INRUSH1

Circuit Board Documentation

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Abstract

This circuit (INRUSH1) provides inrush current limiting for a large load (up to 20A) with the following features:
- Soft start current limiting to around 25A using thermistors
- Relay shorting across the thermistors to minimise power loss after short delay
- Overtemperature trip switch requiring power-cycle to reset
- LED indicators for front panel

Key words: inrush current limit 25A soft start

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 contains hazardous voltages (50–1000 V_{AC} or 75–1500 V_{DC})[1]. To avoid the possibility of electrical shock, the following policies should be strictly observed:

- Operate the board only in an either isolated or properly earthed case, ensuring that live contacts and wires cannot be touched.
- Use only connectors and cables meeting the required specifications and with protection against direct contact.
- Before connecting or disconnecting cables, ensure that the power is disconnected and all internal capacitors are discharged.
- Check the circuit safety at regular intervals, label the unit accordingly, and immediately dispose of defective equipment.

This circuit gets *hot* (> 55 °C, > 130 °F) due to its power consumption. To avoid overheating, fire and burns, observe the following rules:

- Do not block available air vents.
- Give the unit free access to the room ambient air for convection.
- Maintain a safety clearance to inflammable materials.
- Do not touch hot surfaces.

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.

The unit does not contain any mechanical drive system. Therefore, the regulations of the *Machinery Directive* (2006/42/EC) do not apply.

[1] The regulations of the *Low Voltage Directive* (2014/35/EU) 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 enthält gefährliche Spannungen (50–1000 V_{AC} oder 75–1500 V_{DC})[2]. Zur Vermeidung von Stromschlägen sind folgende Regeln strikt einzuhalten:

- Platine nur in einem isolierten oder korrekt geerdeten Gehäuse betreiben, damit spannungsführende Kontakte und Drähte nicht berührt werden können.
- Nur Steckverbinder und Kabel verwenden, welche die nötigen Spezifikationen einhalten und berührungsgeschützt sind.
- Vor dem Ein- und Ausstecken von Kabeln sicherstellen, daß die Betriebsspannung ausgeschaltet ist und alle internen Kondensatoren entladen sind.
- Gerät in regelmäßigen Abständen auf Sicherheit prüfen, entsprechend beschriften und bei Defekten sofort aus dem Verkehr ziehen.

Diese Schaltung wird aufgrund ihrer Verlustleistung *heiß* (> 55 °C, > 130 °F). Um Überhitzung, Feuer und Verbrennungen zu vermeiden, sind folgende Punkte zu beachten:

- Vorhandene Lüftungsöffnungen nicht versperren.
- Gerät zur Konvektion freien Zugang zur Raumluft ermöglichen.
- Sicherheitsabstand zu brennbarem Material einhalten.
- Heiße Oberflächen nicht berühren.

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.

Das Gerät enthält kein mechanisches Antriebssystem – die Bestimmungen der *Maschinenrichtlinie* (2006/42/EG) sind daher nicht anwendbar.

[2] Es gelten die Bestimmungen der *Niederspannungsrichtlinie* (2014/35/EU).

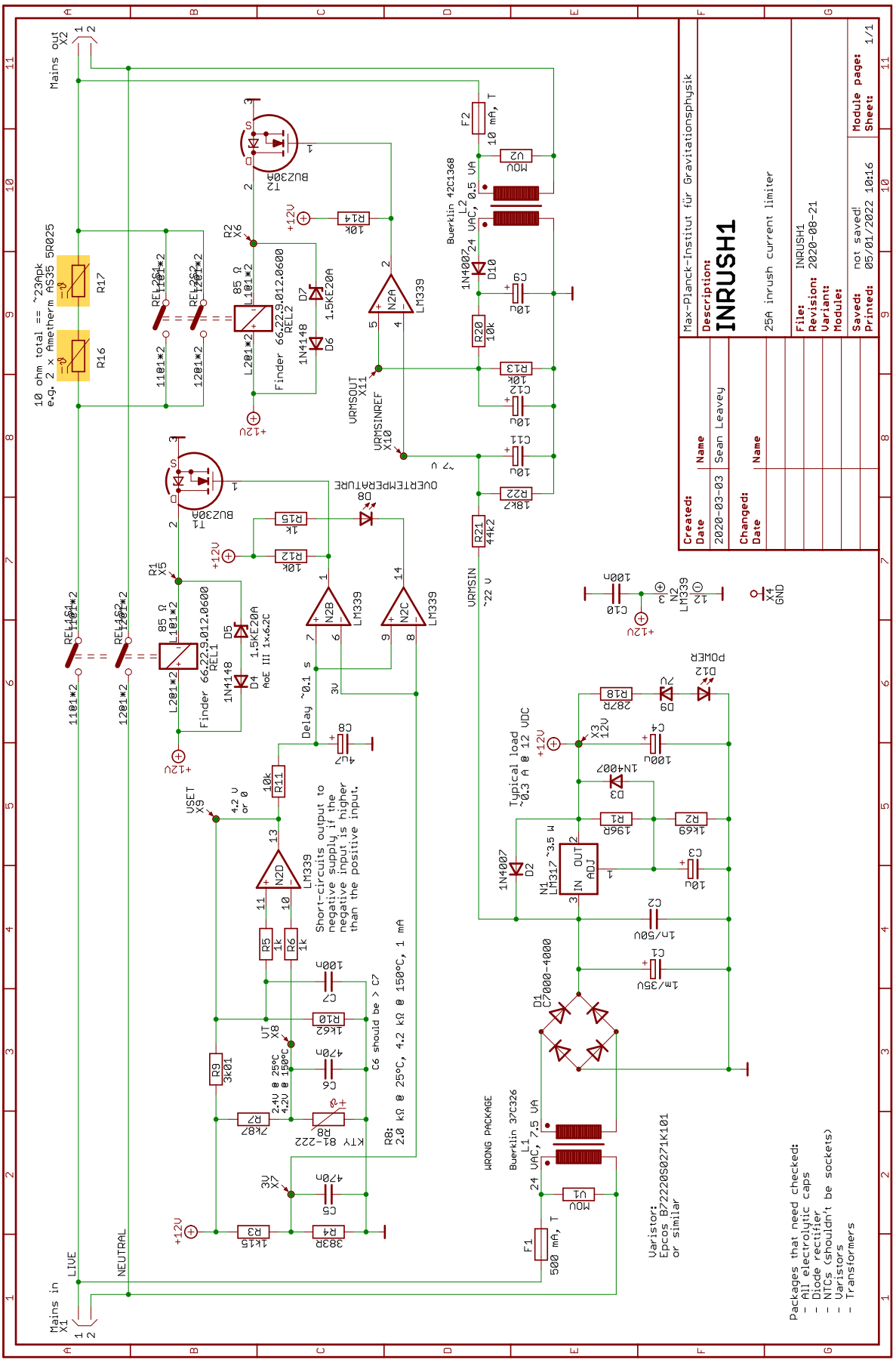

Figure 1: *Design schematics*
Parts with undefined values are highlighted in orange

Circuit Lists

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 *prefixes* and *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	1n/50V	C-0.2"	1	C2 *(miscs)*
2	100n	C-0.2"	2	C7,C10 *(miscs)*
3	470n	C-0.2"	2	C5,C6 *(miscs)*
4	4u7	CE-TANTAL:0.1"	1	C8 *(miscs)*
5	10u	CE-TANTAL:0.1"	4	C3,C9,C11,C12 *(miscs)*
6	100u	CE-TANTAL:0.2"	1	C4 *(miscs)*
7	1m/35V	CE-TANTAL:0.2"	1	C1 *(miscs)*
	— D —			
8	1N4007	D04N-DO41	3	D2,D3,D10 *(diodes)*
9	1N4148	D04N-DO35	2	D4,D6 *(diodes)*
10	7V	DZ-0.4"	1	D9 *(diodes)*
11	1.5KE20A	DSU06N2	2	D5,D7 *(diodes)*
12	C7000-4000	DR02N	1	D1 *(diodes)*
13	*[ignored]*	LED:Header/coded	2	D8,D12 *(optos)*
	— F —			
14	10 mA, T	F02	1	F2 *(miscs)*
15	500 mA, T	F02	1	F1 *(miscs)*
	— L —			
16	24 VAC, 0.5 VA	LT11-0W5	1	L2 *(miscs)*
17	24 VAC, 7.5 VA	LT11-3W2	1	L1 *(miscs)*
	— N —			
18	LM317	TO-220	1	N1 *(ics)*
19	LM339	DIP-14	1	N2 *(opamps)*
	— R —			
20	196R	R-wired:0.6W	1	R1 *(miscs)*
21	287R	R-wired:0.6W	1	R18 *(miscs)*
22	383R	R-wired:0.6W	1	R4 *(miscs)*
23	1k	R-wired:0.6W	3	R5,R6,R15 *(miscs)*
24	1k15	R-wired:0.6W	1	R3 *(miscs)*
25	1k62	R-wired:0.6W	1	R10 *(miscs)*
26	1k69	R-wired:0.6W	1	R2 *(miscs)*
27	3k01	R-wired:0.6W	1	R9 *(miscs)*
28	7k87	R-wired:0.6W	1	R7 *(miscs)*
29	10k	R-wired:0.6W	5	R11-R14,R20 *(miscs)*
30	18k7	R-wired:0.6W	1	R22 *(miscs)*
31	44k2	R-wired:0.6W	1	R21 *(miscs)*
32	KTY 81-222	R01W	1	R8 *(miscs)*
33	*[undefined]*	R01W	2	R16,R17 *(miscs)*
	— REL —			
34	Finder 66.22.9.012.0600	REL-FINDER-66.22-X600	2	REL1,REL2 *(miscs)*
	— T —			
35	BUZ30A	TO-220	2	T1,T2 *(transistors)*
	— V —			
36	MOV	R-wired:2W	2	V1,V2 *(miscs)*

— continued on next page —

Table 0: *Value list — continued*

	Value	Package	Count	Component names *(library)*
	— X —			
37	*[ignored]*	GND-0.2"	1	X4 *(connectors)*
38	*[ignored]*	PIN:0.8mm/ceram.	8	X3,X5,X6,X7,X8,X9,X10,X11 *(connectors)*
39	*[ignored]*	SCREW-TERM:2p./vert.	2	X1,X2 *(connectors)*

Table 0: *Value list*

Part list: The following list shows all components that are available in both schematics *and* board (sorted by part *names*) and can be used to quickly locate components. Additional information can possibly be found directly in the schematics. The column *Sheet* shows the position of a gate in the schematics: Sheet number followed by the cell of the surrounding frame (if available). The column *Board* shows the population layer (**T** for top, **B** for bottom) of a component on the board.

	Part Gate	Sheet	Board
	— C —		
1	C1	1-F4	T
2	C2	1-F4	T
3	C3	1-F4	T
4	C4	1-F5	T
5	C5	1-C2	T
6	C6	1-C3	T
7	C7	1-C4	T
8	C8	1-C5	T
9	C9	1-E9	T
10	C10	1-E7	T
11	C11	1-E8	T
12	C12	1-E8	T
	— D —		
13	D1	1-E3	T
14	D2	1-E4	T
15	D3	1-E5	T
16	D4	1-B6	T
17	D5	1-B6	T
18	D6	1-C9	T
19	D7	1-C9	T
20	D8	1-C7	T
21	D9	1-F6	T
22	D10	1-D9	T
23	D12	1-F6	T
	— F —		
24	F1	1-E1	T
25	F2	1-D11	T
	— L —		
26	L1	1-E2	T
27	L2	1-E10	T
	— N —		
28	N1	1-E4	T
29	N2 A:	1-D9	T
30	B:	1-C7	
31	C:	1-D7	
32	D:	1-C4	
33	P:	1-F7	
	— R —		
34	R1	1-E5	T
35	R2	1-F5	T
36	R3	1-B2	T
37	R4	1-C2	T
38	R5	1-C4	T
39	R6	1-C4	T
40	R7	1-B2	T
41	R8	1-C2	T
42	R9	1-B3	T
43	R10	1-C3	T
44	R11	1-C5	T
45	R12	1-C7	T
46	R13	1-E9	T
47	R14	1-C10	T
48	R15	1-C7	T
49	R16	1-A9	T
50	R17	1-A9	T
51	R18	1-E6	T
52	R20	1-D9	T
53	R21	1-D7	T
54	R22	1-E8	T
	— REL —		
55	REL1 L:	1-B6	T
56	S1:	1-A6	
57	S2:	1-A6	
58	REL2 L:	1-B9	T
59	S1:	1-B9	
60	S2:	1-B9	
	— T —		
61	T1	1-B8	T
62	T2	1-C10	T
	— V —		
63	V1	1-E2	T
64	V2	1-E10	T
	— X —		
65	X1	1-A1	T
66	X2	1-A11	T
67	X3	1-E5	T
68	X4	1-F7	T
69	X5	1-B7	T
70	X6	1-B10	T
71	X7	1-C2	T
72	X8	1-C3	T
73	X9	1-B5	T
74	X10	1-D8	T
75	X11	1-C9	T

Table 1: *Part list*