HV PSU Filter

Circuit Board Documentation

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Abstract

This is a high voltage power supply filter based on a "Maida" style LM317 regulator with high voltage transistor stand-off, but in this case with the transistor replaced with a FET. The LM317 floats off the HV rail so that it doesn't need to be HV rated. Potentiometer P1 is provided to trim the exact voltage output. Both T1 and N1 must be attached to the heat sink. Only T1 dissipates significant heat, but N1's thermal cut-out is useful as an overtemperature shutdown.

This circuit can optionally be populated for negative HV supplies by:

- Swapping the state of jumpers J1 and J2 and using an LM337 regulator in place of the LM317,
- Replacing T1 with an FQPF3P50 or similar,
- Swapping the polarity of all of the diodes and capacitors.

This circuit contains high voltages, and stores significant energy in its capacitors. Ensure the circuit is fully discharged before touching it.

Key words: high voltage power supply ripple noise filter positive negative

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* (2006/95/EC) 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/EC) sind daher nicht anwendbar.

[2]Es gelten die Bestimmungen der *Niederspannungsrichtlinie* (2006/95/EC).

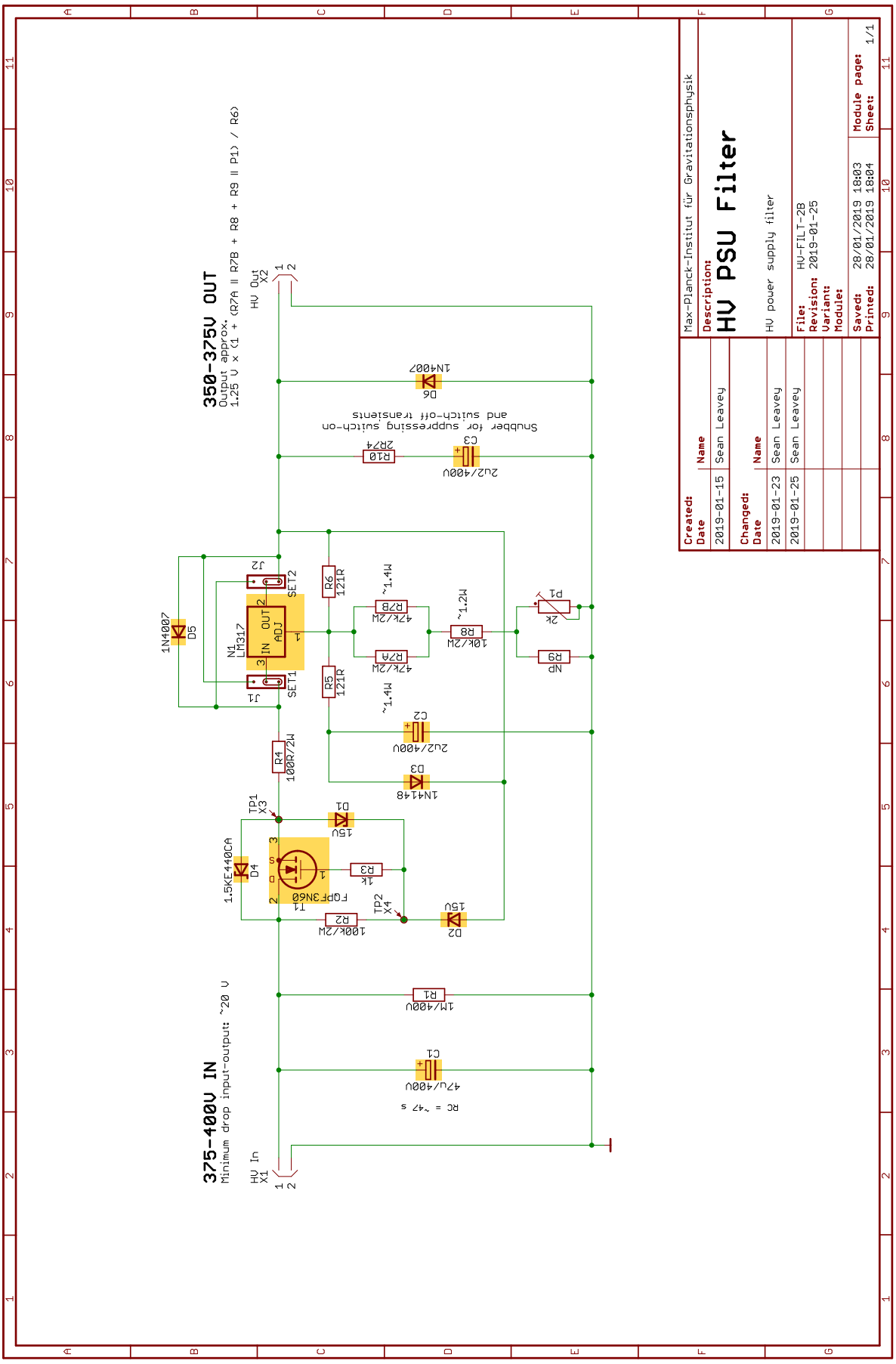

Figure 1: *Project schematics*
Parts with more than one population variant are highlighted in orange

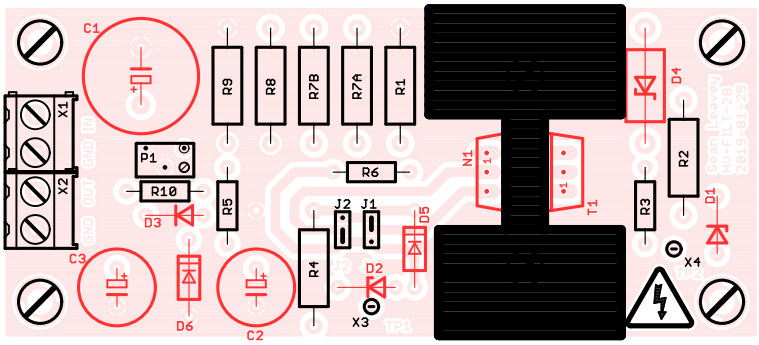

Figure 2: *Board top view showing placeplan with component names*
Components with more than one population variant are shown in red

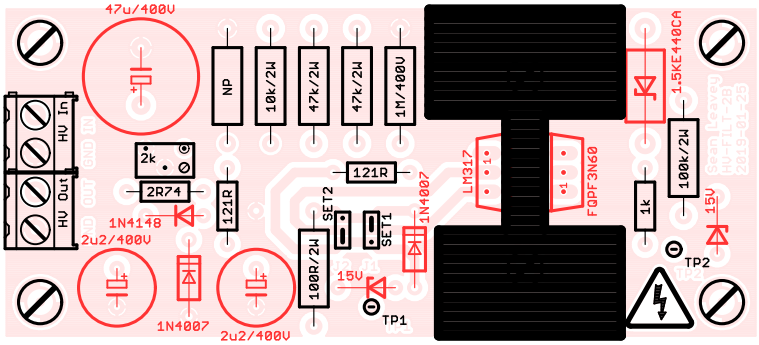

Figure 3: *Board top view showing placeplan with component values*
Components with more than one population variant are shown in red

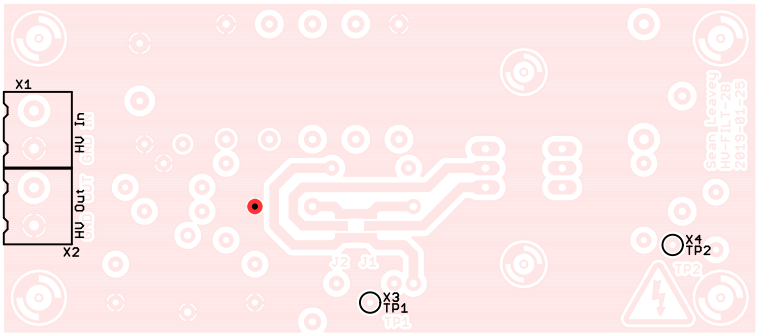

Figure 4: *Board top view showing connectors, test points, vias and wired components*

Figure 5: *Board bottom view showing drills with 0.9 mm (0.035 in) diameter*

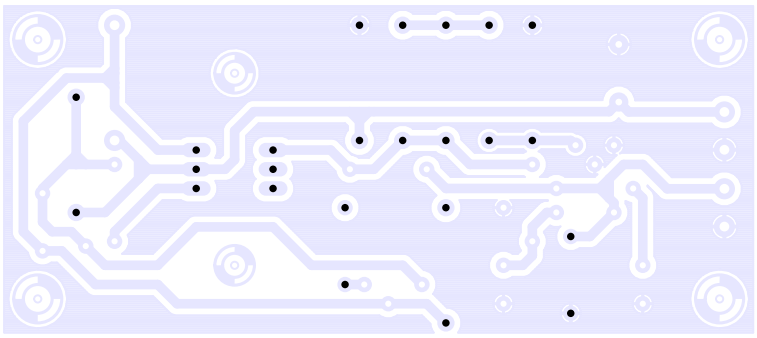

Figure 6: *Board bottom view showing drills with 1.0 mm (0.039 in) diameter*

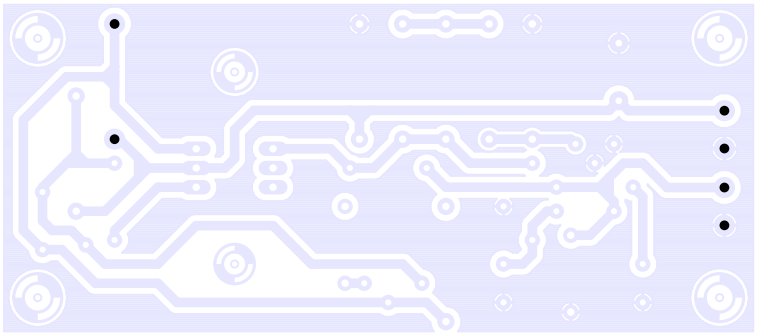

Figure 7: *Board bottom view showing drills with 1.3 mm (0.051 in) diameter*

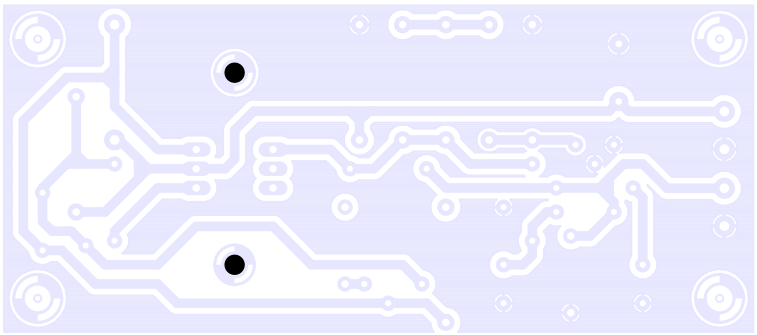

Figure 8: *Board bottom view showing drills with 2.7 mm (0.106 in) diameter*

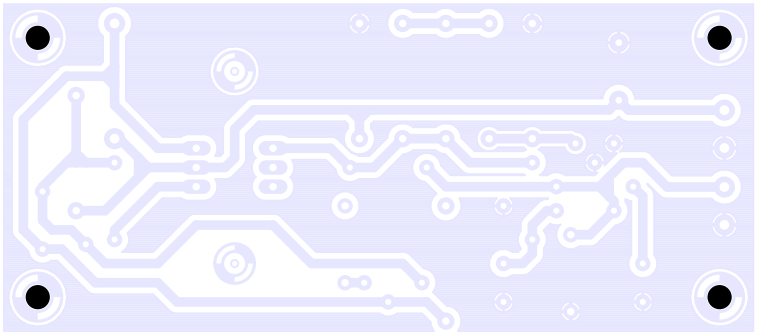

Figure 9: *Board bottom view showing drills with 3.2 mm (0.126 in) diameter*

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	24
889	0.9	0.035	2
991	1.0	0.039	24
1295	1.3	0.051	6
2692	2.7	0.106	2
3200	3.2	0.126	4
		Total	62

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

This circuit features a flexible design, so that its behaviour can be adapted to the user's needs by modifying the board population. Therefore, the board's value list is distributed over several tables: One for the *base* population and one for each population *variant*.

Value list — Variant-independent *base population*: The following list shows the board's base components (sorted by part *values*) common to *all* population variants. Additional information can possibly be found directly on the board (or in the schematics).

	Value	Package	Count	Component names *(library)*
	— J —			
1	*[ignored]*	JMP-SMD:3-pad	2	J1,J2 *(connectors)*
	— P —			
2	2k	Trimmer:7x5mm/vert.	1	P1 *(miscs)*
	— R —			
3	2R74	R-wired:0.6W	1	R10 *(miscs)*
4	100R/2W	R-wired:2W	1	R4 *(miscs)*
5	121R	R-wired:0.6W	2	R5,R6 *(miscs)*
6	1k	R-wired:0.6W	1	R3 *(miscs)*
7	10k/2W	R-wired:2W	1	R8 *(miscs)*
8	47k/2W	R-wired:2W	2	R7A,R7B *(miscs)*
9	100k/2W	R-wired:2W	1	R2 *(miscs)*
10	1M/400V	R-wired:2W	1	R1 *(miscs)*
	— X —			
11	*[ignored]*	ScrewTerminal:2-pin/vert.	2	X1,X2 *(connectors)*
12	*[ignored]*	Testpin:0.8mm/ceramic	2	X3,X4 *(connectors)*
	— [unpopulated] —			
13	*[undefined]*		1	R9 *(miscs)*

Value list for standard population: The following list shows the board components (sorted by part *values*) additionally required to convert the base population to the standard population. Additional information can possibly be found directly on the board (or in the schematics).

	Value	Package	Count	Component names *(library)*
	— C —			
14	2u2/400V	CE-0.2":r=10mm	2	C2,C3 *(miscs)*
15	47u/400V	CE03A	1	C1 *(miscs)*
	— D —			
16	1N4007	D04N-DO41	2	D5,D6 *(diodes)*
17	1N4148	D03N-DO35	1	D3 *(diodes)*
18	15V	DZ-0.3"	2	D1,D2 *(diodes)*
19	1.5KE440CA	DSU06N2	1	D4 *(diodes)*
	— N —			
20	LM317	TO-220	1	N1 *(ics)*
	— T —			
21	FQPF3N60	TO-220	1	T1 *(transistors)*

Value list for variant 1 — *-400V*: The following list shows the board components (sorted by part *values*) additionally required to convert the base population to variant 1. The *origin* column shows where each component value was derived from – either the variant itself (`'v1'`) or, in case the component does not appear in this variant, the standard population (`'-'`). Additional information can possibly be found directly on the board (or in the schematics).

	Value	Package	Origin	Count	Component names *(library)*
	— C —				
22	2u2/400V	CE-0.2":r=10mm	v1	2	C2,C3 *(miscs)*
23	47u/400V	CE03A	v1	1	C1 *(miscs)*
	— D —				
24	1N4007	D04N-DO41	v1	2	D5,D6 *(diodes)*
25	1N4148	D03N-DO35	v1	1	D3 *(diodes)*
26	15V	DZ-0.3"	v1	2	D1,D2 *(diodes)*
27	1.5KE440CA	DSU06N2	v1	1	D4 *(diodes)*
	— N —				
28	LM317	TO-220	v1	1	N1 *(ics)*
	— T —				
29	FDP2670	TO-220	v1	1	T1 *(transistors)*

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 *Sheets* shows the position of *all* the part's gates in the schematics: Gate name followed by sheet number followed by the cell of the surrounding frame (if available). The column *Board* 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). Additional information can possibly be found directly in the schematics.

	Name	Sheets	Board
	— C —		
1	C1	1-D3	T

— *continued on next column* —

Table 4: *Part list — continued*

	Name	Sheets	Board
2	C2	1-D6	T
3	C3	1-D8	T
	— D —		

— *continued on next column* —

Table 4: *Part list — continued*

	Name	Sheets	Board
4	D1	1-C5	T
5	D2	1-D4	T
6	D3	1-D5	T

— *continued on next column* —

Table 4: *Part list — continued*

	Name	Sheets	Board
7	D4	1-B4	T
8	D5	1-B6	T
9	D6	1-D8	T

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
	— J —		
10	J1	1-C6	T
11	J2	1-C7	T

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
	— N —		
12	N1	1-C6	T
	— P —		

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
13	P1	1-E7	T
	— R —		
14	R1	1-D3	T

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
15	R2	1-C4	T
16	R3	1-C4	T
17	R4	1-C5	T

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
18	R5	1-C6	T
19	R6	1-C7	T
20	R7A	1-D6	T

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
21	R7B	1-D7	T
22	R8	1-D6	T
23	R9	1-E6	T

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
24	R10	1-C8	T
	— T —		
25	T1	1-C4	T

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
	— X —		
26	X1	1-C2	T
27	X2	1-C9	T

— continued on next column —

Table 4: *Part list — continued*

	Name	Sheets	Board
28	X3	1-C5	T
29	X4	1-D4	T