
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. (The function and interface document of this control loop can be found in DCC [T-0900630](#).) 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). The control loop will be controlled by EPICS (A user manual of all PSL EPICS screens can be found in DCC [T-0900634](#).) There are some characteristics:

- 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

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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.
-

Front of the Intensity Stabilization Servo

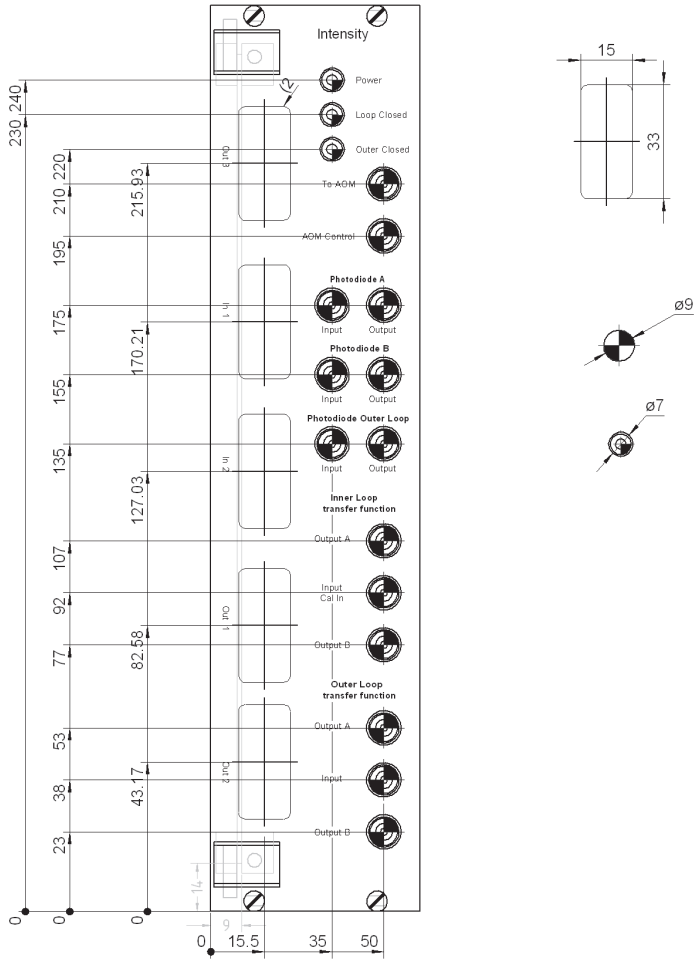
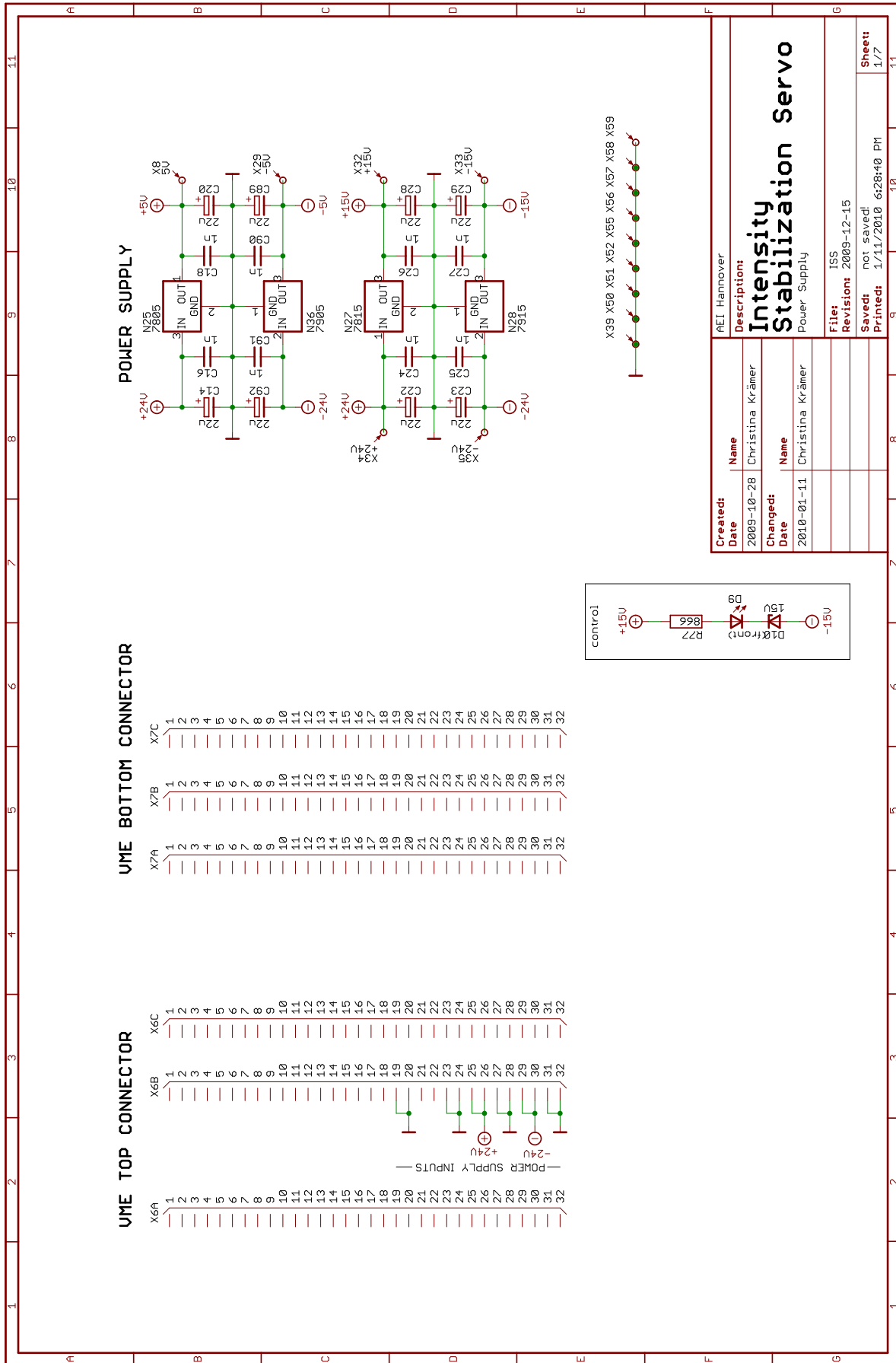


Figure 1: Front



Created:	Name	Description:
Date	2009-10-28	Christina Krämer
Changed:	Name	
Date	2010-01-11	Christina Krämer
File:	ISS	
Revision:	2009-12-15	
Saved:	not saved!	
Printed:	1/11/2010 6:28:40 PM	
Sheet:	1/7	

Figure 2: Project schematics (sheet 1)

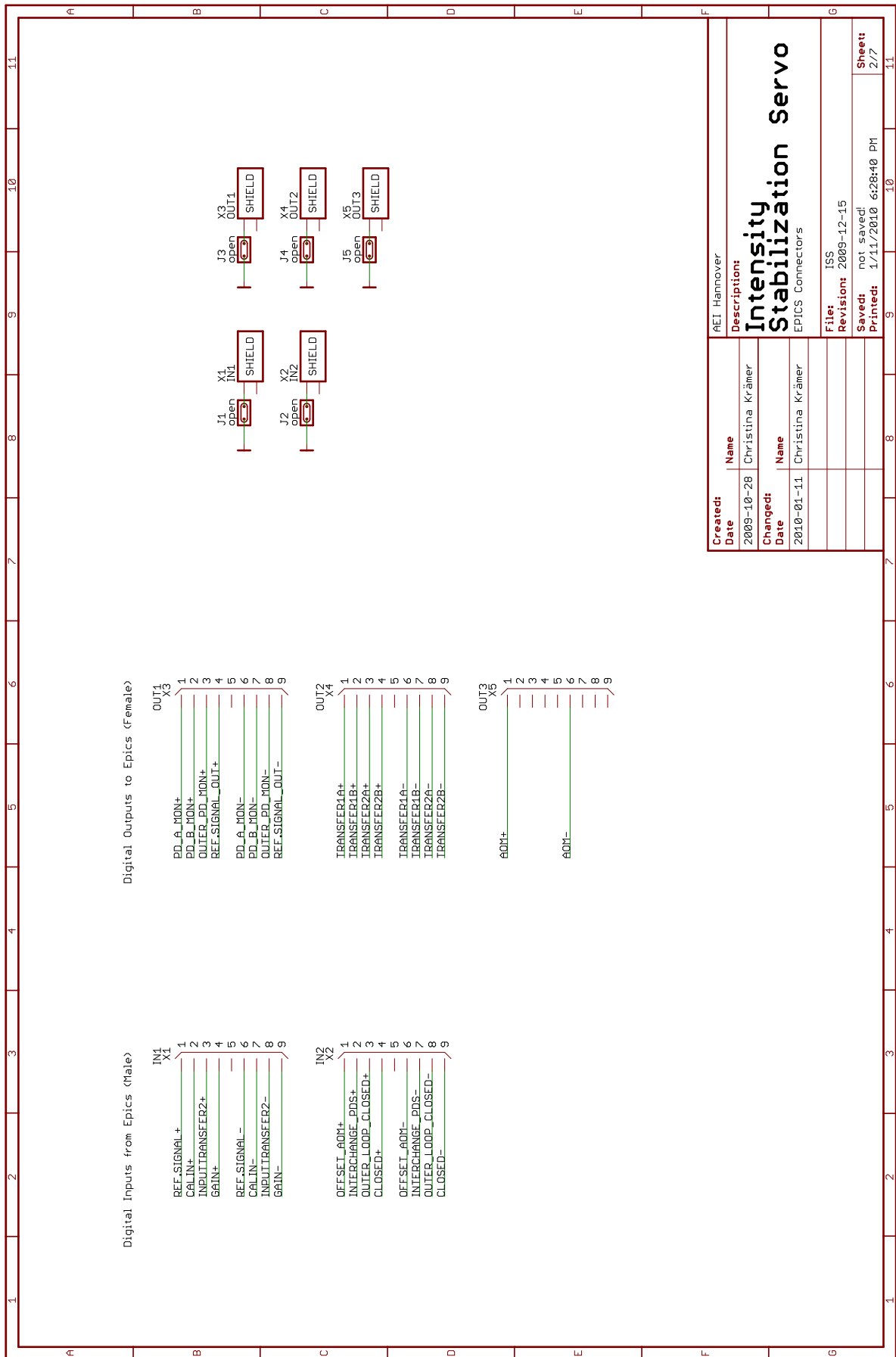


Figure 3: Project schematics (sheet 2)

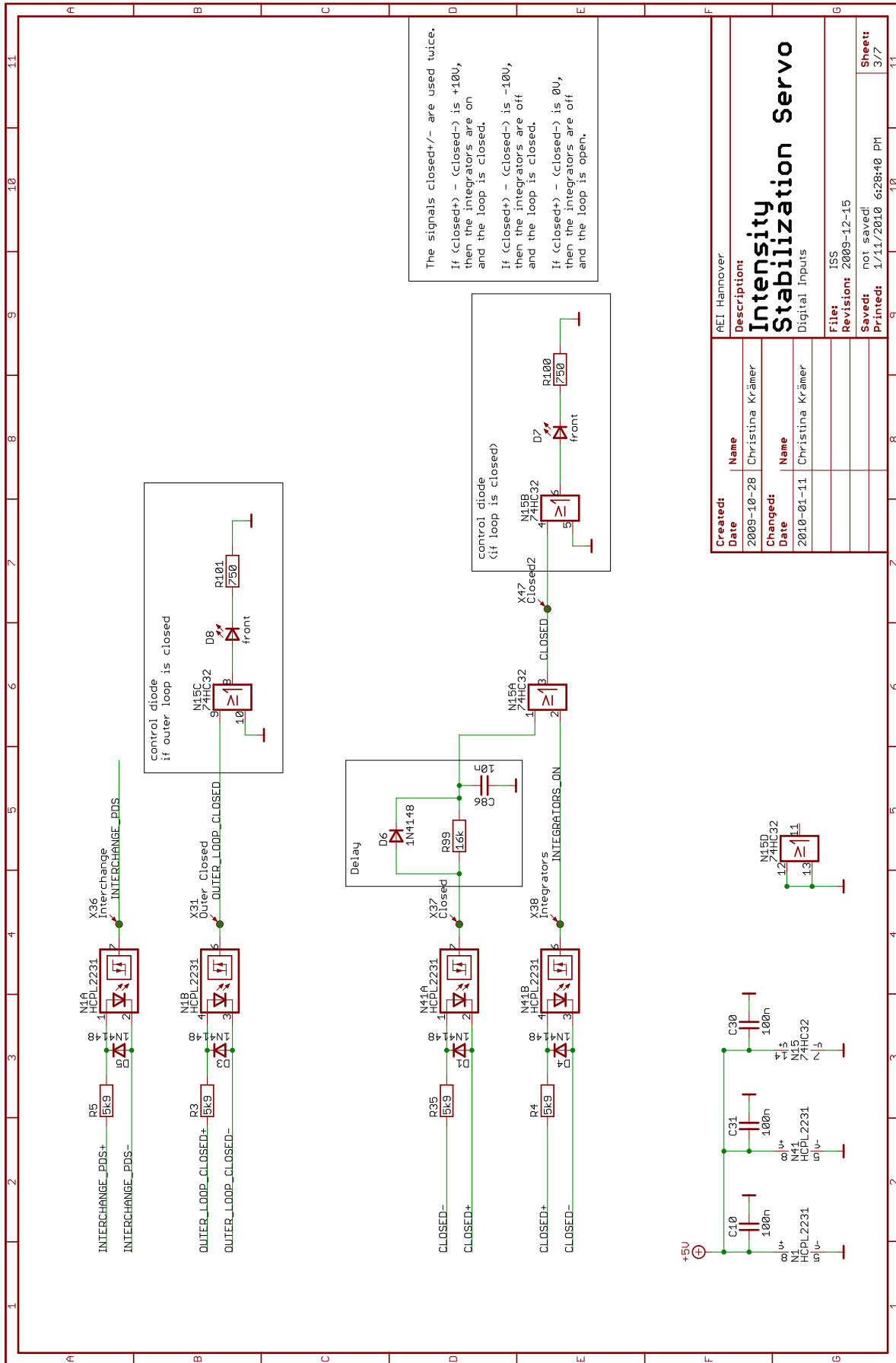


Figure 4: Project schematics (sheet 3)

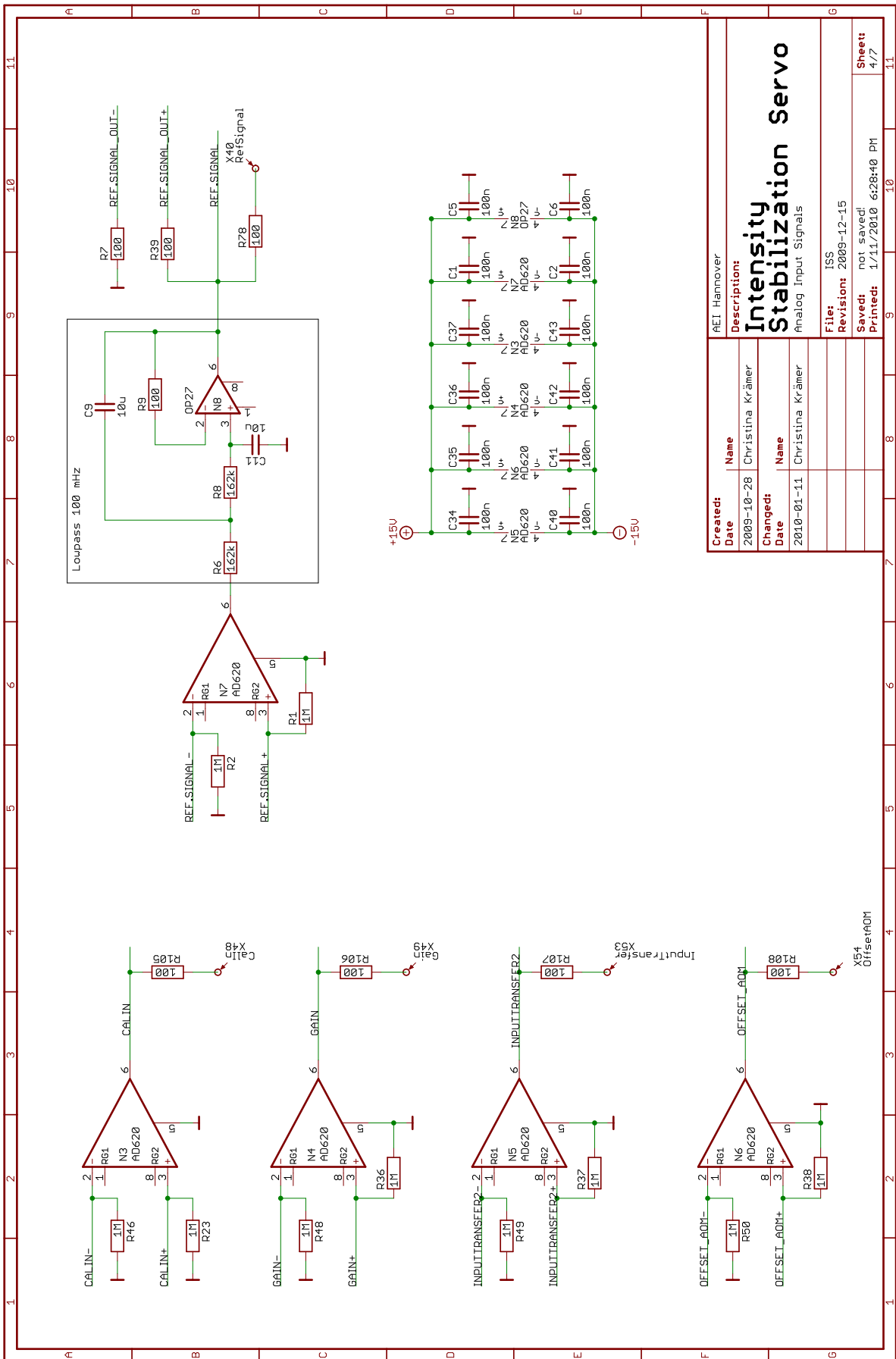
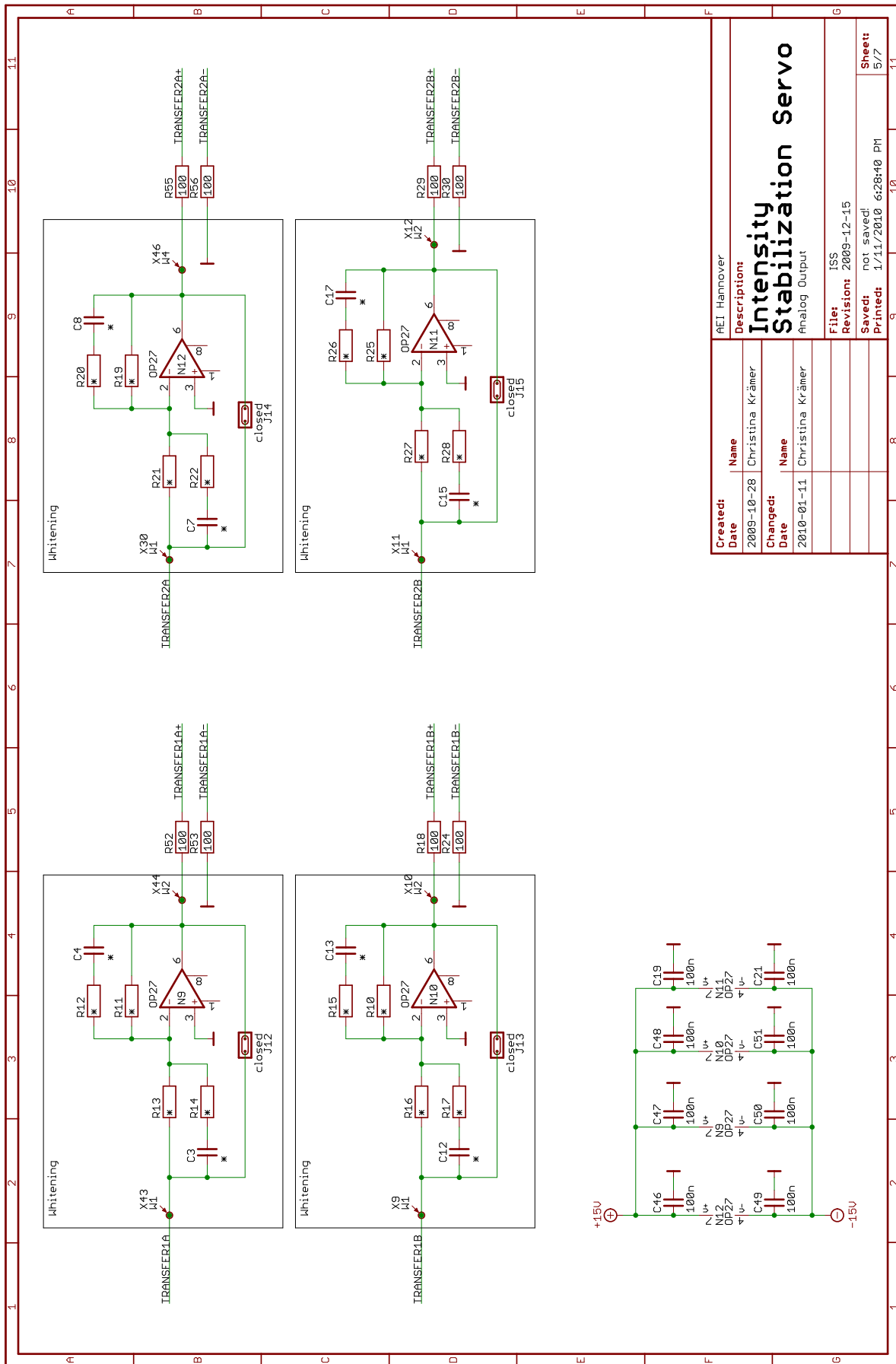


Figure 5: Project schematics (sheet 4)



Created:	Name	AEI Hannover
Date	Christina Krämer	Description
2009-10-28		Intensity Stabilization Servo
Changed:	Name	Analog Output
Date	Christina Krämer	
2010-01-11		
File:	ISS	
Revision:	2009-12-15	
Saved:	not saved!	
Printed:	1/11/2010 6:28:40 PM	Sheet:
		5/7

Figure 6: Project schematics (sheet 5)

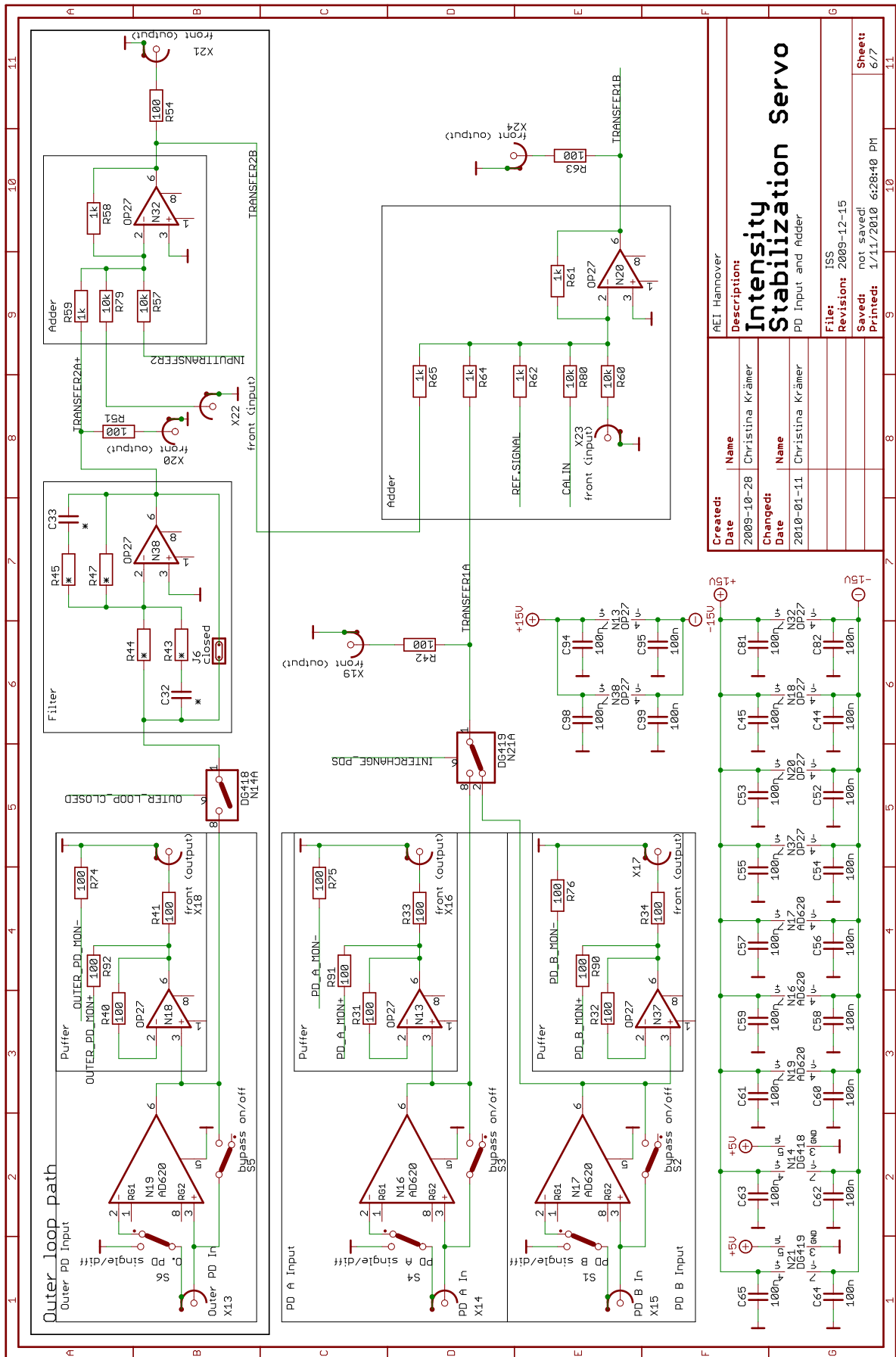


Figure 7: Project schematics (sheet 6)

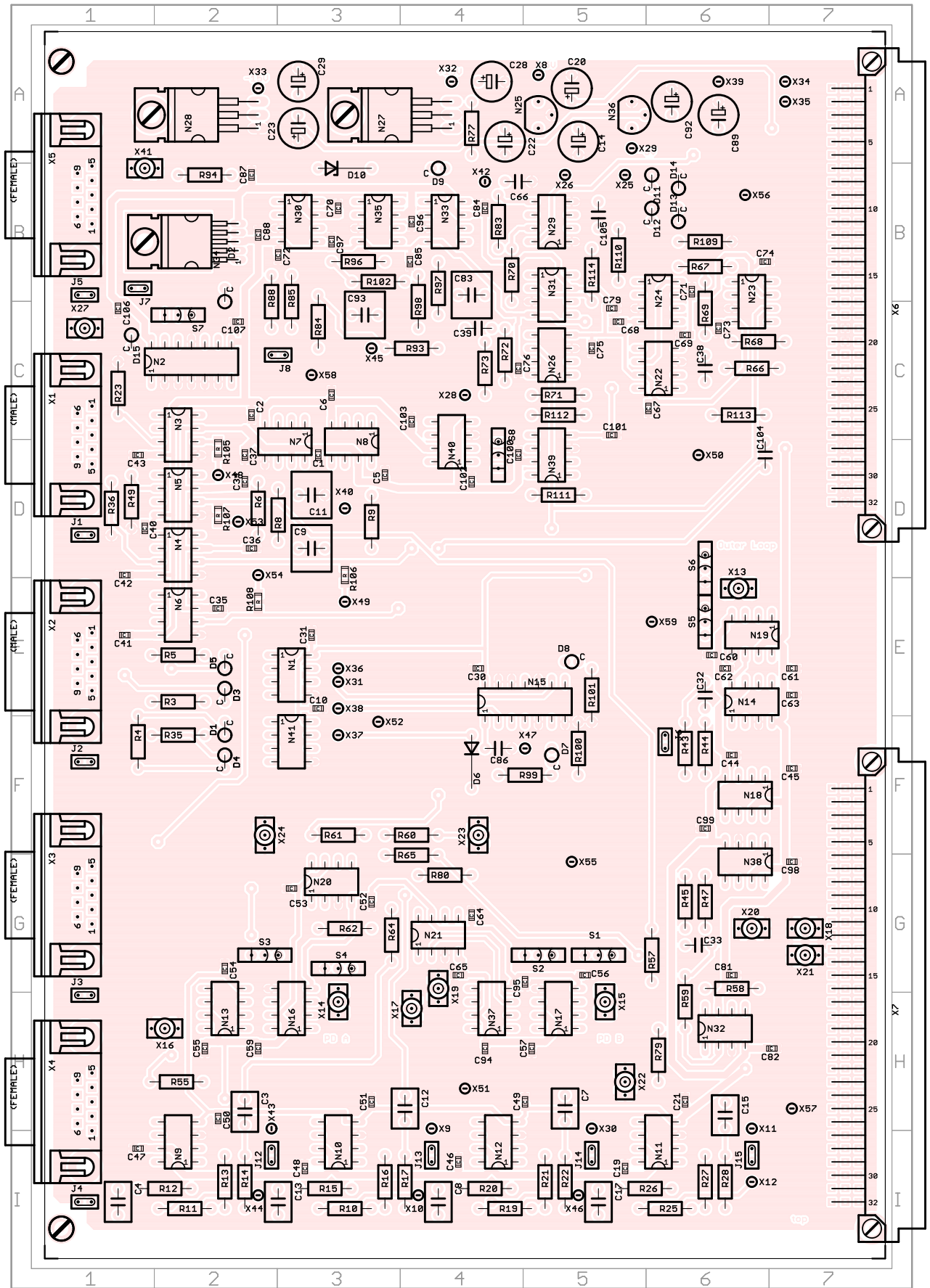


Figure 9: Board top view showing placeplan with component names

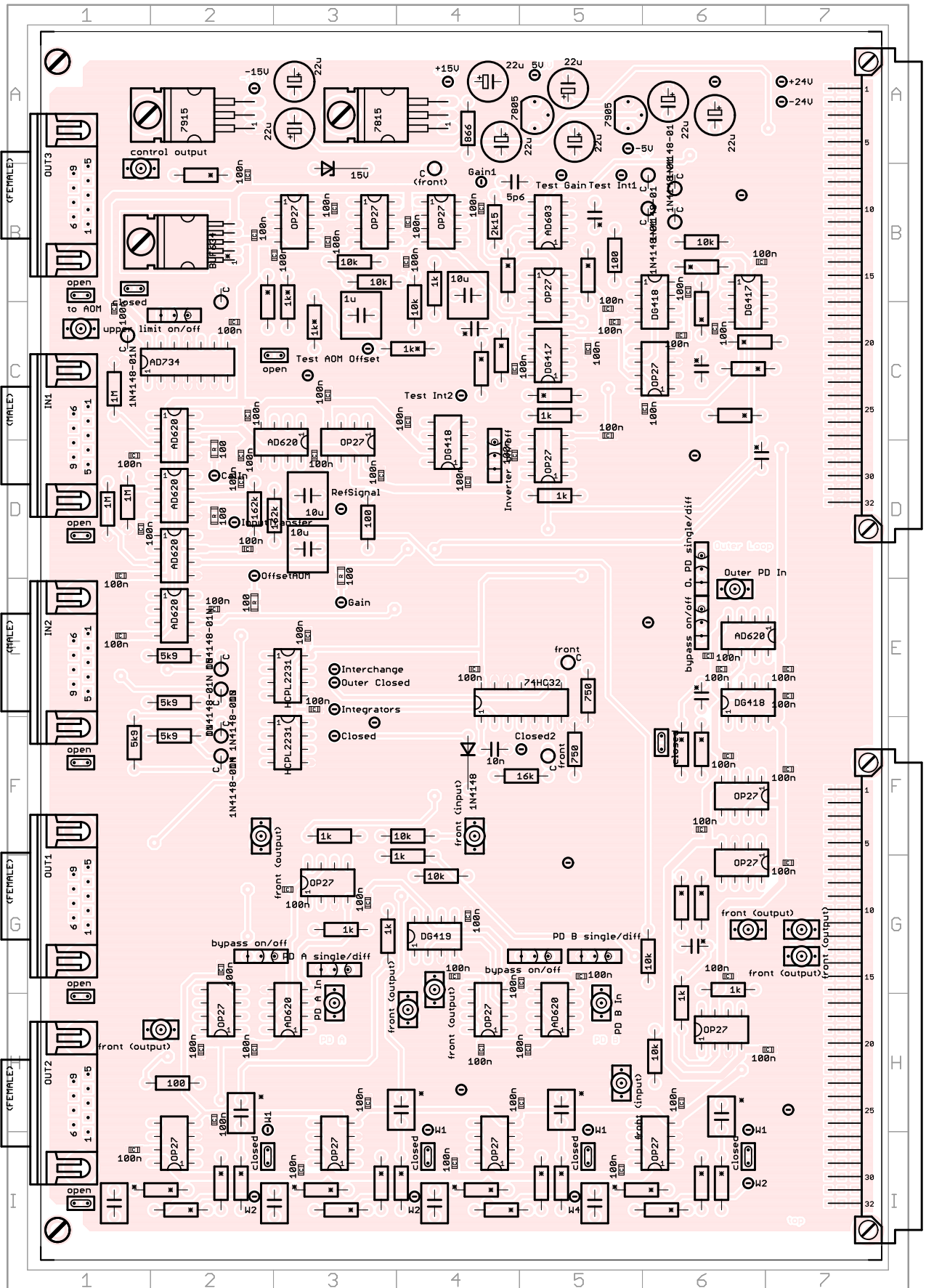


Figure 10: Board top view showing placeplan with component values

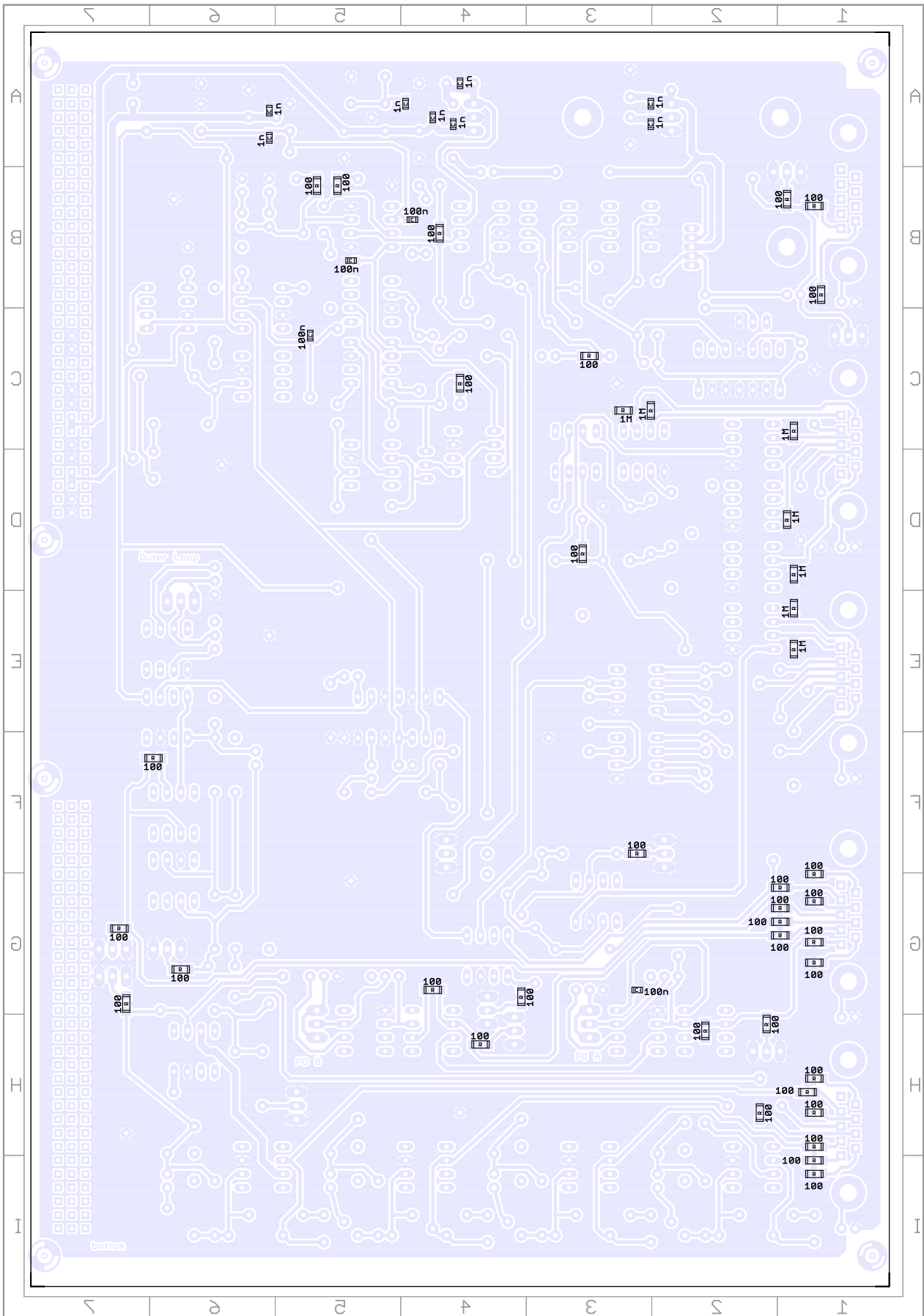


Figure 12: Board bottom view showing placeplan with component values

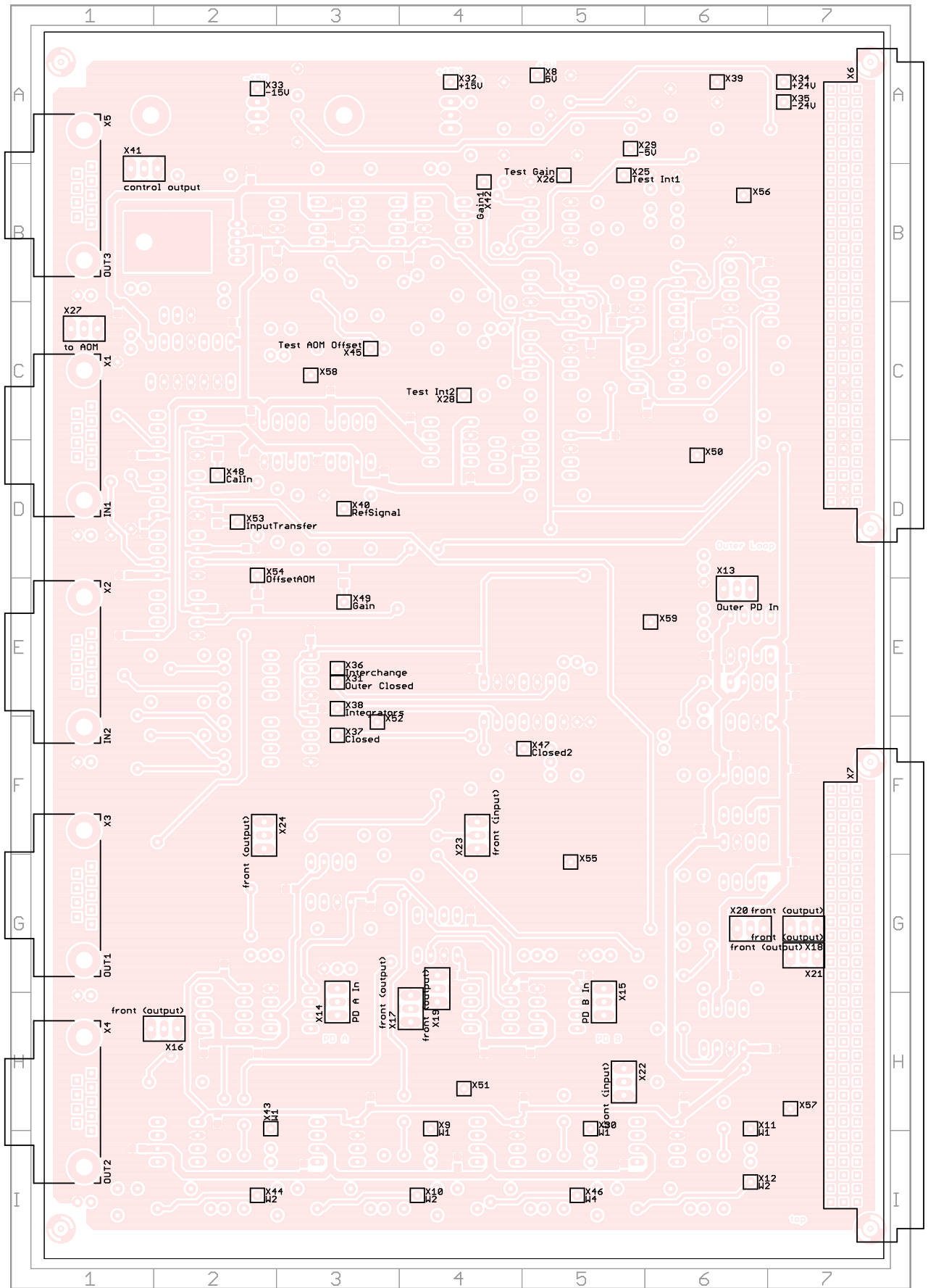


Figure 13: Board top view showing connectors, test points and wired components

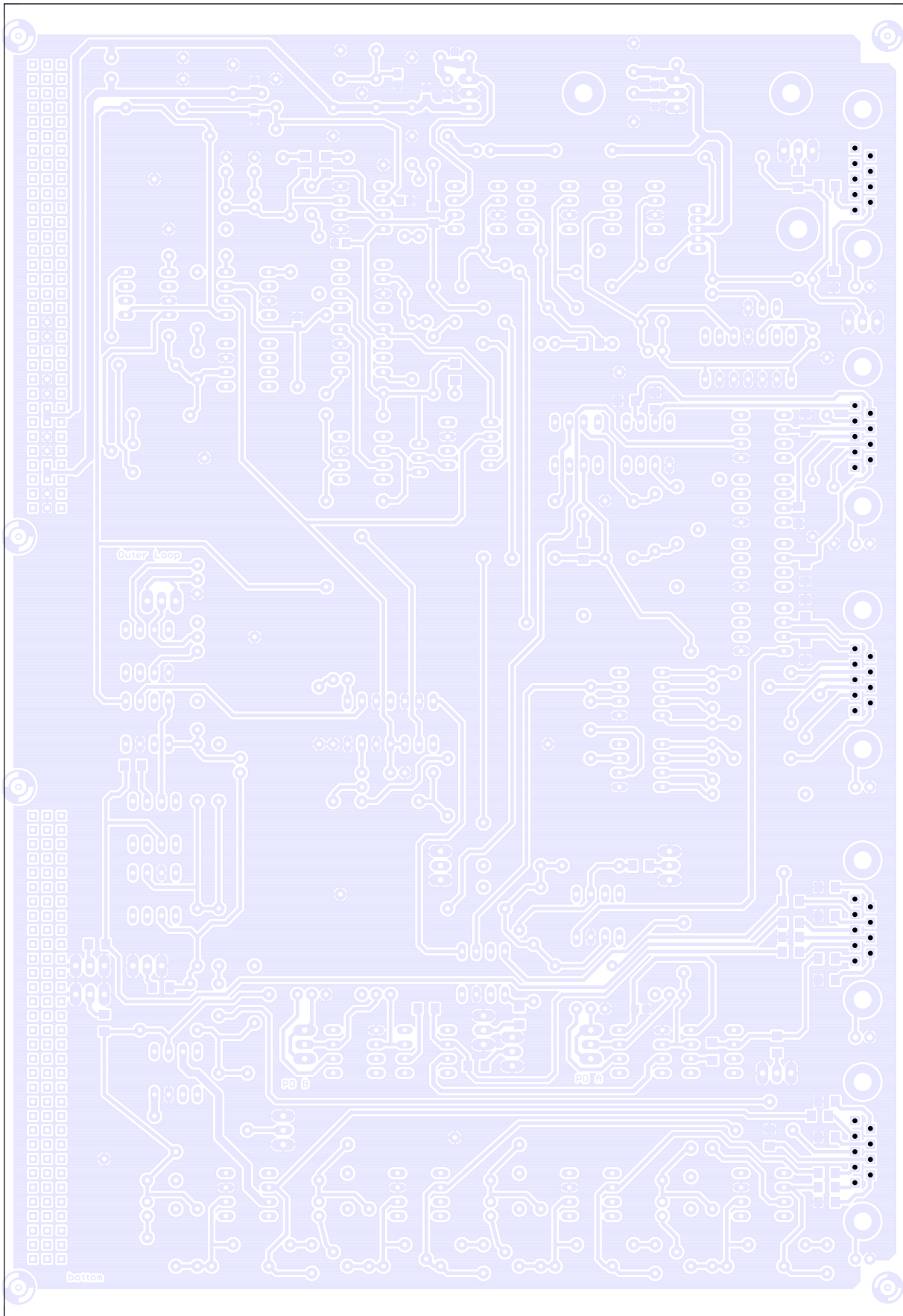


Figure 14: Board bottom view showing drills with 0.9 mm (0.035 in) diameter

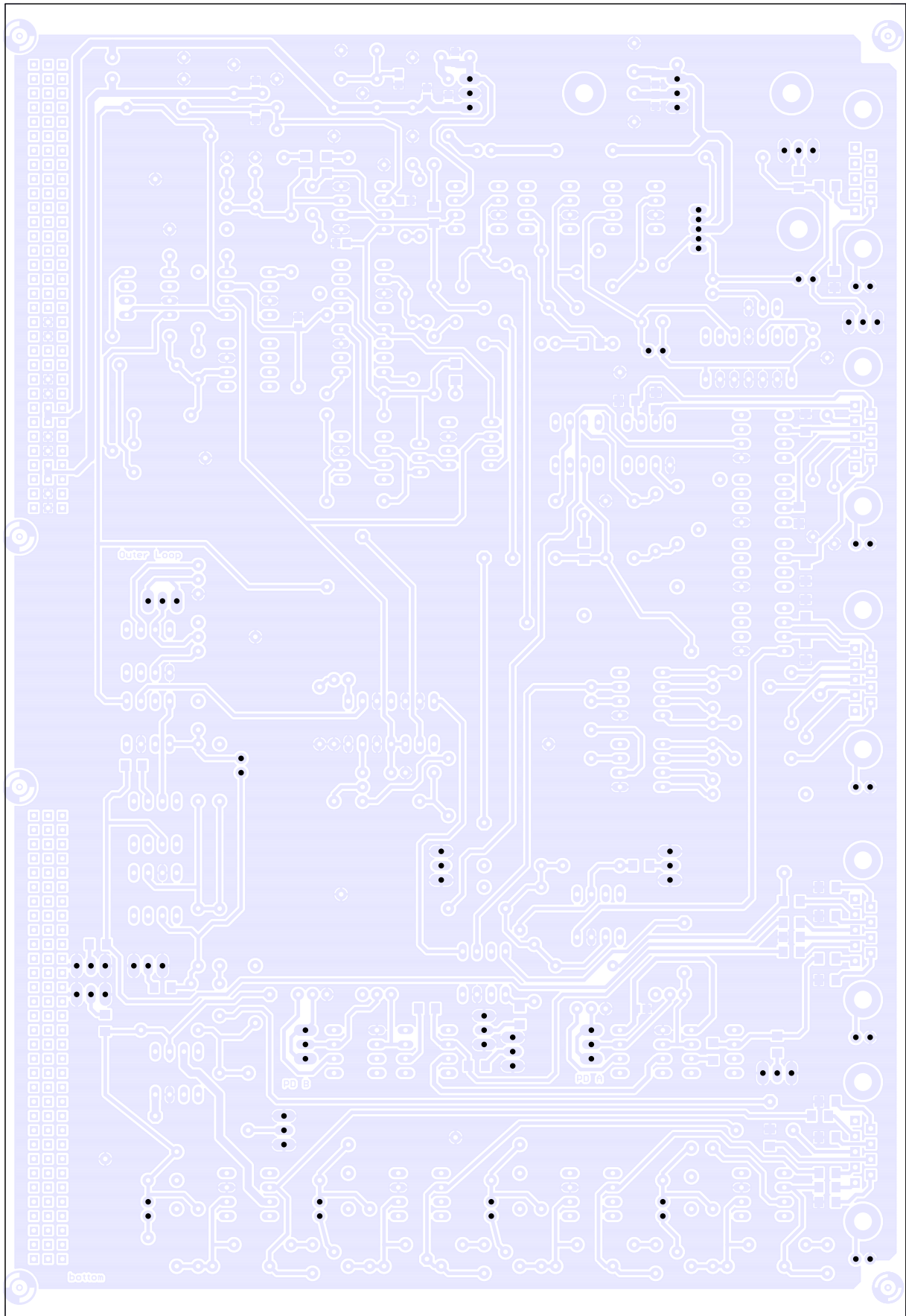


Figure 15: Board bottom view showing drills with 1.0 mm (0.039 in) diameter

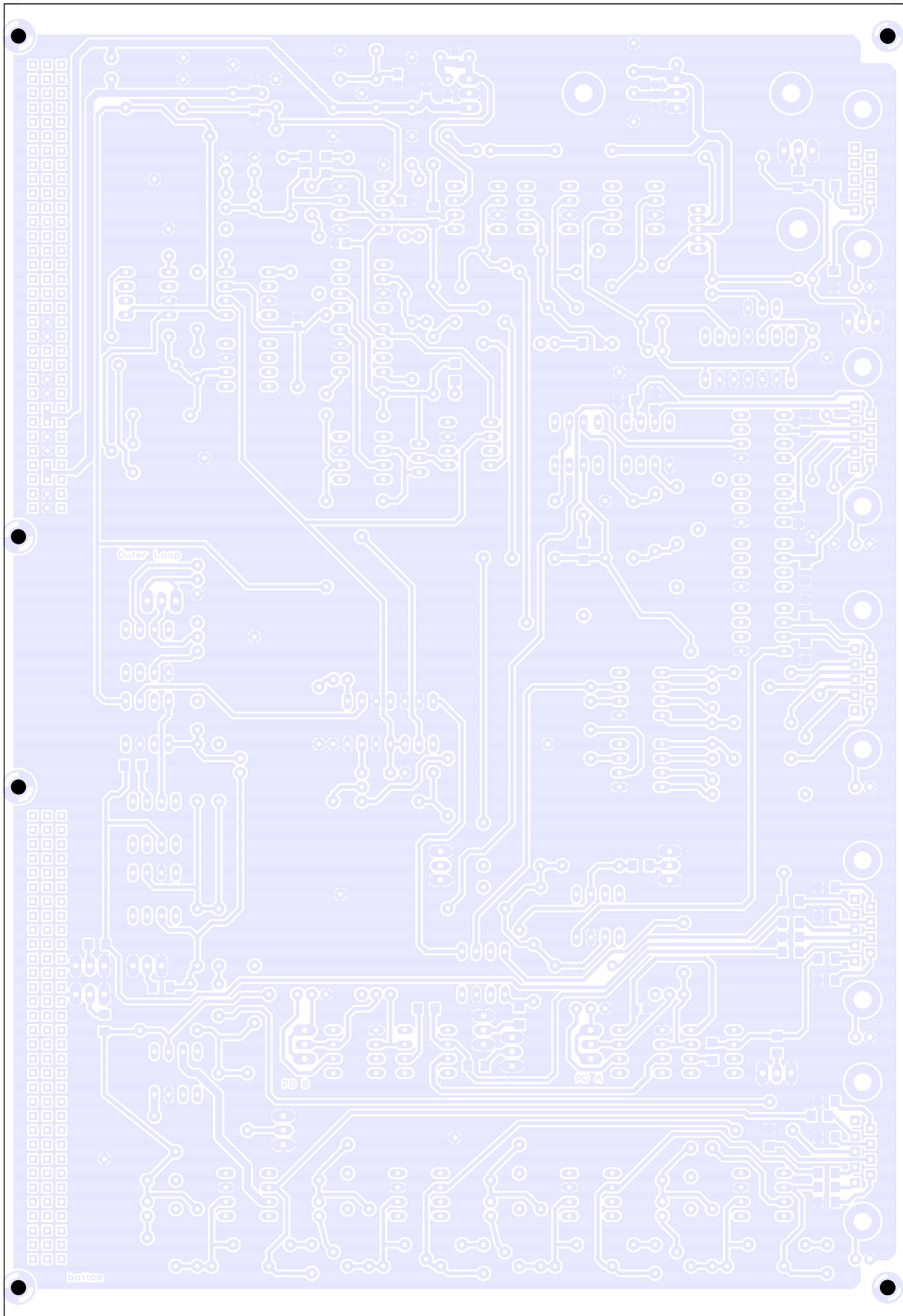


Figure 16: Board bottom view showing drills with 2.7 mm (0.106 in) diameter

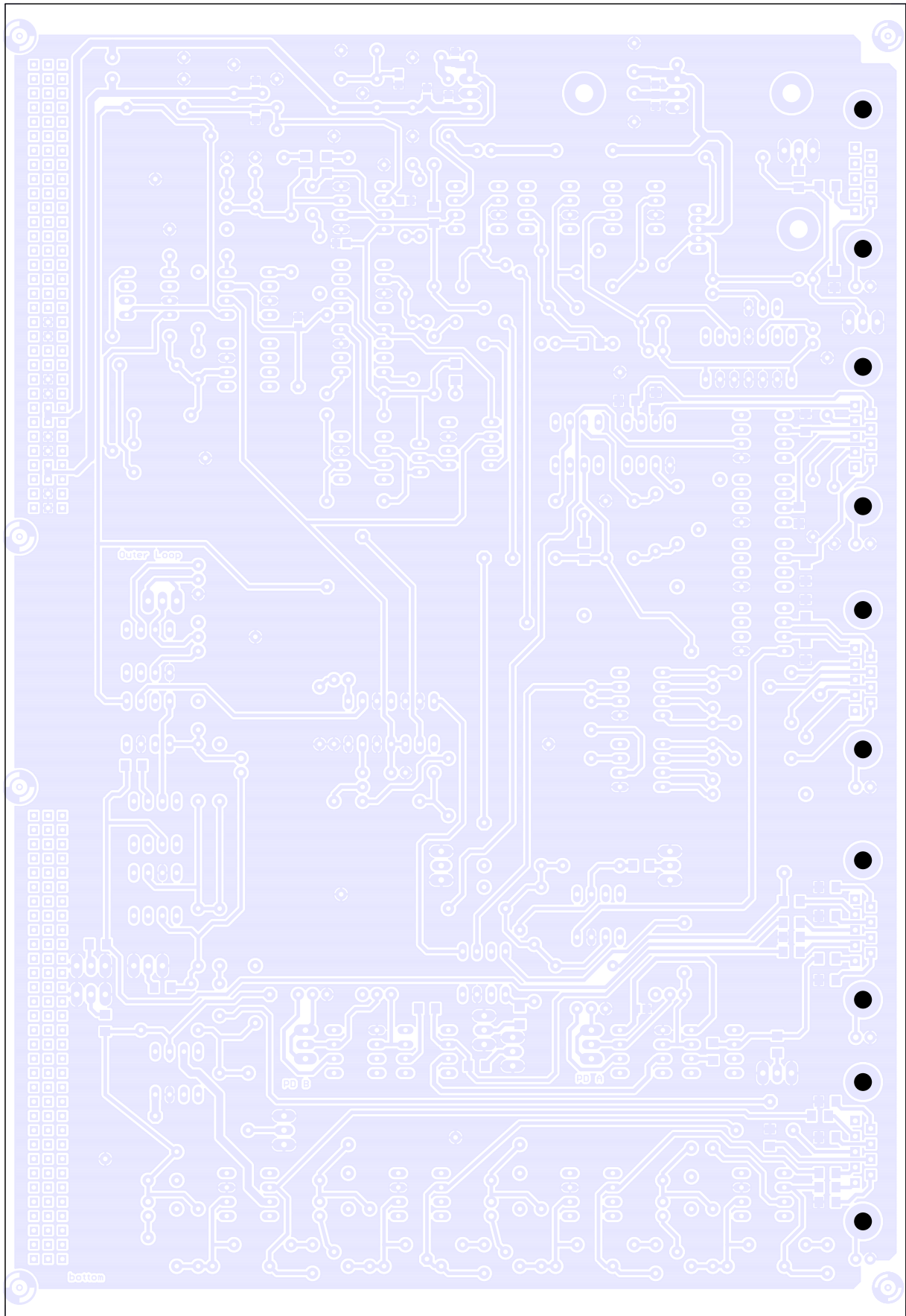


Figure 17: Board bottom view showing drills with 3.2 mm (0.125 in) diameter

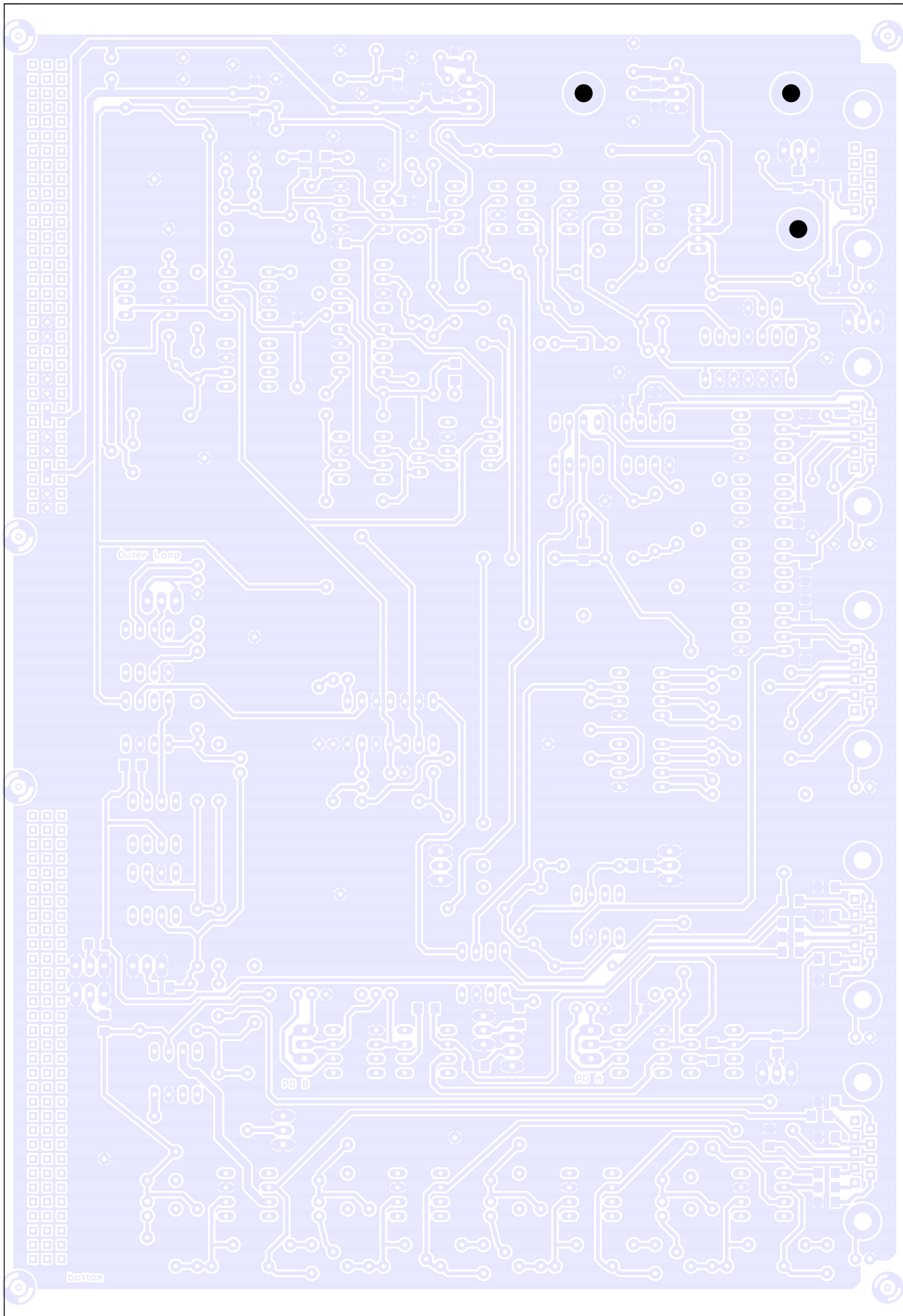


Figure 18: Board bottom view showing drills with 3.2 mm (0.126 in) diameter

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	77
2692	2.7	0.106	10
3175	3.2	0.125	10
3200	3.2	0.126	3
Total			952

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 5.6.0 Copyright (c) 1988-2009 CadSoft
2 Board value list of 'ISS.brd'
3 Exported at 2010-01-11 18:29
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 100n         C-SMD:0805         (71*)   C1, C2, C5, C6, C10, C19, C21, C30, C31, C34, C35,
12                                     C36, C37, C40, C41, C42, C43, C44, C45, C46, C47,
13                                     C48, C49, C50, C51, C52, C53, C54, C55, C56, C57,
14                                     C58, C59, C60, C61, C62, C63, C64, C65, C67, C68,
15                                     C69, C70, C71, C72, C73, C74, C75, C76, C77, C78,
16                                     C79, C80, C81, C82, C84, C85, C87, C88, C94, C95,
17                                     C96, C97, C98, C99, C100, C101, C102, C103, C106,
18                                     C107
19 1u           C02C             (1*)    C93
20 10u          C02C             (3*)    C9, C11, C83
21 22u          CE02D            (8*)    C14, C20, C22, C23, C28, C29, C89, C92
22 *           C-0.2"          (6*)    C32, C33, C38, C39, C104, C105
23             C02B             (8*)    C3, C4, C7, C8, C12, C13, C15, C17
24
25 ---D---
26 1N4148       D-0.4"          (1*)    D6
27 15V          DZ-0.4"         (1*)    D10
28 (front)     LED-3mm         (1*)    D9
29 *           DS-0.1"         (1*)    D2

```

30	1N4148	D-0.1"	(9*)	D1, D3, D4, D5, D11, D12, D13, D14, D15
31	front	LED-3mm	(2*)	D7, D8
32				
33	---J---			
34	closed	JPO2N	(6*)	J6, J7, J12, J13, J14, J15
35	open	JPO2N	(6*)	J1, J2, J3, J4, J5, J8
36				
37	---N---			
38	74HC32	DIP-14	(1*)	N15
39	7805	TO-92	(1*)	N25
40	7815	TO220L	(1*)	N27
41	7905	TO-92	(1*)	N36
42	7915	TO220L	(1*)	N28
43	AD603	DIP-8	(1*)	N29
44	AD620	DIP-8	(8*)	N3, N4, N5, N6, N7, N16, N17, N19
45	AD734	DIP-14	(1*)	N2
46	BUF634	TO220-5H	(1*)	N34
47	DG417	DIP-8	(2*)	N23, N26
48	DG418	DIP-8	(3*)	N14, N24, N40
49	DG419	DIP-8	(1*)	N21
50	HCPL2231	DIP-8	(2*)	N1, N41
51	OP27	DIP-8	(15*)	N8, N10, N11, N13, N18, N20, N22, N30, N31, N32, N33, N35, N37, N38, N39
52				
53	OP27*	DIP-8	(2*)	N9, N12
54				
55	---R---			
56	100	R-0.4"	(3*)	R9, R55, R110
57		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
58				
59				
60				
61	750	R-0.4"	(2*)	R100, R101
62	866	R-0.4"	(1*)	R77
63	1k	R-0.4"	(9*)	R58, R59, R61, R62, R64, R65, R97, R111, R112
64	1k*	R-0.4"	(3*)	R84, R85, R93
65	2k15	R-0.4"	(1*)	R83
66	5k9	R-0.4"	(4*)	R3, R4, R5, R35
67	10k	R-0.4"	(8*)	R57, R60, R79, R80, R96, R98, R102, R109
68	16k	R-0.4"	(1*)	R99
69	162k	R-0.4"	(2*)	R6, R8
70	1M	R-0.4"	(3*)	R23, R36, R49
71		R-SMD:1206	(7*)	R1, R2, R37, R38, R46, R48, R50
72	*	R-0.4"	(32*)	R10, R11, R12, R13, R14, R15, R16, R17, R19, R20, R21, R22, R25, R26, R27, R28, R43, R44, R45, R47, R66, R67, R68, R69, R70, R71, R72, R73, R88, R94, R113, R114
73				
74				
75				
76				
77	---S---			
78	Inverter on/off	S1X2S01L	(1*)	S8
79	0. PD single/diff	S1X2S01N	(1*)	S6
80	PD A single/diff	S1X2S01N	(1*)	S4
81	PD B single/diff	S1X2S01N	(1*)	S1
82	bypass on/off	S1X2S01N	(3*)	S2, S3, S5
83	upper limit on/off	S1X2S01L	(1*)	S7
84				
85	---X---			
86	-24V	XTN	(1*)	X35
87	-15V	XTN	(1*)	X33
88	-5V	XTN	(1*)	X29

89	5V	XTN	(1*)	X8
90	+15V	XTN	(1*)	X32
91	+24V	XTN	(1*)	X34
92		XB96	(2*)	X6,X7
93		XTN	(9*)	X39,X50,X51,X52,X55,X56,X57,X58,X59
94	CalIn	XTN	(1*)	X48
95	Closed	XTN	(1*)	X37
96	Closed2	XTN	(1*)	X47
97	Gain	XTN	(1*)	X49
98	Gain1	XTN	(1*)	X42
99	IN1	XO9-DSUBMALE1	(1*)	X1
100	IN2	XO9-DSUBMALE1	(1*)	X2
101	InputTransfer	XTN	(1*)	X53
102	Integrators	XTN	(1*)	X38
103	Interchange	XTN	(1*)	X36
104	OUT1	XO9-DSUBFEMALE1	(1*)	X3
105	OUT2	XO9-DSUBFEMALE1	(1*)	X4
106	OUT3	XO9-DSUBFEMALE1	(1*)	X5
107	OffsetAOM	XTN	(1*)	X54
108	Outer Closed	XTN	(1*)	X31
109	Outer PD In	XC174N	(1*)	X13
110	PD A In	XC174N	(1*)	X14
111	PD B In	XC174N	(1*)	X15
112	RefSignal	XTN	(1*)	X40
113	Test AOM Offset	XTN	(1*)	X45
114	Test Gain	XTN	(1*)	X26
115	Test Int1	XTN	(1*)	X25
116	Test Int2	XTN	(1*)	X28
117	W1	XTN	(4*)	X9,X11,X30,X43
118	W2	XTN	(3*)	X10,X12,X44
119	W4	XTN	(1*)	X46
120	control output	XC174N	(1*)	X41
121	front (input)	XC174N	(2*)	X22,X23
122	front (output)	XC174N	(7*)	X16,X17,X18,X19,X20,X21,X24
123	to AOM	XC174N	(1*)	X27

Part list: The following list shows all components available in the schematics (sorted by part *names*) and can be used to quickly get component information. The column *Layer/Cell* shows the position of the part on the board: *T* for top layer and *B* for bottom layer, 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 5.6.0 Copyright (c) 1988-2009 CadSoft
2 Schematics part list of 'ISS.sch'
3 Exported at 2010-01-11 18:29
4 Created with macro 'plot.ulp' (c) Andreas Weidner
5 Shown are: Name,Value/Type,Device,Package,Layer/Cell,Sheets/Cells
6
7 ---C---
8 C1 100n CS C-SMD:0805 T-D3 4-D9
9 C2 100n CS C-SMD:0805 T-C2 4-E9
10 C3 * C02B C02B T-H2 5-B2
11 C4 * C02B C02B T-I1 5-A4
12 C5 100n CS C-SMD:0805 T-D3 4-D10
13 C6 100n CS C-SMD:0805 T-C3 4-E10
14 C7 * C02B C02B T-H5 5-B7
15 C8 * C02B C02B T-I4 5-A9
16 C9 10u C02C C02C T-D3 4-A8

```

17	C10	100n	CS	C-SMD:0805	T-E3	3-F2
18	C11	10u	C02C	C02C	T-D3	4-B8
19	C12	*	C02B	C02B	T-H4	5-D2
20	C13	*	C02B	C02B	T-I3	5-C4
21	C14	22u	CE02D	CE02D	T-A5	1-B8
22	C15	*	C02B	C02B	T-H6	5-D8
23	C16	1n	CS	C-SMD:0805	B-A4	1-B9
24	C17	*	C02B	C02B	T-I5	5-C9
25	C18	1n	CS	C-SMD:0805	B-A4	1-B9
26	C19	100n	CS	C-SMD:0805	T-I5	5-F4
27	C20	22u	CE02D	CE02D	T-A5	1-B10
28	C21	100n	CS	C-SMD:0805	T-H6	5-G4
29	C22	22u	CE02D	CE02D	T-A4	1-D8
30	C23	22u	CE02D	CE02D	T-A3	1-D8
31	C24	1n	CS	C-SMD:0805	B-A4	1-D9
32	C25	1n	CS	C-SMD:0805	B-A3	1-D9
33	C26	1n	CS	C-SMD:0805	B-A4	1-D9
34	C27	1n	CS	C-SMD:0805	B-A3	1-D9
35	C28	22u	CE02D	CE02D	T-A4	1-D10
36	C29	22u	CE02D	CE02D	T-A3	1-D10
37	C30	100n	CS	C-SMD:0805	T-E4	3-F3
38	C31	100n	CS	C-SMD:0805	T-E3	3-F2
39	C32	*	C	C-0.2"	T-E6	6-B6
40	C33	*	C	C-0.2"	T-G6	6-A7
41	C34	100n	CS	C-SMD:0805	T-D2	4-D7
42	C35	100n	CS	C-SMD:0805	T-E2	4-D8
43	C36	100n	CS	C-SMD:0805	T-D2	4-D8
44	C37	100n	CS	C-SMD:0805	T-D2	4-D9
45	C38	*	C	C-0.2"	T-C6	7-C2
46	C39	*	C	C-0.2"	T-C4	7-C8
47	C40	100n	CS	C-SMD:0805	T-D1	4-E7
48	C41	100n	CS	C-SMD:0805	T-E1	4-E8
49	C42	100n	CS	C-SMD:0805	T-D1	4-E8
50	C43	100n	CS	C-SMD:0805	T-D1	4-E9
51	C44	100n	C0805	C-SMD:0805	T-F6	6-G6
52	C45	100n	C0805	C-SMD:0805	T-F7	6-F6
53	C46	100n	CS	C-SMD:0805	T-I4	5-F2
54	C47	100n	CS	C-SMD:0805	T-I1	5-F3
55	C48	100n	CS	C-SMD:0805	T-I3	5-F3
56	C49	100n	CS	C-SMD:0805	T-H5	5-G2
57	C50	100n	CS	C-SMD:0805	T-H2	5-G3
58	C51	100n	CS	C-SMD:0805	T-H3	5-G3
59	C52	100n	C0805	C-SMD:0805	T-G3	6-G5
60	C53	100n	C0805	C-SMD:0805	T-G3	6-F5
61	C54	100n	C0805	C-SMD:0805	T-G2	6-G4
62	C55	100n	C0805	C-SMD:0805	T-H2	6-F4
63	C56	100n	C0805	C-SMD:0805	T-G5	6-G4
64	C57	100n	C0805	C-SMD:0805	T-H5	6-F4
65	C58	100n	C0805	C-SMD:0805	B-G3	6-G3
66	C59	100n	C0805	C-SMD:0805	T-H2	6-F3
67	C60	100n	C0805	C-SMD:0805	T-E6	6-G3
68	C61	100n	C0805	C-SMD:0805	T-E7	6-F3
69	C62	100n	C0805	C-SMD:0805	T-E6	6-G2
70	C63	100n	C0805	C-SMD:0805	T-E7	6-F2
71	C64	100n	C0805	C-SMD:0805	T-G4	6-G1
72	C65	100n	C0805	C-SMD:0805	T-G4	6-F1
73	C66	5p6	C	C-0.2"	T-B4	7-C6
74	C67	100n	C0805	C-SMD:0805	T-C6	7-F3
75	C68	100n	C0805	C-SMD:0805	T-C5	7-F5

76	C69	100n	C0805	C-SMD:0805	T-C6	7-G3
77	C70	100n	C0805	C-SMD:0805	T-B3	7-F4
78	C71	100n	C0805	C-SMD:0805	T-B6	7-G5
79	C72	100n	C0805	C-SMD:0805	T-B3	7-G4
80	C73	100n	C0805	C-SMD:0805	T-C6	7-F6
81	C74	100n	C0805	C-SMD:0805	T-B6	7-G6
82	C75	100n	C0805	C-SMD:0805	T-C5	7-F7
83	C76	100n	C0805	C-SMD:0805	T-C4	7-G7
84	C77	100n	C0805	C-SMD:0805	B-B5	7-C11
85	C78	100n	C0805	C-SMD:0805	B-B4	7-C11
86	C79	100n	C0805	C-SMD:0805	T-C5	7-F4
87	C80	100n	C0805	C-SMD:0805	B-C5	7-G4
88	C81	100n	C0805	C-SMD:0805	T-G6	6-F6
89	C82	100n	C0805	C-SMD:0805	T-H7	6-G6
90	C83	10u	C02C	C02C	T-B4	7-D2
91	C84	100n	C0805	C-SMD:0805	T-B4	7-F2
92	C85	100n	C0805	C-SMD:0805	T-B4	7-G2
93	C86	10n	C	C-0.2"	T-F4	3-D5
94	C87	100n	C0805	C-SMD:0805	T-B2	7-F2
95	C88	100n	C0805	C-SMD:0805	T-B2	7-G2
96	C89	22u	CE02D	CE02D	T-A6	1-B10
97	C90	1n	CS	C-SMD:0805	B-A6	1-B9
98	C91	1n	CS	C-SMD:0805	B-A6	1-B9
99	C92	22u	CE02D	CE02D	T-A6	1-B8
100	C93	1u	C02C	C02C	T-C3	7-E4
101	C94	100n	C0805	C-SMD:0805	T-H4	6-E6
102	C95	100n	C0805	C-SMD:0805	T-G5	6-F6
103	C96	100n	C0805	C-SMD:0805	T-B4	7-F1
104	C97	100n	C0805	C-SMD:0805	T-B3	7-G1
105	C98	100n	C0805	C-SMD:0805	T-G7	6-E6
106	C99	100n	C0805	C-SMD:0805	T-F6	6-F6
107	C100	100n	C0805	C-SMD:0805	T-D4	7-F1
108	C101	100n	C0805	C-SMD:0805	T-C5	7-G1
109	C102	100n	C0805	C-SMD:0805	T-D4	7-F5
110	C103	100n	C0805	C-SMD:0805	T-C4	7-G5
111	C104	*	C	C-0.2"	T-D6	7-C1
112	C105	*	C	C-0.2"	T-B5	7-C7
113	C106	100n	C0805	C-SMD:0805	T-C1	7-C10
114	C107	100n	C0805	C-SMD:0805	T-C2	7-C10
115						
116	---D---					
117	D1	1N4148	1N4148-01N	D-0.1"	T-F2	3-D3
118	D2	*	DS01N	DS-0.1"	T-B2	7-E9
119	D3	1N4148	1N4148-01N	D-0.1"	T-E2	3-B3
120	D4	1N4148	1N4148-01N	D-0.1"	T-F2	3-E3
121	D5	1N4148	1N4148-01N	D-0.1"	T-E2	3-A3
122	D6	1N4148	D	D-0.4"	T-F4	3-D5
123	D7	front	DL	LED-3mm	T-F5	3-E8
124	D8	front	DL	LED-3mm	T-E5	3-B6
125	D9	(front)	DL	LED-3mm	T-B4	1-F7
126	D10	15V	DZ	DZ-0.4"	T-B3	1-G7
127	D11	1N4148	1N4148-01	D-0.1"	T-B6	7-B4
128	D12	1N4148	1N4148-01	D-0.1"	T-B6	7-B4
129	D13	1N4148	1N4148-01	D-0.1"	T-B6	7-C4
130	D14	1N4148	1N4148-01	D-0.1"	T-B6	7-C4
131	D15	1N4148	1N4148-01N	D-0.1"	T-C1	7-D8
132						
133	---J---					
134	J1	open	JP02	JP02N	T-D1	2-B8

135	J2	open	JP02	JP02N	T-F1	2-C8
136	J3	open	JP02	JP02N	T-H1	2-B9
137	J4	open	JP02	JP02N	T-I1	2-C9
138	J5	open	JP02	JP02N	T-B1	2-C9
139	J6	closed	JP02	JP02N	T-F6	6-B6
140	J7	closed	JP02	JP02N	T-B1	7-E9
141	J8	open	JP02	JP02N	T-C3	7-F8
142	J12	closed	JP02	JP02N	T-I2	5-B3
143	J13	closed	JP02	JP02N	T-I4	5-D3
144	J14	closed	JP02	JP02N	T-I5	5-B8
145	J15	closed	JP02	JP02N	T-I6	5-D8
146						
147	---N---					
148	N1	HCPL2231	HCPL2231	DIP-8	T-E3	3-A4,3-B4,3-G1
149	N2	AD734	AD734	DIP-14	T-C2	7-C10,7-E8
150	N3	AD620	AD620	DIP-8	T-C2	4-A2,4-E9
151	N4	AD620	AD620	DIP-8	T-D2	4-C2,4-E8
152	N5	AD620	AD620	DIP-8	T-D2	4-E2,4-E7
153	N6	AD620	AD620	DIP-8	T-E2	4-E8,4-F2
154	N7	AD620	AD620	DIP-8	T-D3	4-B6,4-E9
155	N8	OP27	OP27	DIP-8	T-D3	4-B8,4-E10
156	N9	OP27*	OP27	DIP-8	T-I2	5-B4,5-F2
157	N10	OP27	OP27	DIP-8	T-I3	5-D4,5-F3
158	N11	OP27	OP27	DIP-8	T-I6	5-D9,5-F4
159	N12	OP27*	OP27	DIP-8	T-I4	5-B9,5-F2
160	N13	OP27	OP27	DIP-8	T-H2	6-D3,6-E7
161	N14	DG418	DG418	DIP-8	T-E6	6-B5,6-G2
162	N15	74HC32	74HC32	DIP-14	T-E5	3-B6,3-E6,3-E7,3-G3,3-G5
163	N16	AD620	AD620	DIP-8	T-H3	6-D2,6-G3
164	N17	AD620	AD620	DIP-8	T-H5	6-E2,6-G4
165	N18	OP27	OP27	DIP-8	T-F6	6-B3,6-G6
166	N19	AD620	AD620	DIP-8	T-E6	6-B2,6-G3
167	N20	OP27	OP27	DIP-8	T-G3	6-E9,6-G5
168	N21	DG419	DG419	DIP-8	T-G4	6-D5,6-G1
169	N22	OP27	OP27	DIP-8	T-C6	7-C2,7-F3
170	N23	DG417	DG417	DIP-8	T-C6	7-B2,7-F6
171	N24	DG418	DG418	DIP-8	T-C6	7-C3,7-F5
172	N25	7805	7805L1	TO-92	T-A5	1-B9
173	N26	DG417	DG417	DIP-8	T-C5	7-B8,7-F7
174	N27	7815	7815L	TO220L	T-A4	1-C9
175	N28	7915	7915L	TO220L	T-A2	1-D9
176	N29	AD603	AD603	DIP-8	T-B5	7-C5,7-C11
177	N30	OP27	OP27	DIP-8	T-B3	7-E6,7-F4
178	N31	OP27	OP27	DIP-8	T-B5	7-C8,7-F3
179	N32	OP27	OP27	DIP-8	T-H6	6-B10,6-G7
180	N33	OP27	OP27	DIP-8	T-B4	7-E2,7-F2
181	N34	BUF634	BUF634H	TO220-5H	T-B2	7-E9,7-F2
182	N35	OP27	OP27	DIP-8	T-B3	7-E4,7-F1
183	N36	7905	7905L1	TO-92	T-A5	1-C9
184	N37	OP27	OP27	DIP-8	T-H4	6-F3,6-G5
185	N38	OP27	OP27	DIP-8	T-G6	6-B7,6-E6
186	N39	OP27	OP27	DIP-8	T-D5	7-B10,7-F1
187	N40	DG418	DG418	DIP-8	T-D4	7-C9,7-F5
188	N41	HCPL2231	HCPL2231	DIP-8	T-F3	3-D4,3-E4,3-G2
189						
190	---R---					
191	R1	1M	RS	R-SMD:1206	B-C3	4-C6
192	R2	1M	RS	R-SMD:1206	B-C3	4-B5
193	R3	5k9	R	R-0.4"	T-E2	3-B3

194	R4	5k9	R	R-0.4"	T-F1	3-E3
195	R5	5k9	R	R-0.4"	T-E2	3-A3
196	R6	162k	R	R-0.4"	T-D2	4-B7
197	R7	100	R1206	R-SMD:1206	B-G1	4-A10
198	R8	162k	R	R-0.4"	T-D3	4-B8
199	R9	100	R	R-0.4"	T-D3	4-B8
200	R10	*	R	R-0.4"	T-I3	5-C3
201	R11	*	R	R-0.4"	T-I2	5-A3
202	R12	*	R	R-0.4"	T-I2	5-A3
203	R13	*	R	R-0.4"	T-I2	5-B3
204	R14	*	R	R-0.4"	T-I2	5-B3
205	R15	*	R	R-0.4"	T-I3	5-C3
206	R16	*	R	R-0.4"	T-I3	5-D3
207	R17	*	R	R-0.4"	T-I4	5-D3
208	R18	100	RS	R-SMD:1206	B-H1	5-D5
209	R19	*	R	R-0.4"	T-I4	5-A9
210	R20	*	R	R-0.4"	T-I4	5-A9
211	R21	*	R	R-0.4"	T-I5	5-B8
212	R22	*	R	R-0.4"	T-I5	5-B8
213	R23	1M	R	R-0.4"	T-C1	4-B2
214	R24	100	RS	R-SMD:1206	B-H2	5-D5
215	R25	*	R	R-0.4"	T-I6	5-C9
216	R26	*	R	R-0.4"	T-I5	5-C9
217	R27	*	R	R-0.4"	T-I6	5-D8
218	R28	*	R	R-0.4"	T-I6	5-D8
219	R29	100	RS	R-SMD:1206	B-H1	5-D10
220	R30	100	RS	R-SMD:1206	B-H1	5-D10
221	R31	100	R1206	R-SMD:1206	B-H2	6-C3
222	R32	100	R1206	R-SMD:1206	B-G4	6-E3
223	R33	100	R1206	R-SMD:1206	B-H2	6-D4
224	R34	100	R1206	R-SMD:1206	B-H4	6-F4
225	R35	5k9	R	R-0.4"	T-F2	3-D3
226	R36	1M	R	R-0.4"	T-D1	4-D2
227	R37	1M	RS	R-SMD:1206	B-D1	4-E2
228	R38	1M	RS	R-SMD:1206	B-E1	4-G2
229	R39	100	R1206	R-SMD:1206	B-G1	4-B10
230	R40	100	R1206	R-SMD:1206	B-F6	6-A3
231	R41	100	R1206	R-SMD:1206	B-G7	6-B4
232	R42	100	R1206	R-SMD:1206	B-G4	6-D6
233	R43	*	R	R-0.4"	T-F6	6-B6
234	R44	*	R	R-0.4"	T-F6	6-B6
235	R45	*	R	R-0.4"	T-G6	6-A7
236	R46	1M	RS	R-SMD:1206	B-C1	4-A2
237	R47	*	R	R-0.4"	T-G6	6-A7
238	R48	1M	RS	R-SMD:1206	B-D1	4-C2
239	R49	1M	R	R-0.4"	T-D1	4-D2
240	R50	1M	RS	R-SMD:1206	B-E1	4-F2
241	R51	100	R1206	R-SMD:1206	B-G6	6-A8
242	R52	100	RS	R-SMD:1206	B-I1	5-B5
243	R53	100	RS	R-SMD:1206	B-I1	5-B5
244	R54	100	R1206	R-SMD:1206	B-G7	6-B11
245	R55	100	R	R-0.4"	T-H2	5-B10
246	R56	100	RS	R-SMD:1206	B-H1	5-B10
247	R57	10k	R	R-0.4"	T-G6	6-B9
248	R58	1k	R	R-0.4"	T-G6	6-A10
249	R59	1k	R	R-0.4"	T-H6	6-A9
250	R60	10k	R	R-0.4"	T-F4	6-E8
251	R61	1k	R	R-0.4"	T-F3	6-E9
252	R62	1k	R	R-0.4"	T-G3	6-E8

253	R63	100	R1206	R-SMD:1206	B-F3	6-E10
254	R64	1k	R	R-0.4"	T-G3	6-D8
255	R65	1k	R	R-0.4"	T-G4	6-D8
256	R66	*	R	R-0.4"	T-C6	7-C2
257	R67	*	R	R-0.4"	T-B6	7-B3
258	R68	*	R	R-0.4"	T-C6	7-B2
259	R69	*	R	R-0.4"	T-C6	7-C3
260	R70	*	R	R-0.4"	T-B4	7-C7
261	R71	*	R	R-0.4"	T-C5	7-B8
262	R72	*	R	R-0.4"	T-C4	7-B7
263	R73	*	R	R-0.4"	T-C4	7-C8
264	R74	100	R1206	R-SMD:1206	B-G1	6-A4
265	R75	100	R1206	R-SMD:1206	B-G1	6-C4
266	R76	100	R1206	R-SMD:1206	B-G1	6-E4
267	R77	866	R	R-0.4"	T-A4	1-F7
268	R78	100	R1206	R-SMD:1206	B-D3	4-B10
269	R79	10k	R	R-0.4"	T-H6	6-A9
270	R80	10k	R	R-0.4"	T-G4	6-E8
271	R81	100	R1206	R-SMD:1206	B-B5	7-B4
272	R82	100	R1206	R-SMD:1206	B-B5	7-B6
273	R83	2k15	R	R-0.4"	T-B4	7-C6
274	R84	1k*	R	R-0.4"	T-C3	7-E5
275	R85	1k*	R	R-0.4"	T-C3	7-E6
276	R86	100	R1206	R-SMD:1206	B-B1	7-F11
277	R87	100	R1206	R-SMD:1206	B-C4	7-A9
278	R88	*	R	R-0.4"	T-C2	7-D9
279	R89	100	R1206	R-SMD:1206	B-B1	7-E11
280	R90	100	R1206	R-SMD:1206	B-G1	6-E4
281	R91	100	R1206	R-SMD:1206	B-G1	6-C4
282	R92	100	R1206	R-SMD:1206	B-G1	6-A4
283	R93	1k*	R	R-0.4"	T-C4	7-E5
284	R94	*	R	R-0.4"	T-B2	7-E10
285	R95	100	R1206	R-SMD:1206	B-B1	7-D11
286	R96	10k	R	R-0.4"	T-B3	7-E4
287	R97	1k	R	R-0.4"	T-B4	7-D2
288	R98	10k	R	R-0.4"	T-C4	7-E1
289	R99	16k	R	R-0.4"	T-F5	3-D5
290	R100	750	R	R-0.4"	T-F5	3-E9
291	R101	750	R	R-0.4"	T-E5	3-B7
292	R102	10k	R	R-0.4"	T-B3	7-E3
293	R103	100	R1206	R-SMD:1206	B-B4	7-E3
294	R104	100	R1206	R-SMD:1206	B-C3	7-D4
295	R105	100	R1206	R-SMD:1206	T-D2	4-B4
296	R106	100	R1206	R-SMD:1206	T-D3	4-C4
297	R107	100	R1206	R-SMD:1206	T-D2	4-E4
298	R108	100	R1206	R-SMD:1206	T-E2	4-G4
299	R109	10k	R	R-0.4"	T-B6	7-B4
300	R110	100	R	R-0.4"	T-B5	7-C4
301	R111	1k	R	R-0.4"	T-D5	7-A10
302	R112	1k	R	R-0.4"	T-C5	7-B9
303	R113	*	R	R-0.4"	T-C6	7-C2
304	R114	*	R	R-0.4"	T-B5	7-C7
305						
306	---	S---				
307	S1	PD B single/diff	S1X2S01N	S1X2S01N	T-G5	6-E1
308	S2	bypass on/off	S1X2S01N	S1X2S01N	T-G5	6-F2
309	S3	bypass on/off	S1X2S01N	S1X2S01N	T-G2	6-D2
310	S4	PD A single/diff	S1X2S01N	S1X2S01N	T-G3	6-D1
311	S5	bypass on/off	S1X2S01N	S1X2S01N	T-E6	6-B2

312	S6	O. PD single/diff	S1X2S01N	S1X2S01N	T-D6	6-B1
313	S7	upper limit on/off	S1X2S01L	S1X2S01L	T-C2	7-F9
314	S8	Inverter on/off	S1X2S01L	S1X2S01L	T-D4	7-B11
315						
316		---X---				
317	X1	IN1	X09-2S-DMAL	X09-DSUBMALE1	T-C1	2-B3, 2-B8
318	X2	IN2	X09-2S-DMAL	X09-DSUBMALE1	T-E1	2-C8, 2-D3
319	X3	OUT1	X09-2S-DFEM	X09-DSUBFEMALE1	T-G1	2-B6, 2-B10
320	X4	OUT2	X09-2S-DFEM	X09-DSUBFEMALE1	T-H1	2-C10, 2-D6
321	X5	OUT3	X09-2S-DFEM	X09-DSUBFEMALE1	T-B1	2-C10, 2-E6
322	X6		XB96	XB96	T-B7	1-C2, 1-C3
323	X7		XB96	XB96	T-H7	1-C5, 1-C6
324	X8	5V	XT	XTN	T-A5	1-B10
325	X9	W1	XT	XTN	T-H4	5-D2
326	X10	W2	XT	XTN	T-I4	5-D4
327	X11	W1	XT	XTN	T-H6	5-D7
328	X12	W2	XT	XTN	T-I6	5-D10
329	X13	Outer PD In	XC	XC174N	T-E6	6-B1
330	X14	PD A In	XC	XC174N	T-H3	6-D1
331	X15	PD B In	XC	XC174N	T-H5	6-E1
332	X16	front (output)	XC	XC174N	T-H2	6-D5
333	X17	front (output)	XC	XC174N	T-H4	6-F5
334	X18	front (output)	XC	XC174N	T-G7	6-B5
335	X19	front (output)	XC	XC174N	T-G4	6-C6
336	X20	front (output)	XC	XC174N	T-G6	6-B8
337	X21	front (output)	XC	XC174N	T-G7	6-B11
338	X22	front (input)	XC	XC174N	T-H5	6-B8
339	X23	front (input)	XC	XC174N	T-F4	6-E8
340	X24	front (output)	XC	XC174N	T-F2	6-E10
341	X25	Test Int1	XT	XTN	T-B5	7-B4
342	X26	Test Gain	XT	XTN	T-B5	7-B6
343	X27	to AOM	XC	XC174N	T-C1	7-E11
344	X28	Test Int2	XT	XTN	T-C4	7-A9
345	X29	-5V	XT	XTN	T-A5	1-C10
346	X30	W1	XT	XTN	T-H5	5-B7
347	X31	Outer Closed	XT	XTN	T-E3	3-B4
348	X32	+15V	XT	XTN	T-A4	1-C10
349	X33	-15V	XT	XTN	T-A2	1-D10
350	X34	+24V	XT	XTN	T-A7	1-C8
351	X35	-24V	XT	XTN	T-A7	1-D8
352	X36	Interchange	XT	XTN	T-E3	3-A4
353	X37	Closed	XT	XTN	T-F3	3-D4
354	X38	Integrators	XT	XTN	T-E3	3-E4
355	X39		XT	XTN	T-A6	1-E9
356	X40	RefSignal	XT	XTN	T-D3	4-B10
357	X41	control output	XC	XC174N	T-B1	7-D11
358	X42	Gain1	XT	XTN	T-B4	7-E3
359	X43	W1	XT	XTN	T-H2	5-B2
360	X44	W2	XT	XTN	T-I2	5-B4
361	X45	Test AOM Offset	XT	XTN	T-C3	7-D4
362	X46	W4	XT	XTN	T-I5	5-B9
363	X47	Closed2	XT	XTN	T-F5	3-E7
364	X48	CalIn	XT	XTN	T-D2	4-B4
365	X49	Gain	XT	XTN	T-E3	4-D4
366	X50		XT	XTN	T-D6	1-E9
367	X51		XT	XTN	T-H4	1-E9
368	X52		XT	XTN	T-F3	1-E9
369	X53	InputTransfer	XT	XTN	T-D2	4-E4
370	X54	OffsetAOM	XT	XTN	T-D2	4-G4

371	X55	XT	XTN	T-G5	1-E10
372	X56	XT	XTN	T-B6	1-E10
373	X57	XT	XTN	T-H7	1-E10
374	X58	XT	XTN	T-C3	1-E10
375	X59	XT	XTN	T-E6	1-E10