Negative Impedance Converter

Circuit Board Documentation

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Abstract

This circuit provides four negative impedance converter dampener channels. These can be used to both drive and damp voice coils.

There are two operational modes provided, controlled via a set of digital inputs. The first mode allows each pair of coil terminals to be shorted such that they undergo standard eddy current damping. In this mode, the damping performance is limited by the impedance of the coil wires. The second mode introduces an effective negative impedance to the coils via an active circuit, which can be used to counteract the impedance of the coil wires; with this circuit, very high damping performance can be achieved.

Send/receive circuitry is included to allow optional sensing and feedback via CDS. This can be used to tune the cancellation of the coil impedance; for example, by shaping the frequency response. CDS can be avoided by populating appropriate components in the non-inverting feedback path of the OP27 op-amps.

Key words: coil, negative impedance, CDS

Contents

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 Laborausrüstung 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.

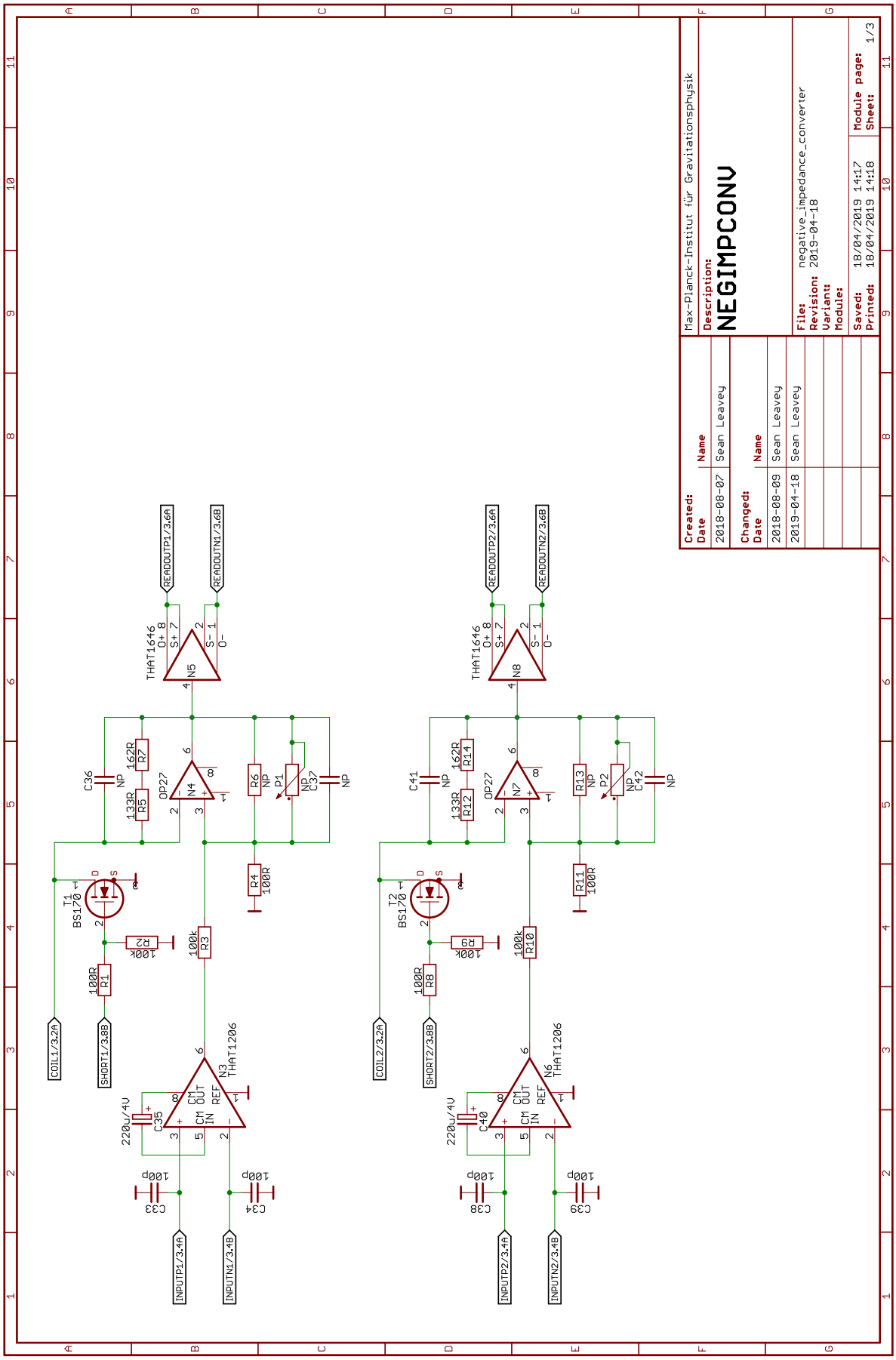

Figure 1: *Project schematics (sheet 1)*

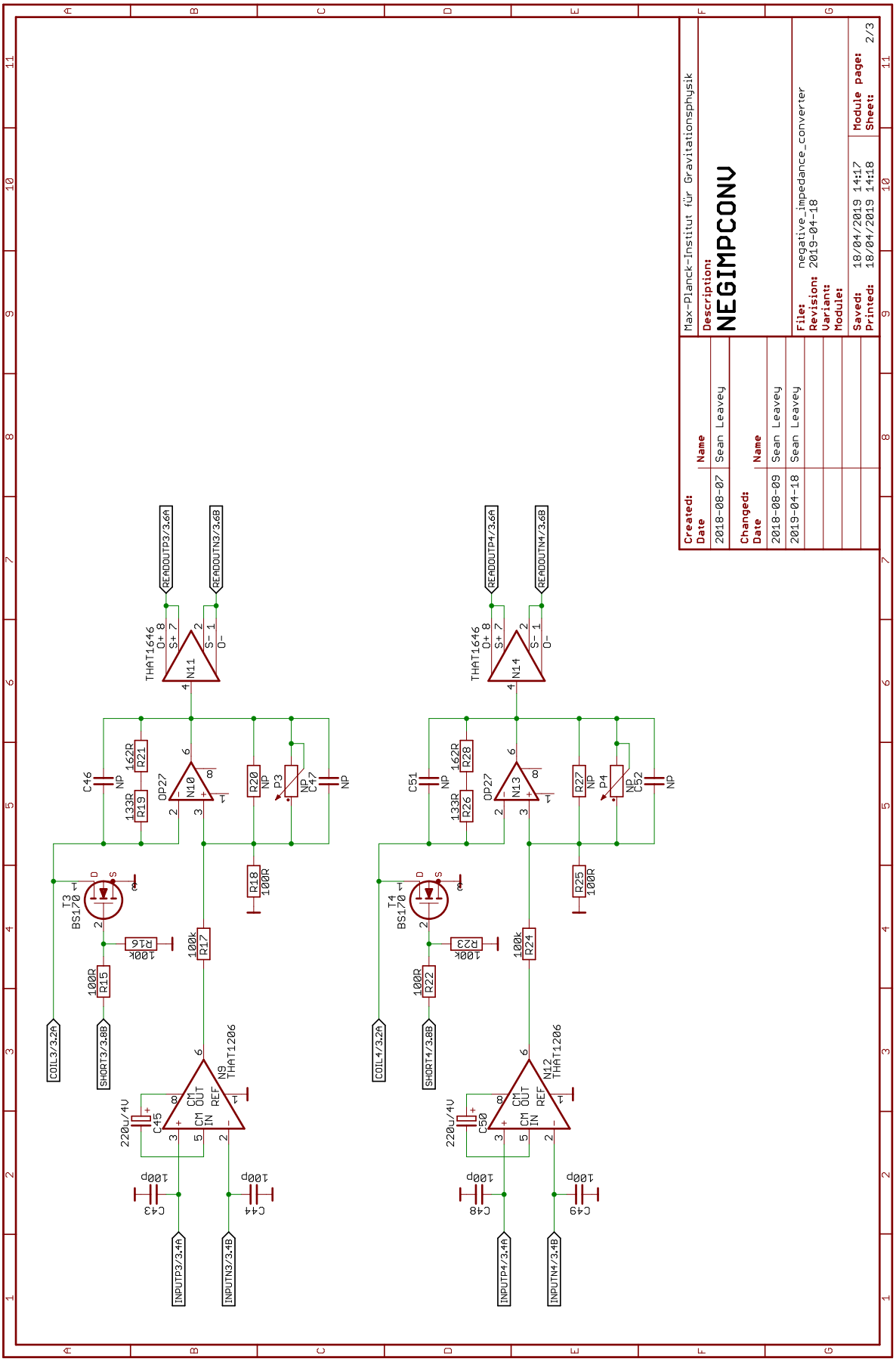

Figure 2: *Project schematics (sheet 2)*

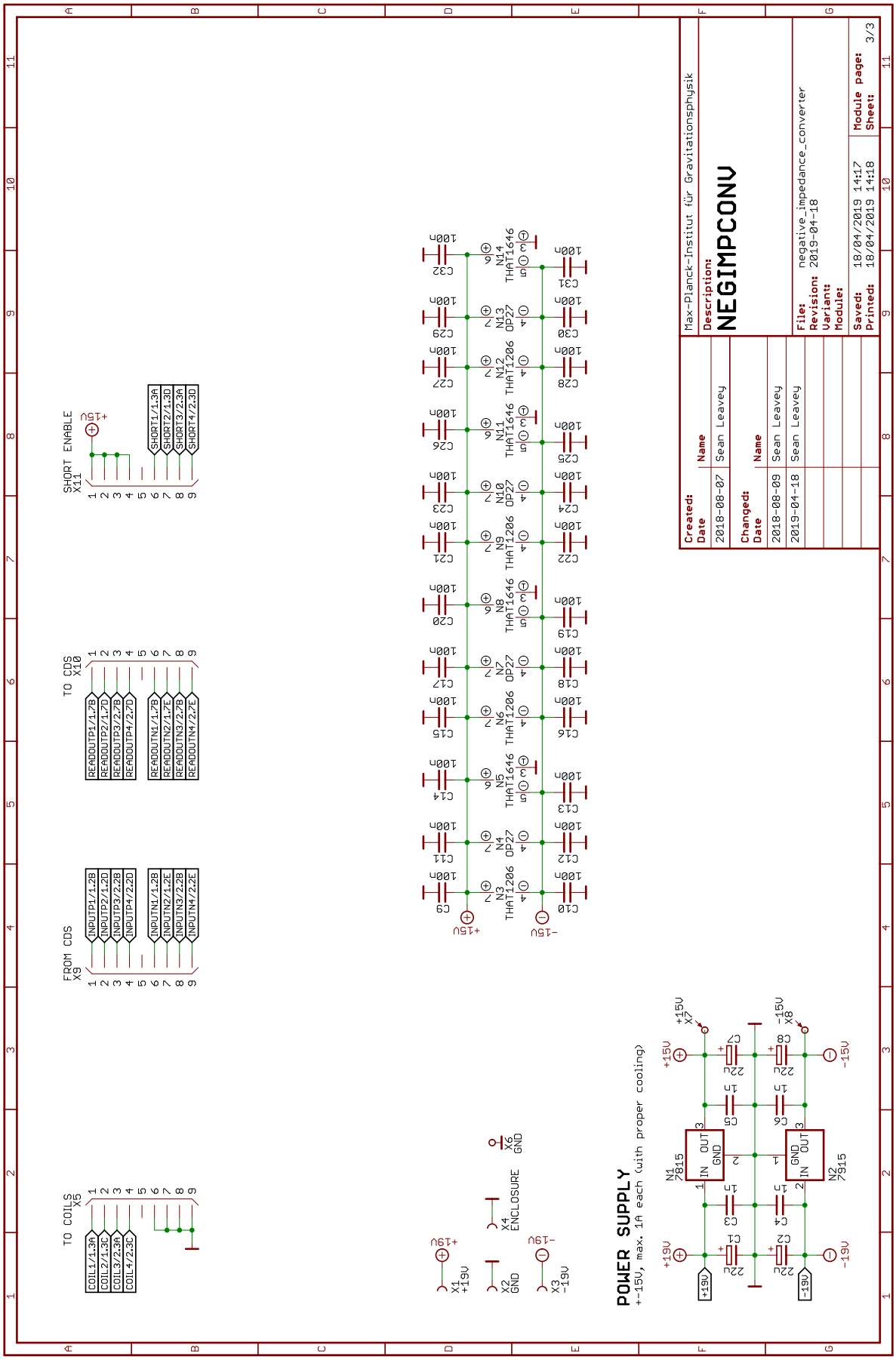

Figure 3: *Project schematics (sheet 3)*

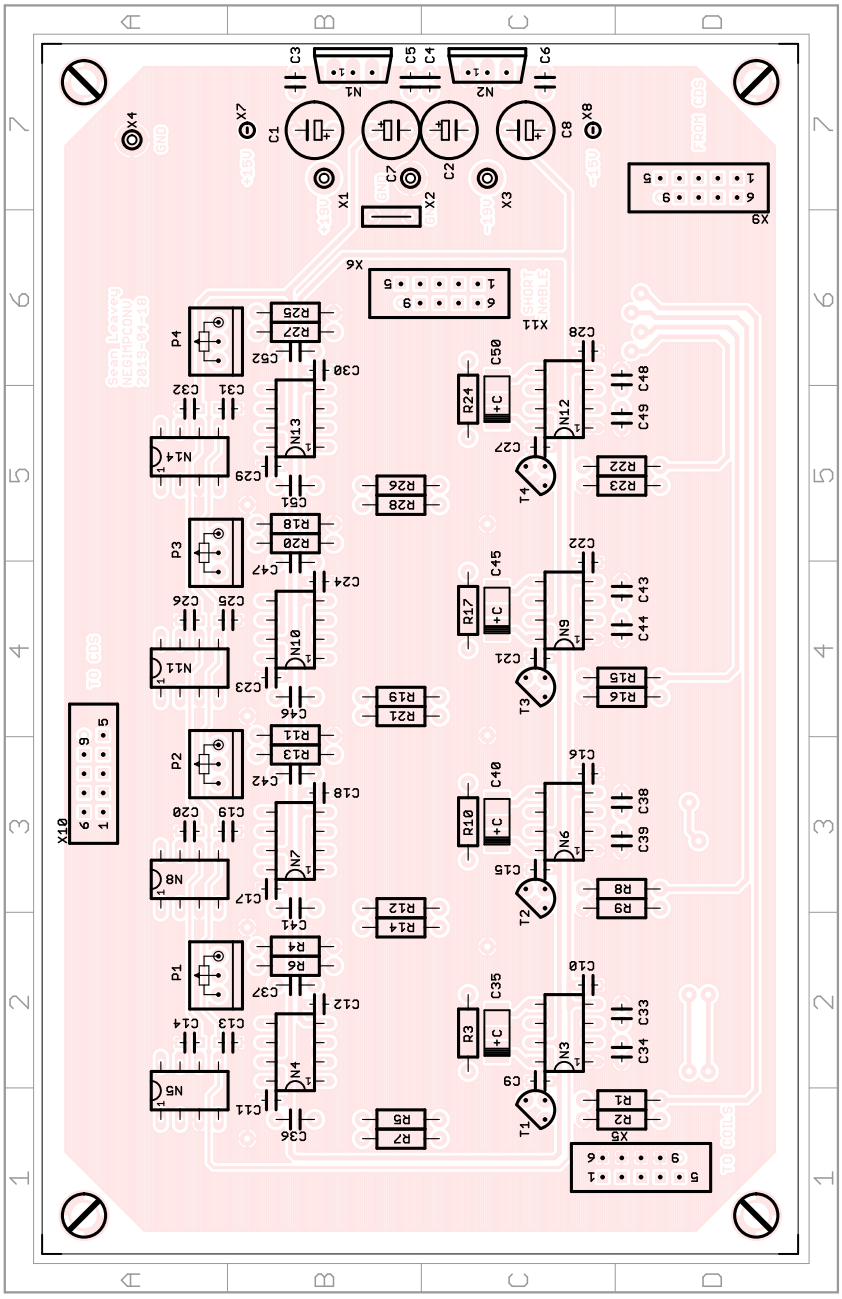

Figure 4: *Board top view showing placeplan with component names*

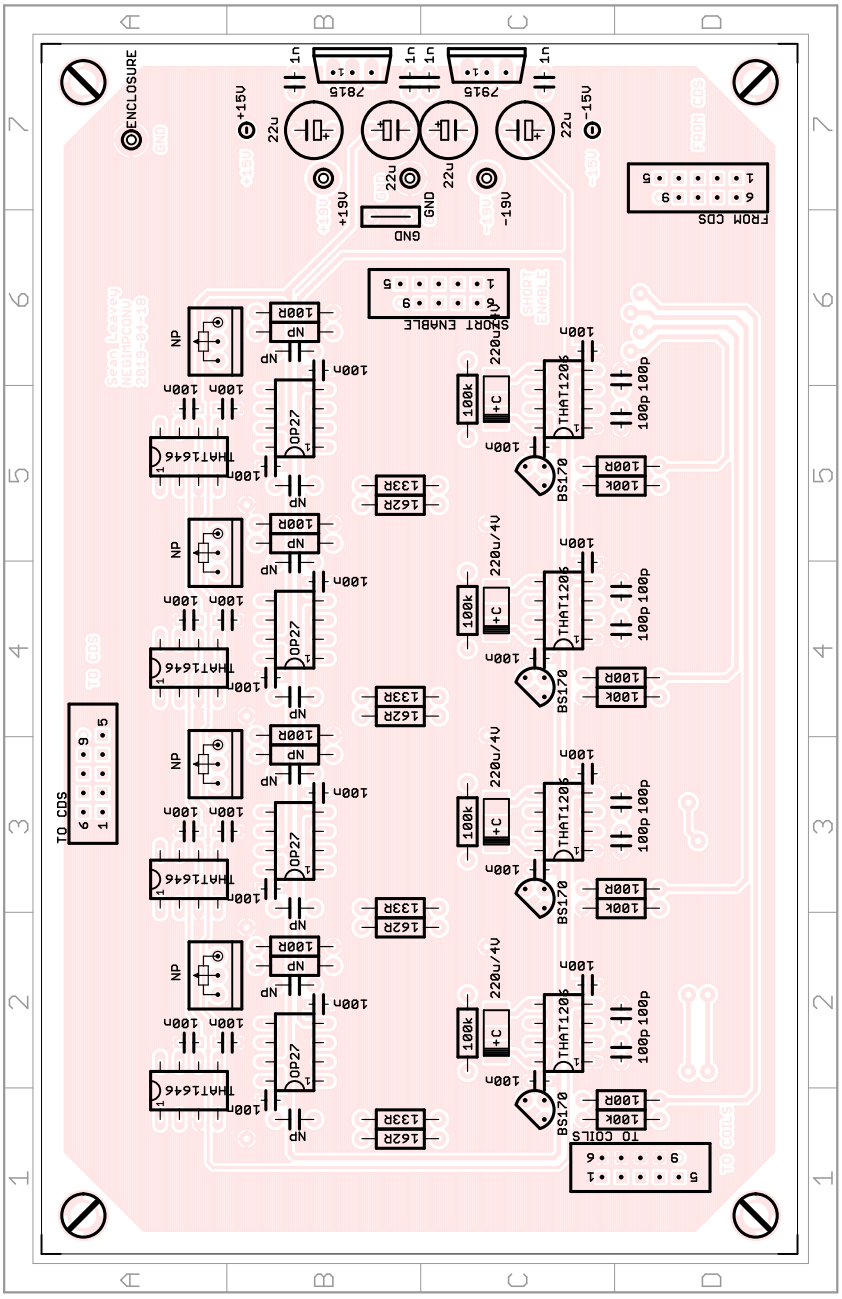

Figure 5: *Board top view showing placeplan with component values*

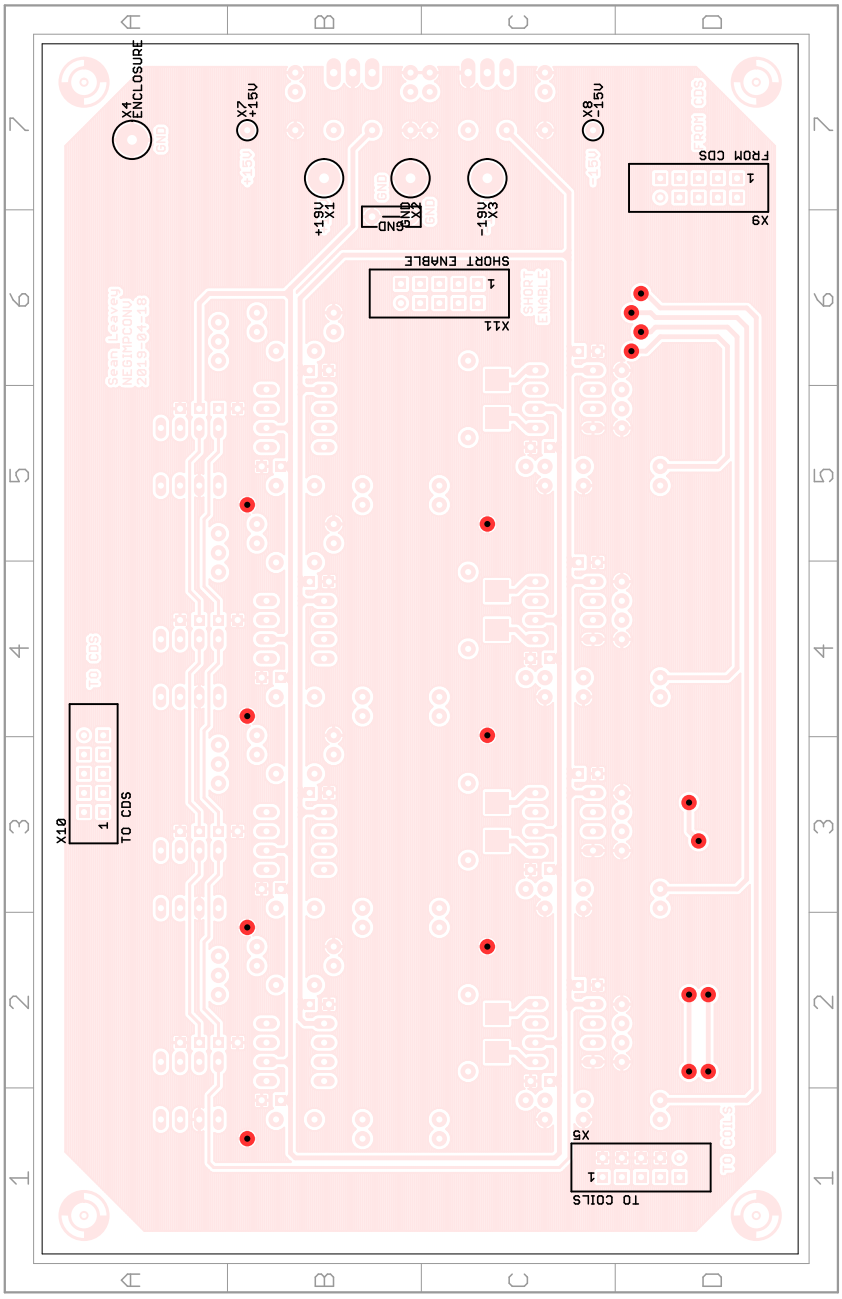

Figure 6: *Board top view showing connectors, test points, vias and wired components*

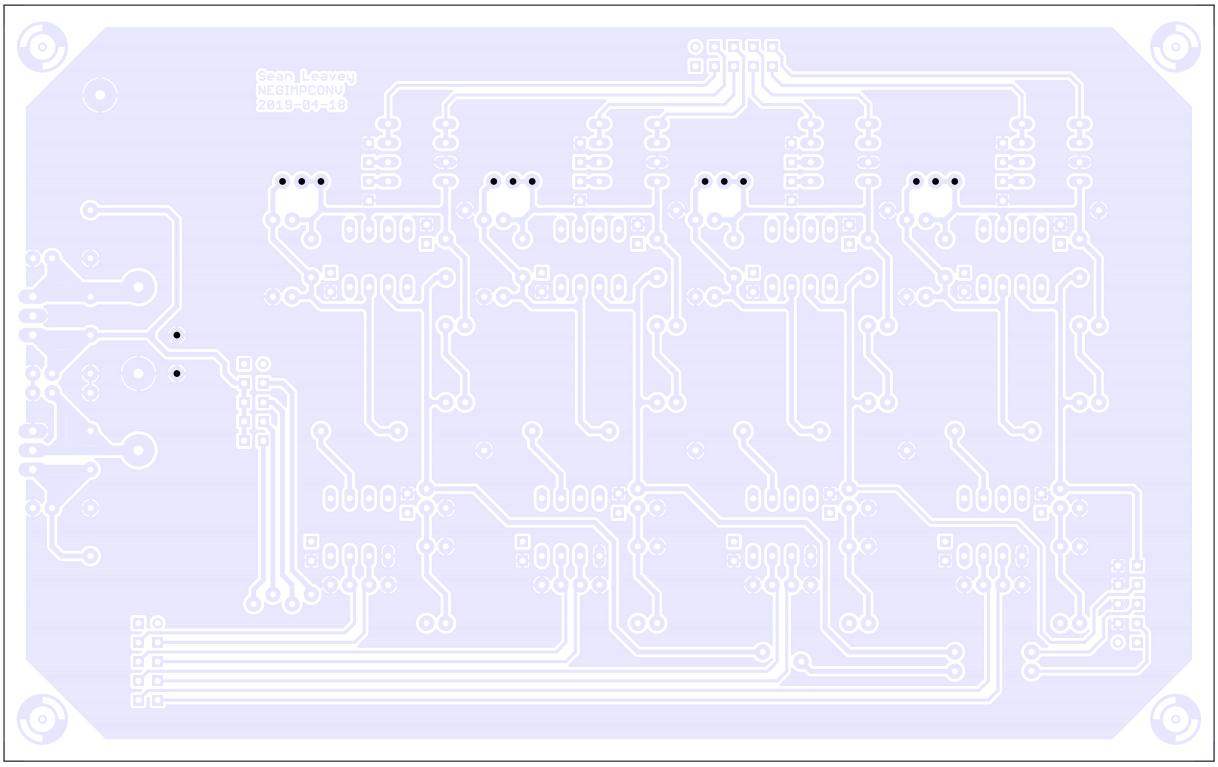

Figure 7: *Board bottom view showing drills with 0.9 mm (0.035 in) diameter*

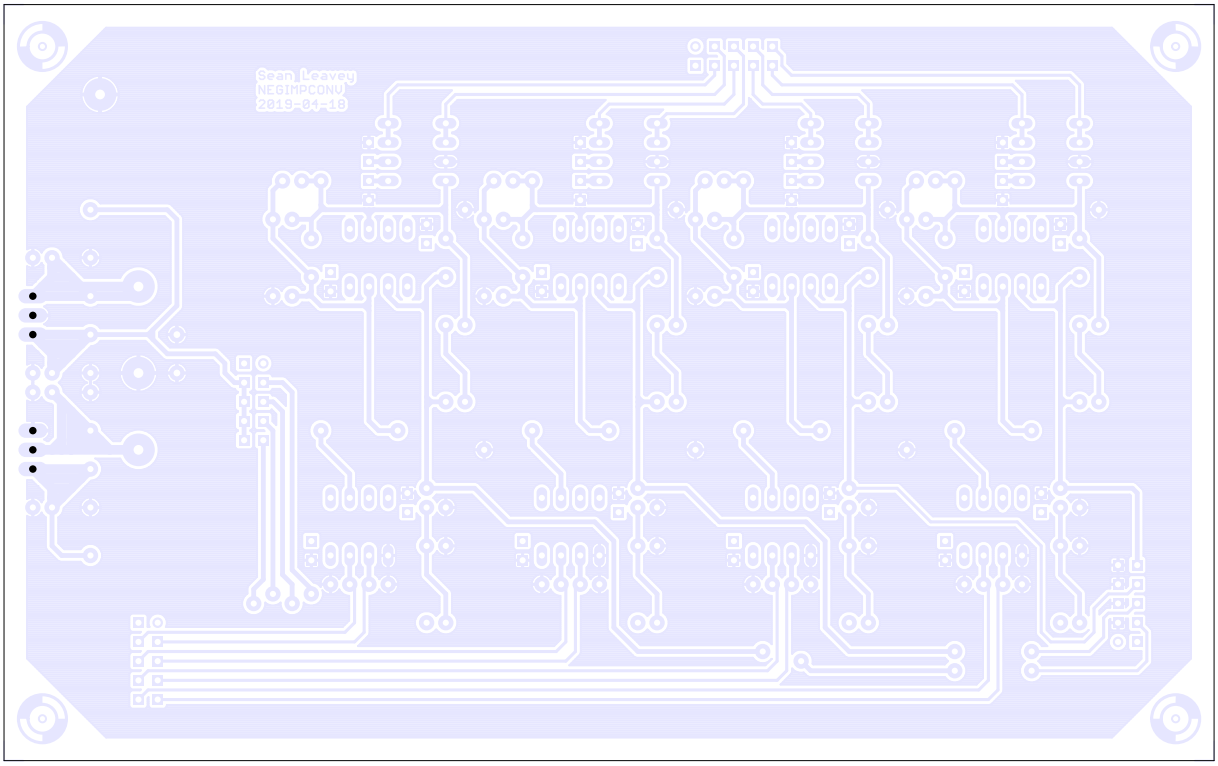

Figure 8: *Board bottom view showing drills with 1.0 mm (0.039 in) diameter*

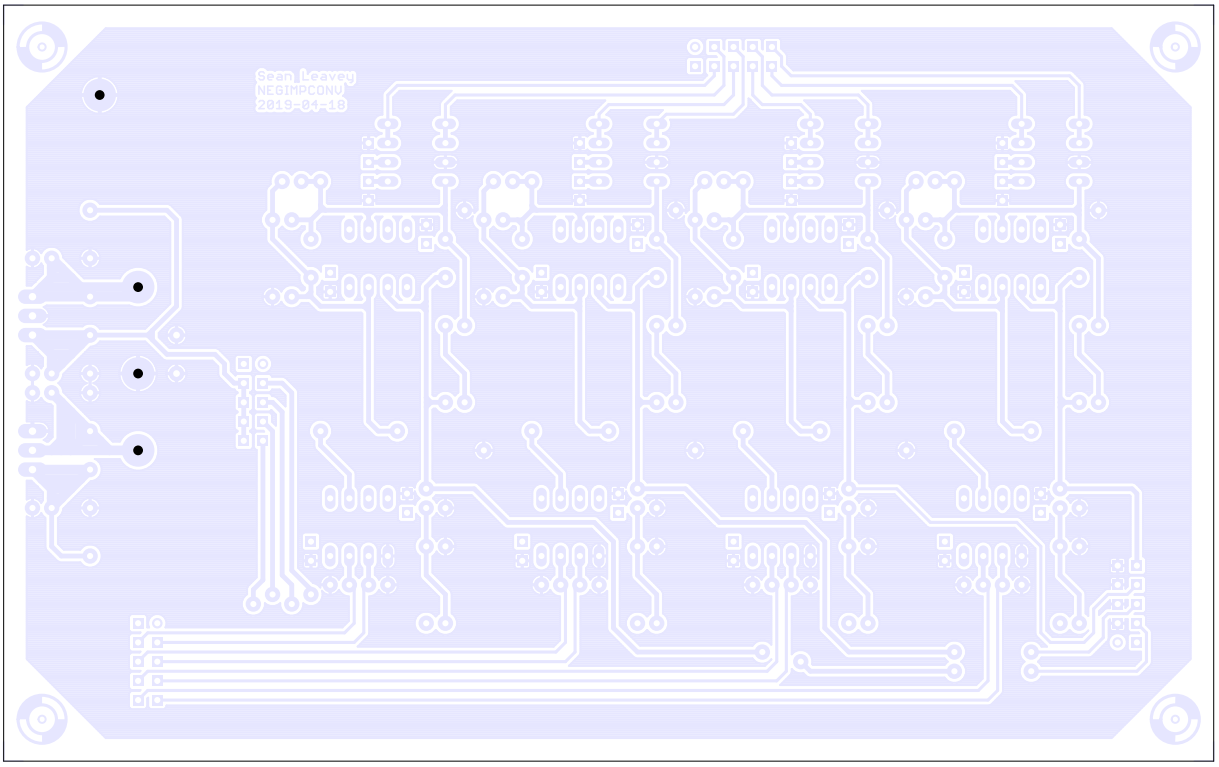

Figure 9: *Board bottom view showing drills with 1.3 mm (0.051 in) diameter*

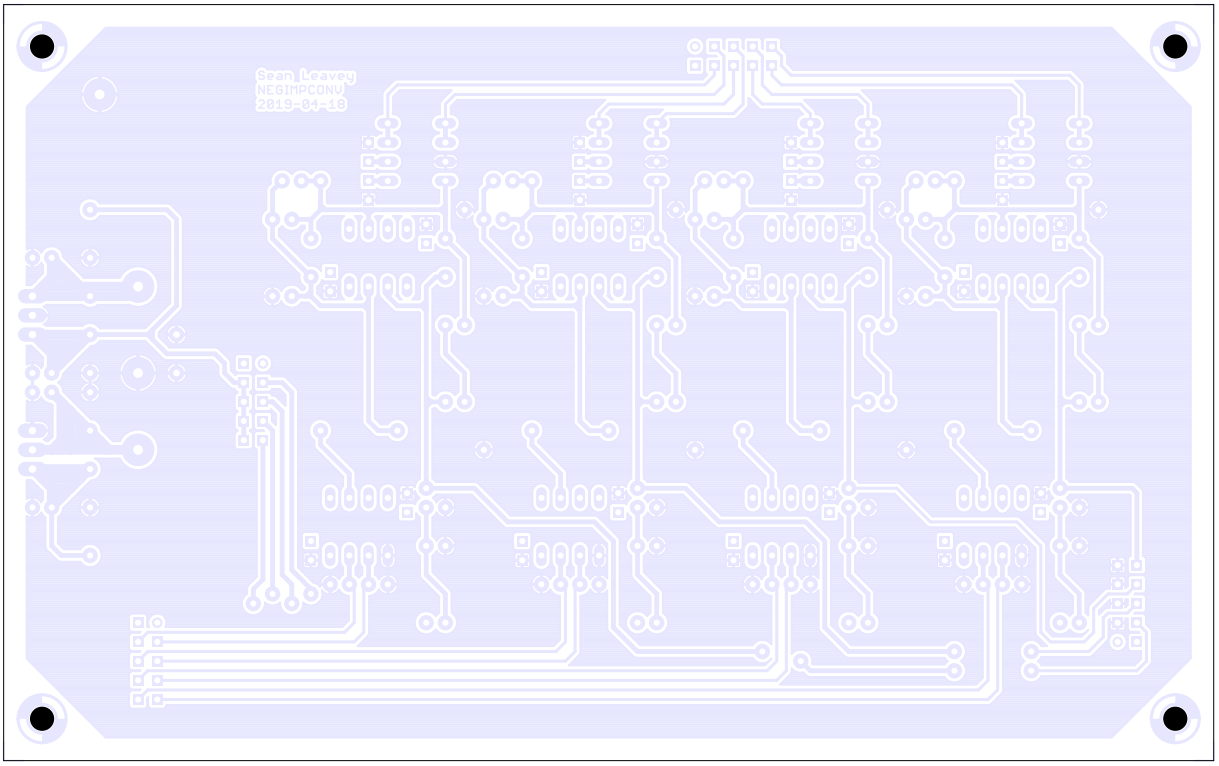

Figure 10: *Board bottom view showing drills with 3.2 mm (0.126 in) diameter*

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.

∅ [µm]	∅ [mm]	∅ [in]	Count
813	0.8	0.032	319
889	0.9	0.035	14
991	1.0	0.039	6
1295	1.3	0.051	4
3200	3.2	0.126	4
		Total	347

Table 1: *Drill diameters used in the board*

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).

	Value	Package	Count	Component names *(library)*
	— C —			
1	100p	C-0.1"	8	C33,C34,C38,C39,C43,C44,C48,C49 *(miscs)*
2	1n	C-CERAMIC:0.1"	4	C3-C6 *(miscs)*
3	100n	C-CERAMIC:0.1"	24	C9-C32 *(miscs)*
4	22u	CE-TANTAL:0.2"	4	C1,C2,C7,C8 *(miscs)*
5	220u/4V	CE-SMD:C	4	C35,C40,C45,C50 *(miscs)*
	— N —			
6	7815	TO-220	1	N1 *(ics)*
7	7915	TO-220	1	N2 *(ics)*
8	OP27	DIP-8	4	N4,N7,N10,N13 *(opamps)*
9	THAT1206	DIP-8	4	N3,N6,N9,N12 *(opamps)*
10	THAT1646	DIP-8	4	N5,N8,N11,N14 *(opamps)*
	— R —			
11	100R	R-wired:0.6W	8	R1,R4,R8,R11,R15,R18,R22,R25 *(miscs)*
12	133R	R-wired:0.6W	4	R5,R12,R19,R26 *(miscs)*
13	162R	R-wired:0.6W	4	R7,R14,R21,R28 *(miscs)*
14	100k	R-wired:0.6W	8	R2,R3,R9,R10,R16,R17,R23,R24 *(miscs)*
	— T —			
15	BS170	TO-92	4	T1-T4 *(transistors)*
	— X —			
16	*[ignored]*	GND-0.2"	1	X6 *(connectors)*
17	*[ignored]*	IDC:10-pin/ribbon	4	X5,X9-X11 *(connectors)*
18	*[ignored]*	Solderpin:1.3mm	4	X1-X4 *(connectors)*
19	*[ignored]*	Testpin:0.8mm/ceramic	2	X7,X8 *(connectors)*
	— [unpopulated] —			
20	*[undefined]*		16	C36,C37,C41,C42,C46,C47-P4,R6,R13,R20,R27 *(miscs)*