

Development Board EPC9106 Quick Start Guide

150 W/8 Ω Class-D Amplifier

Revision D



DESCRIPTION

The EPC9106 demonstration board is a reference design for a 150 W / 8 Ω Class D audio amplifier. The demonstration board uses a Bridge-Tied-Load (BTL) design, composed of four ground-referenced Half-Bridge Output Stages. This architecture and topology allows scalability and expandability.

The EPC9106 reference design has demonstrated 96% efficiency at 150 W / 8 Ω, and 92% efficiency at 250 W / 4 Ω.

The EPC9106 demonstration board features the EPC2016C enhancement mode (eGaN®) field effect transistor (FET), as well as the Texas Instruments LM5113 gate driver.

A complete block diagram of the circuit is given in figure 1. For more information on the EPC2016C eGaN FET please refer to the datasheet available from EPC at www.epc-co.com. The datasheet should be read in conjunction with this quick start guide.

QUICK START PROCEDURE

The EPC9106 demonstration system is easy to set up to evaluate the performance of the EPC2016C eGaN FET in a Class D audio amplifier application. Refer to figure 2 for proper connection and measurement setup before following the testing procedures.

The EPC9106 can be operated using one of two alternative methods:

- a. High Performance Setup
- b. Lower Performance Setup

a. High Performance Setup

1. Connect the left/right analog inputs to the balanced analog input XLR connectors
2. Connect the left/right analog input cables to the audio source (pre-amp)
 - a. Use a CD/DVD player with a high-performance pre-amp
3. Turn the master volume control fully counter-clockwise (minimum volume)
4. Connect the high-voltage power supply
5. Bring up both “+” and “-” power supply rails simultaneously (use a tracking power supply). Both channel LEDs will remain RED until ±20 V is reached.
6. Adjust high voltage power supply rails to around ±27 V_{DC}
7. Connect left and right outputs to the loudspeaker of choice

NOTE: While both loudspeaker outputs are ground-referenced, neither is connected to ground. DO NOT CONNECT EITHER OF THESE LOUDSPEAKER OUTPUTS TO ANY SYSTEM OR TEST EQUIPMENT GROUND!!
8. Play audio source
9. Adjust master volume control to appropriate listening level

Analog Audio Input	
Balanced Input	Differential XLR x 2, 2 V _{RMS} Sensitivity
Unbalanced Input	Single-ended RCA Phone x 2, 2 V _{RMS} Sensitivity
Power Supply	
Bipolar Power Supply	±20 V _{DC} to ±30 V _{DC}
Audio Performance	
THD+N 0.003%	8 Ω, 1 kHz, 5 W Power
THD+N 0.005%	8 Ω, 1 kHz, 15 W Power
THD+N 0.006%	8 Ω, 1 kHz, 50 W Power
THD+N 0.03%	8 Ω, 1 kHz, Full Power
THD+N <0.03%	8 Ω, 20 Hz-20 kHz, -9 dB
Frequency Response	20 Hz – 20 kHz, ±0.5 dB, 8 Ω
SNR/DNR	107.8 dB (Unweighted), 110 dB (A-weighted)
Power Output (8 Ω)	150 W _{RMS} Continuous
Power Output (4 Ω)	250 W _{RMS} Continuous

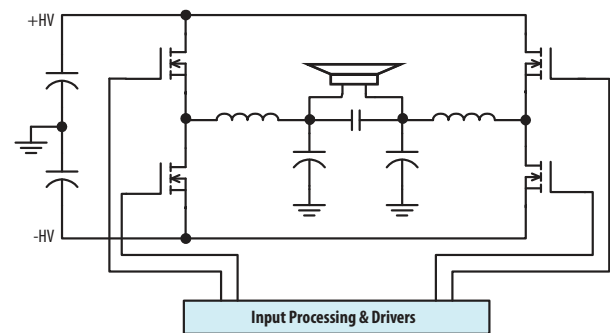


Figure 1: Block diagram of single channel of EPC9106.

b. Lower Performance Setup

1. Connect the left/right analog inputs to the unbalanced analog input RCA phono connectors
2. Connect the left/right analog input cables to the audio source
 - a. Use a CD/DVD player with analog audio outputs
 - b. If you use an MP3 player (or iPod), only use wave files, or PCM audio – DO NOT USE MP3 files for demo!
3. Turn the master volume control fully counter-clockwise (minimum volume)
4. Connect the high-voltage power supply
5. Bring up both “+” and “-” power supply rails simultaneously (use a tracking power supply). Both channel LEDs will remain RED until ±20 V is reached.
6. Adjust high voltage power supply rails to around ±27 V_{DC} (use a tracking power supply)
7. Connect left and right outputs to the loudspeaker of choice

NOTE: While both Loudspeaker Outputs are Ground-Referenced, Neither is connected to Ground. DO NOT CONNECT EITHER OF THESE LOUDSPEAKER OUTPUTS TO ANY SYSTEM OR TEST EQUIPMENT GROUND!!
8. Play audio source
9. Adjust master volume control to appropriate listening level

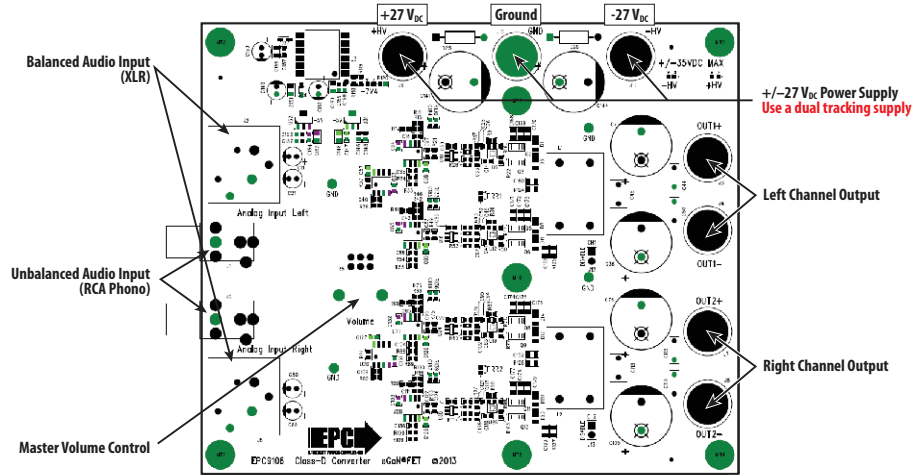


Figure 2: Proper connection and measurement setup.

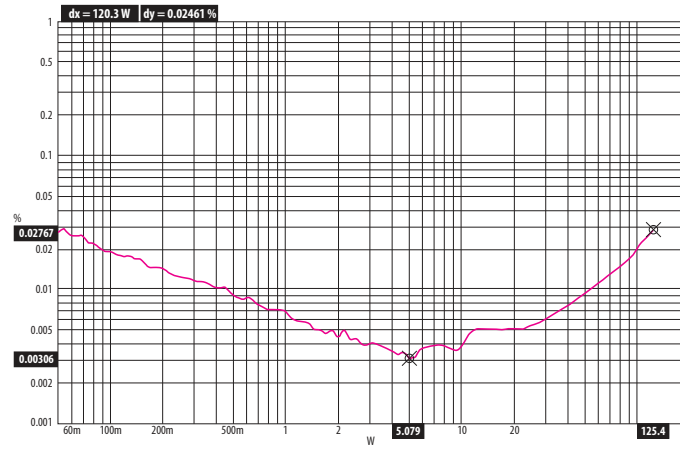
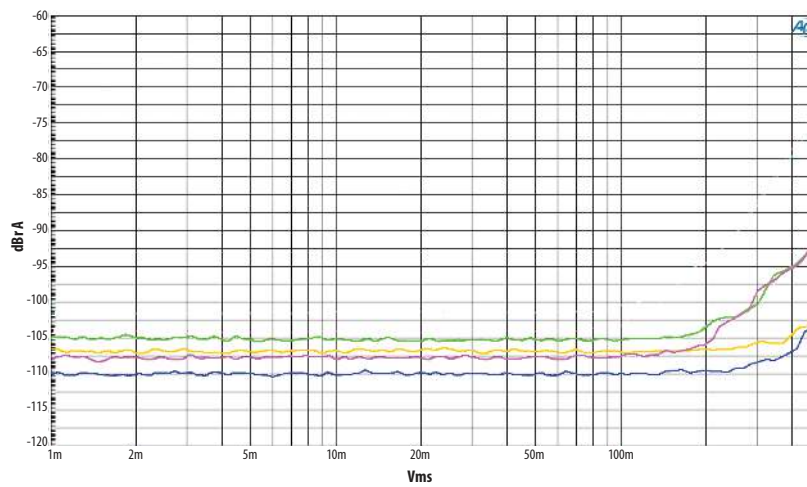


Figure 3: THD+N vs Power at 1 kHz, $\pm 27 V$, 8 Ω .



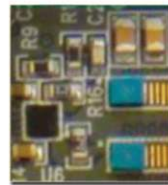
Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment
3	1	Green	Solid	1	Analyzer THD+N Ampl A	Left	Pot Unity, Un-Wtd, -104.9dBc
5	1	Yellow	Solid	1	Analyzer THD+N Ampl A	Left	Pot -6dB, Un-Wtd, -106.4dBc
11	1	Magenta	Solid	1	Analyzer THD+N Ampl A	Left	Pot Unity, A-Wtd, -107.8dBc
13	1	Blue	Solid	1	Analyzer THD+N Ampl A	Left	Pot -6dB, A-Wtd, -109.9dBc

Figure 4: Noise floor ref to 168 W (36.6 VRMS), $\pm 27 V$, 8 Ω .

THERMAL CONSIDERATIONS

With this high efficiency, the EPC9106 design allows for the complete removal of any classical or historical heat sink requirement. This elimination of the heat sink also reduces the potential contribution to radiated EMI/EMC emissions. However, care must be taken to not exceed the absolute maximum die temperature of 150°C and stay within the constraints of the other components within the circuit.

NOTE. The EPC9106 demonstration board does not have any thermal protection on board.



Power block, no heatsink, eGaN FETs.

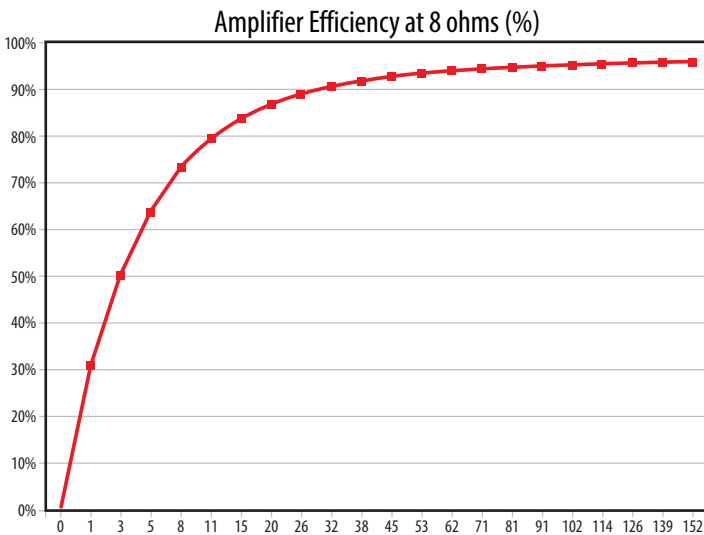


Figure 5: Amplifier efficiency vs. output power at 8 Ω.

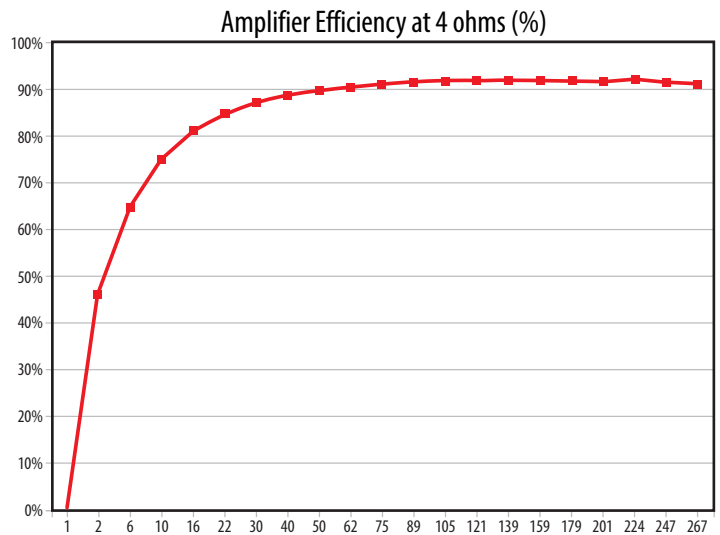


Figure 6: Amplifier efficiency vs. output power at 4 Ω.

Table 1 : Bill of Material

Item	Qty	Reference	Part Description	Manufacturer / Part #
1	10	C1, C9, C37, C70, C78, C106, C140, C143, C163, C164	CAP CER 10 µF 50 V X5R 1206	Taiyo Yuden, UMK316BBJ106ML-T
2	67	C2, C3, C8, C10, C14, C20, C28, C29, C30, C38, C39, C41, C43, C54, C55, C56, C57, C58, C59, C60, C62, C63, C64, C65, C71, C72, C77, C79, C83, C87, C97, C98, C99, C107, C108, C110, C116, C123, C124, C125, C126, C127, C128, C129, C131, C132, C133, C134, C139, C142, C146, C147, C153, C154, C157, C159, C165, C184, C185, C186, C187, C188, C189, C190, C191, C192, C193	CAP, CER, 0.1 µF, 50V, 10%, X7R, 0603	Kemet, C0603C104K5RACTU
3	7	C4, C73, C148, C151, C155, C156, C160	CAP CER 10 µF 10 V 10% X7R 0805	Taiyo Yuden, LMK212B7106KG-TD
4	2	C5, C74	CAP, CERAMIC, 100 µF, 6.3 V, 20%, X5R, 1206	Taiyo Yuden, JMK316BJ107ML-T
5	16	C6, C15, C16, C23, C35, C40, C42, C66, C75, C84, C85, C92, C104, C109, C111, C136	CAP CER 100 pF 50 V 1% NP0 0603	AVX Corporation, 06035A101FAT2A
6	6	C7, C36, C76, C105, C141, C144	CAP ALUM 1000 µF 50 V 20% RADIAL	Nichicon, UPW1H102MHD
7	4	C11, C21, C80, C88	CAP AL ELECT, 22 µF, 16 V, 20%, RADIAL, 5x11MM	Nichicon, UPW1C220MDD
8	8	C12, C19, C34, C47, C81, C91, C103, C114	CAP, CER, 1000 pF, 100 V, 5%, NPO, 0603	Murata Electronics North America, GRM-1885C2A102JA01D
9	4	C13, C17, C82, C86	CAP FILM 1000 pF 50 VDC 0805	Panasonic, ECH-U1H102JX5
10	4	C18, C69, C90, C138	CAP, CER, 0.033 µF, 100 V, 10%, X7R, 1210	AVX Corporation, 12101C333KAT2A
11	4	C22, C68, C89, C137	CAP, CER, 0.68 µF, 100 V, 10%, X7R, 1210	Murata Electronics North America, GRM-32CR72A684KA01L
12	8	C25, C33, C52, C67, C95, C102, C121, C135	CAP FILM 100 pF 16 VDC 0603	Panasonic, ECH-U1C101GX5
13	7	C26, C49, C94, C118, C145, C152, C167	CAP CER 1 µF 25 V 10% X7R 0603	Taiyo Yuden, TMK107B7105KA-T
14	4	C27, C53, C96, C122	CAP, FILM 100 pF, 16 V 0603	DNP
15	2	C32, C101	CAP, CER, 100 pF, 50 V, 5%, NP0, 0603	Kemet, C0603C101J5GACTU
16	4	C44, C50, C115, C119	CAP, MET POLY FILM, 0.47 µF, 100 VDC, 5%, RADIAL	Kemet, R82EC3470DQ70J
17	4	C45, C51, C112, C120	CAP, CER, 3300 pF, 100 V, 5%, NPO, 0805	TDK Corporation, C2012C0G2A332J
18	2	C46, C113	CAP, MET POLY FILM, 0.22 µF, 100 VDC, 5%, RADIAL	Kemet, R82EC3220AA70J
19	3	C149, C150, C161	CAP, AL ELECT, 100 µF, 10 V, 20%, RADIAL, 5X15MM	Nichicon, UPW1A101MDD6
20	2	C158, C166	CAP, CER, 0.01 µF, 50 V, 10%, X7R, 0603	Kemet, C0603C103K5RACTU
21	1	C162	CAP CER 0.033 µF 50 V 10% X7R 0603	Samsung, CL31B333KBCNNNC
22	4	C168, C171, C174, C177	CAP, CER, 0.22 µF, 100 V, 20%, X7S, 0805	TDK Corporation, C2012X7S2A224M
23	4	C169, C172, C175, C178	CAP, CER, 0.01 µF, 100 V, 10%, X7R, 0805	TDK Corporation, C2012X7R2A103KT5
24	4	C170, C173, C176, C179	CAP, CER, 2200 pF, 100 V, 10%, X7R, 0805	TDK Corporation, C2012X7R2A222K
25	4	C180, C181, C182, C183	CAP, CER, 47 pF, 50 V, 5%, COG, 0805	Kemet, C0805C470J5GACTU
26	8	D1, D5, D8, D11, D14, D17, D20, D23	DIODE SCHOTKY 100 V 2 A SOD-123FL	Micro Commercial, SL210PL-TP
27	14	D2, D4, D7, D9, D13, D15, D19, D22, D27, D28, D29, D30, D31, D32	DIODE, ZHCS400, SCHOTTKY BARR, 40 V, 400 MA, SOD-323	Zetex Semiconductors, ZHCS400
28	8	D3, D6, D10, D12, D16, D18, D21, D24	DIODE SCHOTTKY 40 V 150 MW SOD-523	Diodes Inc, SDM03U40-7
29	2	D25, D26	DIODE, 1N4003, 1 AMP, 200 V, DO-41	Fairchild Semiconductor, 1N4003
30	2	D35, D37	DIODE ZENER 39 V 200 MW SOD323	Diodes Inc, BZT52C39S-7-F
31	2	D36, D38	DIODE ZENER 18 V 200 MW SOD323	ON Semiconductor, MM3Z18VT1G
32	4	D39, D40, D41, D42	DIODE ZENER 5.1 V 200 MW SOD323	ON Semiconductor, MM3Z5V1T1G
33	4	D43, D44, D45, D46	DIODE ZENER 27 V 300 MW SOD323	NXP Semiconductors, BZX384-B27, 115
34	2	J1, J5	Jack, Phono RCA, w/Switch, R/A, PCB Mount	Keystone Electronics, 972
35	2	J2, J6	XLR Connectors 3P FEMALE HORIZ PIN 1 & GRD SEPARATE	Neutrik, NC3FAH2
36	4	J3, J7, J9, J11	JACK, BINDING BANANA, INSUL, RED	Keystone Electronics, 7006
37	3	J4, J8, J10	JACK, BINDING BANANA, INSUL, BLACK	Keystone Electronics, 7007
38	2	J12, J13	CONN, HDR, 2x1, 0.100, GOLD FLASH	FCI, 68001-202HLF

Table 1 : Bill of Material (continued)

Item	Qty	Reference	Part Description	Manufacturer / Part #
39	2	LED1, LED2	LED, SMT, RED, 10 mcd, 10 mA, 1.8 V, 0603	Lite-On, LTST-C190CKT
40	2	LED3, LED4	LED, Green, TSS TYPE, 0603, 5 mA, 12 mcd, 2.9 Vfd	Panasonic, LNJ326W83RA
41	1	LED5	LED, Pure Blue, TSS TYPE, 0603, 5 mA, 12 mcd, 2.9 Vfd	Panasonic, LNJ926W8CRA
42	2	L1, L2	INDCTR, SHLD, 15 µH, 20%, Dual, 12.5 A	Sagami, 7W15B-150M-R
43	1	L3	INDUCTOR/XFRMR 27.4 µH 0.29 A SMD	Cooper Bussmann, VPH1-0190-R
44	6	Q1, Q7, Q17, Q18, Q22, Q24	XSTR, FMMT593, PNP, 100 V, 1 A, SOT-23	Diodes Inc, FMMT53TA
45	8	Q2, Q3, Q5, Q6, Q8, Q9, Q11, Q12	TRANS GAN 100 V 11 A BUMPED DIE	EPC, EPC2016C
46	7	Q4, Q10, Q19, Q20, Q21, Q23, Q25	XSTR, FMMT493, NPN, 100 V, 1 A, SOT-23	Diodes Inc, FMMT493TA
47	4	Q13, Q14, Q15, Q16	XSTR, MBT2907A, PNP, 60 V, 500 MA, SOT-23	Diodes Inc, MMBT2907A-7-F
48	4	R1, R32, R56, R86	RES 0.022 Ω 2 W 1% 2512	TE Connectivity, RLP73M3AR022FTDF
49	10	R2, R8, R33, R57, R62, R87, R129, R132, R135, R138	RES, 4.99 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF4991V
50	12	R3, R4, R13, R14, R58, R59, R67, R68, R142, R146, R147, R150	RES, 10.0 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF1002V
51	1	R5	POTROTARY 10 K Ω AUDIO 14 MM DUAL	Alps, RK09L12D0A1T
52	12	R6, R17, R28, R31, R43, R53, R60, R70, R82, R85, R97, R107	RES, 100 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF1000V
53	8	R7, R11, R35, R55, R61, R65, R89, R109	RES, 100 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF1003V
54	4	R9, R36, R63, R90	RES, 22.1 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF2212V
55	4	R12, R41, R69, R95	RES, 15.0 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF1502V
56	4	R15, R42, R66, R96	RES, 750 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF7503V
57	8	R16, R22, R44, R50, R71, R77, R98, R105	RES, 2.2, 1%, 1/10 W, 0603	Panasonic, ERJ-3RQF2R2V
58	8	R19, R37, R38, R46, R73, R91, R92, R100	RES, 2.21 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF2211V
59	8	R20, R47, R74, R101, R128, R131, R134, R137	RES, 562, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF5620V
60	4	R21, R49, R75, R103	RES, 18.2 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF1822V
61	5	R25, R79, R123, R149, R152	RES, 1 K, 1%, 1/16 W, 0603	Panasonic, ERJ-3EKF1001V
62	6	R26, R80, R130, R133, R136, R139	RES, 681, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF6810V
63	14	R27, R30, R81, R84, R121, R140, R141, R143, R144, R145, R148, R151, R153, R154	RES, 49.9 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF4992V
64	2	R29, R83	RES, 1 K, 1%, 1/10 W, 0805	Panasonic, ERJ-6ENF1001V
65	4	R34, R54, R88, R108	RES, 7.5 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF7501V
66	4	R40, R48, R94, R102	RES, 10.0 K, 1%, 1/8 W, 0805	Panasonic, ERJ-6ENF1002V
67	8	R110, R111, R112, R113, R114, R115, R116, R117	RES, 3.32 K, 1%, 1 W, 2512	Vishay/Dale, CRCW25123K32FKEG
68	2	R118, R119	RES, 0, JMP, 1/10 W, 0603	Panasonic, ERJ-3GEY0R00V
69	1	R120	RES 806 Ω 1/10 W 1% 0603 SMD	Panasonic, ERJ-3EKF8060V
70	1	R122	RES, 7.87K, 1%, 1/16 W, 0603	Panasonic, ERJ-3EKF7871V
71	4	R124, R125, R126, R127	RES, 680, 1%, 1/8 W, 0805	Panasonic, ERJ-6ENF6800V
72	4	R155, R160, R161, R166	RES, 200, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF2000V
73	4	R156, R159, R162, R165	RES, 18.7 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF1872V
74	4	R157, R158, R163, R164	RES, 1.82 K, 1%, 1/10 W, 0603	Panasonic, ERJ-3EKF1821V
75	4	R167, R168, R169, R170	RES, 10.0 K, 1%, 1/8 W, 0805	Panasonic, ERJ-6ENF1002V
76	2	U1, U17	IC, LM1117, 5 V REG, 800 MA, SOT-223	STMicroelectronics, LD1117S50CTR
77	4	U2, U11, U18, U25	IC GATE AND 2-INPUT SGL SOT-23-5	Fairchild Semiconductor, NC7S208M5X
78	4	U3, U4, U7, U20	IC, NJM4580E, OP AMP, DUAL, SOIC8-150	NJR, NJM4580E
79	4	U5, U13, U21, U27	IC COMP GRND-SENSNG LOWPWR SOIC8	Linear Technology, LT1671CS8#PBF
80	4	U6, U12, U19, U26	IC GATE DRVR HALF BRDG 5 A 125 MD	Texas Instruments, LM5113TME/NOPB
81	4	U8, U14, U22, U28	IC, LM4562, OP AMP, DUAL, SOIC8-150	Texas Instruments, LM4562MA/NOPB
82	4	U9, U15, U23, U29	IC GATE NOR 2-INPUT SGL SOT-23	Fairchild Semiconductor, NC7S202M5X
83	4	U10, U16, U24, U30	IC, NC7SZ04, UHSINVERTER, SOT23-5	Fairchild Semiconductor, NC7SZ04M5X
84	1	U31	IC, 78L05, 5 V REG, 100 mA, SOT89	STMicroelectronics, L78L05ACUTR
85	1	U32	IC, 79L05, -5 V REG, +5 V, 100 mA, SOT-89	STMicroelectronics, L79L05ACUTR
86	1	U33	IC REG BUCK SYNC ADJ 20TSSOP	Texas Instruments, LM3102MH/NOPB
87	4	X1, X2, X3, X4	Test Point, PCB, Thru-Hole, Black	Keystone Electronics, 5011

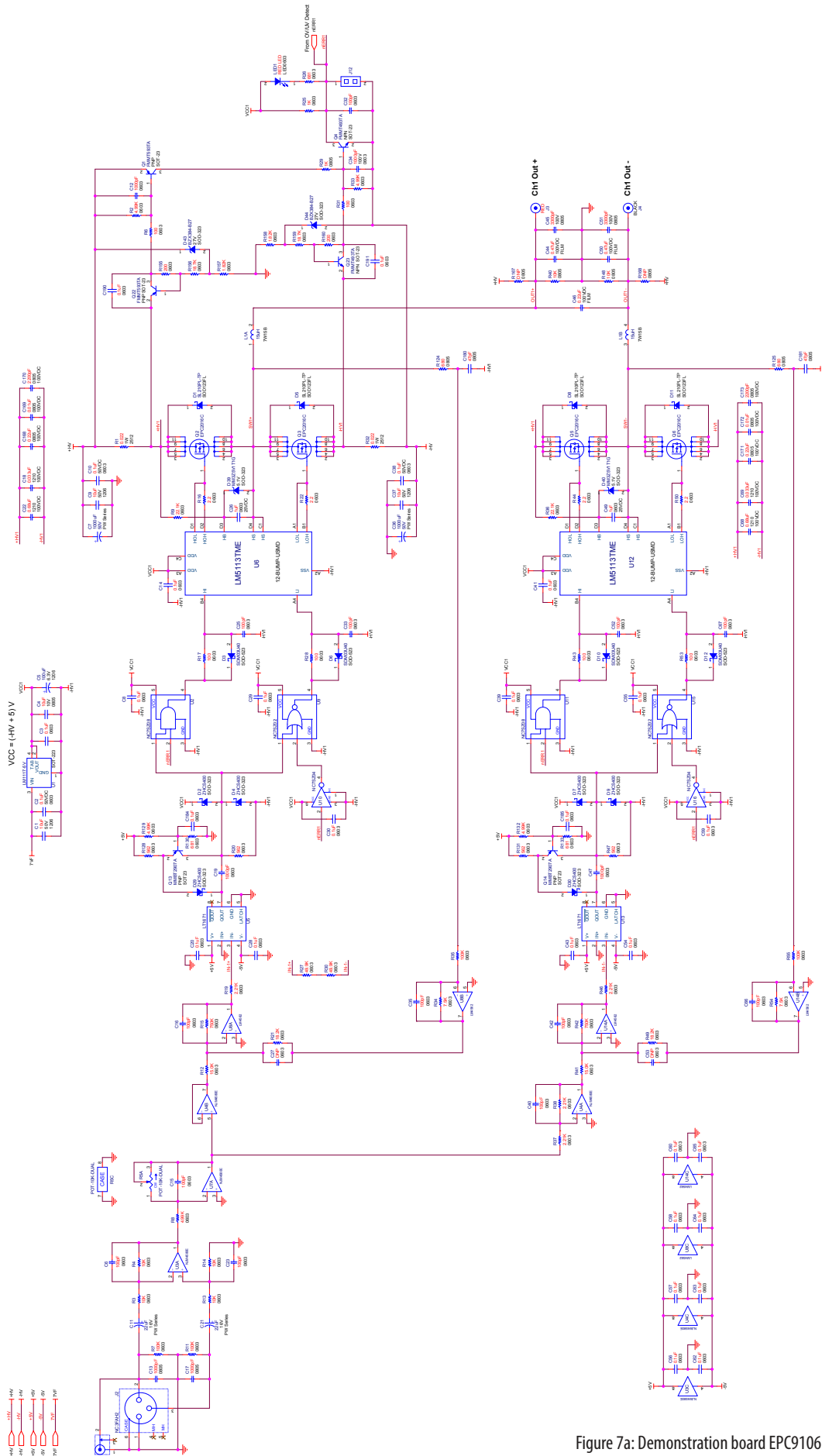


Figure 7a: Demonstration board EPC9106 schematic, channel 1.

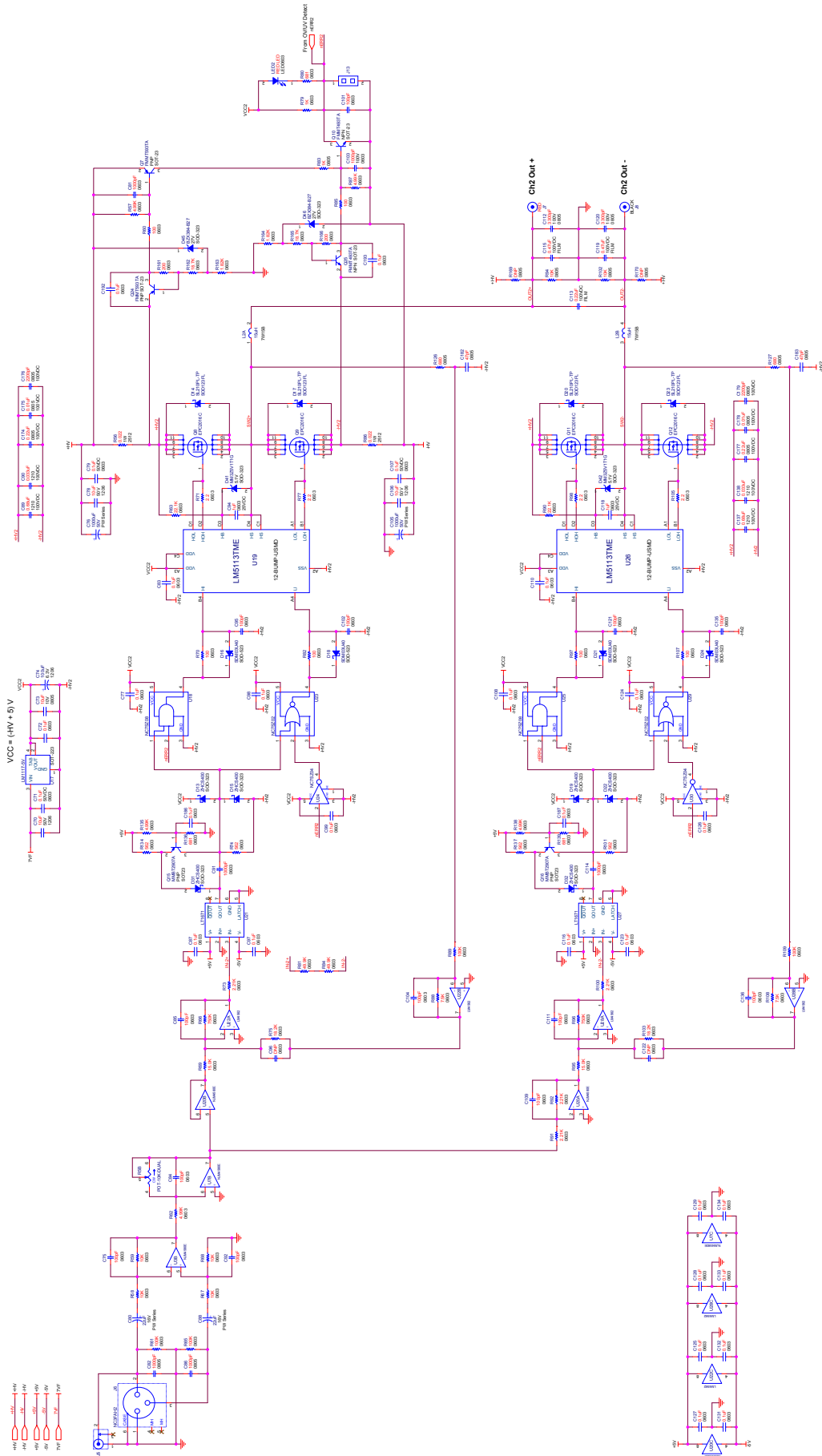


Figure 7b: Demonstration board EPC9106 schematic, channel 2.

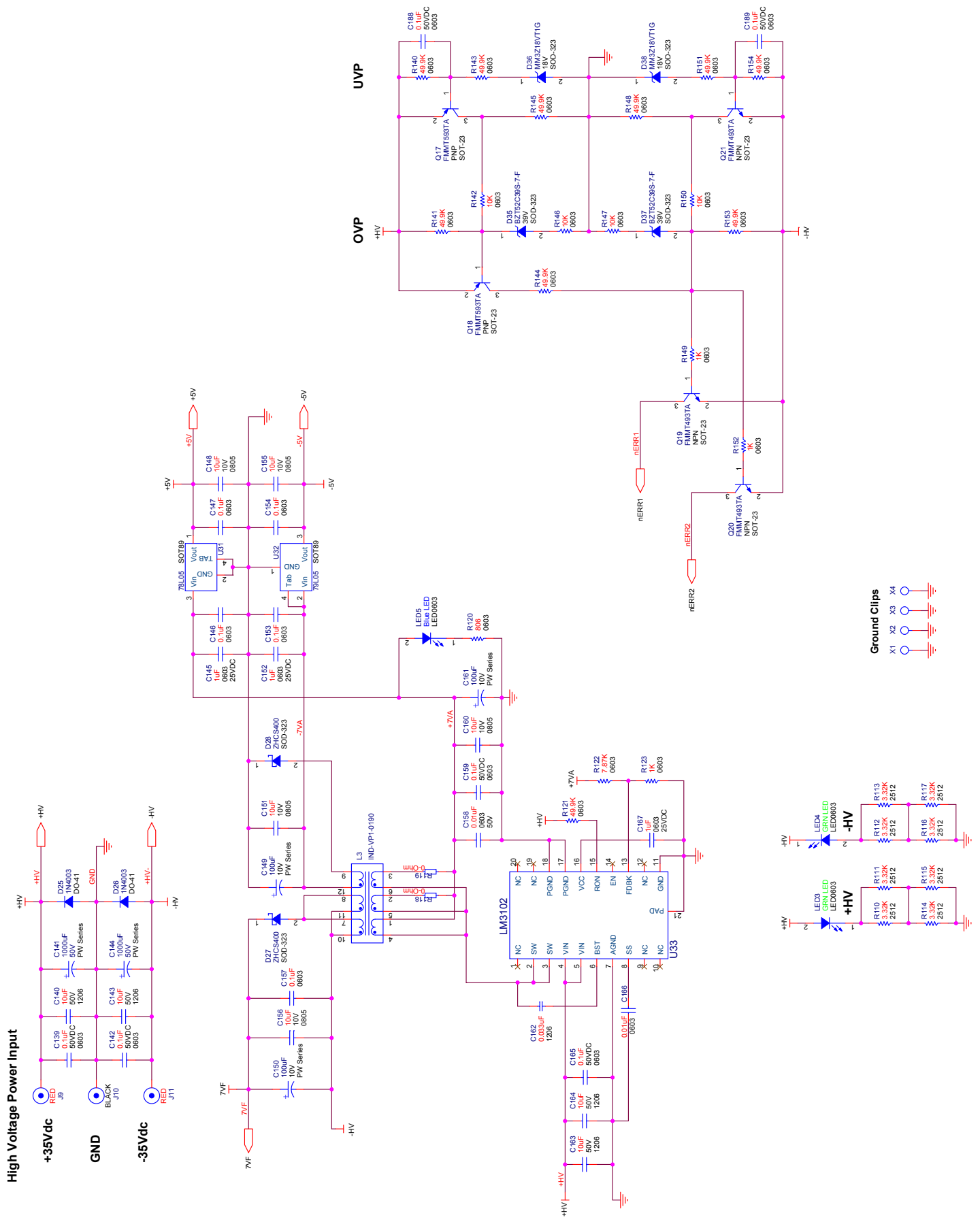


Figure 7c: Demonstration board EPC9106 schematic, power supplies.

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The EPC9106 board is intended for product evaluation purposes only and is not intended for commercial use. Replace components on the Evaluation Board only with those parts shown on the parts list (or Bill of Materials) in the Quick Start Guide. Contact an authorized EPC representative with any questions.

This board is intended to be used by certified professionals, in a lab environment, following proper safety procedures. Use at your own risk.

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