THE WIENER

User Manual – Stereo and PBTL cards

Document version 1.0 – May 8/2016

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About the Wiener

The “Wiener” is my attempt to make the best possible host platform for the Texas Instruments TPA3118 class D audio amplifier chip. The design features include:

- Good component selection.
- Output filter matched to desired load impedance.
- Very tight 2-layer PCB design, with large power/ground planes and low impedance routing.
- “Wideband” TPA3118 decoupling. Multiple layers of decoupling capacitors are used to provide a very low power supply impedance well up into the tens of MHz.
- Many common tweaks/modifications performed on TPA3116 cards are built into the design, including additional filtering on the AVCC power pin and output snubbers (aka “bootstrap snubbers”)
- Microprocessor controlled muting of the TPA3118 chip, to avoid pops when turning the amplifier on and off.
- Every controllable setting that the TPA3118 chip has is easily and quickly configurable including gain, master/slave synchronization modes, switching frequency, class D modulation mode and PLIMIT threshold.

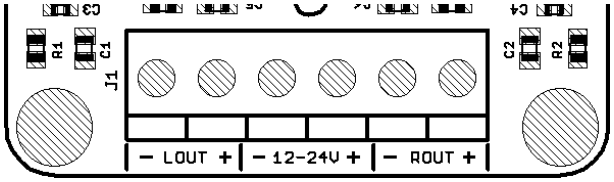
The original credit for the idea goes to AudioLapDance on the diyaudio forums, who made a plea on the Class D subform for a “Proper TPA3116 PCB”, spelling out a list of features he wanted in a hypothetical card. Stuck home during a snowstorm one day, I decided to bang out a card design that met his requirements. Before long a large conversation ensued, lots of design ideas and suggestions were tossed around, and the design evolved into something we all felt very good about. AudioLapDance himself proclaimed “we have a wiener!” and the name stuck.

The TPA3118 chip used on the Wiener contains the same silicon IC as a the well known TPA3116, but the package has the thermal pad on the bottom instead of the top. Using the PCB as a heatsink makes for a simpler design, and allows components to be placed closer to the TPA for better performance.

Design Copyright and Trademarks

Board Connections - Stereo card

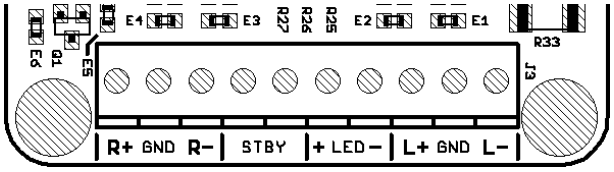
Output and power connections



LOUT +/- and ROUT +/-
Speaker audio outputs; connect these to your speakers.

12-24V:
Power supply input. The power supply **must** be in the 10-26V range, and try to stay within 12-24V. 12V lead acid batteries, 19V-20V laptop power adapters, 24V DC supplies and so forth are all acceptable.

Audio input and control/status connections



R+/GND/R- and L+/GND/L-
Balanced audio inputs and grounds. The Wiener's power supply ground and the audio source ground must be connected together. See the “example wiring diagrams” section.

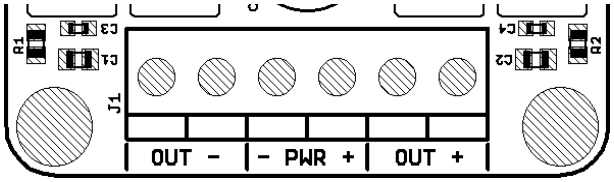
Note: Revision 1.0/1.1 cards from the first and second group buys do not have the audio input ground terminals. Ground your audio inputs to the power supply negative terminal instead, or to the corner mounting holes using ring terminals.

STBY
Standby input. Short these two pins together to put the card into standby mode. You can leave these disconnected if you're switching the amp on and off with its power supply.

LED +/-
Connect a status LED here. This LED is lit when the amplifier is enabled, and is unlit if the amp is in standby mode or the TPA3118 indicates a fault (overcurrent or temperature protection).

Board Connections - PBTL card

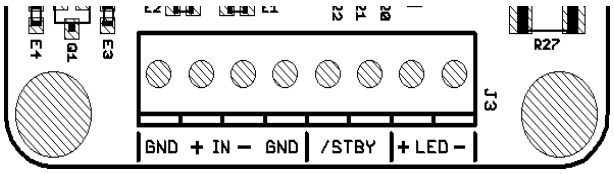
Output and power connections



OUT– and OUT+
Speaker audio outputs; connect these to your speakers.

PWR +/-:
Power supply input. The power supply **must** be in the 10-26V range, and try to stay within 12-24V. 12V lead acid batteries, 19V-20V laptop power adapters, 24V DC supplies and so forth are all acceptable.

Audio input and control/status connections

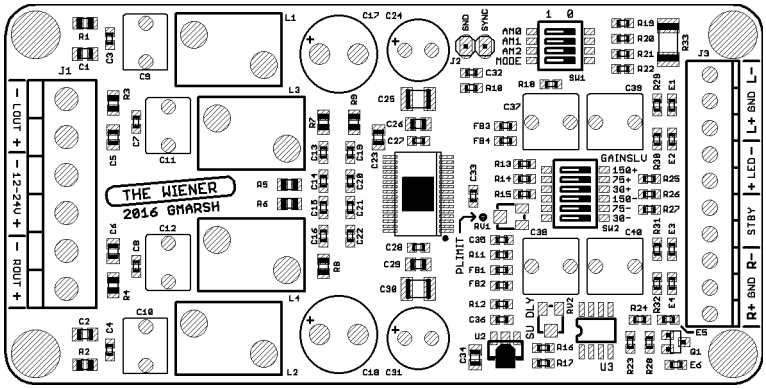


IN+ / IN- and GND
Balanced audio input and ground. The Wiener's power supply ground and the audio source ground must be connected together. See the “example wiring diagrams” section.

/STBY
Standby input. Short these two pins together to put the card into standby mode. You can leave these disconnected if you're switching the amp on and off with its power supply.

LED +/-
Connect a status LED here. This LED is lit when the amplifier is enabled, and is unlit if the amp is in standby mode or the TPA3118 indicates a fault (overcurrent or temperature protection).

Board Configuration



(Rev2 Stereo card shown, PBTL configuration settings are identical)

Mode/Frequency configuration

AM2	AM1	AM0	Switching frequency
0	0	0	400KHz
0	0	1	500KHz
0	1	0	600KHz
0	1	1	1MHz
1	0	0	1.2MHz
All other combinations			"Reserved"

Higher switching frequencies make the amp run less efficiently and produce more heat.

MODE	Operation mode
0	BD mode
1	1SPW mode

BD mode produces slightly better THD performance. 1SPW requires half the quiescent current and is better suited for battery powered applications.

Gain / slave mode

Gain	Sync mode	150+	75+	30+	150-	75-	30-
20dB	Master	OFF	OFF	OFF	OFF	OFF	**ON**
26dB	Master	**ON**	OFF	OFF	OFF	OFF	**ON**
32dB	Master	OFF	**ON**	OFF	OFF	OFF	**ON**
36dB	Master	**ON**	**ON**	OFF	OFF	OFF	**ON**
20dB	Slave	OFF	**ON**	OFF	OFF	**ON**	OFF
26dB	Slave	OFF	OFF	**ON**	**ON**	**ON**	OFF
32dB	Slave	OFF	OFF	**ON**	OFF	**ON**	OFF
36dB	Slave	OFF	OFF	**ON**	**ON**	OFF	OFF

PLIMIT adjustment

The RV1 plot is used to adjust the voltage applied to the TPA3118's PLIMIT pin. Refer to section 7.3.4 in the TPA3118 datasheet for more information on this feature.

The available adjustment range is approximately 25% to 100% of GVDD. An unmasked via is provided (pointed to by the PLIMIT --> arrow) allowing the voltage to be measured with a DMM. By default, this pot is set to fully clockwise, which sets the PLIMIT to to GVDD, effectively disabling the feature.

Startup delay adjustement

The RV2 pot is used to adjust the length of the startup phase, the time delay between the TPA3118 being enabled (/SDZ set high) to unmuted (MUTE set low). The adjustment range is approximately 100mS to 5 seconds, and the default setting is approximately 2.5 seconds.

The startup delay gives the input coupling capacitors of the TPA3118 time to charge up and settle. If the delay is set too short, you may hear a thump on startup. Unequal input impedances (eg, having the – input tied to ground and the + input coming from the wiper of a potentiometer) will tend to exacerbate this effect.

Synchronization support

Multiple Wiener cards may be synchronized together. To accomplish this, connect the SYNC headers of all boards together. One of the boards must be set to Master mode via the GAINSLV configuration switches, and all other boards must be set to Slave mode.

There is no requirement for synchronized boards to run at the same frequency setting. The master board sends out a ~100KHz clock on its SYNC terminal regardless of its AMx setting, and slave boards multiply this clock internally with a PLL to make their own 400 to 1200KHz switching frequency based on the AMx pin setting.

Thermal pad / Mounting Kit

For applications where the card will be dissipating substantial heat, such as driving low impedance loads at high volumes and/or running high switching frequencies, it may be desirable to heatsink the card to the chassis through a thermal pad for better cooling performance.

The card is designed to use a t-Global “H48-6G-20-20-4-1A” thermal pad, which is available from Digikey (part # 1168-1677-ND). The bottom silkscreen has a dotted outline showing where to stick the thermal pad to the card.

The mounting kit includes 4-40 hardware. Mount the enclosure to the chassis using the following stackup:

Top nut
Top spring lock washer
Top round washer (this washer is slightly less in diameter than the other two)
Wiener PCB
Aluminum spacer
Round washer
Amplifier chassis
Round washer
Bottom spring lock washer
Screw

Bill of Materials

Stereo card

Ref Des	Mfg	Part #	Description
C1,C2,C5,C6	Murata	GRM2195C1H103JA01D	10nF/50V, 5%, NPO, 0805
C3,C4,C7,C8,C27,C28	Murata	GRM1885C1H102JA01D**	1000pF/50V, 5%, NPO, 0603
C9-C12	Epcos TDK	B32529C155J B32529C684J B32529C474J	1.5uF film, 5% (4 ohm load) 0.68uF film, 5% (6 ohm) 0.47uF film, 5% (8 ohm)
C13-C16,C32	Murata	GRM1885C1H331JA01D	330pF/50V, 5%, NPO, 0603
C17, C18	United Chemi-Con	EKZN350ELL471MJ20S	470uF/35V low-ESR electrolytic
C19-C22,C35	Murata	GRM188R71E224KA88D	220nF/25V, 5%, X7R, 0603
C23,C26,C29,C34	Murata	GRM219R71H334KA88D**	330nF/50V, 5%, X7R, 0805
C24, C31	Panasonic	35SEPF82M**	82uF/35V OSCON
C25, C30	Murata	GRM32ER71H106KA12L**	10uF/50V, 10% X7R, 1210
C33, C36	Murata	GRM188R61E105KA12D	1uF/25V, 10%, X7R, 0603
C37-C40	Epcos TDK	B32529D225J	2.2uF Film, 5%
E1-E6	Comchip	CPUDR24V	ESD suppressor
FB1-FB4	Laird	HZ0603B751R-10	Ferrite bead
J1	Phoenix Contact	1935200	Terminal block, 6 pos, 5mm
J3	Phoenix Contact	1984675 1984691	Terminal block, 8 pos, 3.5mm (Rev 1.x) Terminal block, 10 pos, 3.5mm (Rev 2.x)
L1-L4	ICE Components Sagami (Alternative part)	1D14A-100M 1D14A-150M 7G14A-100M 7G14A-150M	10uH (4 and 6 ohm load) 15uH (8 ohm load) 10uH (4 and 6 ohm load) 15uH (8 ohm load)
Q1	ON Semiconductor	2N7002LT1G	N-channel FET, SOT-23
R1-R4	KOA	RK73H2ATTD3R30F	3.3 ohm, 1%, 0805
R5-R9	KOA	RK73H2ATTD10R0F	10 ohm, 1%, 0805
R10	KOA	RK73H1JTTD1000F	100 ohm, 1%, 0603
R11, R15, R27, R29-R32	KOA	RK73H1JTTD3012F	30.1K, 1%, 0603
R12, R17-R22	KOA	RK73H1JTTD1003F	100K, 1%, 0603
R13, R25	KOA	RK73H1JTTD1503F	150K, 1%, 0603
R14, R23, R26	KOA	RK73H1JTTD7502F	75K, 1%, 0603
R16, R24, R28	KOA	RK73H1JTTD1002F	10K, 1%, 0603
R33	KOA	RK73B2HTTE222J	2.2K, 5%, 2010
RV1, RV2	TT Electronics	22AR100KLFTR	100K trimmer potentiometer
SW1	CTS	218-4LPST	4 position SOIC DIP switch
SW2	CTS	218-6LPST	6 position SOIC DIP switch
U1	Texas Instruments	TPA3118D2DAPR	Audio amplifier IC
U2	NJR	NJM78L05UA-TE2	+5V voltage regulator
U3	Atmel	ATTINY13A-SU***	Microcontroller

** Most parts can be substituted as required/desired, but I don't recommend changing these.
*** Typically I provide this with the PCB.

PBTL card

Ref Des	Mfg	Part #	Description
C1,C2	Murata	GRM2195C1H103JA01D	10nF/50V, 5%, NPO, 0805
C3,C4,C22,C23	Murata	GRM1885C1H102JA01D**	1000pF/50V, 5%, NPO, 0603
C5, C8	Epcos TDK	B32529C155J B32529C684J B32529C474J B32529C334J	1.5uF film, 5% (2 ohm load) 1uF film 5% (4 ohm) 0.47uF film, 5% (6 ohm) 0.33uF film, 5% (8 ohm)
C6, C7	Epcos TDK	B32529C155J B32529C474J B32529C224J B32529C154J	1.5uF film, 5% (2 ohm load) 0.47uF film 5% (4 ohm) 0.22uF film, 5% (6 ohm) 0.15uF film, 5% (8 ohm)
C11,C12,C26	Murata	GRM1885C1H331JA01D	330pF/50V, 5%, NPO, 0603
C9,C10	United Chemi-Con	EKZN350ELL471MJ20S**	470uF/35V low-ESR electrolytic
C13-C16,C29	Murata	GRM188R71E224KA88D	220nF/25V, 5%, X7R, 0603
C17,C21,C24,C28	Murata	GRM219R71H334KA88D**	330nF/50V, 5%, X7R, 0805
C18,C19	Panasonic	35SEPF82M**	82uF/35V OSCON
C20,C25	Murata	GRM32ER71H106KA12L**	10uF/50V, 10% X7R, 1210
C27,C30	Murata	GRM188R61E105KA12D	1uF/25V, 10%, X7R, 0603
C31,C32	Epcos TDK	B32529D225J	2.2uF Film, 5%
E1-E4	Comchip	CPUDR24V	ESD suppressor
FB1,FB2	Laird	HZ0603B751R-10	Ferrite bead
J1	Phoenix Contact	1935200	Terminal block, 6 pos, 5mm
J3	Phoenix Contact	1984675	Terminal block, 8 pos, 3.5mm
L1-L4	Coilcraft	VER2923-472KL VER2923-103KL VER2923-153KL	4.7uH (2 ohm load) 10uH (4 and 6 ohm load) 15uH (8 ohm load)
Q1	ON Semiconductor	2N7002LT1G	N-channel FET, SOT-23
R1,R2	KOA	RK73H2ATTD3R30F	3.3 ohm, 1%, 0805
R3,R4,R5	KOA	RK73H2ATTD10R0F	10 ohm, 1%, 0805
R6	KOA	RK73H1JTTD1000F	100 ohm, 1%, 0603
R10,R13,R22,R24,R25X	KOA	RK73H1JTTD3012F	30.1K, 1%, 0603
R7,R12,R14-R18,R26	KOA	RK73H1JTTD1003F	100K, 1%, 0603
R8,R20	KOA	RK73H1JTTD1503F	150K, 1%, 0603
R9,R21	KOA	RK73H1JTTD7502F	75K, 1%, 0603
R11,R19,R23	KOA	RK73H1JTTD1002F	10K, 1%, 0603
R27	KOA	RK73B2HTTE222J	2.2K, 5%, 2010
RV1, RV2	TT Electronics	22AR100KLFTR	100K trimmer potentiometer
SW1	CTS	218-4LPST	4 position SOIC DIP switch
SW2	CTS	218-6LPST	6 position SOIC DIP switch
U1	Texas Instruments	TPA3118D2DAPR	Audio amplifier IC
U2	NJR	NJM78L05UA-TE2	+5V voltage egulator
U3	Atmel	ATTINY13A-SU***	Microcontroller

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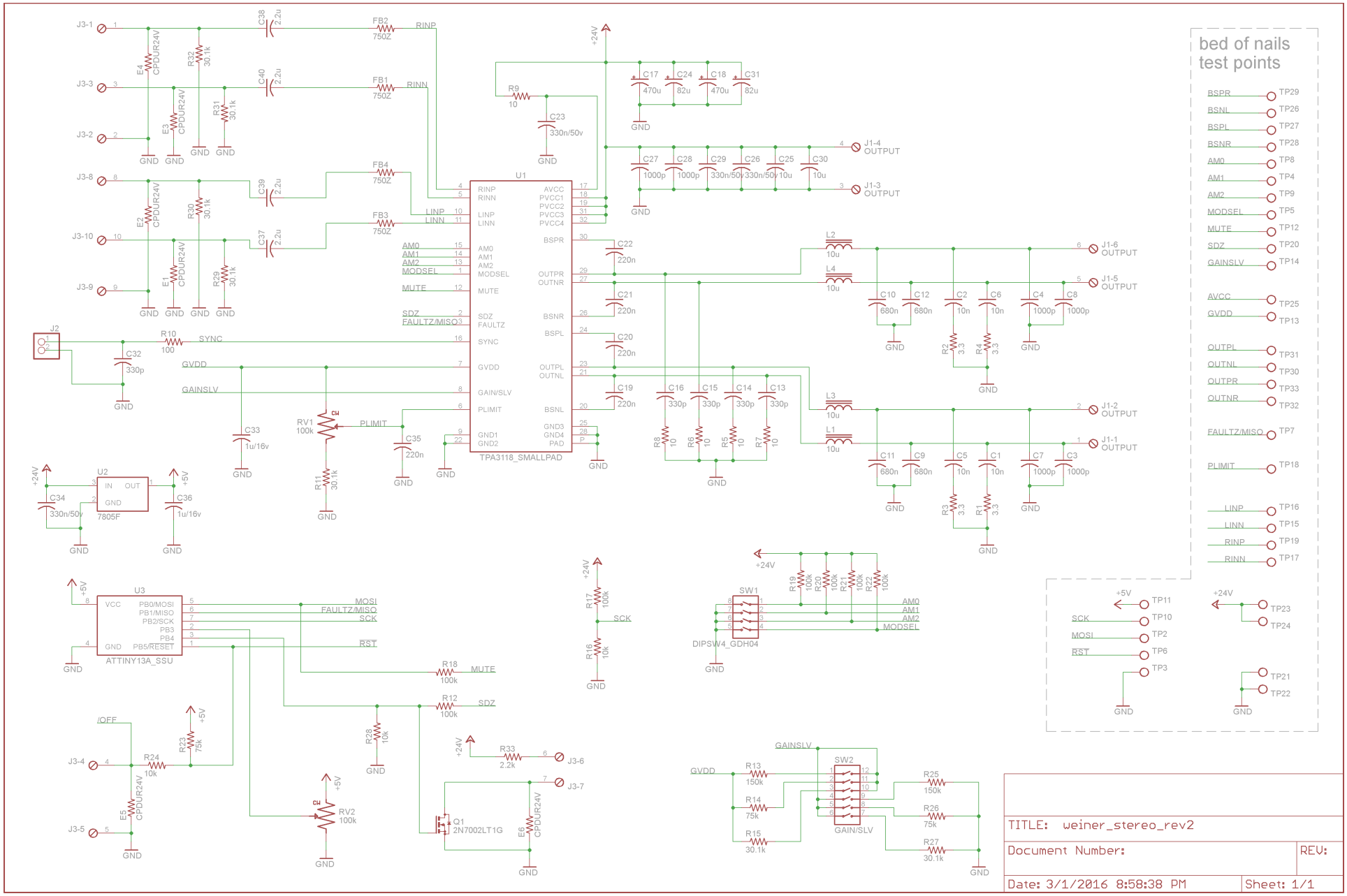
bed of nails
test points
TP29 BSPR
TP26 BSNL
TP27 BSPL
TP28 BSNR
TP8 AM0
TP4 AM1
TP9 AM2
TP5 MODSEL
TP12 MUTE
TP20 SDZ
TP14 GAINSLV
TP25 AVCC
TP13 GVDD
TP31 OUTPL
TP30 OUTNL
TP33 OUTPR
TP32 OUTNR
TP7 FAULTZ/MISO
TP18 PLIMIT
TP16 LINP
TP15 LINN
TP19 RINP
TP17 RINN
TP11 +5V
TP10 SCK
TP2 MOSI
TP6 RST
TP3 GND
TP23 +24V
TP24
TP21 GND
TP22
U1
TPA3118_SMALLPAD
U2
7805F
U3
ATTINY13A_SSU
SW1
DIPSW4_GDH04
SW2
GAIN/SLV
Q1
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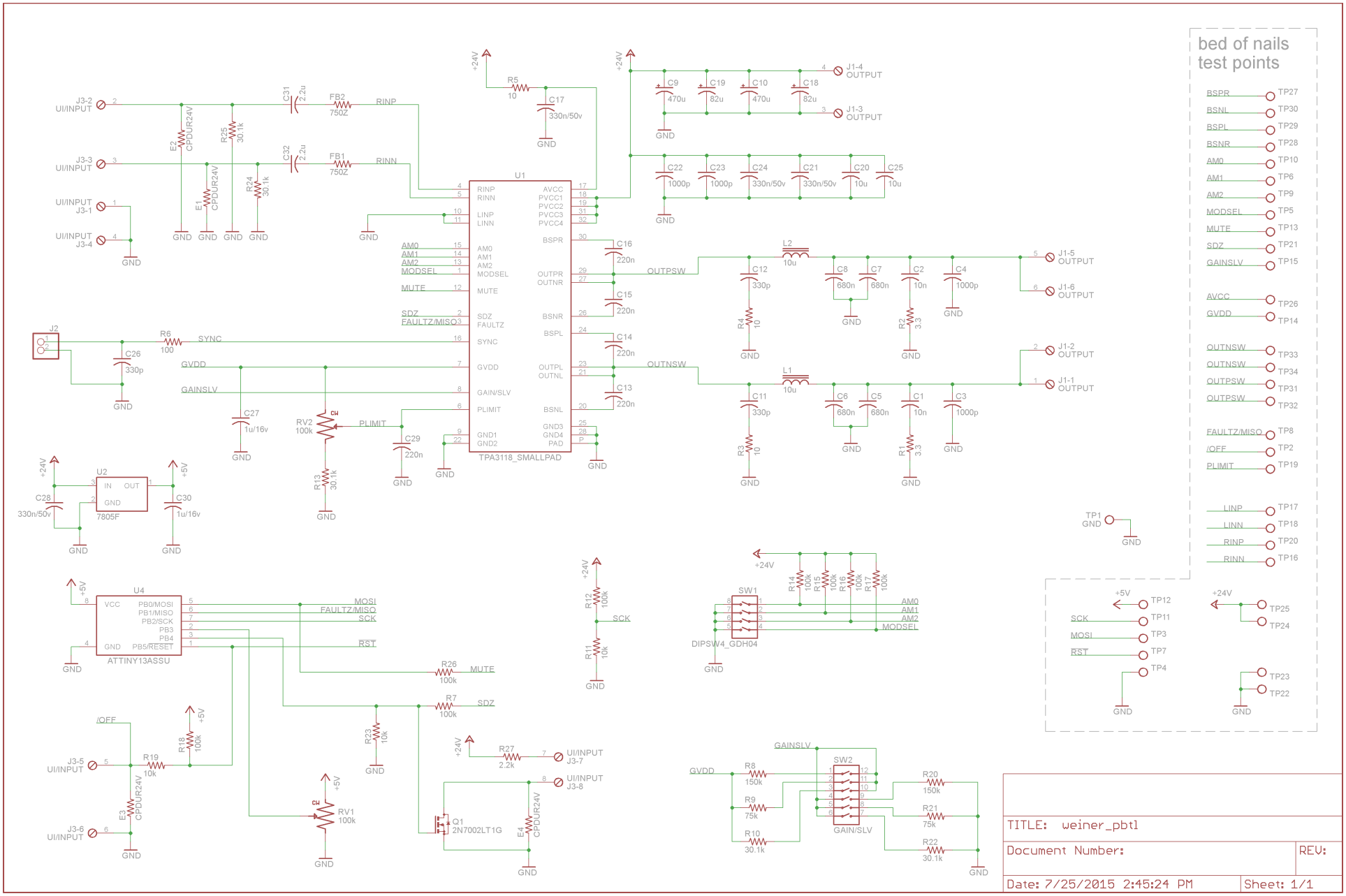
bed of nails
test points
U1
TPA3118_SMALLPAD
U2
7805F
U4
ATTINY13ASSU
SW1
DIPSW4_GDH04
SW2
GAIN/SLV
Q1
2N7002LT1G
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Assembly Directions

The Wiener design is primarily surface mount. If you've never done surface mount assembly before, Dave Jones at EEVblog has a pretty good tutorial:

https://www.youtube.com/watch?v=b9FC9fAlfQE

Equipment you'll need

- A temperature controlled soldering iron. Weller WES51 and Hakko 936/FX-888 are good hobbyist choices. I highly recommend buying genuine equipment; if you decide to buy a clone station, make sure you get a well reviewed unit from a well reviewed seller, as there are some very crappy and unsafe clones out there.
- Good solder. I use Kester 63/37 SnPb in fine and medium sizes. Pb solder is much more “hobbyist friendly” than lead free solder.
- Liquid flux, which is compatible with your solder.
- Fine solder wick (for the inevitable pin-to-pin shorts you'll get on the TPA3118)
- Side cutters for cutting through-hole leads.
- Highly recommended: an ESD mat to work on. In addition to protecting what you're working on from ESD zaps, they keep your desk/table from getting scratched by component leads and burnt by hot solder.

Soldering the TPA3118 chip

Here is my process for hand-soldering the IC without a hot air station:

- Turn the board upside down. The thermal pad for the TPA3118 is mirrored on the bottom of the board, fill the vias with hot solder. You want the solder to be flush with the surface of the PCB on the top component side, and a slight blob (maybe 1mm high) on the bottom solder side.
- Carefully hold the TPA3118 upside down. Tin the thermal pad on the bottom of the IC, do this as quickly as possible to avoid damaging the IC. You want the surface of the thermal pad wet with solder; don't make a blob.
- Solder one side of the TPA3118. Don't worry about cleaning up solder bridges yet.
- Flip the card over and melt the “blob” of solder on the back of the themal pad, this should attach the TPA3118 to the card. Keep the solder liquid for 5 seconds or so to make sure everything's well melted.
- Using a thin object such as a thin guitar pick, try to lift the unsoldered side of the TPA3118 to confirm the thermal pad is soldered correctly. If you can lift the chip, resolder the thermal pad.
- Solder the other side of the TPA3118.
- Using liquid flux and solder wick, remove any solder bridges between the pins of the chip. Ensure all pins are soldered.

Programming the microcontroller

Programming the ATTiny13A requires an Atmel AVR compatible programmer. I use an AVR ISP MKII programmer primarily but have also used a Dangerous Prototypes Bus Pirate for the job with good success. I haven't provided a programming header on the card (there wasn't room for one, sorry...) but the pogo pin pads for the ISP interface are labelled on the bottom of the PCB.

So far everyone who has bought a PCB from me has bought a preprogrammed microcontroller to go along with it, so this hasn't been a major issue for anyone yet.