

## LTC3738CUHF and LTC3731CUH

### DESCRIPTION

Demonstration circuits 721A-A and 721A-B are high current step-down converters for Intel VRM/VRD10 and VRM9 processor power applications. The demo circuits feature the current-mode PolyPhase™ controllers LTC3738CUHF and LTC3731CUH. The input voltage is from 8V to 14V and the output voltage is controlled by the VID setting. DC721A-A is a 6-phase LTC3738 and LTC3731 supply that can provide up to 120A output current. DC721A-B is a single LTC3738 3-phase 65A output supply. Both LTC3738CUHF and LTC3731CUH controllers are in the QFN packages to minimize the supply footprint size and improve the thermal performance.

The LTC3738 controller has 6 VID pins to program the output voltage according to Intel VRM9 or VRM/VRD10 requirement. Accurate active voltage positioning (AVP) is implemented with LTC3738 to meet Intel's tight load line regulation requirement. Optional 0.1% external voltage reference and external Op-Amp compensation circuits are also available on DC721A-A and DC721A-B for applications requiring <0.5% output voltage regulation accuracy and optimum transient response.

**Design files for this circuit board are available. Call the LTC factory.**

LTC, PolyPhase are trademarks of Linear Technology Corporation

**Table 1. Performance Summary (T<sub>A</sub> = 25°C)**

PARAMETER	TEST CONDITION	VALUE
Minimum Input Voltage		8V
Maximum Input Voltage		14V
Output Voltage V <sub>OUT</sub>	Controlled by VID setting: VRM9: 1.100V-1.850V, 25mV VID step VRM/VRD10: 0.8375V-1.6000V, 12.5mV VID step	Meet Intel VRM9 and VRM/VRD10 static and transient specifications
Maximum Continuous Output Current	DC721A-A, 6-phase LTC3738+3731 design	120 A <sub>DC</sub>
	DC721A-B, 3-phase LTC3738 design	65 A <sub>DC</sub>
Efficiency	DC721A-A, V <sub>IN</sub> = 12V, V <sub>OUT</sub> =1.5V <sub>VID</sub> , I <sub>OUT</sub> = 120A	87.6% Typical, See Figure 1
	DC721A-B, V <sub>IN</sub> = 12V, V <sub>OUT</sub> =1.5V <sub>VID</sub> , I <sub>OUT</sub> = 65A	87.6% Typical
Output Voltage Load Line	DC721A-A, V <sub>IN</sub> = 12V, V <sub>OUT</sub> =1.35V <sub>VID</sub>	See Figure 2
Output Load Transient Response	DC721A-A, V <sub>IN</sub> = 12V, V <sub>OUT</sub> =1.5V <sub>VID</sub>	See Figure 3

### QUICK START PROCEDURE

Demonstration circuits 721A-A and 721A-B are easy to set up to evaluate the performance of the LTC3738CUHF and LTC3731CUH. Refer to Figure 4 for proper measurement equipment setup and follow the procedure below:

1. Place jumpers in the following positions:

+5V Select	INT 5V	DLC BIAS	DLC	VRM SELECT
	INT	ON	OFF	VRM10

# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B

## 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY

---

2. With power off, connect the input power supply to  $V_{in}$  and GND. Connect an active load to  $V_{OUT+}$  and  $V_{OUT-}$ . Preset the load to 0A.
3. Set the VID dip-switch S1 as follows:

B4	B3	B2	B1	B0	B5
0	1	1	1	0	1

**NOTE:** Make sure that the input voltage does not exceed 14V.

4. Turn on the power at the input. Check for the proper output voltages. With above VID setting, the output voltage should be within 1.450V-1.500V at 0A load.

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. With above VID setting, the output voltage should be within 1.391V-1.441V at 65A load current.

**NOTE:** The maximum current of DC721A-A is 120A and DC721A-B is 65A. A cooling fan is needed to limit board temperature rise if output current is higher than 50A for DC721A-B or 90A for DC721A-A.

# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY

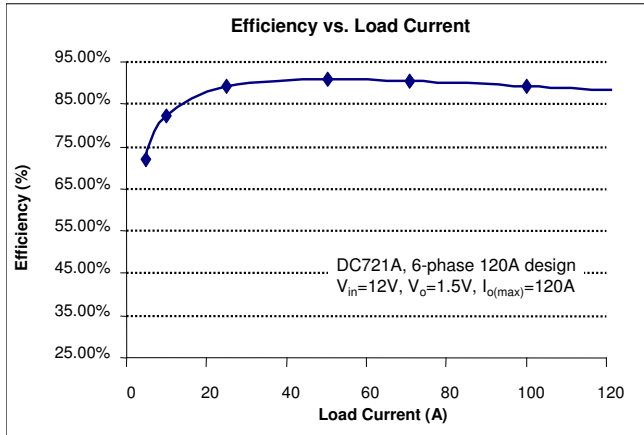


Figure 1. Measured efficiency vs. load current

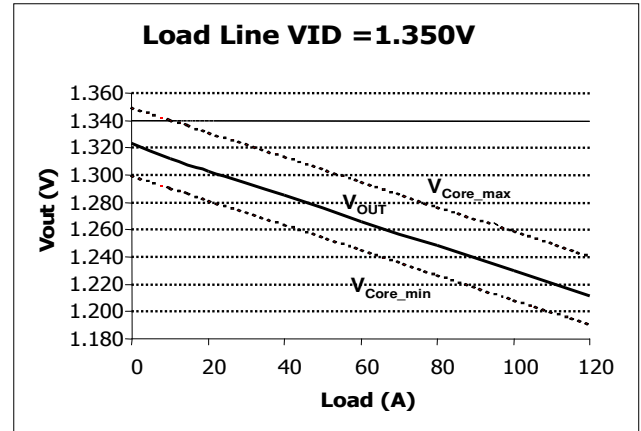


Figure 2. Output load line meets Intel VRD10 spec

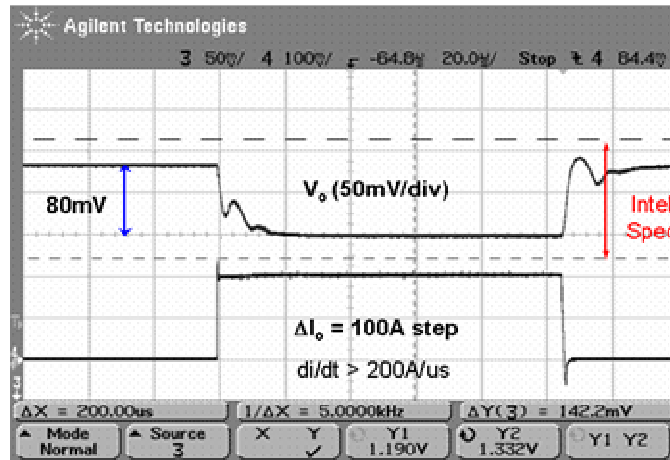


Figure 3 Load transient @ 12V<sub>IN</sub>, 1.5V<sub>O</sub> of DC721A-A

QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B  
 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY

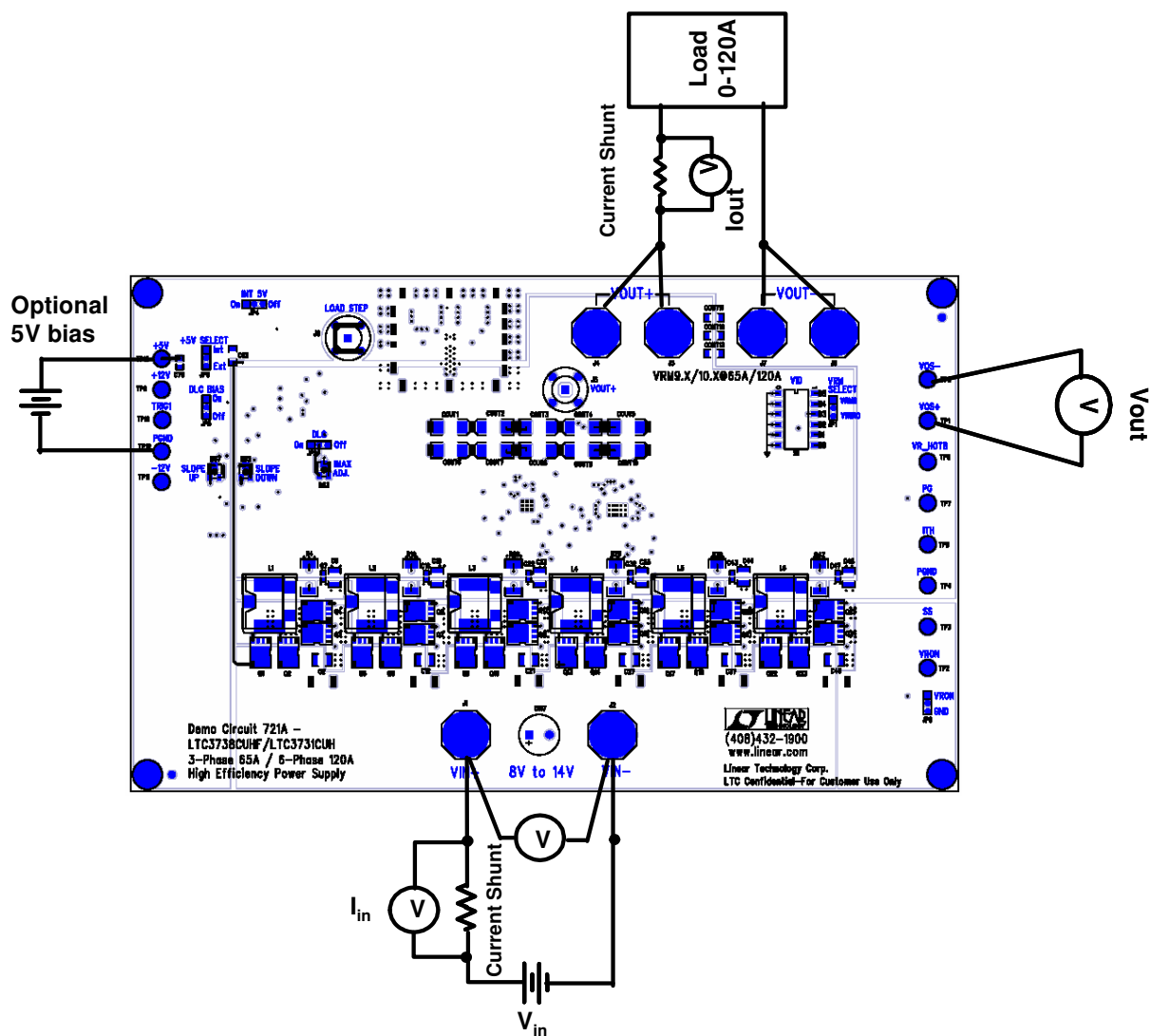
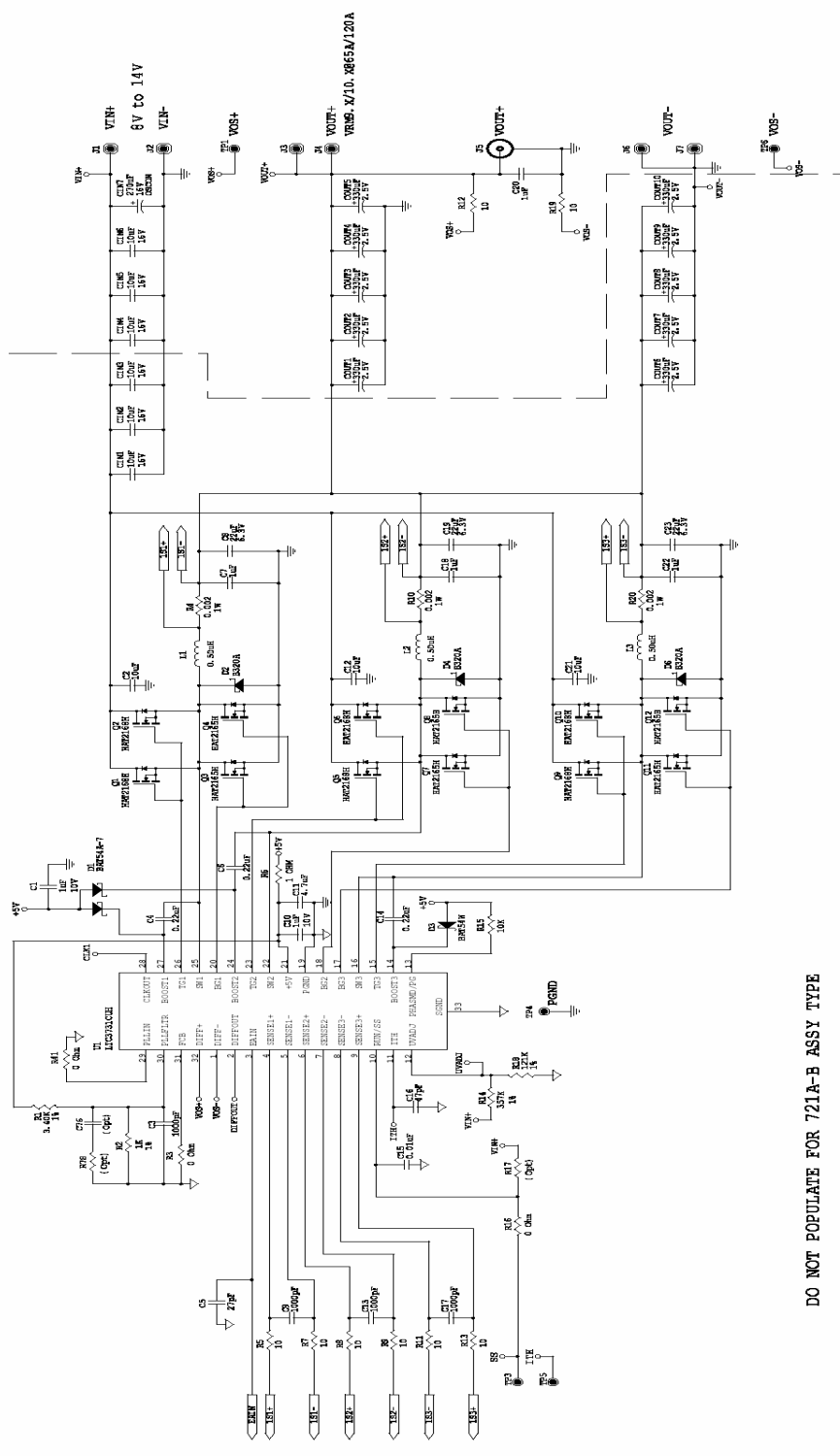


Figure 4. Test Setup of DC721A-A and DC721A-B

# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY

## DC721A-A - 6 Phase 120A

This circuit is proprietary to Linear Technology and supplied for use with Linear Technology parts. While the design is provided as a guide, it is not intended to be used as a design or to be modified. It remains the customer's responsibility to verify proper operation of the circuit and to ensure that the design meets the application and printed circuit board layout requirements for proper operation and performance. Contact your Application Engineering representative for assistance.

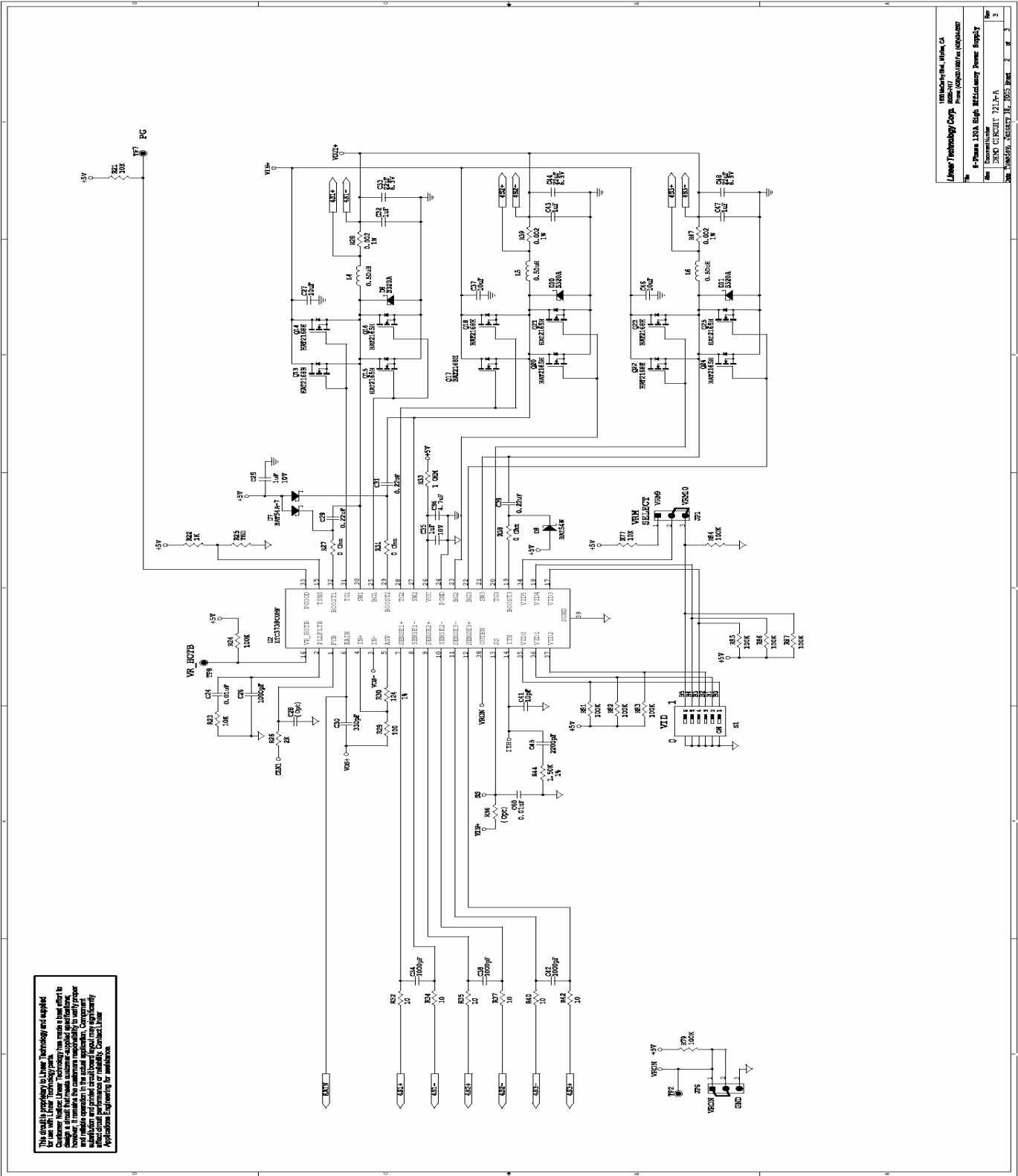


DO NOT POPULATE FOR 721A-B ASSY TYPE

721A-A 6-Phase, 120A All Components Assembled  
721A-B 3-Phase, 65A Delete Components within dashed lines.

Linear Technology Corp.		1000 Technology Blvd., Milpitas, CA	
Tel: (415) 964-7000		Fax: (415) 964-7001	
www.linear.com		www.linear.com	
© 2005 Linear Technology Corp.		All Rights Reserved	
DC721A-A 6-Phase, 120A		Rev. 1.0	
Date: 11/03/05		Page: 1 of 1	

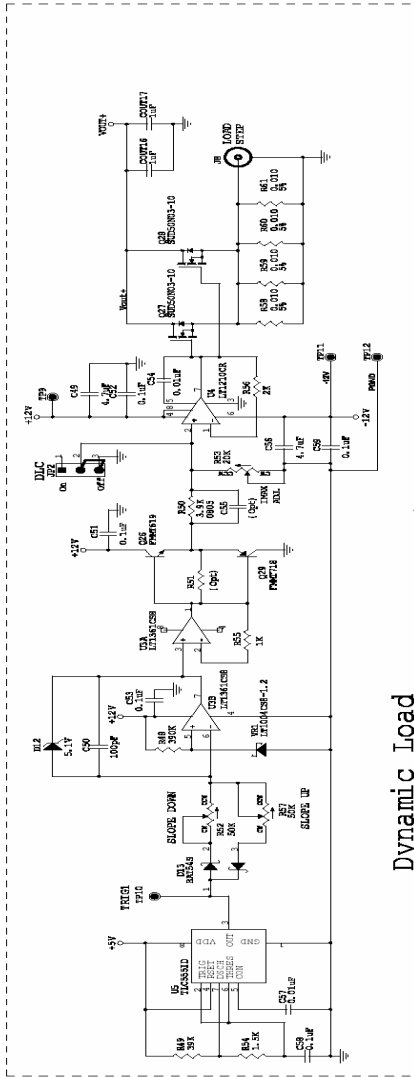
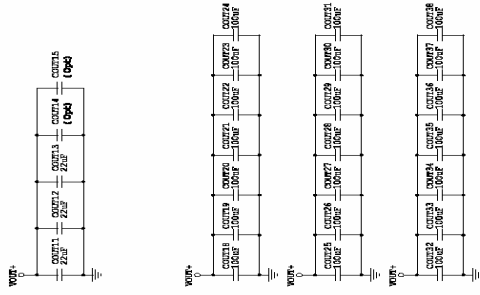
# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY



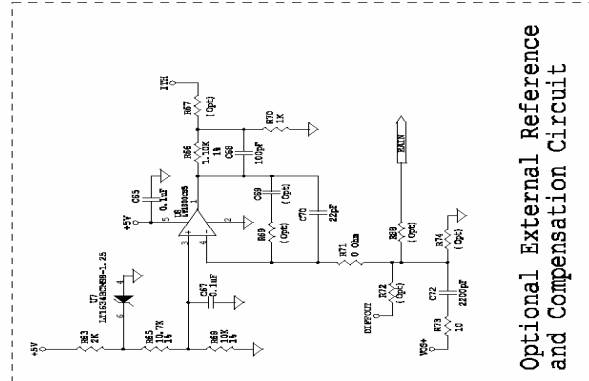
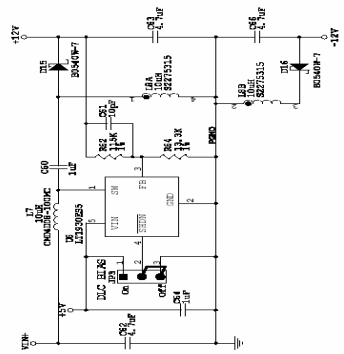
Rev	Document Number	Doc. Number	Rev
1	721A-A	721A-A	1
2	721A-B	721A-B	2
3	721A-C	721A-C	3

This circuit is provided as a guide only. Linear Technology and its subsidiaries are not responsible for any damage or loss of data that may result from the use of this circuit. The user assumes all liability for any damage or loss of data that may result from the use of this circuit. Applications Engineering for assistance.

# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY



Dynamic Load Circuit



Optional External Reference and Compensation Circuit

This circuit is provided as a demonstration of Linear Technology and applied to the design of a power supply. Linear Technology has made a best effort to design a circuit that meets customer-specified requirements. Customer is responsible for verifying the circuit meets all requirements and for any modifications and printed circuit board layout may significantly affect the circuit's performance. Linear Technology is not responsible for any consequences arising from the use of the information contained in this document.

Linear Technology Corp.	100 Brook Hill Drive, Wilmington, MA 01890
Phone	(603) 886-1000 Fax (603) 886-1001
Web	www.linear.com
Doc. No.	721A-A/B
Rev.	1.0
Date	01/15/01

# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B

## 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY

Item	Qty	Reference	Part Description	Manufacture / Part #
1	13	CIN1-CIN6, C2,C12, C21,C27,C37,C46,C74	Cap., X5R 10uF 16V 20%	Taiyo Yuden EMK325BJ106MN
2	1	CIN7	Cap., Alum 270uF 16V 20%	OSCON 16SP270M
3	10	COU11-COU10	Cap., POSCAP 330uF 2.5V 20%	SANYO 2R5TPE330M9
4	3	COU11,COU12,COU13	Cap., X5R 22uF 6.3V 10%	Taiyo Yuden JMK316BJ226KL-T
5	0	COU15,COU14 (Opt)	Cap., X5R 22uF 6.3V 10%	Taiyo Yuden JMK316BJ226KL-T
6	5	COU16,COU17,C60,C73,C75	Cap., X5R 1uF 16V 20%	Taiyo Yuden EMK212BJ105MG
7	21	COU18-COU38	Cap., X5R 100uF 6.3V 20%	TDK C3225X5R0J107M
9	12	C1,C7,C10,C18,C20,C22, C25,C32,C35,C43,C47,C64	Cap., X5R 1uF 10V 20%	Taiyo Yuden LMK107BJ105MA
10	8	C3,C9,C13,C17,C26,C34, C38,C42	Cap., NPO 1000pF 25V 5%	AVX 06033A102JAT1A
11	7	C4,C6,C14,C29,C31,C39,C71	Cap., X5R 0.22uF 16V 20%	Taiyo Yuden EMK107BJ224MA
12	1	C5	Cap., NPO 27pF 25V 5%	AVX 06033A270JAT1A
13	6	C8,C19,C23,C33,C44,C48	Cap., X5R 22uF 6.3V 20%	Taiyo Yuden JMK325BJ226MM-T
14	7	C11,C36,C49,C56,C62,C63,C66	Cap., X5R 4.7uF 16V 20%	Taiyo Yuden EMK316BJ475ML
15	5	C15,C24,C40,C54,C57	Cap., X7R 0.01uF 25V 10%	AVX 06033C103KAT2A
16	1	C16	Cap., NPO 47pF 50V 10%	AVX 06035A470KAT1A
17	0	C28,C55,C69,C76 (Opt)	Cap., TBD	
18	1	C30	Cap., NPO 330pF 25V 5%	AVX 06033A331JAT1A
19	2	C50,C68	Cap, NPO 100pF 25V 5%	AVX 06033A101JAT2A
20	7	C51-C53,C58,C59,C65,C67	Cap., X7R 0.1uF 16V 10%	AVX 0603YC104KAT1A
21	2	C61,C41	Cap., NPO 10pF 25V 10%	AVX 06033A100KAT2A
22	1	C70	Cap., NPO 22pF 50V 10%	AVX 06035A220KAT1A
23	2	C72,C45	Cap., X7R 2200pF 25V 20%	AVX 06033C222MAT2A
24	2	D7,D1	Schottky (Comm-Anode) Diode	Diode Inc. BAT54A-7
25	6	D2,D4,D6,D8,D10,D11	Schottky Rect., 20V/3Amp	Diodes Inc. B320A
26	2	D9,D3	Schottky Diode	Diodes Inc. BAT54W
27	1	D12	Zener Diode, 5.1V	On Semi. MMBZ5231B
28	1	D13	Schottky (Dual)Diode, BAT54S	Zetex BAT54S-7
29	2	D15,D16	Diode Schotkky, 40V	Diodes Inc. B0540W-7
30	1	D17	Schottky Diode, Super-Mini	Central Semi. Corp CMDSH-3-LTC
31	1	D18	Diode Schotkky, 30V	Diodes Inc. B0530W-7
32	6	JP1-JP6	Headers, 3 Pins 2mm Ctrs.	CommConn Con Inc. 2802S-03G2
33	6	XJP1-XJP6	SHUNT, .079" CENTER	COMM-CON CCIJ2MM-138GW
34	6	J1-J4,J6,J7	Stud, Testpin	PEM KFH-032-10
35	2	J8,J5	BNC Connector	Connex 112404
36	6	L1-L6	Inductor, 0.50uH	Pulse PG0006.601
37	1	L7	Inductor, 10uH	Sumida CMD4D08-100MC
38	1	L8	Inductor, 10uH	Sumida S2275315
39	1	L9	Inductor, 15uH	TOKO A914BYW-150M
40	12	Q1,Q2,Q5,Q6,Q9,Q10,Q13, Q14,Q17,Q18,Q22,Q23	Mosfet N-Chan., 30V	Renesas HAT2168H
41	12	Q3,Q4,Q7,Q8,Q11,Q12,Q15, Q16,Q20,Q21,Q24,Q25	Mosfet N-Chan., 30V	Renesas HAT2165H
42	1	Q26	Trans., NPN	Zetex FMMT619
43	2	Q28,Q27	Mosfet, N-Channel 30V	Siliconix SUD50N03-10
44	1	Q29	Trans., PNP	Zetex FMMT718
45	1	R1	Res., Chip 3.40K 0.1W 1%	AAC CR16-3401FM
46	1	R2	Res., Chip 1K 0.1W 1%	AAC CR16-1001FM
47	7	R3,R16,R27,R31,R38,R41,R71	Jumper, Chip 0 Ohm 1/16W 5%	AAC CJ06-000M



# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B

## 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY

48	6	R4,R10,R20,R28,R39,R47	Res., Chip 0.002 1W 1%	Panasonic ERJM1WTF2M0U
49	15	R5,R7-R9,R11-R13,R19, R32,R34,R35,R37,R40, R42, R73	Res., Chip 10 0.1W 5%	AAC CR16-100JM
50	2	R33,R6	Res., Chip 1 OHM 0.06W 5%	AAC CR16-1R0JM
51	1	R14	Res., Chip 357K 0.1W 1%	AAC CR16-3573FM
52	4	R15,R21,R23,R77	Res., Chip 10K 0.1W 5%	AAC CR16-103JM
53	0	R17,R25,R36,R51,R67,R69,R78	Res., TBD	(Opt)
54	1	R18	Res., Chip 121K 0.1W 1%	AAC CR16-1213FM
55	3	R22,R55,R70	Res., Chip 1K 0.06W 5%	AAC CR16-102JM
56	9	R24,R79,R81-R87	Res., Chip 100K 0.1W 5%	AAC CR16-104JM
57	3	R26,R56,R63	Res., Chip 2K 0.1W 5%	AAC CR16-202JM
58	1	R29	Res., Chip 100 0.06W 5%	AAC CR16-101JM
59	1	R30	Res., Chip 124 0.1W 1%	Vishay CRCW0603 100 124 Ohms
60	1	R44	Res., Chip 1.50K 0.1W 1%	AAC CR16-1501FM
61	1	R48	Res., Chip 390K 0.1W 5%	AAC CR16-394JM
62	1	R49	Res., Chip 39K 0.1W 5%	AAC CR16-393JM
63	1	R50	Res., Chip 3.9K 0.1W 5%	AAC CR10-392JM
64	2	R52,R57	Pot. 11 Turns 50K	Bourns 3313J-1-503E
65	1	R53	Pot. 11 Turns 20K	Bourns 3313J-1-203E
66	1	R54	Res., Chip 1.5K 0.1W 5%	AAC CR16-152JM
67	4	R58,R59,R60,R61	Res., LRC 0.010 0.5W 1%	IRC LRF2010-01-R010-F
68	1	R62	Res., Chip 115K 0.1W 1%	AAC CR16-1153FM
69	1	R64	Res., Chip 13.3K 0.1W 1%	AAC CR16-1332FM
70	1	R65	Res., Chip 10.7K 0.1W 1%	AAC CR16-1072FM
71	1	R66	Res., Chip 1.10K 0.1W 1%	AAC CR16-1101FM
72	1	R68	Res., Chip 10K 0.1W 1%	AAC CR16-1002FM
73	0	R72 (Opt)	Res., Chip 12.1K 0.1W 1%	AAC CR16-1212FM
74	0	R74,R88 (Opt)	Res., Chip 8.06K 0.1W 1%	AAC CR16-8061FM
75	1	R75	Res., Chip 6.65K 0.06W 1%	AAC CR16-6651FM
76	1	R76	Res., Chip 20K 0.1W 1%	AAC CR16-2002FM
77	1	S1	SMD switch, 6-pos.	Apem DM-06
78	13	TP1-TP13	Turret, Testpoint	Mill Max 2501-2
79	1	U1	I.C., Voltage Reg.	Linear Tech. Corp. LTC3731CUH
80	1	U2	I.C., Voltage Reg.	Linear Tech. Corp. LTC3738CUHF
81	1	U3	I.C., Dual Op-Amp	Linear Tech. Corp. LT1361CS8
82	1	U4	I.C., Feedback Amp	Linear Tech. Corp. LT1210CR
83	1	U5	I.C., Low Pwr Timer	Texas Inst. TLC555ID
84	1	U6	I.C., Volt. Reg.	Linear Tech. Corp. LT1930ES5
85	1	U7	I.C., Volt. Ref.	Linear Tech. Corp. LT1634BCMS8-1.25
86	1	U8	I.C., Op Amp	Linear Tech. Corp. LT1800CS5
87	1	U9	I.C., Volt. Reg.	Linear Tech. Corp. LT1616ES6
88	1	VR1	I.C., Volt. Ref.	Linear Tech. Corp. LT1004CS8-1.2
89	12		NUT, BRASS NUTS # 10-32	ANY #10-32
90	6		RING, LUG RING # 10	KEYSTONE #10
91	6		WASHER, TIN PLATED BRASS	ANY #10
92	4		SCREW, #4-40, 1/4"	ANY
93	4		STANDOFF, #4-40 1/2"	MICRO PLASTICS 14HTSP003
94	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT #721A
95	2		STENCIL (TOP & BOTTOM)	STENCIL 721A

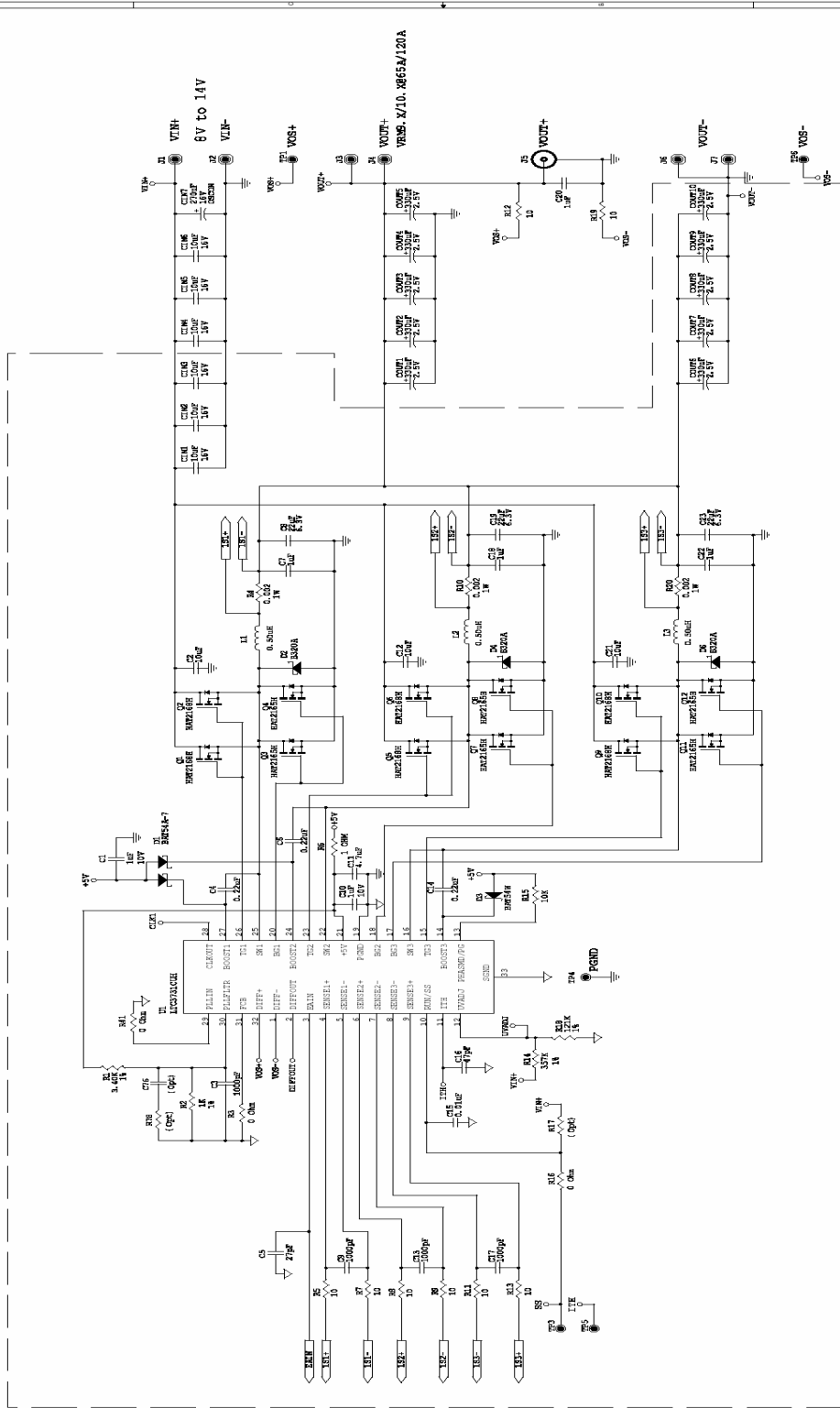




# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY

## Do Not Populate for DC721B 3-Phase Design

This circuit is provided "As Is". Linear Technology and its suppliers make no warranty, representation or guarantee, either expressed or implied, regarding the accuracy, completeness, or reliability of the information contained herein. The user assumes all liability for any and all damages, including consequential damages, arising from the use of this information. Copyright © 2004 Linear Technology Corporation. All rights reserved. Applications Engineering for assistance.



Company	Linear Technology Corp.
Product	VRM9_X/10_VRM65A/120A
Version	1.0
Date	2004-01-01
Author	Applications Engineering
Part Number	DC721B
Revision	1.0

# QUICK START GUIDE FOR DEMONSTRATION CIRCUITS 721A-A/B

## 6-PHASE 120A / 3-PHASE 65A HIGH EFFICIENCY VRM9/VRD10 POWER SUPPLY

Item	Qty	Reference	Part Description	Manufacture / Part #
2	7	CIN4-CIN6,C27,C37,C46,C74	Cap., X5R 10uF 16V 20%	Taiyo Yuden EMK325BJ106MN
3	1	CIN7	Cap., Alum 270uF 16V 20%	OSCON 16SP270M
4	5	COU11-COU5,	Cap., POSCAP 330uF 2.5V 20%	SANYO 2R5TPE330M9
6	3	COU11,COU12,COU13	Cap., X5R 22uF 6.3V 10%	Taiyo Yuden JMK316BJ226KL-T
8	5	COU16,COU17,C60,C73,C75	Cap., X5R 1uF 16V 20%	Taiyo Yuden EMK212BJ105MG
9	21	COU18-COU38	Cap., X5R 100uF 6.3V 20%	TDK C3225X5R0J107M
18	7	C20,C25,C32,C35,C43,C47,C64	Cap., X5R 1uF 10V 20%	Taiyo Yuden LMK107BJ105MA
19	4	C29,C31,C39,C71	Cap., X5R 0.22uF 16V 20%	Taiyo Yuden EMK107BJ224MA
20	1	C30	Cap., NPO 330pF 25V 5%	AVX 06033A331JAT1A
21	3	C33,C44,C48	Cap., X5R 22uF 6.3V 20%	Taiyo Yuden JMK325BJ226MM-T
22	4	C34,C38,C42,C45	Cap., NPO 1000pF 25V 5%	AVX 06033A102JAT1A
23	6	C36,C49,C56,C62,C63,C66	Cap., X5R 4.7uF 16V 20%	Taiyo Yuden EMK316BJ475ML
24	3	C40,C54,C57	Cap., X7R 0.01uF 25V 10%	AVX 06033C103KAT2A
25	3	C41,C50,C68	Cap, NPO 100pF 25V 5%	AVX 06033A101JAT2A
26	7	C51-C53,C58,C59,C65,C67	Cap., X7R 0.1uF 16V 10%	AVX 0603YC104KAT1A
28	1	C61	Cap., NPO 10pF 25V 10%	AVX 06033A100KAT2A
29	1	C70	Cap., NPO 22pF 50V 10%	AVX 06035A220KAT1A
30	1	C72	Cap., X7R 2200pF 25V 20%	AVX 06033C222MAT2A
34	1	D7	Schottky (Comm-Anode) Diode	Diode Inc. BAT54A-7
35	3	D8,D10,D11	Schottky Rect., 20V/3Amp	Diodes Inc. B320A
36	1	D9	Schottky Diode	Diodes Inc. BAT54W
37	1	D12	Zener Diode, 5.1V	On Semi. MMBZ5231B
38	1	D13	Schottky (Dual)Diode, BAT54S	Zetex BAT54S
39	2	D15,D16	Diode Schotkky, 40V	Diodes Inc. B0540W-7
40	1	D17	Schottky Diode, Super-Mini	Central Semi. Corp CMDSH-3-LTC
41	1	D18	Diode Schotkky, 30V	Diodes Inc. B0530W-7
42	6	JP1,JP2,JP3,JP4,JP5,JP6	Headers, 3 Pins 2mm Ctrs.	CommConn Con Inc. 2802S-03G2
43	6	XJP1-XJP6	SHUNT, .079" CENTER	COMM-CON CCIJ2MM-138GW
44	6	J1,J2,J3,J4,J6,J7	Stud, Testpin	PEM KFH-032-10
45	2	J8,J5	BNC Connector	Connex 112404
47	3	L4,L5,L6	Inductor, 0.50uH	Pulse PG0006.601
48	1	L7	Inductor, 10uH	Sumida CMD4D08-100MC
49	1	L8	Inductor, 10uH	Sumida S2275315
50	1	L9	Inductor, 15uH	TOKO A914BYW-150M
53	6	Q13,Q14,Q17,Q18,Q22,Q23	Mosfet N-Chan., 30V	Renesas HAT2168H
54	6	Q15,Q16,Q20,Q21,Q24,Q25	Mosfet N-Chan., 30V	Renesas HAT2165H
55	1	Q26	Trans., NPN	Zetex FMMT619
56	2	Q28,Q27	Mosfet, N-Channel 30V	Siliconix SUD50N03-10
57	1	Q29	Trans., PNP	Zetex FMMT718
64	9	R12,R19,R32,R34,R35,R37, R40,R42,R73	Res., Chip 10 0.1W 5%	AAC CR16-100JM
69	2	R21,R77	Res., Chip 10K 0.1W 5%	AAC CR16-103JM
70	5	R22,R55,R70, <b>R89/*C26,R90/*C28</b>	Res., Chip 1K 0.06W 5%	AAC CR16-102JM
71	9	R24,R79,R81-R87	Res., Chip 100K 0.1W 5%	AAC CR16-104JM
73	4	R27,R31,R38,R71	Jumper, Chip 0 Ohm 1/16W 5%	AAC CJ06-000M
74	3	R28,R39,R47	Res., Chip 0.002 1W 1%	Panasonic ERJM1WTF2M0U
75	1	R29	Res., Chip 100 0.06W 5%	AAC CR16-101JM
76	1	R30	Res., Chip 249 0.1W 1%	AAC CR16-2490FM
77	1	R33	Res., Chip 1 OHM 0.06W 5%	AAC CR16-1R0JM
78	2	R44,R68	Res., Chip 10K 0.1W 1%	AAC CR16-1002FM

