
ISS inner loop circuit board documentation

LIGO-T0900631

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Abstract

This is the electronic part of the feedback control system to stabilize the power of the Advanced LIGO laser behind the PMC. This loop is called the inner loop (in contrast to the outer loop that senses downstreams of the suspended mode cleaner and feeds back into the inner loop's error point). It will be controlled by EPICS. There are different possibilities for this electronics:

- the inner loop and the out of loop photodiode are interchangeable
- a first whitening filter and a gain stage for the photodiodes have to be placed on the photo detectors in order to reduce the effect on the cable to the servo board
- the offset of the AOM power actuator is digital adjustable
- input for the outer loop stabilization
- for the measurement of the transfer function there are analog and digital channels for the inner loop as well as for the outer loop
- digital switch to turn the control loop on and off

Contents

Safety Instructions	2
Sicherheitshinweise	2
Circuit Figures	3
Schematics	3
Board Placeplans	12
Board Drillmaps	18
Circuit Lists	23
Drill List	23
Standard Properties	23
Value List	23
Part List	25

Safety Instructions

In order to operate the circuit properly and safely, review the following guidelines before installing and using the unit. Failure to do so may result in equipment damage or bodily injury:



This circuit was designed as a laboratory equipment to be operated only by trained and qualified technicians in research institutes or development departments. For safety reasons, usage by other persons or in other environments is *not* recommended.



- This circuit uses extra-low voltage ($< 50 V_{AC}$ and $< 75 V_{DC}$) and is therefore exempt from the regulations of the *Low Voltage Directive* (2006/95/EC).
 - The unit does not contain any mechanical drive system. Therefore, the regulations of the *Machinery Directive* (2006/42/EC) do not apply.
-

Sicherheitshinweise

Nehmen Sie vor Aufbau und Inbetriebnahme des Geräts folgende Empfehlungen zur Kenntnis, um die Schaltung korrekt und sicher zu betreiben sowie Schäden und Verletzungen zu vermeiden:



Diese Schaltung wurde als Laborausstattung entworfen, die nur von qualifizierten und eingewiesenen Technikern in Forschungsinstituten oder Entwicklungsabteilungen benutzt wird. Aus Sicherheitsgründen wird die Verwendung durch andere Personen oder in anderer Umgebung *nicht* empfohlen.



- Diese Schaltung verwendet Kleinspannung ($< 50 V_{AC}$ und $< 75 V_{DC}$) und unterliegt daher nicht den Bestimmungen der *Niederspannungsrichtlinie* (2006/95/EC).
 - Das Gerät enthält kein mechanisches Antriebssystem – die Bestimmungen der *Maschinenrichtlinie* (2006/42/EC) sind daher nicht anwendbar.
-

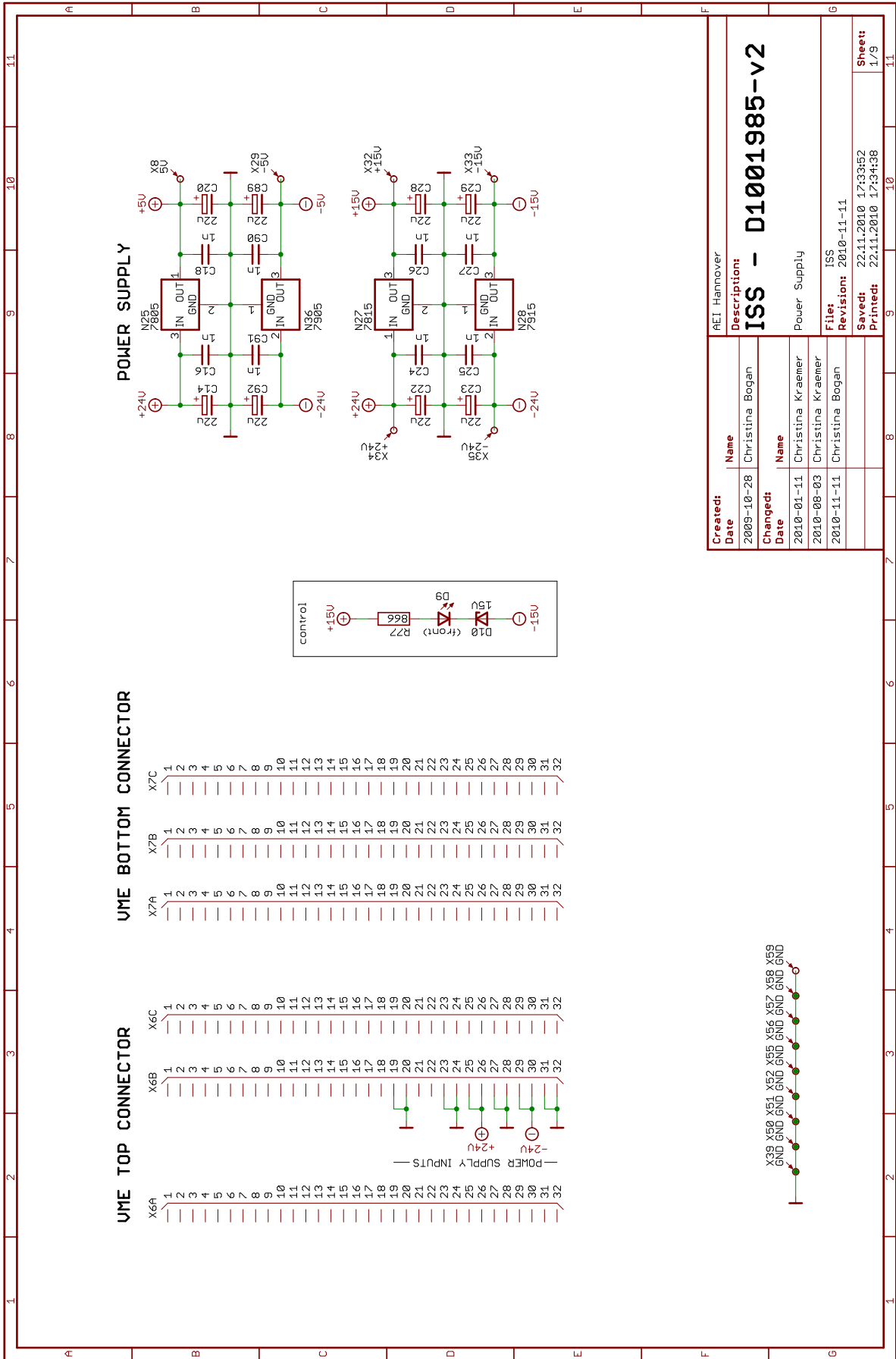


Figure 1: Project schematics (sheet 1)

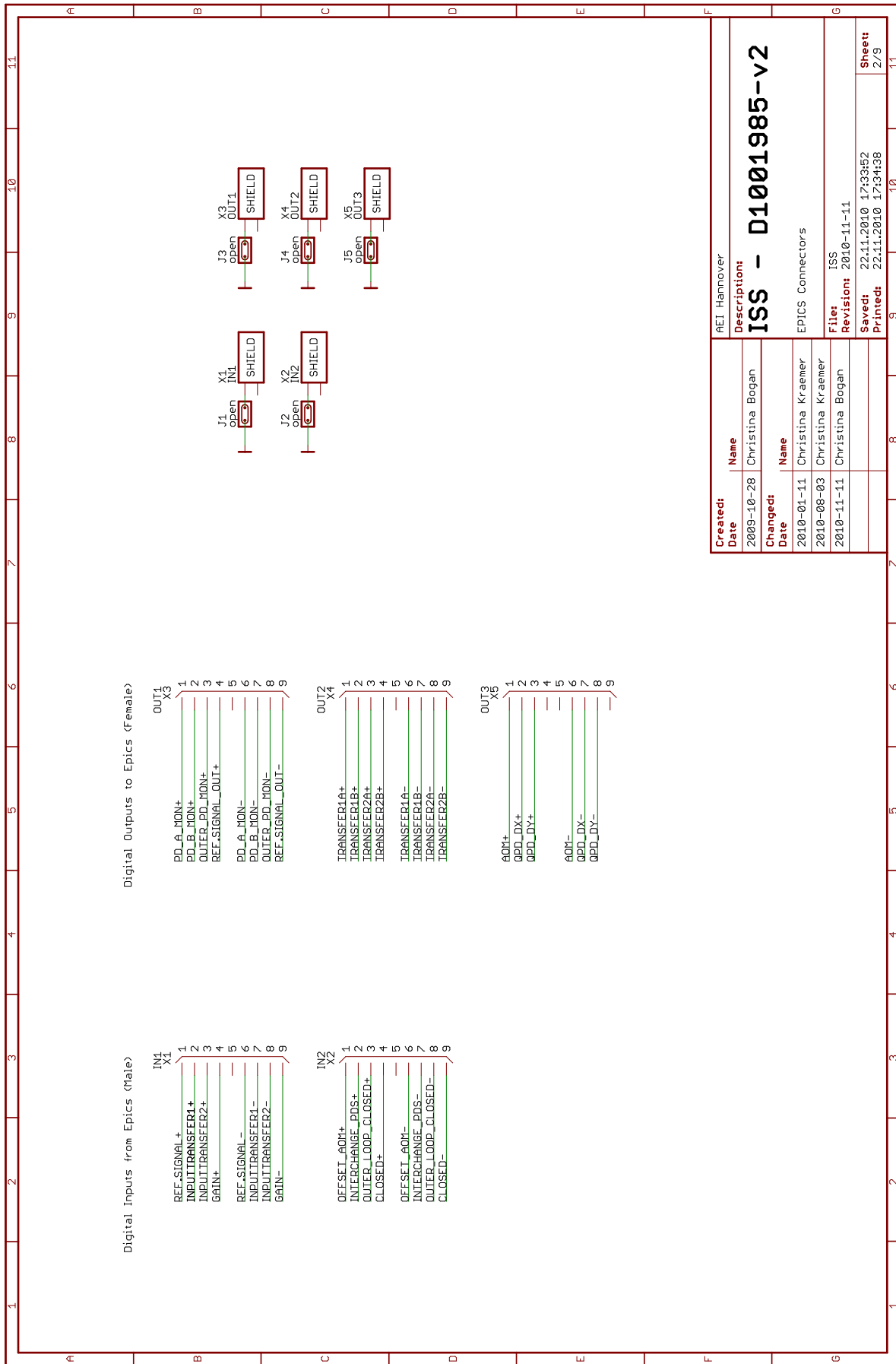


Figure 2: Project schematics (sheet 2)

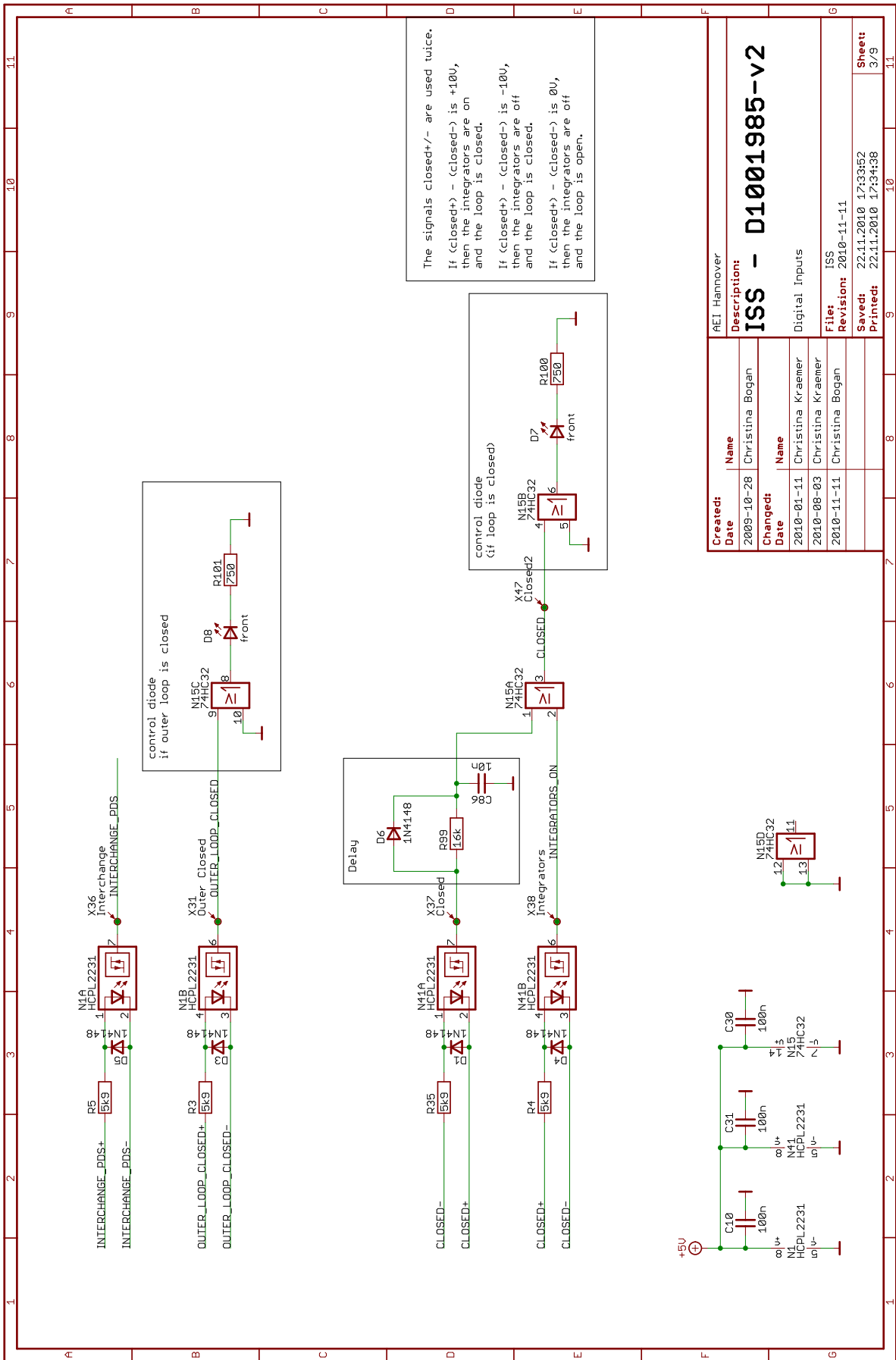


Figure 3: Project schematics (sheet 3)

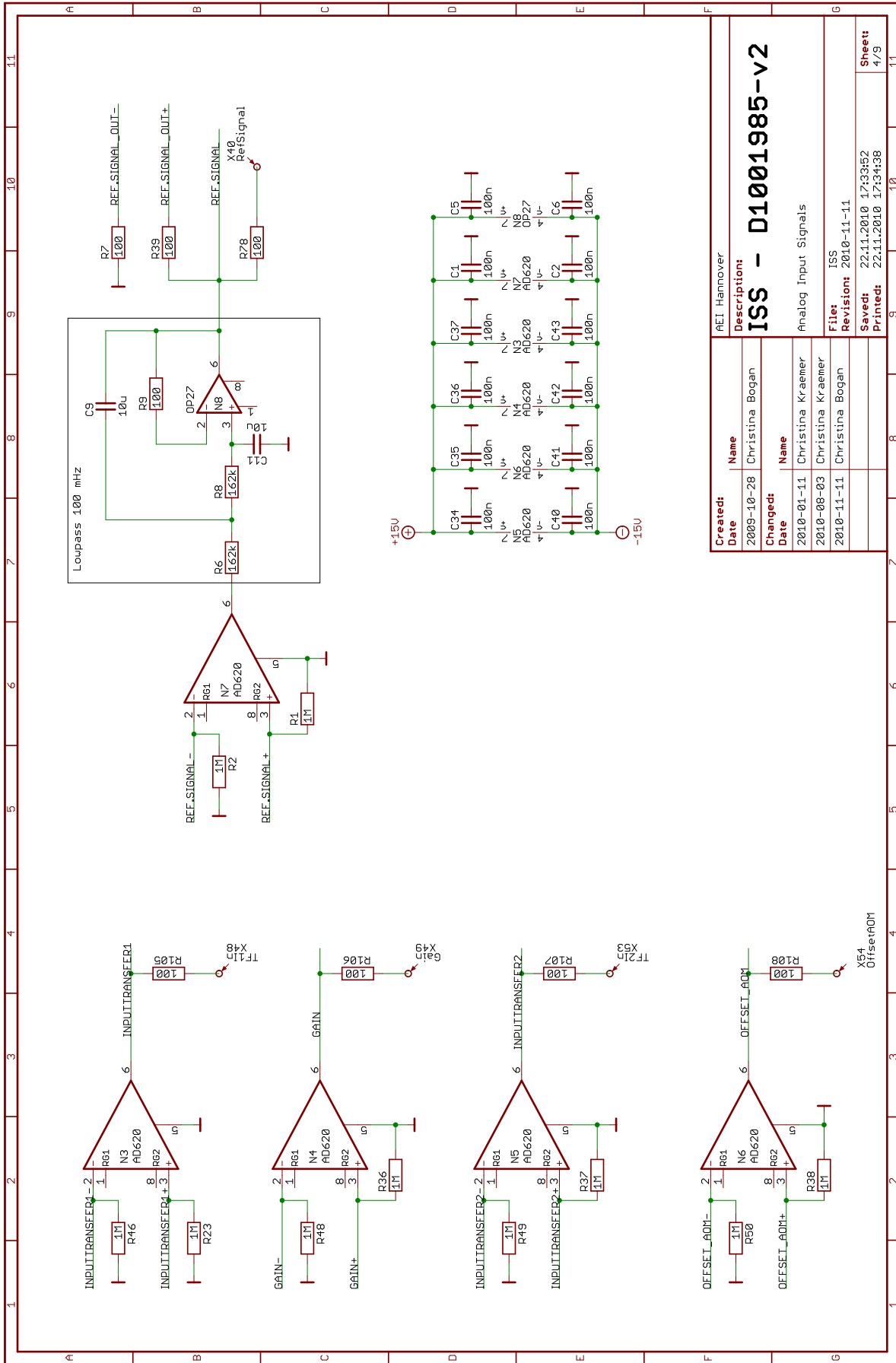
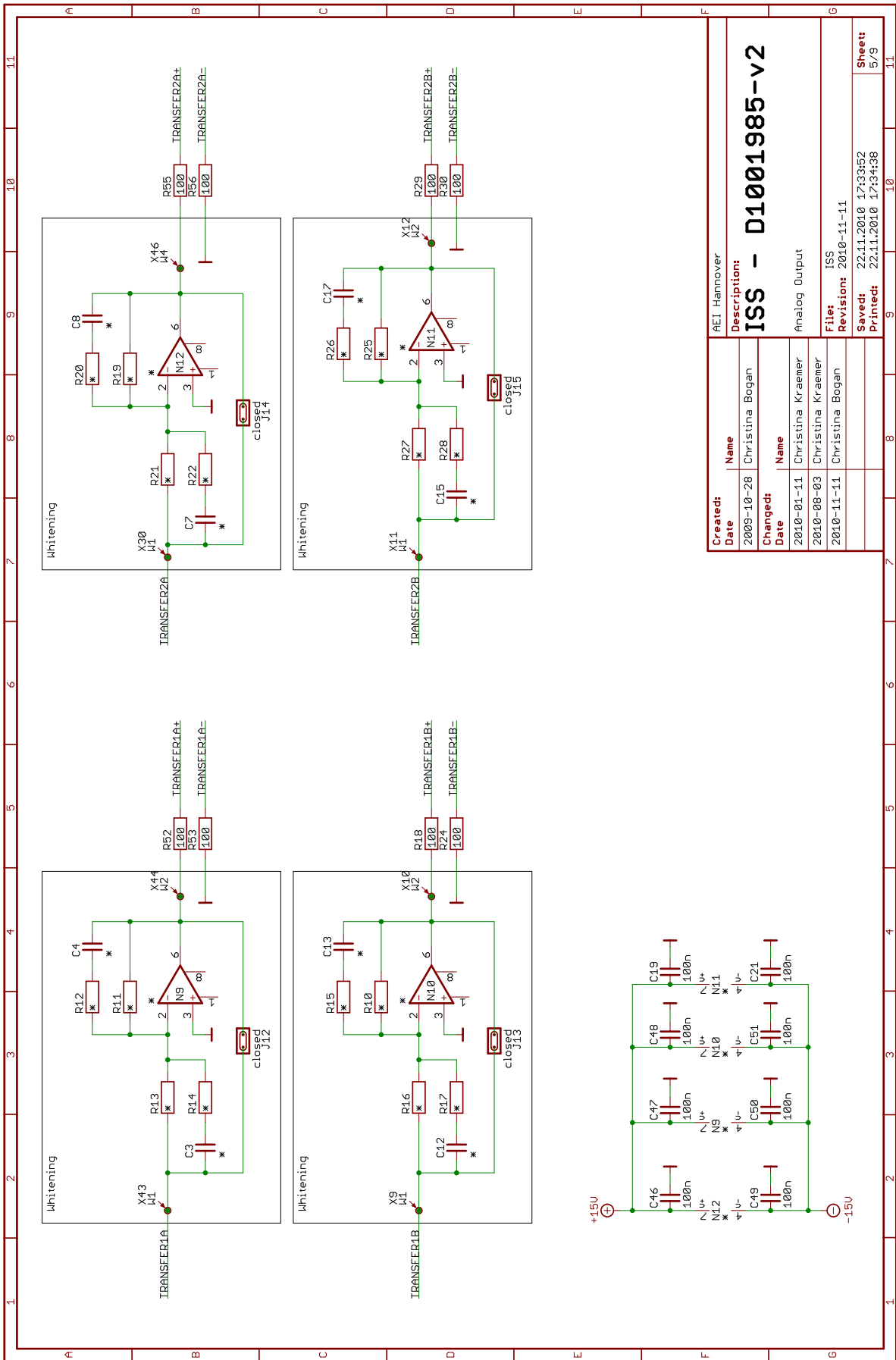


Figure 4: Project schematics (sheet 4)

Created:		AEI Hammer	
Date	Name	Description	
2009-10-28	Christina Bogan	ISS - D1001985-v2	
Changed:		Analog Input Signals	
Date	Name	File:	ISS
2010-01-11	Christina Kraemer	Revision:	2010-11-11
2010-08-03	Christina Kraemer	Saved:	22.11.2010 17:34:52
2010-11-11	Christina Bogan	Printed:	22.11.2010 17:34:38
			Sheet: 4/9



Created:		Description:	
Date	Name	AEI Hannover	
2009-10-28	Christina Bogan	ISS - D1001985-v2	
Changed:		Analog Output	
Date	Name	File:	
2010-01-11	Christina Kraemer	Revision: 2010-11-11	
2010-08-03	Christina Kraemer	Saved: 22.11.2010 17:33:52	
2010-11-11	Christina Bogan	Printed: 22.11.2010 17:34:38	
		Sheet:	
		5/9	

Figure 5: Project schematics (sheet 5)

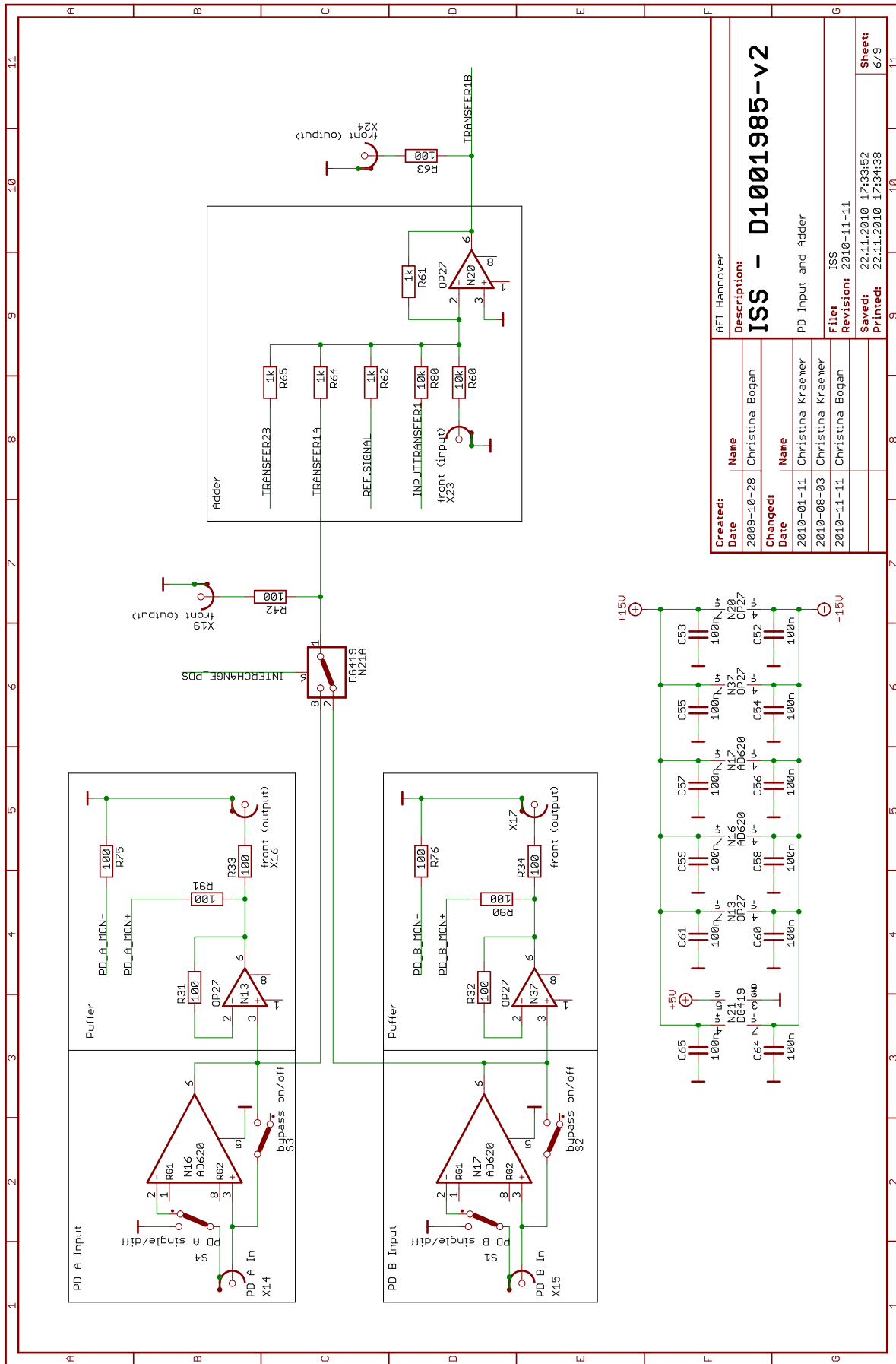
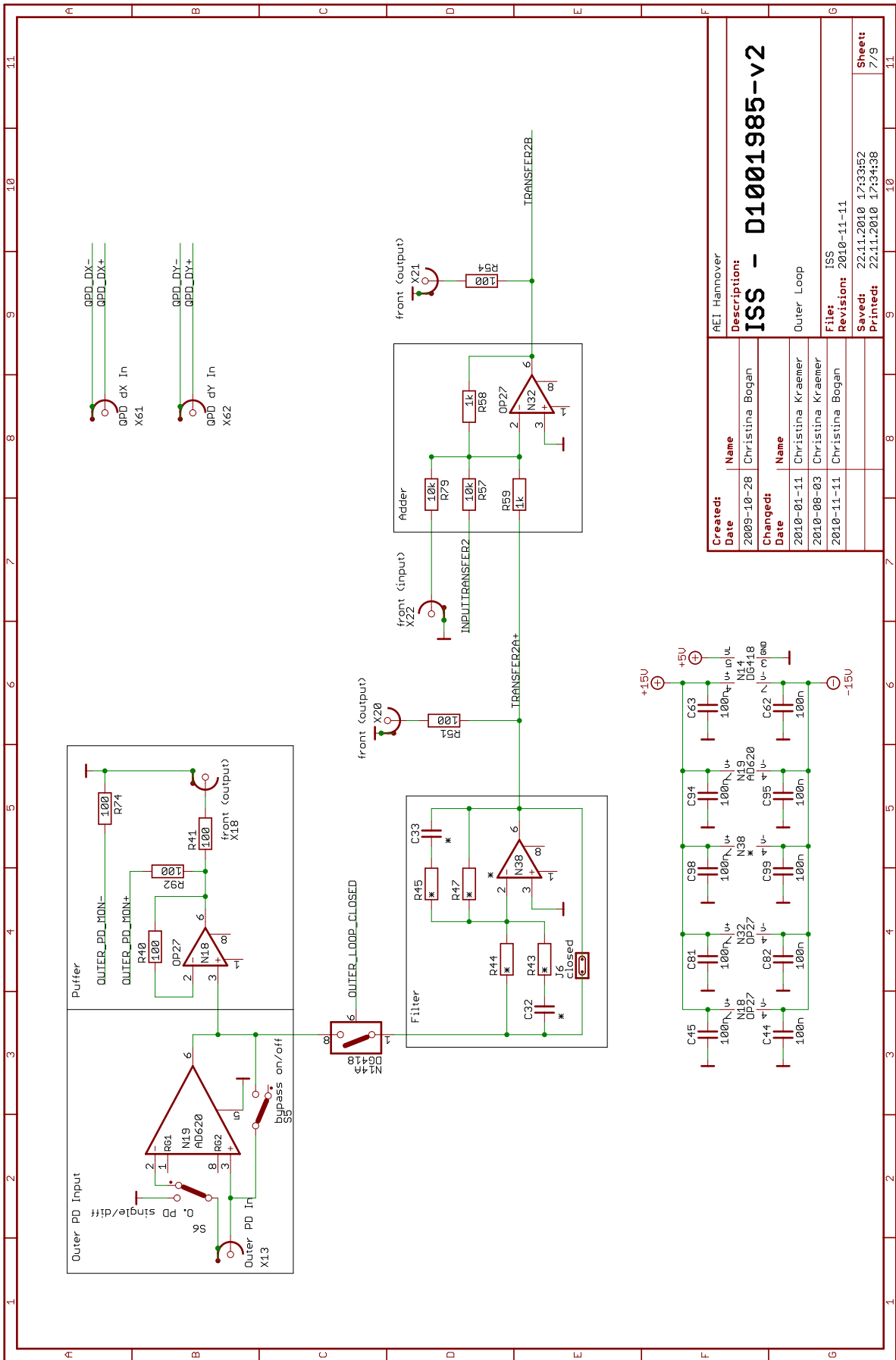


Figure 6: Project schematics (sheet 6)



Created:	Name
AEI Hannover	Christina Bogan
Date	Name
2009-10-28	Christina Bogan
Changed:	Name
2010-01-11	Christina Kraemer
2010-08-03	Christina Kraemer
2010-11-11	Christina Bogan
File: ISS Revision: 2010-11-11 Saved: 22.11.2010 17:33:52 Printed: 22.11.2010 17:34:38	

ISS - D1001985-v2

Outer Loop

Figure 7: Project schematics (sheet 7)

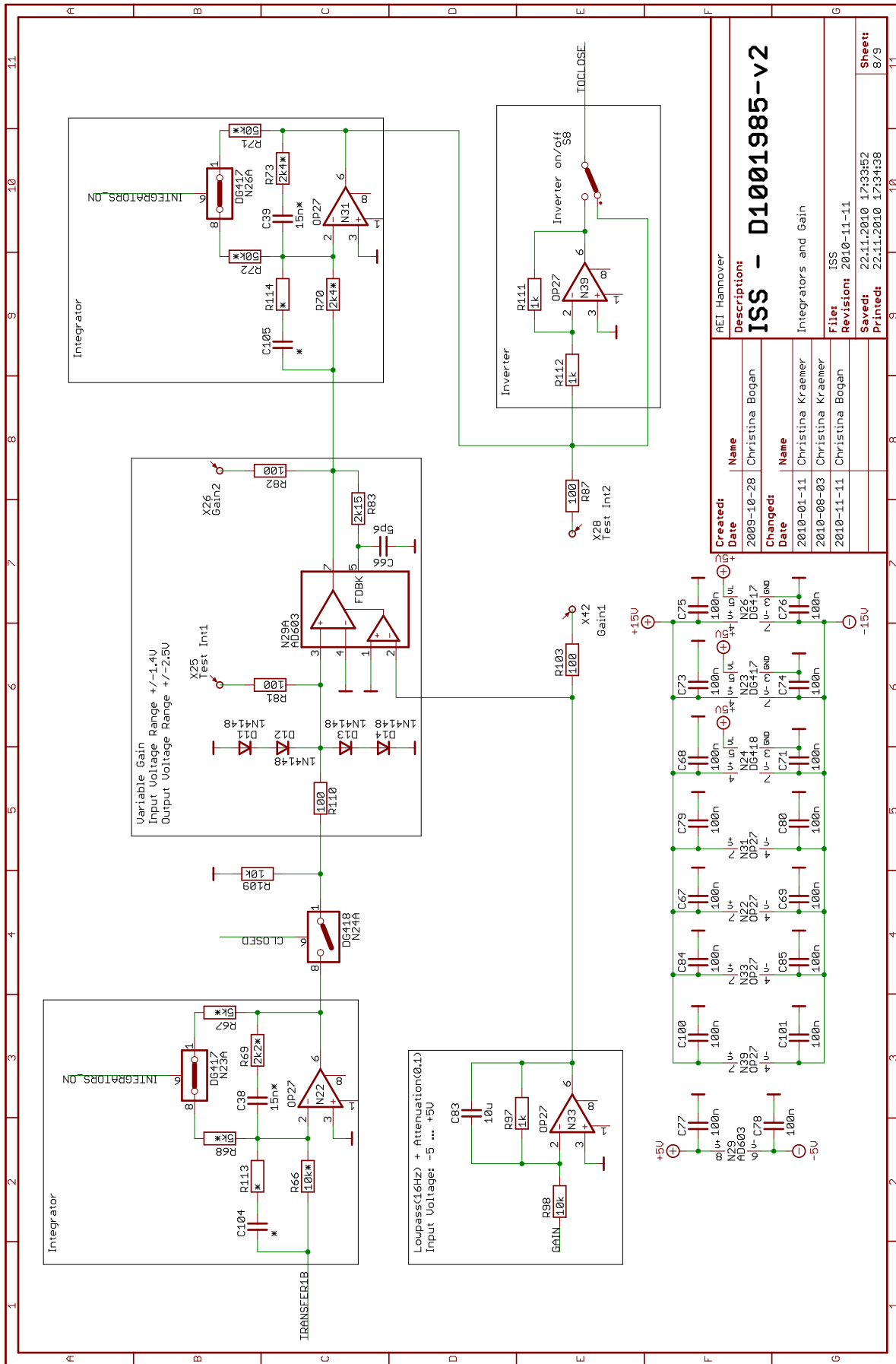


Figure 8: Project schematics (sheet 8)

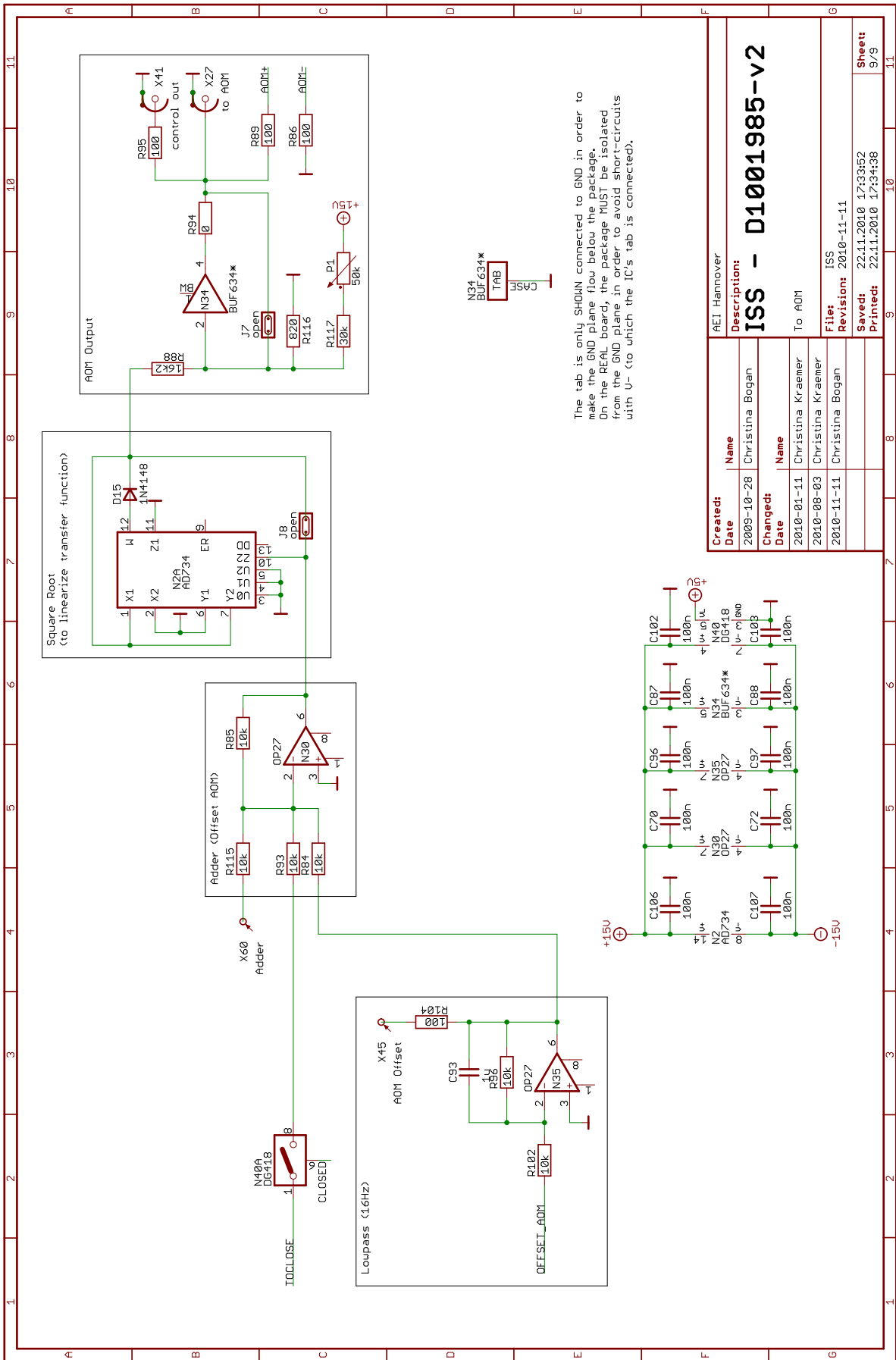


Figure 9: Project schematics (sheet 9)

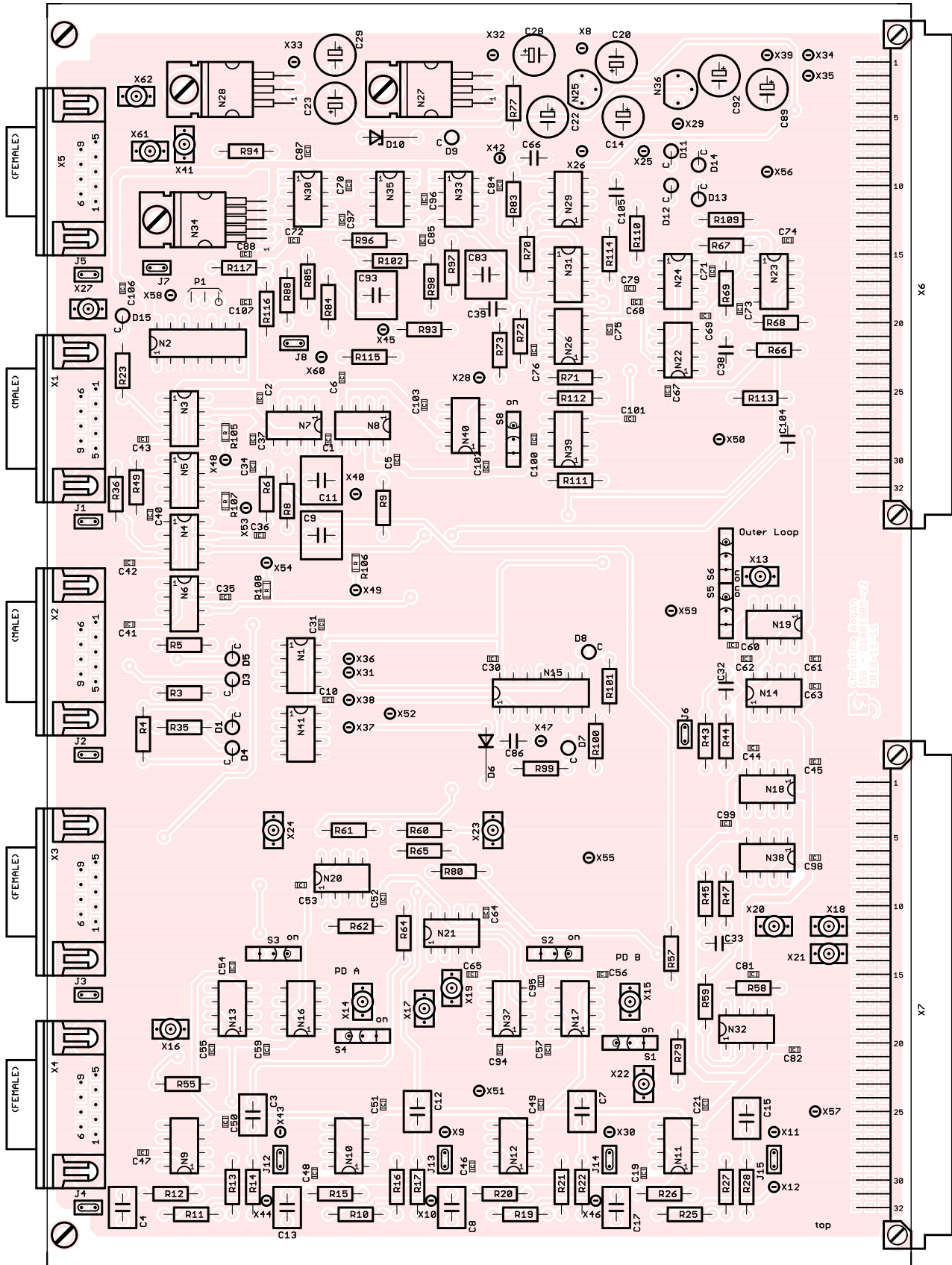


Figure 10: Board top view showing placeplan with component names

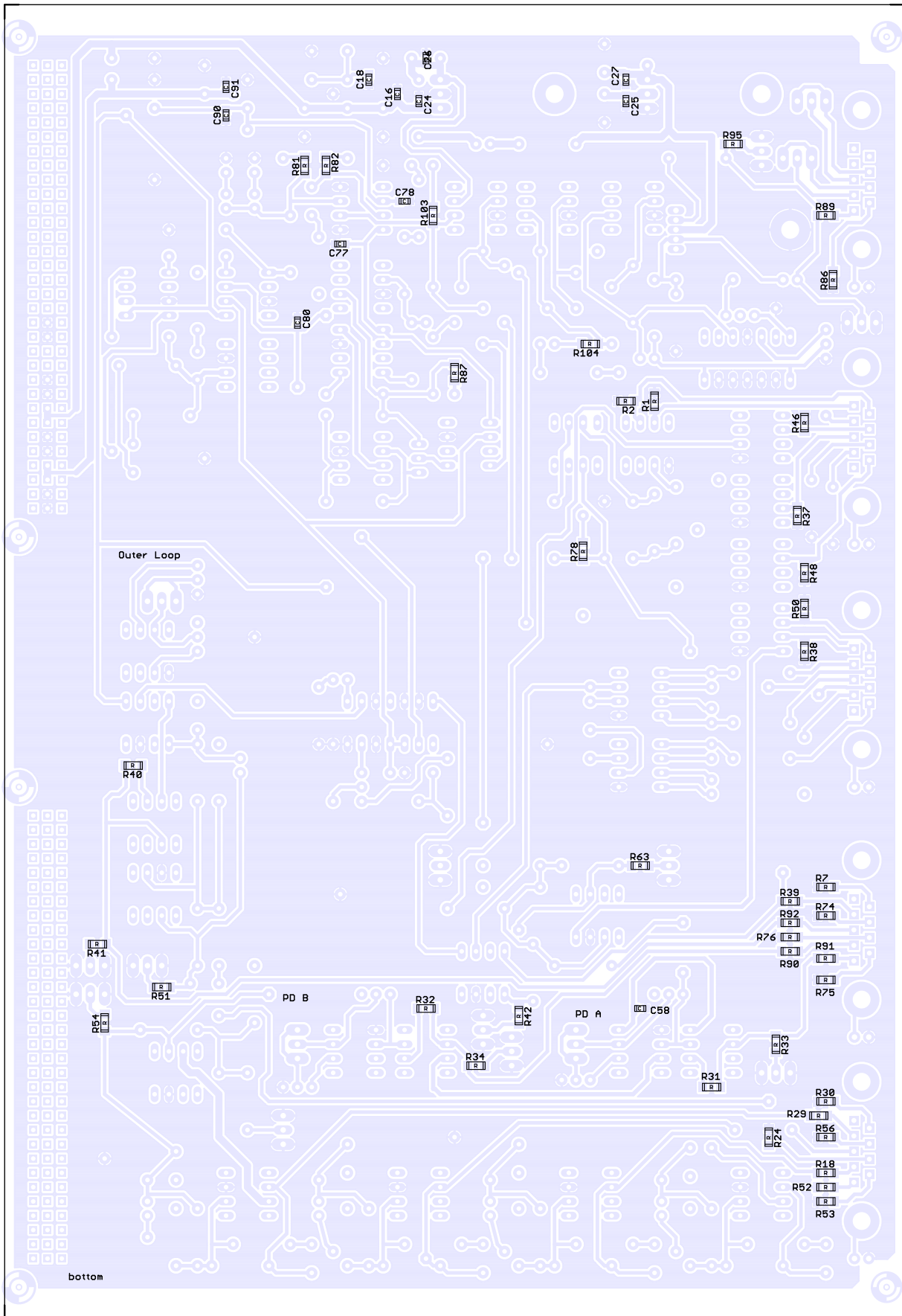


Figure 12: Board bottom view showing placeplan with component names

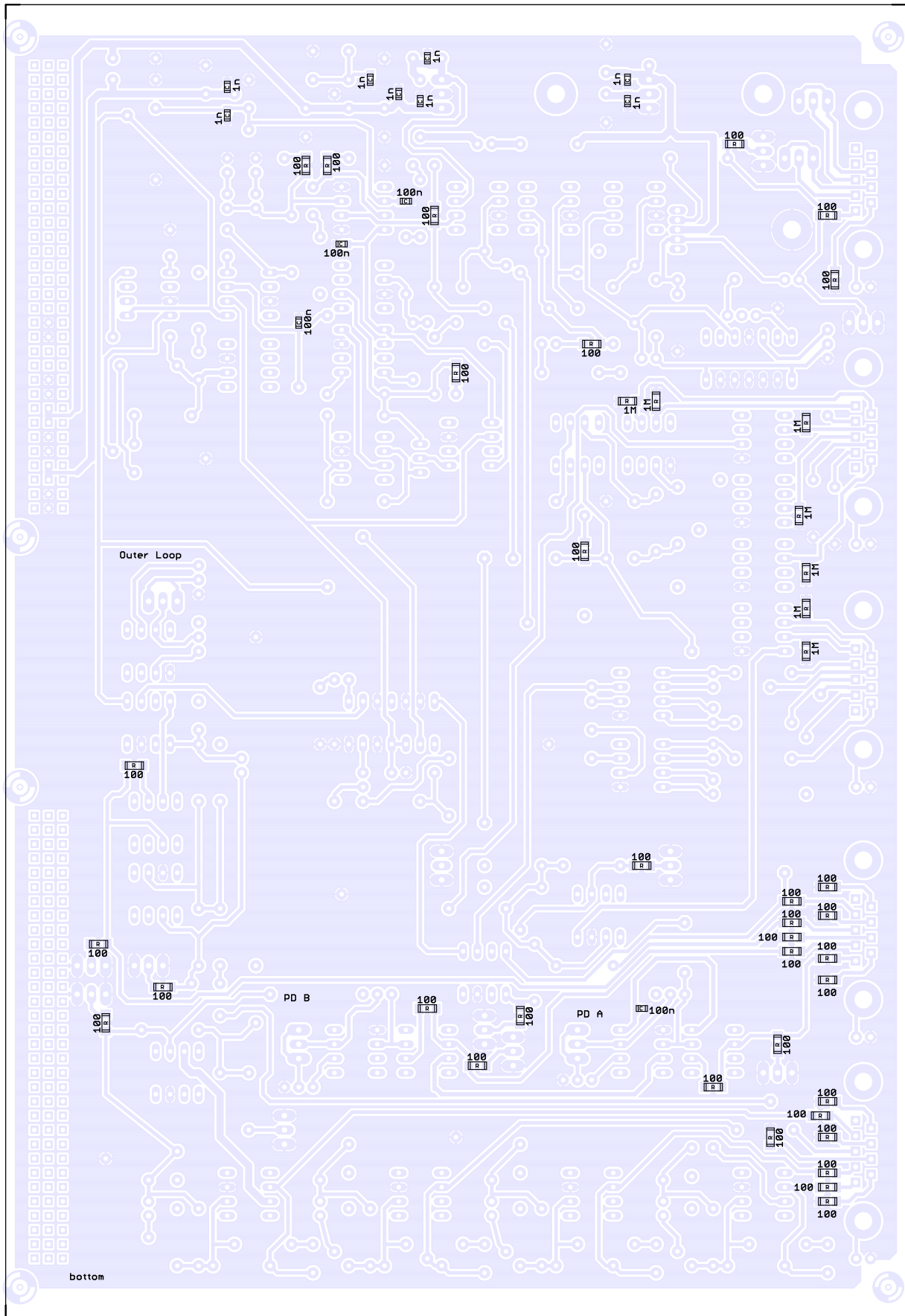


Figure 13: Board bottom view showing placeplan with component values

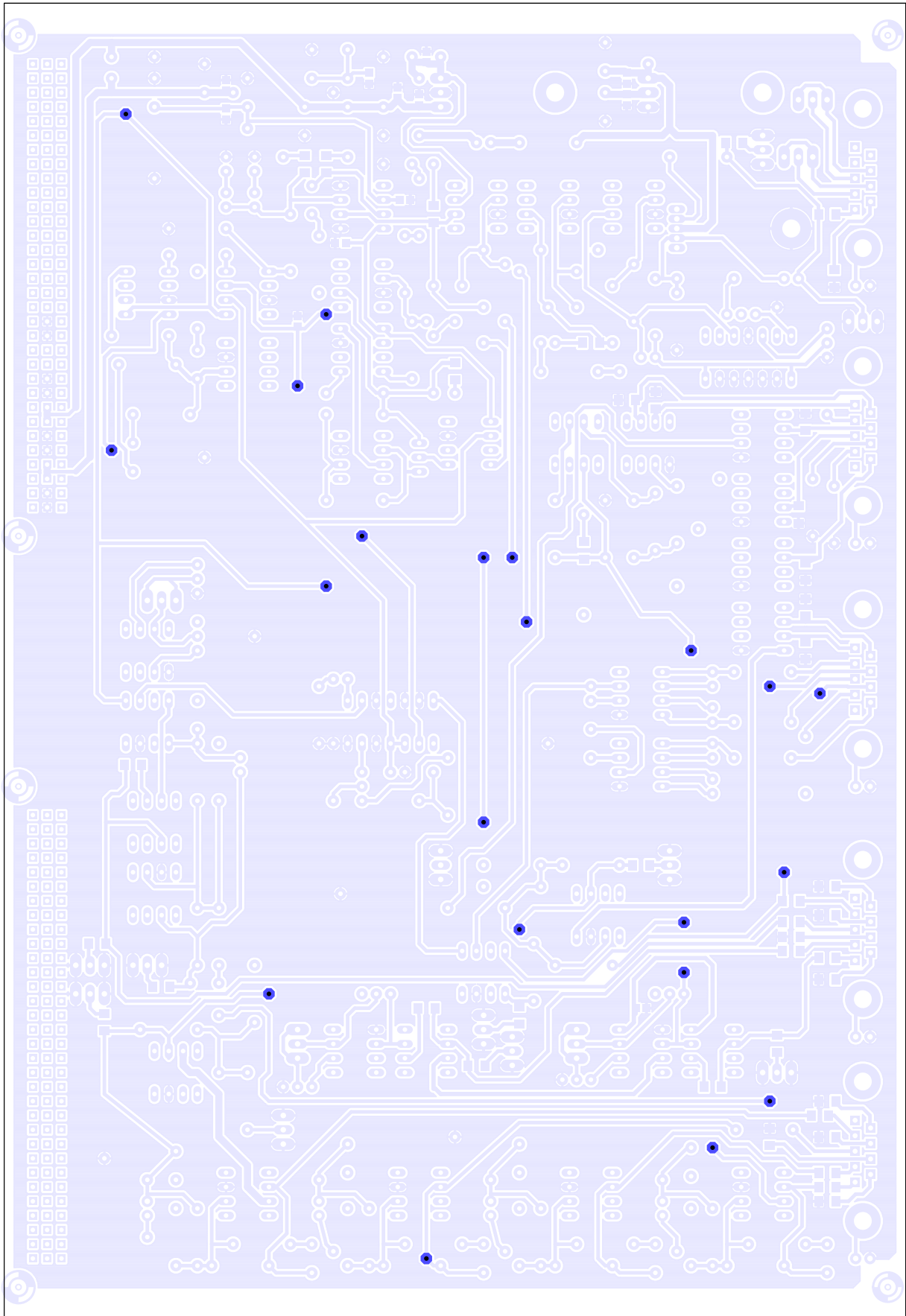


Figure 15: Board bottom view showing connectors, test points, vias and wired components

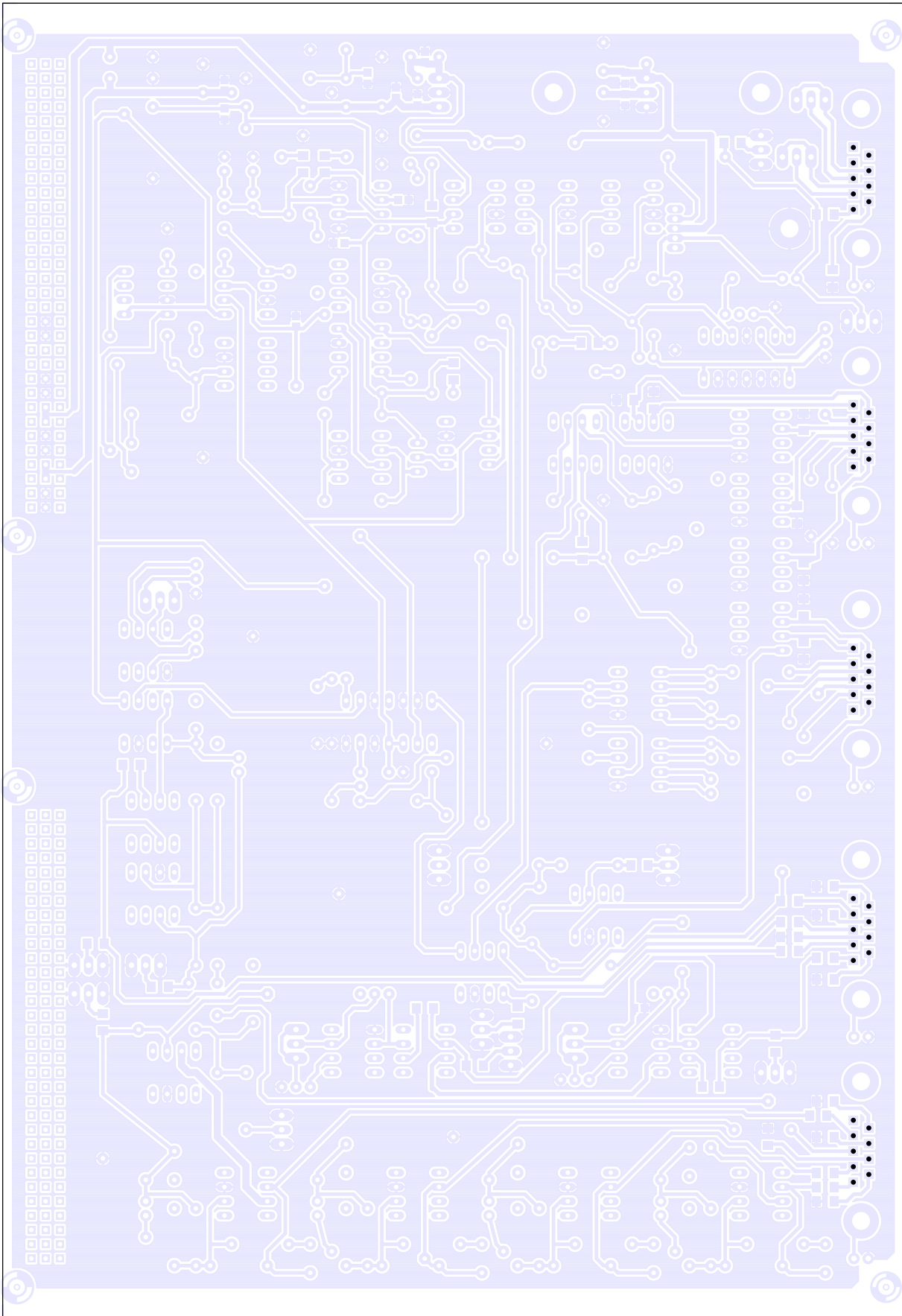


Figure 16: Board bottom view showing drills with 0.9 mm (0.035 in) diameter

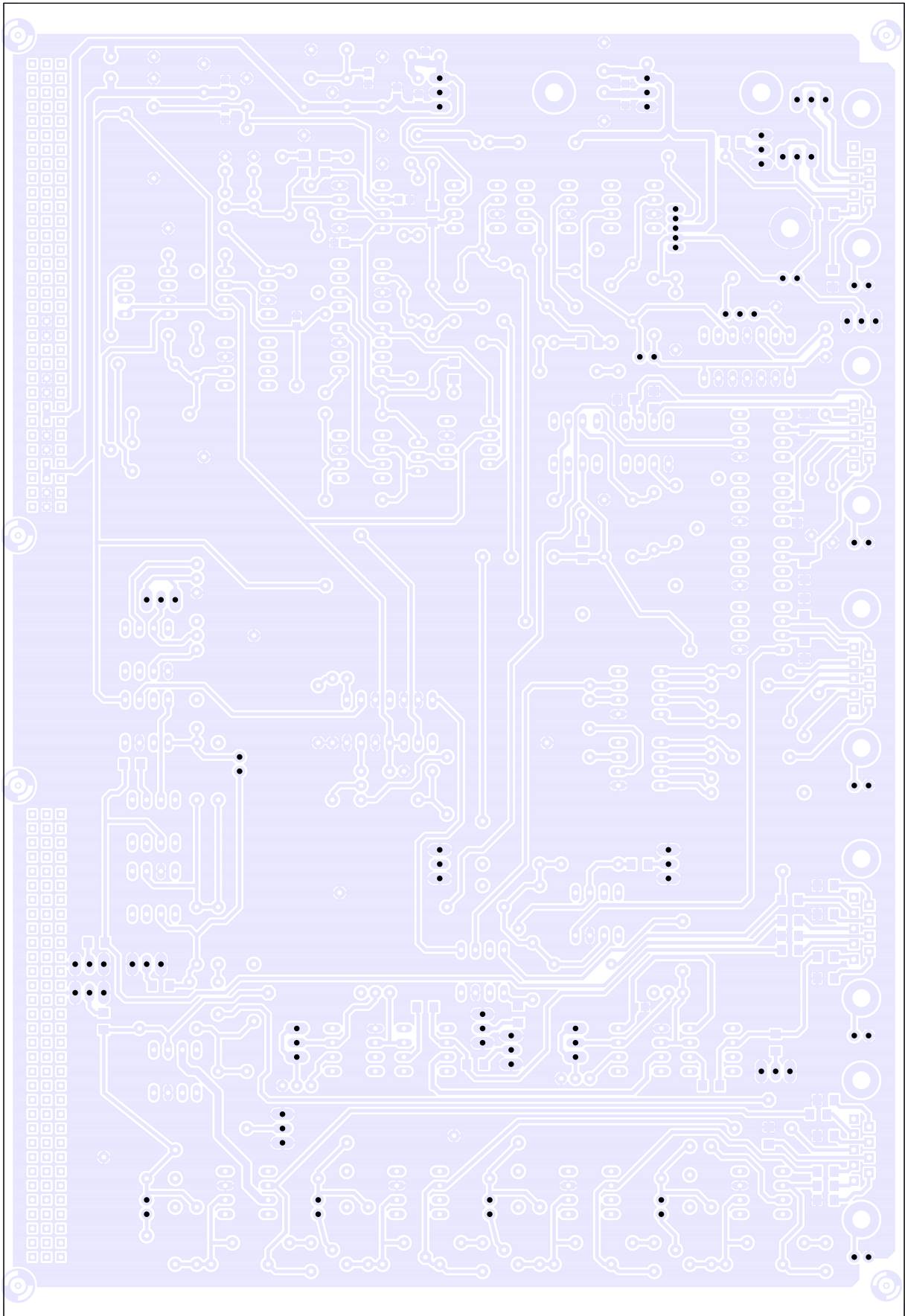


Figure 17: Board bottom view showing drills with 1.0 mm (0.039 in) diameter

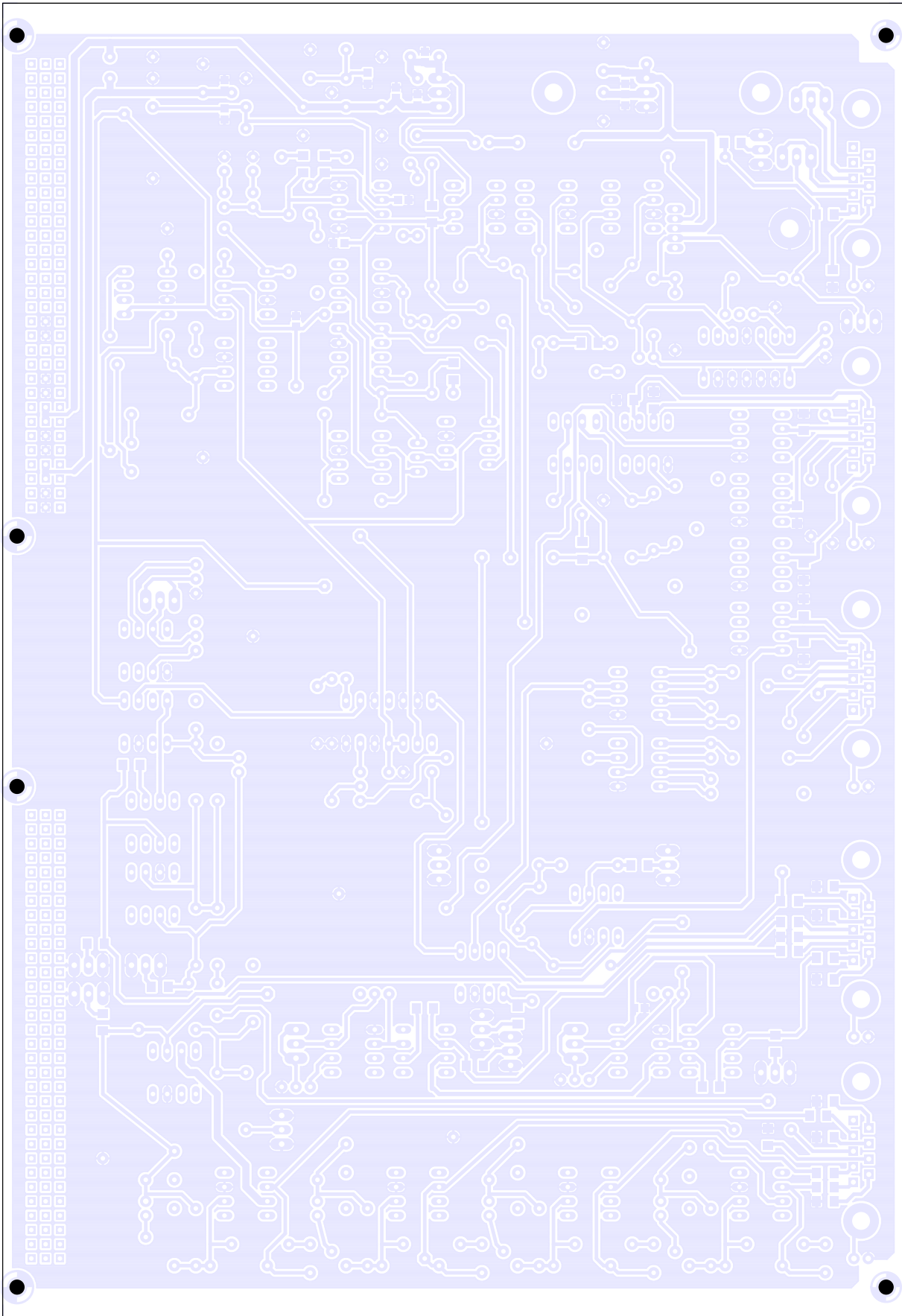


Figure 18: Board bottom view showing drills with 2.7 mm (0.106 in) diameter

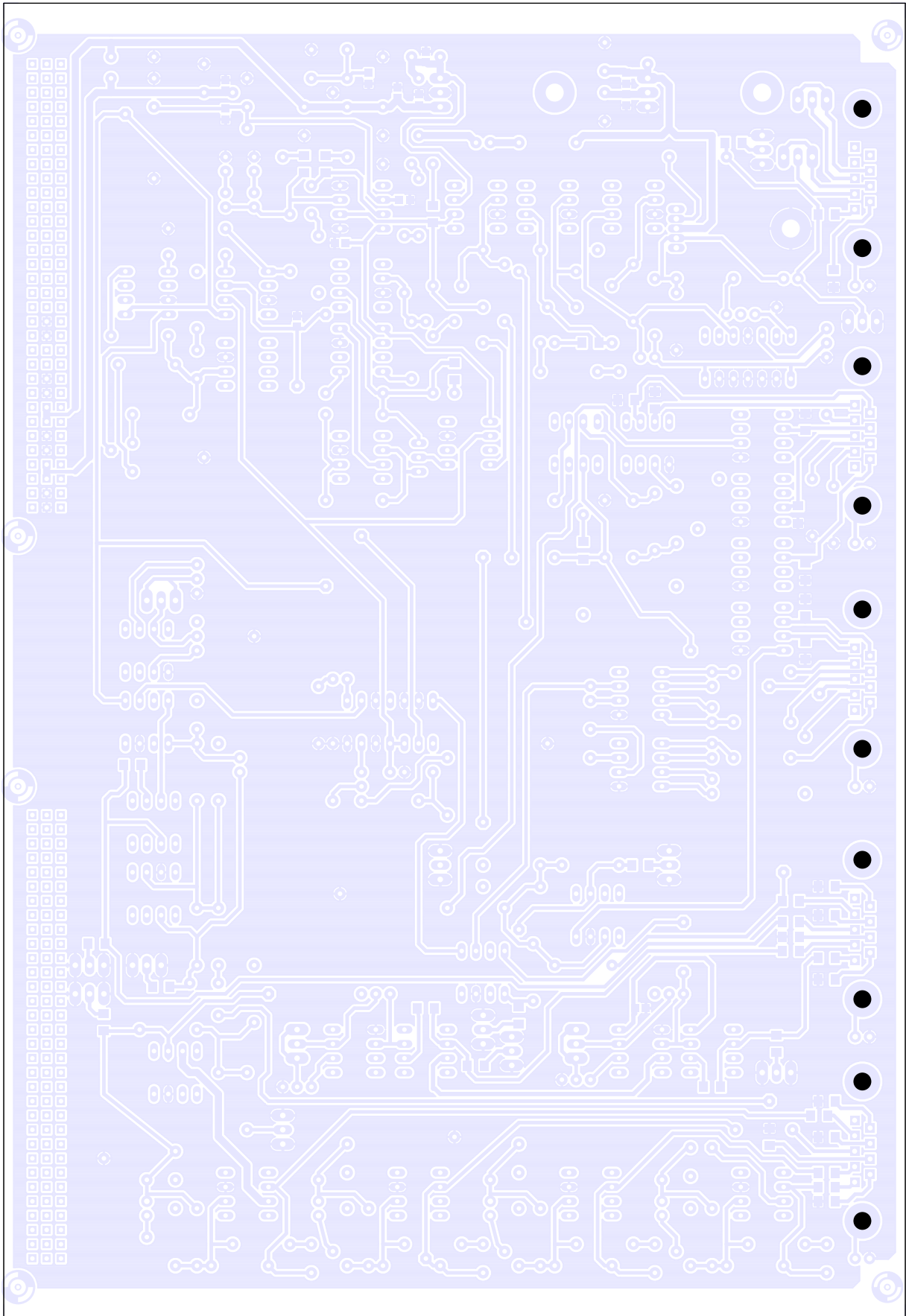


Figure 19: Board bottom view showing drills with 3.2 mm (0.125 in) diameter

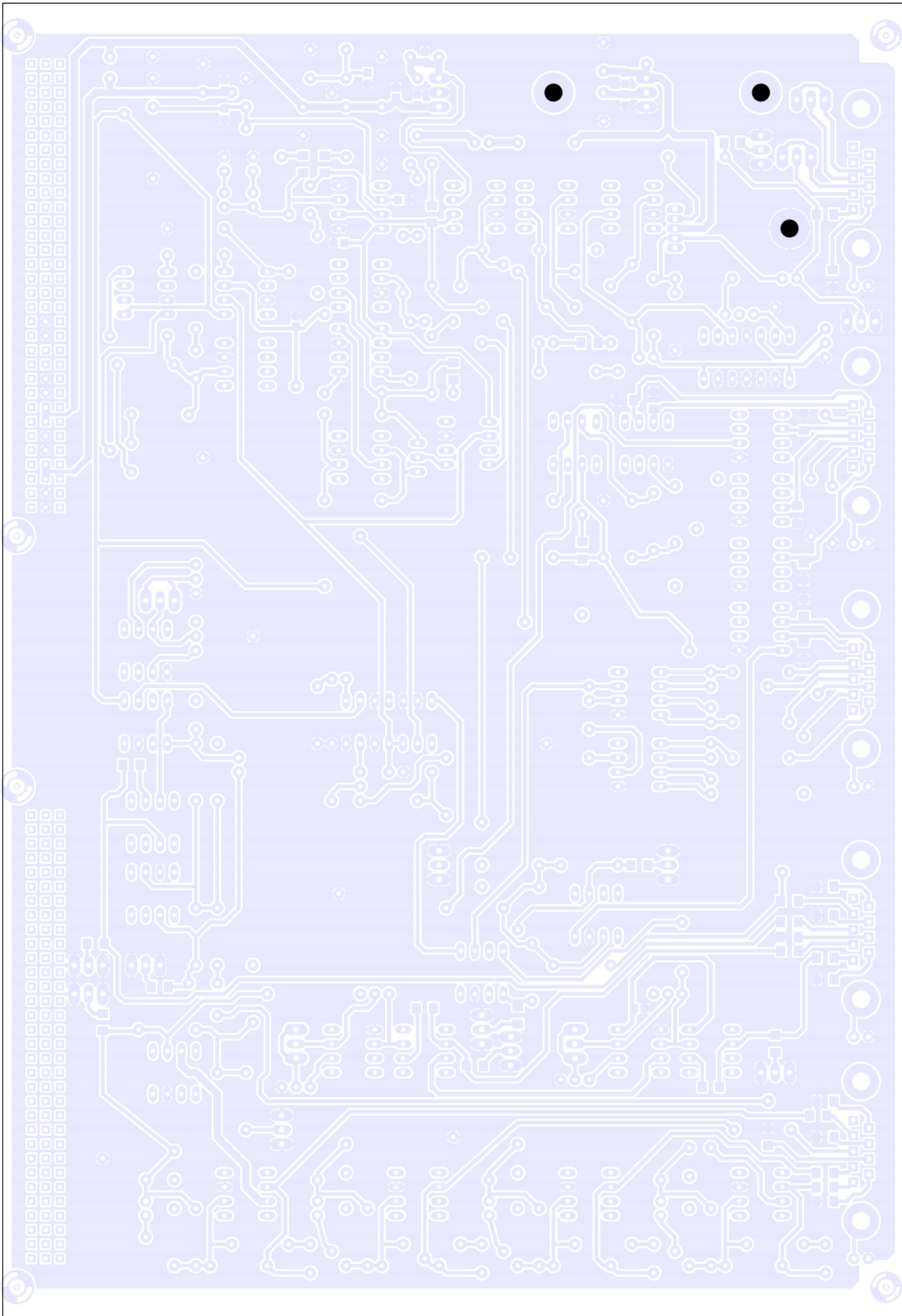


Figure 20: Board bottom view showing drills with 3.2 mm (0.126 in) diameter

Circuit Lists

Drill list: The following table shows all *final* drill diameters used in the board. When manually drilling the clearance holes, round up to the nearest available drill bit diameter, ensuring that all components fit well. When manufacturing *through-plated* boards, adjust for the additional copper coating by increasing the diameter accordingly.

\varnothing [μm]	\varnothing [mm]	\varnothing [in]	Count
812	0.8	0.032	807
889	0.9	0.035	45
990	1.0	0.039	86
2692	2.7	0.106	6
3175	3.2	0.125	10
3200	3.2	0.126	3
Total			957

Table 1: Drill diameters used in the board

Standard properties: If not explicitly stated otherwise in the schematics or value and part lists, the circuit components have the following standard properties. Parts with ‘better’ properties can be easily substituted, but care should be taken if the specifications are *not* met.

- Wired resistors: Metal film 0.6 W, 1%, 200 V, TK 100
- SMD resistors: 1%, 150 V, TK 50, MiniMELF in thin film, other packages in thick film technology

Value list: The following list shows all components available on the board (sorted by part *values*) and can be used to quickly gather components. Additional information can possibly be found directly on the board (or in the schematics).

```

1 EAGLE Version 5.10.0 Copyright (c) 1988-2010 CadSoft
2 Board value list of 'ISS.brd'
3 Exported at 2010-11-22 17:38
4 Created with macro 'plot.ulp' (c) Andreas Weidner
5 Shown are: Value/Type,Package,Number,Names
6
7 ---C---
8 5p6          C-0.2"          (1*)    C66
9 1n           C-SMD:0805        (8*)    C16, C18, C24, C25, C26, C27, C90, C91
10 10n         C-0.2"          (1*)    C86
11 15n*        C-0.2"          (2*)    C38, C39
12 100n        C-SMD:0805        (71*)   C1, C2, C5, C6, C10, C19, C21, C30, C31, C34,
13                                     C35, C36, C37, C40, C41, C42, C43, C44, C45,
14                                     C46, C47, C48, C49, C50, C51, C52, C53, C54,
15                                     C55, C56, C57, C58, C59, C60, C61, C62, C63,
16                                     C64, C65, C67, C68, C69, C70, C71, C72, C73,
17                                     C74, C75, C76, C77, C78, C79, C80, C81, C82,
18                                     C84, C85, C87, C88, C94, C95, C96, C97, C98,
19                                     C99, C100, C101, C102, C103, C106, C107
20 1u          C-WIMA:MKS2-0.2" (1*)    C93
21 10u         C-WIMA:MKS2-0.2" (3*)    C9, C11, C83
22 22u         CE-TANTAL:0.2"   (8*)    C14, C20, C22, C23, C28, C29, C89, C92
23 *           C-0.2"          (4*)    C32, C33, C104, C105
24             C-WIMA:MKS2-0.2" (8*)    C3, C4, C7, C8, C12, C13, C15, C17
25
26 ---D---
27 1N4148      D-0.1"          (9*)    D1, D3, D4, D5, D11, D12, D13, D14, D15
28             D-0.4"          (1*)    D6
29 15V         DZ-0.4"          (1*)    D10

```

30	(front)	LED-3mm	(1*)	D9
31	front	LED-3mm	(2*)	D7, D8
32				
33	---J---			
34	closed	JMP:2-pin	(5*)	J6, J12, J13, J14, J15
35	open	JMP:2-pin	(7*)	J1, J2, J3, J4, J5, J7, J8
36				
37	---N---			
38	*	DIP-8	(3*)	N10, N11, N38
39	74HC32	DIP-14	(1*)	N15
40	7805	TO-92	(1*)	N25
41	7815	TO-220	(1*)	N27
42	7905	TO-92	(1*)	N36
43	7915	TO-220	(1*)	N28
44	AD603	DIP-8	(1*)	N29
45	AD620	DIP-8	(8*)	N3, N4, N5, N6, N7, N16, N17, N19
46	AD734	DIP-14	(1*)	N2
47	BUF634H	TO220-5-HORZ	(1*)	N34
48	DG417	DIP-8	(2*)	N23, N26
49	DG418	DIP-8	(3*)	N14, N24, N40
50	DG419	DIP-8	(1*)	N21
51	HCPL2231	DIP-8	(2*)	N1, N41
52	OP27	DIP-8	(12*)	N8, N13, N18, N20, N22, N30, N31, N32, N33, N35, N37, N39
53				
54	OP27*	DIP-8	(2*)	N9, N12
55				
56	---P---			
57	50k	P01N	(1*)	P1
58				
59	---R---			
60	0	R-0.4"	(1*)	R94
61	100	R-0.4"	(3*)	R9, R55, R110
62		R-SMD:1206	(38*)	R7, R18, R24, R29, R30, R31, R32, R33, R34, R39, R40, R41, R42, R51, R52, R53, R54, R56, R63, R74, R75, R76, R78, R81, R82, R86, R87, R89, R90, R91, R92, R95, R103, R104, R105, R106, R107, R108
63				
64				
65				
66				
67	750	R-0.4"	(2*)	R100, R101
68	820	R-0.4"	(1*)	R116
69	866	R-0.4"	(1*)	R77
70	1k	R-0.4"	(9*)	R58, R59, R61, R62, R64, R65, R97, R111, R112
71	2k15	R-0.4"	(1*)	R83
72	2k2*	R-0.4"	(1*)	R69
73	2k4*	R-0.4"	(2*)	R70, R73
74	5k*	R-0.4"	(2*)	R67, R68
75	5k9	R-0.4"	(4*)	R3, R4, R5, R35
76	10k	R-0.4"	(12*)	R57, R60, R79, R80, R84, R85, R93, R96, R98, R102, R109, R115
77				
78	10k*	R-0.4"	(1*)	R66
79	16k	R-0.4"	(1*)	R99
80	16k2	R-0.4"	(1*)	R88
81	30k	R-0.4"	(1*)	R117
82	50k*	R-0.4"	(2*)	R71, R72
83	162k	R-0.4"	(2*)	R6, R8
84	1M	R-0.4"	(3*)	R23, R36, R49
85		R-SMD:1206	(7*)	R1, R2, R37, R38, R46, R48, R50
86	*	R-0.4"	(22*)	R10, R11, R12, R13, R14, R15, R16, R17, R19, R20, R21, R22, R25, R26, R27, R28, R43, R44, R45, R47, R113, R114
87				
88				

89				
90	---S---			
91	Inverter on/off	Toggle-DIP:1*2	(1*)	S8
92	O. PD single/diff	Toggle-DIP:1*2	(1*)	S6
93	PD A single/diff	Toggle-DIP:1*2	(1*)	S4
94	PD B single/diff	Toggle-DIP:1*2	(1*)	S1
95	bypass on/off	Toggle-DIP:1*2	(3*)	S2, S3, S5
96				
97	---X---			
98	-24V	Testpin	(1*)	X35
99	-15V	Testpin	(1*)	X33
100	-5V	Testpin	(1*)	X29
101	5V	Testpin	(1*)	X8
102	+15V	Testpin	(1*)	X32
103	+24V	Testpin	(1*)	X34
104	AOM Offset	Testpin	(1*)	X45
105	Adder	Testpin	(1*)	X60
106	Closed	Testpin	(1*)	X37
107	Closed2	Testpin	(1*)	X47
108	GND	Testpin	(9*)	X39, X50, X51, X52, X55, X56, X57, X58, X59
109	Gain	Testpin	(1*)	X49
110	Gain1	Testpin	(1*)	X42
111	Gain2	Testpin	(1*)	X26
112	IN1	D-SUB:9-pin/US/male	(1*)	X1
113	IN2	D-SUB:9-pin/US/male	(1*)	X2
114	Integrators	Testpin	(1*)	X38
115	Interchange	Testpin	(1*)	X36
116	OUT1	D-SUB:9-pin/US/female	(1*)	X3
117	OUT2	D-SUB:9-pin/US/female	(1*)	X4
118	OUT3	D-SUB:9-pin/US/female	(1*)	X5
119	OffsetAOM	Testpin	(1*)	X54
120	Outer Closed	Testpin	(1*)	X31
121	Outer PD In	Crimp:RG174/vert.	(1*)	X13
122	PD A In	Crimp:RG174/vert.	(1*)	X14
123	PD B In	Crimp:RG174/vert.	(1*)	X15
124	QPD dX In	Crimp:RG174/vert.	(1*)	X61
125	QPD dY In	Crimp:RG174/vert.	(1*)	X62
126	RefSignal	Testpin	(1*)	X40
127	TF1In	Testpin	(1*)	X48
128	TF2In	Testpin	(1*)	X53
129	Test Int1	Testpin	(1*)	X25
130	Test Int2	Testpin	(1*)	X28
131	W1	Testpin	(4*)	X9, X11, X30, X43
132	W2	Testpin	(3*)	X10, X12, X44
133	W4	Testpin	(1*)	X46
134	[undefined]	Backplane:96-pin/ABC	(2*)	X6, X7
135	control out	Crimp:RG174/vert.	(1*)	X41
136	front (input)	Crimp:RG174/vert.	(2*)	X22, X23
137	front (output)	Crimp:RG174/vert.	(7*)	X16, X17, X18, X19, X20, X21, X24
138	to AOM	Crimp:RG174/vert.	(1*)	X27

Part list: The following list shows all components available in the schematics (sorted by part *names*) and can be used to quickly locate components. The column *Layer/Cell* shows the position of the part on the board: *T* for top side and *B* for bottom side, followed by the cell of the surrounding frame (if available). The column *Sheets/Cells* shows the position of *all* the part's gates in the schematics: Sheet number followed by the cell of the surrounding frame (if available). Additional information can possibly be found directly in the schematics.

1 EAGLE Version 5.10.0 Copyright (c) 1988-2010 CadSoft

2 Schematics part list of 'ISS.sch'
3 Exported at 2010-11-22 17:38
4 Created with macro 'plot.ulp' (c) Andreas Weidner
5 Shown are: Name,Value/Type,Package,Device,Layer/Cell,Sheets/Cells

6
7 ---C---

8	C1	100n	C-SMD:0805	CS	T-D3	4-D9
9	C2	100n	C-SMD:0805	CS	T-C2	4-E9
10	C3	*	C-WIMA:MKS2-0.2"	C02B	T-H2	5-B2
11	C4	*	C-WIMA:MKS2-0.2"	C02B	T-I1	5-A4
12	C5	100n	C-SMD:0805	CS	T-D3	4-D10
13	C6	100n	C-SMD:0805	CS	T-C3	4-E10
14	C7	*	C-WIMA:MKS2-0.2"	C02B	T-H5	5-B7
15	C8	*	C-WIMA:MKS2-0.2"	C02B	T-I4	5-A9
16	C9	10u	C-WIMA:MKS2-0.2"	C02C	T-D3	4-A8
17	C10	100n	C-SMD:0805	CS	T-E3	3-F2
18	C11	10u	C-WIMA:MKS2-0.2"	C02C	T-D3	4-B8
19	C12	*	C-WIMA:MKS2-0.2"	C02B	T-H4	5-D2
20	C13	*	C-WIMA:MKS2-0.2"	C02B	T-I3	5-C4
21	C14	22u	CE-TANTAL:0.2"	CE02D	T-A5	1-B8
22	C15	*	C-WIMA:MKS2-0.2"	C02B	T-H6	5-D8
23	C16	1n	C-SMD:0805	CS	B-A4	1-B9
24	C17	*	C-WIMA:MKS2-0.2"	C02B	T-I5	5-C9
25	C18	1n	C-SMD:0805	CS	B-A5	1-B9
26	C19	100n	C-SMD:0805	CS	T-I5	5-F4
27	C20	22u	CE-TANTAL:0.2"	CE02D	T-A5	1-B10
28	C21	100n	C-SMD:0805	CS	T-H6	5-G4
29	C22	22u	CE-TANTAL:0.2"	CE02D	T-A5	1-D8
30	C23	22u	CE-TANTAL:0.2"	CE02D	T-A3	1-D8
31	C24	1n	C-SMD:0805	CS	B-A4	1-D9
32	C25	1n	C-SMD:0805	CS	B-A3	1-D9
33	C26	1n	C-SMD:0805	CS	B-A4	1-D9
34	C27	1n	C-SMD:0805	CS	B-A3	1-D9
35	C28	22u	CE-TANTAL:0.2"	CE02D	T-A4	1-D10
36	C29	22u	CE-TANTAL:0.2"	CE02D	T-A3	1-D10
37	C30	100n	C-SMD:0805	CS	T-E4	3-F3
38	C31	100n	C-SMD:0805	CS	T-E3	3-F2
39	C32	*	C-0.2"	C	T-E6	7-E3
40	C33	*	C-0.2"	C	T-G6	7-D5
41	C34	100n	C-SMD:0805	CS	T-D2	4-D7
42	C35	100n	C-SMD:0805	CS	T-E2	4-D8
43	C36	100n	C-SMD:0805	CS	T-D2	4-D8
44	C37	100n	C-SMD:0805	CS	T-D2	4-D9
45	C38	15n*	C-0.2"	C	T-C6	8-B3
46	C39	15n*	C-0.2"	C	T-C4	8-C10
47	C40	100n	C-SMD:0805	CS	T-D1	4-E7
48	C41	100n	C-SMD:0805	CS	T-E1	4-E8
49	C42	100n	C-SMD:0805	CS	T-D1	4-E8
50	C43	100n	C-SMD:0805	CS	T-D1	4-E9
51	C44	100n	C-SMD:0805	C0805	T-F6	7-G3
52	C45	100n	C-SMD:0805	C0805	T-F7	7-F3
53	C46	100n	C-SMD:0805	CS	T-I4	5-F2
54	C47	100n	C-SMD:0805	CS	T-I1	5-F3
55	C48	100n	C-SMD:0805	CS	T-I3	5-F3
56	C49	100n	C-SMD:0805	CS	T-H5	5-G2
57	C50	100n	C-SMD:0805	CS	T-H2	5-G3
58	C51	100n	C-SMD:0805	CS	T-H3	5-G3
59	C52	100n	C-SMD:0805	C0805	T-G3	6-G6
60	C53	100n	C-SMD:0805	C0805	T-G3	6-F6

61	C54	100n	C-SMD:0805	C0805	T-G2	6-G6
62	C55	100n	C-SMD:0805	C0805	T-H2	6-F6
63	C56	100n	C-SMD:0805	C0805	T-G5	6-G5
64	C57	100n	C-SMD:0805	C0805	T-H5	6-F5
65	C58	100n	C-SMD:0805	C0805	B-G3	6-G5
66	C59	100n	C-SMD:0805	C0805	T-H2	6-F5
67	C60	100n	C-SMD:0805	C0805	T-E6	6-G4
68	C61	100n	C-SMD:0805	C0805	T-E7	6-F4
69	C62	100n	C-SMD:0805	C0805	T-E6	7-G6
70	C63	100n	C-SMD:0805	C0805	T-E7	7-F6
71	C64	100n	C-SMD:0805	C0805	T-G4	6-G3
72	C65	100n	C-SMD:0805	C0805	T-G4	6-F3
73	C66	5p6	C-0.2"	C	T-B4	8-C7
74	C67	100n	C-SMD:0805	C0805	T-C6	8-F4
75	C68	100n	C-SMD:0805	C0805	T-C5	8-F5
76	C69	100n	C-SMD:0805	C0805	T-C6	8-G4
77	C70	100n	C-SMD:0805	C0805	T-B3	9-F5
78	C71	100n	C-SMD:0805	C0805	T-B6	8-G5
79	C72	100n	C-SMD:0805	C0805	T-B3	9-G5
80	C73	100n	C-SMD:0805	C0805	T-C6	8-F6
81	C74	100n	C-SMD:0805	C0805	T-B6	8-G6
82	C75	100n	C-SMD:0805	C0805	T-C5	8-F7
83	C76	100n	C-SMD:0805	C0805	T-C4	8-G7
84	C77	100n	C-SMD:0805	C0805	B-B5	8-F2
85	C78	100n	C-SMD:0805	C0805	B-B4	8-G2
86	C79	100n	C-SMD:0805	C0805	T-C5	8-F5
87	C80	100n	C-SMD:0805	C0805	B-C5	8-G5
88	C81	100n	C-SMD:0805	C0805	T-G6	7-F4
89	C82	100n	C-SMD:0805	C0805	T-H7	7-G4
90	C83	10u	C-WIMA:MKS2-0.2"	C02C	T-B4	8-D3
91	C84	100n	C-SMD:0805	C0805	T-B4	8-F4
92	C85	100n	C-SMD:0805	C0805	T-B4	8-G4
93	C86	10n	C-0.2"	C	T-F4	3-D5
94	C87	100n	C-SMD:0805	C0805	T-B3	9-F6
95	C88	100n	C-SMD:0805	C0805	T-B2	9-G6
96	C89	22u	CE-TANTAL:0.2"	CE02D	T-A6	1-B10
97	C90	1n	C-SMD:0805	CS	B-A6	1-B9
98	C91	1n	C-SMD:0805	CS	B-A6	1-B9
99	C92	22u	CE-TANTAL:0.2"	CE02D	T-A6	1-B8
100	C93	1u	C-WIMA:MKS2-0.2"	C02C	T-C3	9-D3
101	C94	100n	C-SMD:0805	C0805	T-H4	7-F5
102	C95	100n	C-SMD:0805	C0805	T-G5	7-G5
103	C96	100n	C-SMD:0805	C0805	T-B4	9-F5
104	C97	100n	C-SMD:0805	C0805	T-B3	9-G5
105	C98	100n	C-SMD:0805	C0805	T-G7	7-F4
106	C99	100n	C-SMD:0805	C0805	T-F6	7-G4
107	C100	100n	C-SMD:0805	C0805	T-D4	8-F3
108	C101	100n	C-SMD:0805	C0805	T-C5	8-G3
109	C102	100n	C-SMD:0805	C0805	T-D4	9-F6
110	C103	100n	C-SMD:0805	C0805	T-C4	9-G6
111	C104	*	C-0.2"	C	T-D6	8-B2
112	C105	*	C-0.2"	C	T-B5	8-C9
113	C106	100n	C-SMD:0805	C0805	T-C1	9-F4
114	C107	100n	C-SMD:0805	C0805	T-C2	9-G4
115						
116	---	D---				
117	D1	1N4148	D-0.1"	1N4148-01N	T-F2	3-D3
118	D3	1N4148	D-0.1"	1N4148-01N	T-E2	3-B3
119	D4	1N4148	D-0.1"	1N4148-01N	T-F2	3-E3

120	D5	1N4148	D-0.1"	1N4148-01N	T-E2	3-A3
121	D6	1N4148	D-0.4"	D	T-F4	3-D5
122	D7	front	LED-3mm	DL	T-F5	3-E8
123	D8	front	LED-3mm	DL	T-E5	3-B6
124	D9	(front)	LED-3mm	DL	T-A4	1-D7
125	D10	15V	DZ-0.4"	DZ	T-A3	1-D7
126	D11	1N4148	D-0.1"	1N4148-01	T-B6	8-B5
127	D12	1N4148	D-0.1"	1N4148-01	T-B6	8-C5
128	D13	1N4148	D-0.1"	1N4148-01	T-B6	8-C5
129	D14	1N4148	D-0.1"	1N4148-01	T-B6	8-C5
130	D15	1N4148	D-0.1"	1N4148-01N	T-C1	9-A8
131						
132	---J---					
133	J1	open	JMP:2-pin	JP02	T-D1	2-B8
134	J2	open	JMP:2-pin	JP02	T-F1	2-C8
135	J3	open	JMP:2-pin	JP02	T-H1	2-B9
136	J4	open	JMP:2-pin	JP02	T-I1	2-C9
137	J5	open	JMP:2-pin	JP02	T-B1	2-C9
138	J6	closed	JMP:2-pin	JP02	T-F6	7-E4
139	J7	open	JMP:2-pin	JP02	T-B1	9-C9
140	J8	open	JMP:2-pin	JP02	T-C3	9-C7
141	J12	closed	JMP:2-pin	JP02	T-I2	5-B3
142	J13	closed	JMP:2-pin	JP02	T-I4	5-D3
143	J14	closed	JMP:2-pin	JP02	T-I5	5-B8
144	J15	closed	JMP:2-pin	JP02	T-I6	5-D8
145						
146	---N---					
147	N1	HCPL2231	DIP-8	HCPL2231	T-E3	3-A4, 3-B4, 3-G1
148	N2	AD734	DIP-14	AD734	T-C2	9-B7, 9-F4
149	N3	AD620	DIP-8	AD620	T-C2	4-A2, 4-E9
150	N4	AD620	DIP-8	AD620	T-D2	4-C2, 4-E8
151	N5	AD620	DIP-8	AD620	T-D2	4-E2, 4-E7
152	N6	AD620	DIP-8	AD620	T-E2	4-E8, 4-F2
153	N7	AD620	DIP-8	AD620	T-D3	4-B6, 4-E9
154	N8	OP27	DIP-8	OP27	T-D3	4-B8, 4-E10
155	N9	OP27*	DIP-8	OP27	T-I2	5-B4, 5-F2
156	N10	*	DIP-8	OP27	T-I3	5-D4, 5-F3
157	N11	*	DIP-8	OP27	T-I6	5-D9, 5-F4
158	N12	OP27*	DIP-8	OP27	T-I4	5-B9, 5-F2
159	N13	OP27	DIP-8	OP27	T-H2	6-B4, 6-F4
160	N14	DG418	DIP-8	DG418	T-E6	7-C3, 7-F6
161	N15	74HC32	DIP-14	74HC32	T-E5	3-B6, 3-E6, 3-E7, 3-G3, 3-G5
162						
163	N16	AD620	DIP-8	AD620	T-H3	6-B2, 6-F5
164	N17	AD620	DIP-8	AD620	T-H5	6-D2, 6-F5
165	N18	OP27	DIP-8	OP27	T-F6	7-B4, 7-F3
166	N19	AD620	DIP-8	AD620	T-E6	7-B3, 7-F5
167	N20	OP27	DIP-8	OP27	T-G3	6-D9, 6-F7
168	N21	DG419	DIP-8	DG419	T-G4	6-C6, 6-F3
169	N22	OP27	DIP-8	OP27	T-C6	8-C3, 8-F4
170	N23	DG417	DIP-8	DG417	T-C6	8-B3, 8-F6
171	N24	DG418	DIP-8	DG418	T-C6	8-C4, 8-F5
172	N25	7805	TO-92	7805L1	T-A5	1-B9
173	N26	DG417	DIP-8	DG417	T-C5	8-B10, 8-F7
174	N27	7815	TO-220	7815L	T-A4	1-D9
175	N28	7915	TO-220	7915L	T-A3	1-D9
176	N29	AD603	DIP-8	AD603	T-B5	8-C7, 8-F2
177	N30	OP27	DIP-8	OP27	T-B3	9-C5, 9-F5
178	N31	OP27	DIP-8	OP27	T-B5	8-C10, 8-F5

179	N32	OP27	DIP-8	OP27	T-H6	7-E8,7-F4
180	N33	OP27	DIP-8	OP27	T-B4	8-E3,8-F4
181	N34	BUF634H	TO220-5-HORZ	BUF634-CASE	T-B2	9-B9,9-D9,9-F6
182	N35	OP27	DIP-8	OP27	T-B3	9-E3,9-F5
183	N36	7905	TO-92	7905L1	T-A6	1-C9
184	N37	OP27	DIP-8	OP27	T-H4	6-E4,6-F6
185	N38	*	DIP-8	OP27	T-G6	7-E5,7-F5
186	N39	OP27	DIP-8	OP27	T-D5	8-E9,8-F3
187	N40	DG418	DIP-8	DG418	T-D4	9-C2,9-F6
188	N41	HCPL2231	DIP-8	HCPL2231	T-F3	3-D4,3-E4,3-G2
189						
190	---P---					
191	P1	50k	P01N	P	T-C2	9-C9
192						
193	---R---					
194	R1	1M	R-SMD:1206	RS	B-C3	4-C6
195	R2	1M	R-SMD:1206	RS	B-C3	4-B5
196	R3	5k9	R-0.4"	R	T-E2	3-B3
197	R4	5k9	R-0.4"	R	T-F1	3-E3
198	R5	5k9	R-0.4"	R	T-E2	3-A3
199	R6	162k	R-0.4"	R	T-D2	4-B7
200	R7	100	R-SMD:1206	R1206	B-G1	4-A10
201	R8	162k	R-0.4"	R	T-D3	4-B8
202	R9	100	R-0.4"	R	T-D3	4-B8
203	R10	*	R-0.4"	R	T-I3	5-C3
204	R11	*	R-0.4"	R	T-I2	5-A3
205	R12	*	R-0.4"	R	T-I2	5-A3
206	R13	*	R-0.4"	R	T-I2	5-B3
207	R14	*	R-0.4"	R	T-I2	5-B3
208	R15	*	R-0.4"	R	T-I3	5-C3
209	R16	*	R-0.4"	R	T-I3	5-D3
210	R17	*	R-0.4"	R	T-I4	5-D3
211	R18	100	R-SMD:1206	RS	B-H1	5-D5
212	R19	*	R-0.4"	R	T-I4	5-A9
213	R20	*	R-0.4"	R	T-I4	5-A9
214	R21	*	R-0.4"	R	T-I5	5-B8
215	R22	*	R-0.4"	R	T-I5	5-B8
216	R23	1M	R-0.4"	R	T-C1	4-B2
217	R24	100	R-SMD:1206	RS	B-H2	5-D5
218	R25	*	R-0.4"	R	T-I6	5-C9
219	R26	*	R-0.4"	R	T-I5	5-C9
220	R27	*	R-0.4"	R	T-I6	5-D8
221	R28	*	R-0.4"	R	T-I6	5-D8
222	R29	100	R-SMD:1206	RS	B-H1	5-D10
223	R30	100	R-SMD:1206	RS	B-H1	5-D10
224	R31	100	R-SMD:1206	R1206	B-H2	6-B4
225	R32	100	R-SMD:1206	R1206	B-G4	6-D4
226	R33	100	R-SMD:1206	R1206	B-H2	6-B5
227	R34	100	R-SMD:1206	R1206	B-H4	6-E5
228	R35	5k9	R-0.4"	R	T-F2	3-D3
229	R36	1M	R-0.4"	R	T-D1	4-D2
230	R37	1M	R-SMD:1206	RS	B-D1	4-E2
231	R38	1M	R-SMD:1206	RS	B-E1	4-G2
232	R39	100	R-SMD:1206	R1206	B-G1	4-B10
233	R40	100	R-SMD:1206	R1206	B-F6	7-B4
234	R41	100	R-SMD:1206	R1206	B-G7	7-B5
235	R42	100	R-SMD:1206	R1206	B-G4	6-C7
236	R43	*	R-0.4"	R	T-F6	7-E4
237	R44	*	R-0.4"	R	T-F6	7-D4

238	R45	*	R-0.4"	R	T-G6	7-D4
239	R46	1M	R-SMD:1206	RS	B-C1	4-A2
240	R47	*	R-0.4"	R	T-G6	7-D4
241	R48	1M	R-SMD:1206	RS	B-D1	4-C2
242	R49	1M	R-0.4"	R	T-D1	4-D2
243	R50	1M	R-SMD:1206	RS	B-E1	4-F2
244	R51	100	R-SMD:1206	R1206	B-G6	7-D6
245	R52	100	R-SMD:1206	RS	B-I1	5-B5
246	R53	100	R-SMD:1206	RS	B-I1	5-B5
247	R54	100	R-SMD:1206	R1206	B-G7	7-D9
248	R55	100	R-0.4"	R	T-H2	5-B10
249	R56	100	R-SMD:1206	RS	B-H1	5-B10
250	R57	10k	R-0.4"	R	T-G6	7-D8
251	R58	1k	R-0.4"	R	T-G6	7-D8
252	R59	1k	R-0.4"	R	T-H6	7-E8
253	R60	10k	R-0.4"	R	T-F4	6-D8
254	R61	1k	R-0.4"	R	T-F3	6-D9
255	R62	1k	R-0.4"	R	T-G3	6-C8
256	R63	100	R-SMD:1206	R1206	B-F3	6-D10
257	R64	1k	R-0.4"	R	T-G3	6-C8
258	R65	1k	R-0.4"	R	T-G4	6-C8
259	R66	10k*	R-0.4"	R	T-C6	8-C2
260	R67	5k*	R-0.4"	R	T-B6	8-B3
261	R68	5k*	R-0.4"	R	T-C6	8-B2
262	R69	2k2*	R-0.4"	R	T-C6	8-B3
263	R70	2k4*	R-0.4"	R	T-B4	8-C9
264	R71	50k*	R-0.4"	R	T-C5	8-B10
265	R72	50k*	R-0.4"	R	T-C4	8-B9
266	R73	2k4*	R-0.4"	R	T-C4	8-C10
267	R74	100	R-SMD:1206	R1206	B-G1	7-A5
268	R75	100	R-SMD:1206	R1206	B-G1	6-A5
269	R76	100	R-SMD:1206	R1206	B-G1	6-D5
270	R77	866	R-0.4"	R	T-A4	1-D7
271	R78	100	R-SMD:1206	R1206	B-D3	4-B10
272	R79	10k	R-0.4"	R	T-H6	7-D8
273	R80	10k	R-0.4"	R	T-G4	6-D8
274	R81	100	R-SMD:1206	R1206	B-B5	8-C6
275	R82	100	R-SMD:1206	R1206	B-B5	8-C8
276	R83	2k15	R-0.4"	R	T-B4	8-C7
277	R84	10k	R-0.4"	R	T-C3	9-C5
278	R85	10k	R-0.4"	R	T-C3	9-B6
279	R86	100	R-SMD:1206	R1206	B-B1	9-C10
280	R87	100	R-SMD:1206	R1206	B-C4	8-E8
281	R88	16k2	R-0.4"	R	T-C3	9-B9
282	R89	100	R-SMD:1206	R1206	B-B1	9-C10
283	R90	100	R-SMD:1206	R1206	B-G1	6-D4
284	R91	100	R-SMD:1206	R1206	B-G1	6-B4
285	R92	100	R-SMD:1206	R1206	B-G1	7-B4
286	R93	10k	R-0.4"	R	T-C4	9-C5
287	R94	0	R-0.4"	R	T-B2	9-B10
288	R95	100	R-SMD:1206	R1206	B-A2	9-B10
289	R96	10k	R-0.4"	R	T-B3	9-D3
290	R97	1k	R-0.4"	R	T-B4	8-E3
291	R98	10k	R-0.4"	R	T-C4	8-E2
292	R99	16k	R-0.4"	R	T-F5	3-D5
293	R100	750	R-0.4"	R	T-F5	3-E9
294	R101	750	R-0.4"	R	T-E5	3-B7
295	R102	10k	R-0.4"	R	T-B3	9-E2
296	R103	100	R-SMD:1206	R1206	B-B4	8-E6

297	R104	100	R-SMD:1206	R1206	B-C3	9-D3
298	R105	100	R-SMD:1206	R1206	T-D2	4-B4
299	R106	100	R-SMD:1206	R1206	T-D3	4-C4
300	R107	100	R-SMD:1206	R1206	T-D2	4-E4
301	R108	100	R-SMD:1206	R1206	T-E2	4-G4
302	R109	10k	R-0.4"	R	T-B6	8-B4
303	R110	100	R-0.4"	R	T-B5	8-C5
304	R111	1k	R-0.4"	R	T-D5	8-E9
305	R112	1k	R-0.4"	R	T-C5	8-E9
306	R113	*	R-0.4"	R	T-C6	8-B2
307	R114	*	R-0.4"	R	T-B5	8-C9
308	R115	10k	R-0.4"	R	T-C3	9-B5
309	R116	820	R-0.4"	R	T-C2	9-C9
310	R117	30k	R-0.4"	R	T-B2	9-C9
311						
312	---S---					
313	S1	PD B single/diff	Toggle-DIP:1*2	S1X2S01N	T-H5	6-D2
314	S2	bypass on/off	Toggle-DIP:1*2	S1X2S01N	T-G5	6-E2
315	S3	bypass on/off	Toggle-DIP:1*2	S1X2S01N	T-G2	6-B2
316	S4	PD A single/diff	Toggle-DIP:1*2	S1X2S01N	T-H3	6-B2
317	S5	bypass on/off	Toggle-DIP:1*2	S1X2S01N	T-E6	7-B3
318	S6	O. PD single/diff	Toggle-DIP:1*2	S1X2S01N	T-D6	7-B2
319	S8	Inverter on/off	Toggle-DIP:1*2	S1X2S01L	T-D4	8-E10
320						
321	---X---					
322	X1	IN1	D-SUB:9-pin/US/male	X09-2S-DMAL	T-C1	2-B3,2-B8
323	X2	IN2	D-SUB:9-pin/US/male	X09-2S-DMAL	T-E1	2-C8,2-D3
324	X3	OUT1	D-SUB:9-pin/US/female	X09-2S-DFEM	T-G1	2-B6,2-B10
325	X4	OUT2	D-SUB:9-pin/US/female	X09-2S-DFEM	T-H1	2-C10,2-D6
326	X5	OUT3	D-SUB:9-pin/US/female	X09-2S-DFEM	T-B1	2-C10,2-E6
327	X6	[undefined]	Backplane:96-pin/ABC	XB96	T-B7	1-C2,1-C3
328	X7	[undefined]	Backplane:96-pin/ABC	XB96	T-H7	1-C4,1-C5
329	X8	5V	Testpin	XT	T-A5	1-B10
330	X9	W1	Testpin	XT	T-H4	5-D2
331	X10	W2	Testpin	XT	T-I4	5-D4
332	X11	W1	Testpin	XT	T-H6	5-D7
333	X12	W2	Testpin	XT	T-I6	5-D10
334	X13	Outer PD In	Crimp:RG174/vert.	XC	T-E6	7-B1
335	X14	PD A In	Crimp:RG174/vert.	XC	T-H3	6-B1
336	X15	PD B In	Crimp:RG174/vert.	XC	T-H5	6-E1
337	X16	front (output)	Crimp:RG174/vert.	XC	T-H2	6-B5
338	X17	front (output)	Crimp:RG174/vert.	XC	T-H4	6-E5
339	X18	front (output)	Crimp:RG174/vert.	XC	T-G7	7-B5
340	X19	front (output)	Crimp:RG174/vert.	XC	T-G4	6-B7
341	X20	front (output)	Crimp:RG174/vert.	XC	T-G6	7-D6
342	X21	front (output)	Crimp:RG174/vert.	XC	T-G7	7-D9
343	X22	front (input)	Crimp:RG174/vert.	XC	T-H5	7-D7
344	X23	front (input)	Crimp:RG174/vert.	XC	T-F4	6-D8
345	X24	front (output)	Crimp:RG174/vert.	XC	T-F2	6-C10
346	X25	Test Int1	Testpin	XT	T-B5	8-B6
347	X26	Gain2	Testpin	XT	T-B5	8-B8
348	X27	to AOM	Crimp:RG174/vert.	XC	T-C1	9-B11
349	X28	Test Int2	Testpin	XT	T-C4	8-E7
350	X29	-5V	Testpin	XT	T-A6	1-C10
351	X30	W1	Testpin	XT	T-H5	5-B7
352	X31	Outer Closed	Testpin	XT	T-E3	3-B4
353	X32	+15V	Testpin	XT	T-A4	1-D10
354	X33	-15V	Testpin	XT	T-A3	1-D10
355	X34	+24V	Testpin	XT	T-A7	1-D8

356	X35	-24V	Testpin	XT	T-A7	1-D8
357	X36	Interchange	Testpin	XT	T-E3	3-A4
358	X37	Closed	Testpin	XT	T-F3	3-D4
359	X38	Integrators	Testpin	XT	T-E3	3-E4
360	X39	GND	Testpin	XT	T-A6	1-G2
361	X40	RefSignal	Testpin	XT	T-D3	4-B10
362	X41	control out	Crimp:RG174/vert.	XC	T-B2	9-B11
363	X42	Gain1	Testpin	XT	T-B4	8-E7
364	X43	W1	Testpin	XT	T-H2	5-B2
365	X44	W2	Testpin	XT	T-I2	5-B4
366	X45	AOM Offset	Testpin	XT	T-C3	9-C3
367	X46	W4	Testpin	XT	T-I5	5-B9
368	X47	Closed2	Testpin	XT	T-F5	3-E7
369	X48	TF1In	Testpin	XT	T-D2	4-B4
370	X49	Gain	Testpin	XT	T-E3	4-D4
371	X50	GND	Testpin	XT	T-D6	1-G2
372	X51	GND	Testpin	XT	T-H4	1-G2
373	X52	GND	Testpin	XT	T-F3	1-G3
374	X53	TF2In	Testpin	XT	T-D2	4-E4
375	X54	OffsetAOM	Testpin	XT	T-D2	4-G4
376	X55	GND	Testpin	XT	T-G5	1-G3
377	X56	GND	Testpin	XT	T-B6	1-G3
378	X57	GND	Testpin	XT	T-H7	1-G3
379	X58	GND	Testpin	XT	T-C2	1-G3
380	X59	GND	Testpin	XT	T-E6	1-G4
381	X60	Adder	Testpin	XT	T-C3	9-B4
382	X61	QPD dX In	Crimp:RG174/vert.	XC	T-B1	7-A8
383	X62	QPD dY In	Crimp:RG174/vert.	XC	T-A1	7-B8