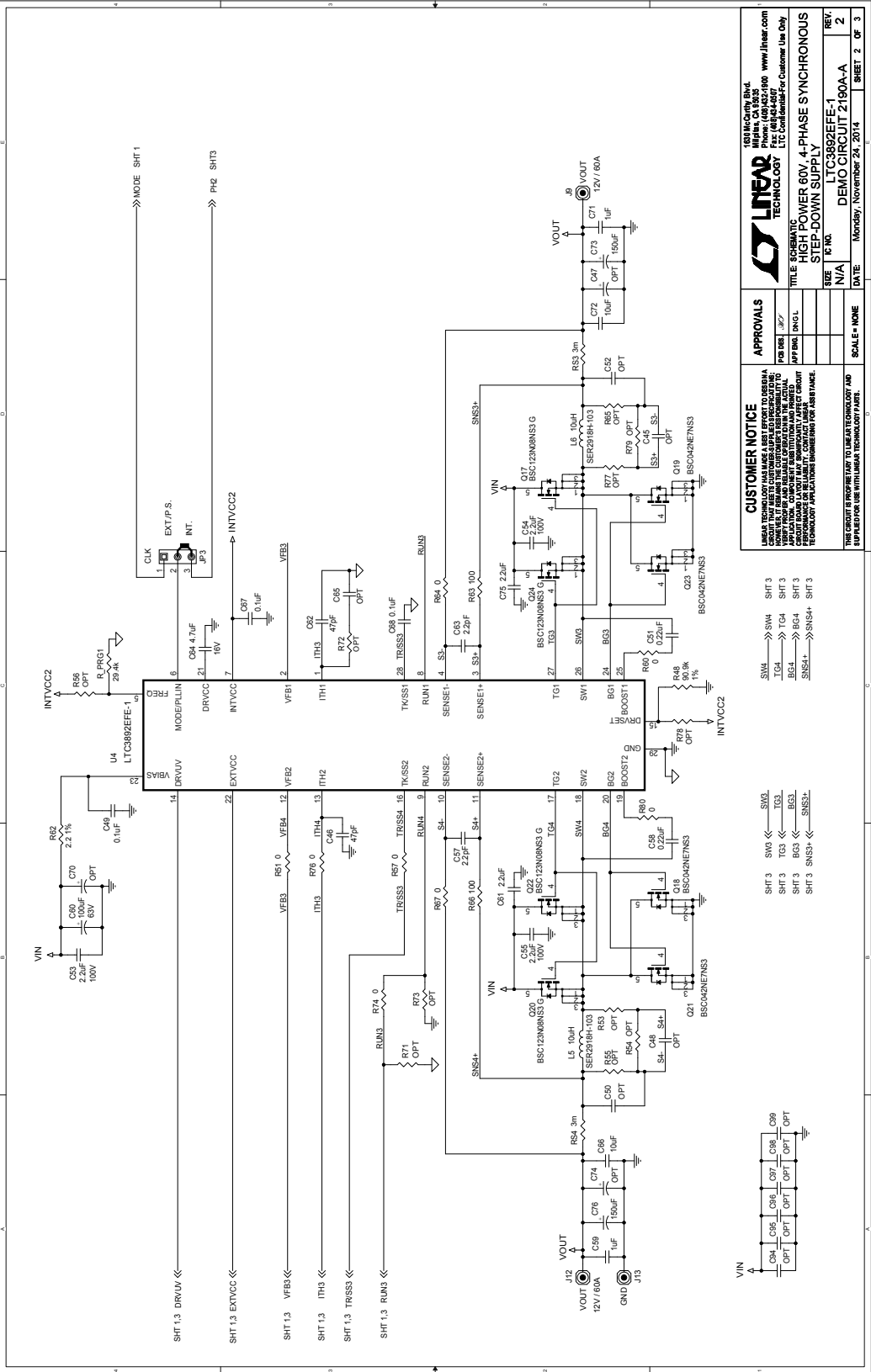
SCHEMATIC DIAGRAM



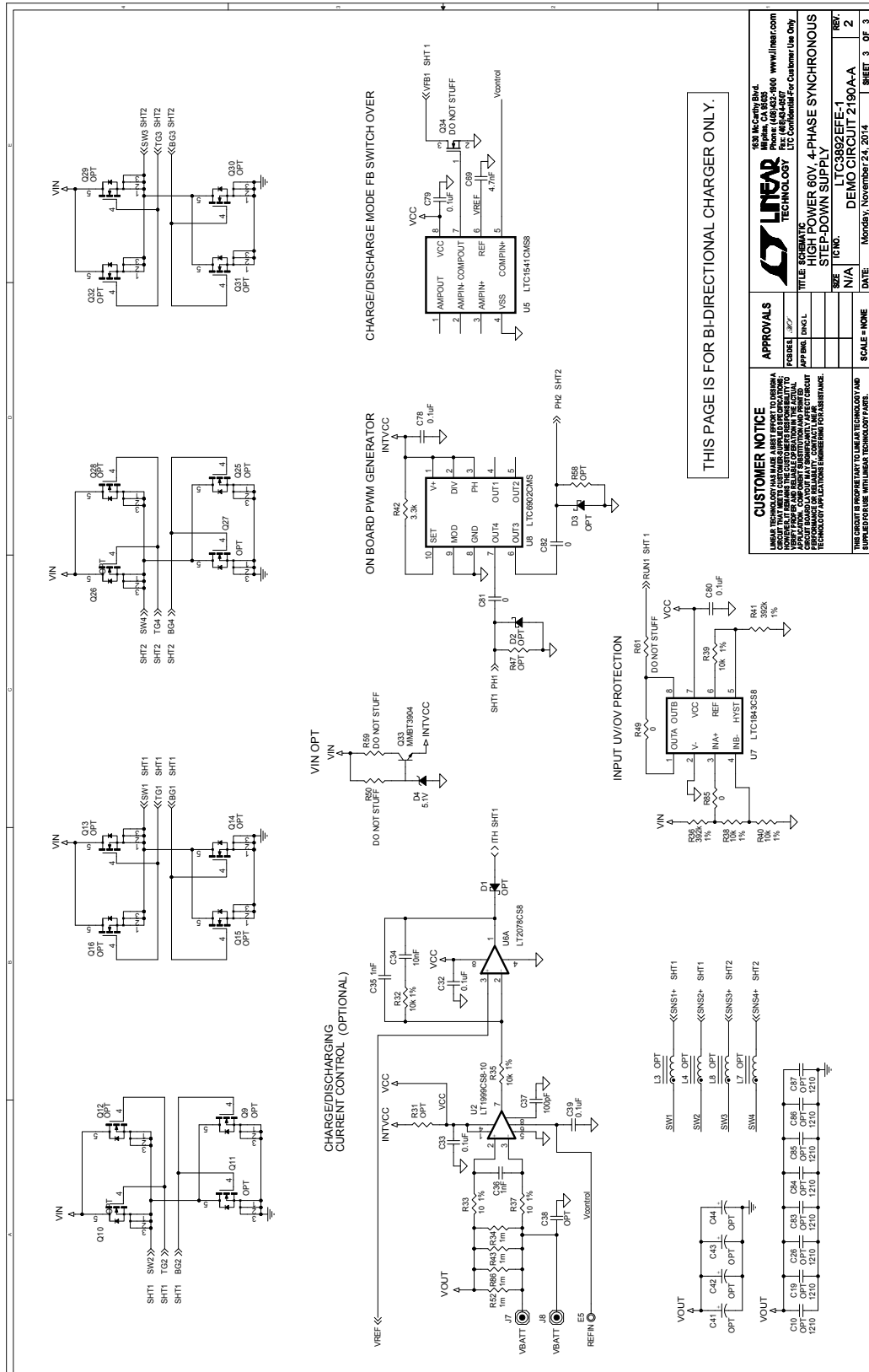
DEMO MANUAL

DC2190A-A/DC2190A-B

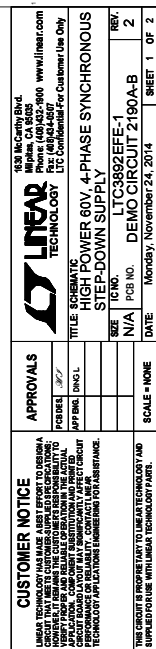
SCHEMATIC DIAGRAM



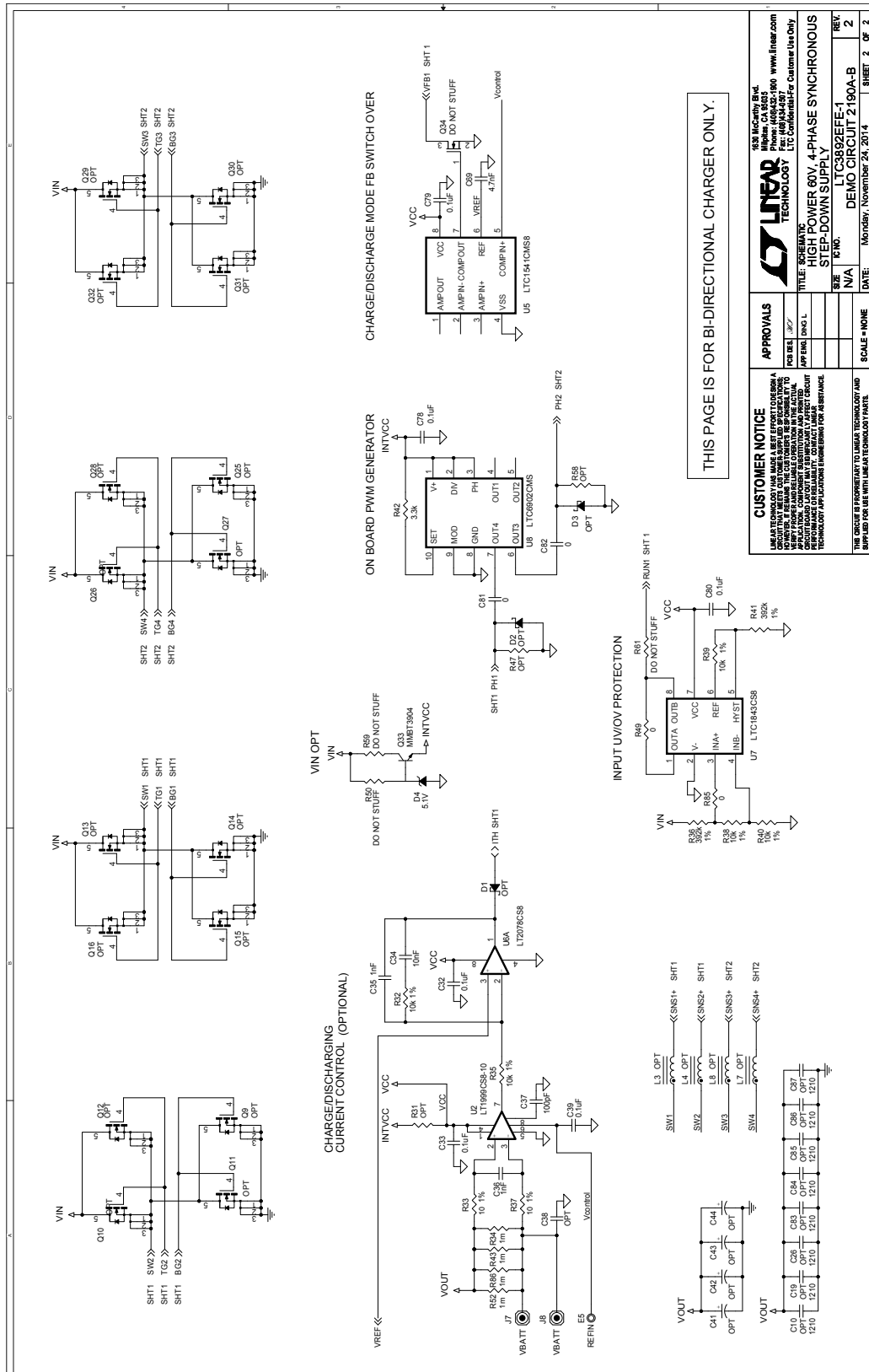
SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



DEMO MANUAL

DC2190A-A/DC2190A-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.

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- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



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