

PAPER HORNET

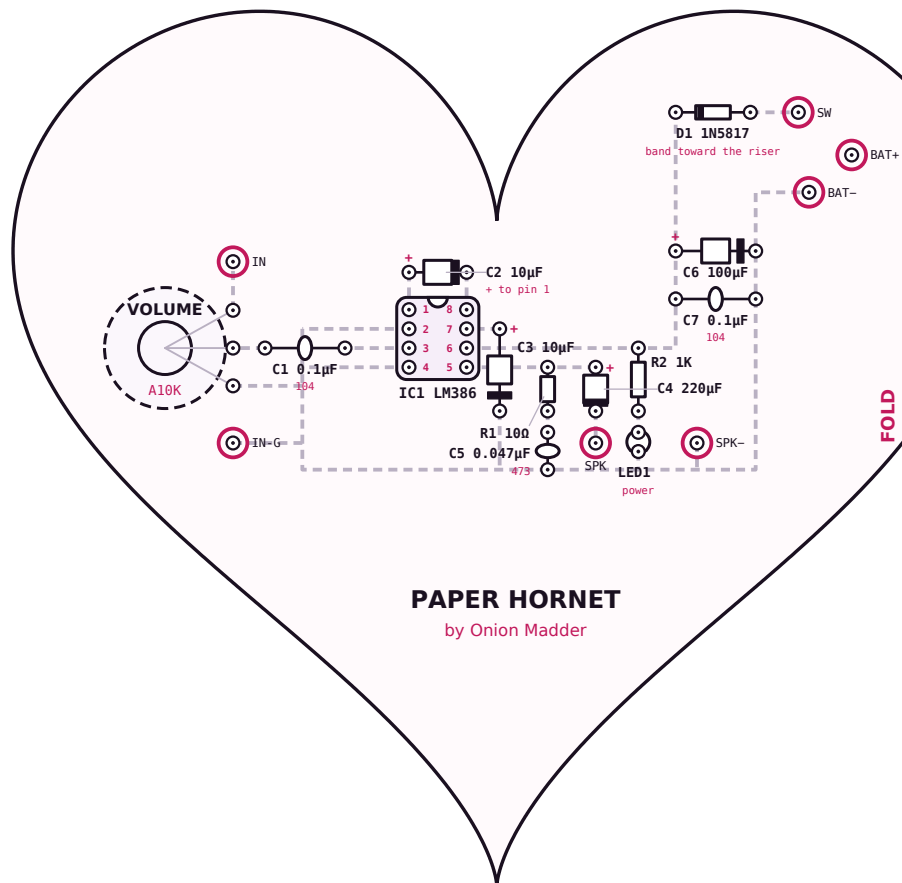
an LM386 amp as a paper circuit, for the other paper builds · fold sheet, print at 100% / Actual size

Onion Madder // messopedals.com · paper-circuit method after Peter Blasser / Ciat-Lonbarde



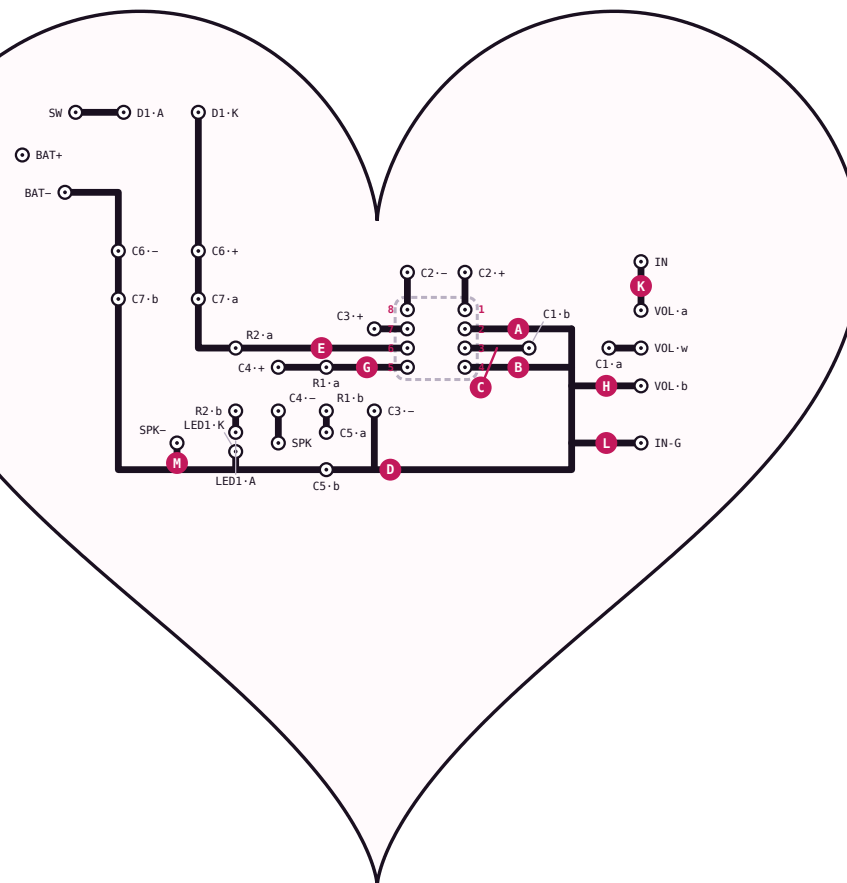
FRONT - parts side

parts go in from this face · knob up · plug a paper synth into IN, a speaker into SPK



BACK - solder side

folds behind the front · mirror image · bare wire along every line



✂ glue up first, then cut along the heart outline through all four layers · don't cut the fold

build-up: blank sheet folded + glued as the core, then this sheet folded around it and glued = 4 sheets thick

Paper Hornet

the Hornet LM386 amp, rebuilt as a heart-shaped paper circuit for the other paper builds

A paper circuit is a circuit board you print: the drawing is the board, the holes are poked with an awl, and the traces are bare wire laid along the lines on the back. This is the **Hornet** on paper: an LM386 amp with a volume knob, made to sit beside the other paper builds. Plug a Paper Mosquito or a Paper Cicada into IN and a small speaker into SPK, and it is loud.

It is my built Hornet Amp, part for part: the gain cap across pins 1 and 8 for the loud setting, the bypass cap, the 220 μF out to the speaker and the little 10 Ω and 0.047 μF that keep it from oscillating.

44 steps. Page 1 is the fold sheet; everything after it is the recipe.

Reading the sheet

Front: each part is drawn where it sits, with its value printed next to it. The faint dashed lines are only a preview of what connects on the back. The ringed holes are for wires going off the board: BAT+, BAT– and SW for power, IN and IN-G for the input, SPK and SPK– for the speaker. The VOLUME pot has three holes: the input, the wiper in the middle, and ground.

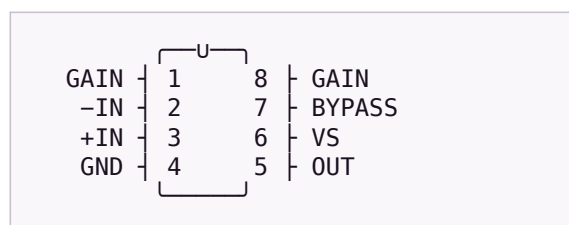
Back: every bold black line is bare wire or a bent part leg. The lines with a pink letter are bare wire, and the steps name them by that letter; the short unlettered ones are a part's own leg, bent along the line. Small pink numbers beside the chip holes are its pin numbers.

The LM386 circuit is the datasheet's; this one is my Hornet Amp. The paper-circuit method is Peter Blasser's / Ciat-Lonbarde's. This layout and the words are Onion Madder's.

What you'll need

- **1× LM386 audio amp (IC1)** · *spot it:* LM386 printed on top (N-1, -3 or -4), notch or dot at pin 1. It solders straight to the paper, no socket.
- **1× A10K pot (volume)** · *spot it:* marked A10K; A = audio taper, which feels natural for volume
- **1× 0.1 μ F ceramic (C1)** · *spot it:* printed 104. Blocks DC from whatever you plug in.
- **2× 10 μ F electrolytic (C2, C3)** · *spot it:* little cans, stripe marks the – leg. C2 is the gain cap, C3 the bypass.
- **1× 220 μ F electrolytic (C4)** · *spot it:* a big can. The output cap to the speaker.
- **1× 0.047 μ F ceramic (C5)** · *spot it:* printed 473. Half of the Zobel.
- **1× 10 Ω resistor (R1)** · *spot it:* brown-black-black. The other half of the Zobel.
- **1× 100 μ F electrolytic (C6) and 1× 0.1 μ F ceramic (C7)** · *spot it:* across the supply
- **1× 1K resistor (R2) and 1× LED (LED1)** · *spot it:* brown-black-red; the LED's long leg is +, the flat side of the rim –
- **1× 1N5817 Schottky diode (D1)** · *spot it:* small black body, gray or silver band marks the cathode
- **A small speaker, 8 Ω** · *spot it:* it hangs off the SPK pads on two wires
- **An input jack, or a lead from another paper build** · *spot it:* tip to IN, sleeve to IN-G
- **Bare tinned wire** · *spot it:* for the traces on the back
- **SPST toggle, 9V battery and snap** · *spot it:* the toggle hangs off the board on wires
- **A second sheet of plain printer paper, glue stick, an awl** · *spot it:* the blank sheet becomes the core; any sharp point works in place of an awl

The chip, from above



The chip sits on the sheet exactly like this, notch toward the top edge. C2 lies across the top of it, from pin 1 to pin 8.

Before you start

Paper burns. Keep the iron moving, quick joints, and don't rest it on the sheet. Work over something that isn't flammable, and keep a damp sponge handy.

Chip straight in. The LM386 is soldered straight to the paper with no socket, and most parts end at one of its pins. Keep each joint quick: touch, flow, lift.

Mind the cans. C2, C3, C4 and C6 are polarized: the stripe is the – leg, and the sheet marks the + hole of each. C2's + goes to pin 1.

It is loud. Start with VOLUME at zero, and the speaker well away from your ears.

Print, fold, glue, poke

The sheet is the circuit board, and it's four sheets of paper thick. A plain sheet folded in half and glued to itself makes the core, then the printed hearts fold around the core and glue on, one heart on each face.

Print at 100% / "Actual size". Fit-to-page shrinks it and the holes stop matching the chip's legs.

STEP	DO
1	Print page 1 on plain printer paper at 100% / Actual size.
2	Measure the 100 mm bar at the top right of the sheet. If it isn't 100 mm, fix the print scale and print again.
3	Fold a second, blank sheet of printer paper in half.
4	Glue-stick the whole inside of the blank sheet, close it, and press it flat. That's the core: two sheets thick.
5	Fold the printed sheet along the FOLD line, printing on the outside, so the two hearts sit back to back.
6	Unfold it again and glue-stick the back of the FRONT heart.
7	Press the core onto the glued back of the FRONT heart.
8	Glue-stick the back of the BACK heart, fold it over onto the other face of the core, and press it flat. Now it's four sheets thick.
9	Let the glue set for a few minutes, then cut along the heart outline through all four layers. Don't cut across the FOLD hinge.
10	Poke the 8 chip holes from the front with an awl or other sharp point, straight down through all four layers.
11	Poke the other 32 dots the same way. Check the back and open any hole that didn't come all the way through.

Start in the middle: the chip and the gain cap

Everything builds outward from the chip. C2 lies right across the top of it.

Quick dabs only. Paper scorches if you sit on it: touch, flow, lift.

STEP	DO
12	Push the LM386 into the IC1 holes from the front, notch toward the top edge (the drawn notch).
13	On the back, bend pins 1, 4, 5 and 8 outward slightly so the chip can't fall out.
14	C2, 10 μ F: long + leg into C2+ (above pin 1), striped leg into C2- (above pin 8). On the back, bend each leg down to its pin and solder at all four joints.
15	Trace A: bare wire from pin 2 out to the left ground rail. Solder at pin 2.

16	Trace B: bare wire from pin 4 out to the left ground rail. Solder at pin 4.
17	Trace C: bare wire from pin 3 out to C1·b. Solder at pin 3.
18	Trace G: bare wire from pin 5 out through R1·a to C4·+. Solder at pin 5.
19	Trace E: bare wire from pin 6 out through R2·a, then up the supply riser through C7·a and C6·+ to D1·K. Solder at pin 6.

The ground

One long ground wire runs down the left side, along the bottom and up the right side to the battery.

STEP	DO
20	Trace D, ground: bare wire from trace A down the left rail, along the bottom and up the right riser to the BAT– pad. Solder where traces A and B meet it, and at BAT–.
21	Trace M: short bare wire from the SPK– pad down to the ground line. Solder at SPK– and at the line.

The output side

Pin 5 feeds the speaker through C4, and the Zobel (R1 and C5) hangs off the same line to ground so the amp stays calm. C3 is the bypass cap on pin 7.

STEP	DO
22	C3, 10 μ F: long + leg into C3·+, striped leg into C3·–. Bend C3·+’s leg to pin 7 and solder at both; bend C3·–’s leg down to the ground line and solder.
23	R1, 10 Ω (brown-black-black): legs into R1·a and R1·b. Solder R1·a on trace G.
24	C5, 0.047 μ F (473): legs into C5·a and C5·b. Bend R1·b’s leg down to C5·a and solder at both; solder C5·b on the ground line.
25	C4, 220 μ F: long + leg into C4·+, striped leg into C4·–. Solder C4·+ where trace G ends; bend C4·–’s leg down to the SPK pad and solder at both.
26	R2, 1K (brown-black-red): legs into R2·a and R2·b. Solder R2·a on trace E.
27	LED1: long leg into LED1·A, short leg into LED1·K. Bend R2·b’s leg down to LED1·A and solder; bend LED1·K’s leg down to the ground line and solder.

The input side

The VOLUME pot sits on the paper. The input comes in on IN to one end of it, the other end is ground, and the wiper goes through C1 into pin 3.

With solder-lug pots, solder a short wire to each lug and push the wires through instead.

STEP	DO
28	VOLUME pot, A10K: lugs into the three VOL holes from the front, knob up, the middle lug (the wiper) in VOL·w.
29	Trace K: bare wire from VOL·a up to the IN pad. Solder at both.

- 30** Trace H: bare wire from VOL·b across to the left ground rail. Solder at VOL·b and at the rail.
- 31** Trace L: bare wire from the IN-G pad across to the left ground rail. Solder at IN-G and at the rail.
- 32** C1, 0.1 μ F (104): legs into C1·a and C1·b. Solder C1·b where trace C ends; bend C1·a's leg to VOL·w and solder at both.

Power corner

Power comes in at the top right. D1 only lets current through one way, so a battery clipped on backwards does nothing. C6 and C7 sit across the supply, right beside it.

D1's band goes in D1·K, on the supply riser.

STEP	DO
33	D1, 1N5817: band end into D1·K, plain end into D1·A. Solder D1·K where trace E ends; bend D1·A's leg right to the SW pad and solder at both.
34	C6, 100 μ F: long + leg into C6·+ on the supply riser, striped leg into C6·– on the ground line. Solder both.
35	C7, 0.1 μ F (104): legs into C7·a and C7·b. Solder both.
36	Snip every leg tail that sticks past its joint.

Off the board

The battery clips onto the board; the toggle, the input and the speaker hang off pads on flying leads.

Leave the battery unclipped until the meter checks.

STEP	DO
37	Battery snap red (+) to the BAT+ pad, black (–) to the BAT– pad.
38	A wire from the BAT+ pad to one lug of the SPST toggle, and from its other lug to the SW pad.
39	Input jack tip (or the OUT of another paper build) to IN, sleeve (or its OUT-G) to IN-G.
40	The speaker's two leads to the SPK and SPK– pads.

Check, then play

Meter it before you play it. These readings are with the chip in.

STEP	DO
41	VOLUME to zero. Clip the battery on and toggle on. LED1 should light.
42	Meter pin 6 to pin 4: battery voltage minus about 0.3 V.
43	Meter pin 5 to pin 4: about half of that. The output sits at half the supply when nothing is playing.
44	Plug a paper build into IN and bring VOLUME up slowly.

Voltage check

METER BETWEEN	EXPECT (toggle on, nothing playing)
BAT+ pad → BAT− pad	battery voltage
pin 6 → pin 4	battery voltage minus about 0.3 V
pin 5 → pin 4	about half of pin 6

If it won't sing

SYMPTOM	CHECK
Dead, LED dark	D1 in backwards (the band goes in D1·K), the battery snap reversed, or the toggle wires not on BAT+ and SW.
LED lit, no sound	Pin 5 should sit at about half the supply. Then C4's stripe (it goes toward the speaker), and the input on IN and IN-G.
Howls or motorboats	C6 and C7 across the supply, C3 on pin 7, and the Zobel (R1 and C5). All four keep it calm.
Quiet even turned up	C2 is the gain: it has to be across pins 1 and 8 with its + on pin 1. Without it the gain drops from 200 to 20.
Volume works backwards	Swap the two outer lugs' jobs: the input on VOL·b and ground on VOL·a.
Paper scorched or a hole tore	Glue a scrap of paper over the back, re-poke, carry on. It is paper.

Things to try

- Leave C2 out for gain 20: cleaner and quieter.
- Put a resistor in series with C2 across pins 1 and 8 for a gain somewhere between 20 and 200.