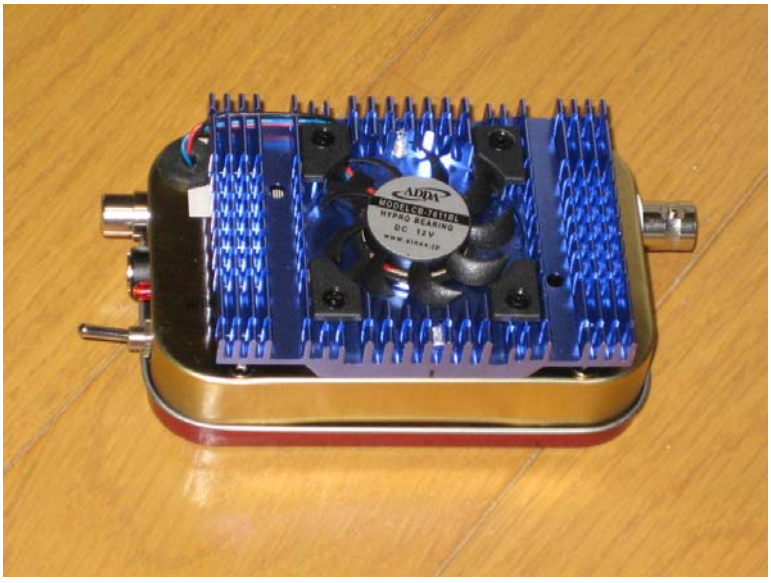
ALTOIDS P.A.　ASSEMBLY MANUAL



2008.02.28 rev. β

Makoto Kasahara / JN1GLB

Disclaimer:

The Altoids PA is an experimental device produced purely for enjoyment and the makers are in no way responsible to those who choose to build it. All usual disclaimers apply: aside from providing the necessary parts and PCB, it's really up to the maker how successful this project will be. The Altoids PA may not be used for profit. Responsibility for the construction and repair of the Altoids PA is solely that of the owner. Additionally, although most of the parts in the kit are RoHS-complaint, no claim is made beyond that of the original parts manufacturer. No responsibility is assumed for any environmental damages associated with the making or disposal of this item. Any damages or hardship associated with the use of this item are solely the responsibility of the builder or owner of the completed (or partially completed) Altoids PA.

If you agree with the terms above, then let's get started building!

Specifications:

- PCB dimensions: 69mm x 52mm (2.7" x 2")
- PA board + 6 modular LPF boards
- Power Supply Voltage 13.8V (typical)
- Transmit Current: about 4A
- Avg. Output: 20W (typical)
- Forced Air Ventilation (on-demand during transmit)
- LED Transmit Indicator
- Power Switch

Getting Started

I decided the Altoids PA should fit inside of a standard Altoids breath mint tin, in keeping with Steve Weber JD1KV's popular Appalachian Trail Sprint (ATS) series of QRP transceivers. After some research online, the design took shape. The design of this small RF power amplifier is primarily that of Komachi-san, JA9MAT—with some variations. My small contribution has been primarily miniaturization and packaging of the device, and cleaning up some of the details of the layout according to my vision. As with most homebrewed devices, your results may vary, depending on the skill and ingenuity of the builder.

Near the beginning of my tinkering, Jonathan Haynes KC7FYS/7J1AWL took interest in my online photos and inquired about the Altoids PA. Thanks for compiling the English version of this manual, Jonathan.

[Note: I received this manual in Japanese, and being only partly literate in the language, bounced translation ideas off friends—most of whom scratched their heads because it was far too topical for them. Any errors or suggestions for more effective translation would be welcome at kc7fys@yahoo.com. Mr. Kasahara's Naturally, the original Japanese version of this manual is more accurate, and to be consulted in the event of quibbling. –Haynes]

Skills required to construct the Altoids PA include basic soldering and the ability to read and interpret a schematic. This instruction manual is the best source of information on the assembly of this device, and if examined thoroughly, should guide the builder through any problems that may occur during actual construction.

Customization Concerns

As with most kits of this type, user mods and tweaks are commonplace and expected. However, if the builder wishes, using only the parts supplied with the kit, his or her own standard issue Altoids mint tin, and a PC processor cooling fan and heat sink as described above—a "stock" Altoids PA can be built. The intent of the maker is to have a complete kit that can be enjoyed with a minimum of trips to the parts store (which often simply doesn't exist) or rummaging through the junkbox. These instructions will assume that the builder is building a stock amp. Any variations are purely up to the individual hobbyist, and may occasionally be suggested throughout this assembly manual.

Working with SMDs

1. One popular method of soldering surface-mount components (SMDs), involves tinning one of the pads where the SMD is to be installed. In order to avoid mistakes, it is advised that all parts of the same value be installed at once, tinning one pad in each of these locations on the board.
2. The component should be held in place and soldered, taking care to use as little solder and heat as possible and to apply heat to the joint of the two parts to assure uniform solder flow.
3. This is the best time to double-check component placement and make any necessary changes.
4.When you are certain all SMDs are properly placed, the remaining pad is soldered.

Note: A Google or YouTube search for "SMD soldering" will yield a mountain of useful information on various methods for working with surface-mount technology of ever-shrinking dimensions. The "Cash-Olsen" method, employing solder paste and hot air, is remarkably simple and inexpensive to execute in the average shack. The use of the whimsically-named "doofus" is also popular as a third-hand holding device. These instructions, however, will describe the more traditional soldering iron method of SMD installation, which is quite adequate for the difficulty level of the Altoids PA.

Parts Identification and Inventory

To avoid confusion, some of the parts have been color-coded as indicated below. Please double check the following bill of materials with the parts in your kit.

PA-main board (A)

QTY	Part	Label	Value(Size)	Marking
2	Ceramic cap	C1,2	0.0022u (2012)	222
1	Ceramic cap	C3	0.01u (2012)	103
7	Ceramic cap	C4,5,6,7,8,9,10	0.1u (2012)	104
1	Ceramic cap	CC1	10u/25V (3216)	106
2	Electrolytic cap	CC2,3	100u/25V	107
1	diode	D1	1SS319	A4
1	Diode	D2	1S10	1S10
1	Zener diode	D3	HZ6B-1-E	6 B1
1	LED	D4	red	
1	Inductor	L1	LAL03NA 1R0M	
3	Transistor	Q1,5,6	2SC3325	CEO/CEY
1	Transistor	Q2	2SA1313	ACO/ACY
1	resistor	R1	4.7K (2012)	472
1	Resistor	R2	RLF1SJ56Ω 1W	
1	Resistor	R3	RLF1SJ51Ω 1W	
1	Resistor	R4	3.3K (RD16S)	
1	Resistor	R5	2.2K (2012)	222
1	Resistor	R6	10K (2012)	103
2	Resistor	R7,9	100 (2012)	101
2	Resistor	R8,10	1K (RD16S)	
3	trimpot	VR1,2,3	3314J 10K	103
16	Pin socket	CN2,3,4		

PA-main board (B)

QTY	Part	Label	Value(Size)	Marking
1	connector	CN1	MJ-14	
1	Pin jack	J1	RJ-2290N/Y	
1	BNC or Pin jack	J2	B-014IF / RJ-2290N/R	
1	LPF	L2	FT50-43	
2	MOS FET	Q3,4	IRF510PbF	
1	Relay	RL1	G5V2 12V	
1	Switch	SW1	N-31AIM	
3	Transformer	T1,2	BN43-302	
4	Standoff nuts		M3x5mm	
4	Screw/nuts		M3x10mm	
2	Lug terminal		7326	

2	Nylon bolt		M3x12	
2	Insulators		TC30AG-TO220	
1	grommet			

LPF

QTY	Part	Label	Value(Size)	Marking
6	Trimpot		3314J 10K	103
80	Pin header			
6	Iron toroid		T37-2	
6	Iron toroid		T37-6	
2	Ceramic cap		820p/200V	821K
1	Ceramic cap		1800p/100V	182K
1	Ceramic cap		1000p/200V	102K
3	Ceramic cap		470p/200V	471K
1	Ceramic cap		680p/200V	681K
3	Ceramic cap		330p/200V	331K
2	Ceramic cap		220p/200V	221K
1	Ceramic cap		390p/200V	391K
2	Ceramic cap		180p/200V	181K
2	Ceramic cap		150p/200V	151K

WIRE

QTY	Part	Value(Size)	
4m	Polyurethane electric wire	0.5UEW	
30cm	Polyurethane electric wire	0.6UEW	
15cm	Heat-proof wire	FEP 0.3mm^2	thick
50cm	Wrapping wire	ETFE 0.32mm	thin

There is also some variation possible in the exact specs of some of the parts in the table above. These differences, however, are not known to result in a change in efficiency.

Band-specific LPF boards

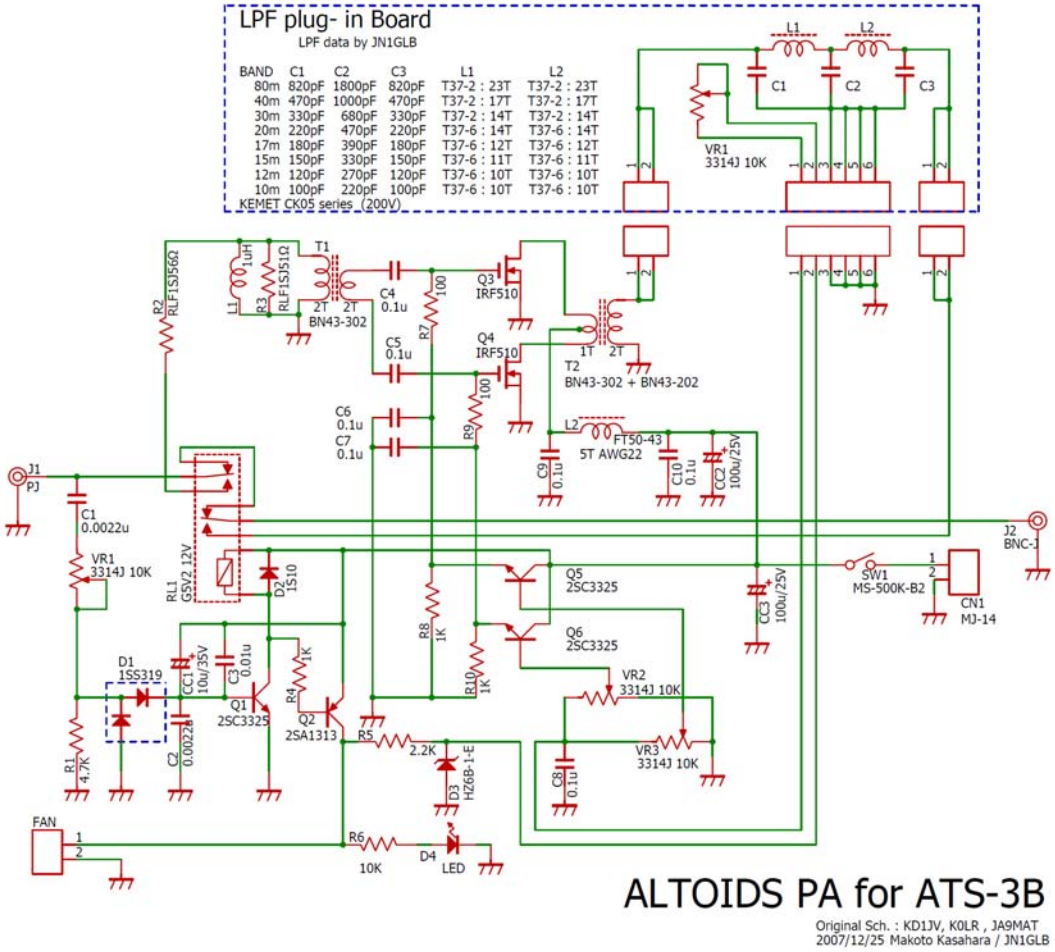
BAND	C1	C2	C3	L1	L2
3.5M	820pF	1800pF	820pF	T37-2(red) 23T	T37-2(red) 23T
7M	470pF	1000pF	470pF	T37-2(red) 17T	T37-2(red) 17T
10M	330pF	680pF	330pF	T37-2(red) 14T	T37-2(red) 14T
14M	220pF	470pF	220pF	T37-6(yel) 14T	T37-6(yel) 14T
18M	180pF	390pF	180pF	T37-6(yel) 12T	T37-6(yel) 12T
21M	150pF	330pF	150pF	T37-6(yel) 11T	T37-6(yel) 11T
24M*	120pF	270pF	120pF	T37-6(yel) 10T	T37-6(yel) 10T
28M*	100pF	220pF	100pF	T37-6(yel) 10T	T37-6(yel) 10T

* Components for these grayed-out bands are not included.

In addition to the parts detailed to this point, a suitable case and cooling fan (which draws 100mA or less) must be supplied at the builder's discretion.

(This section should be expanded slightly.)

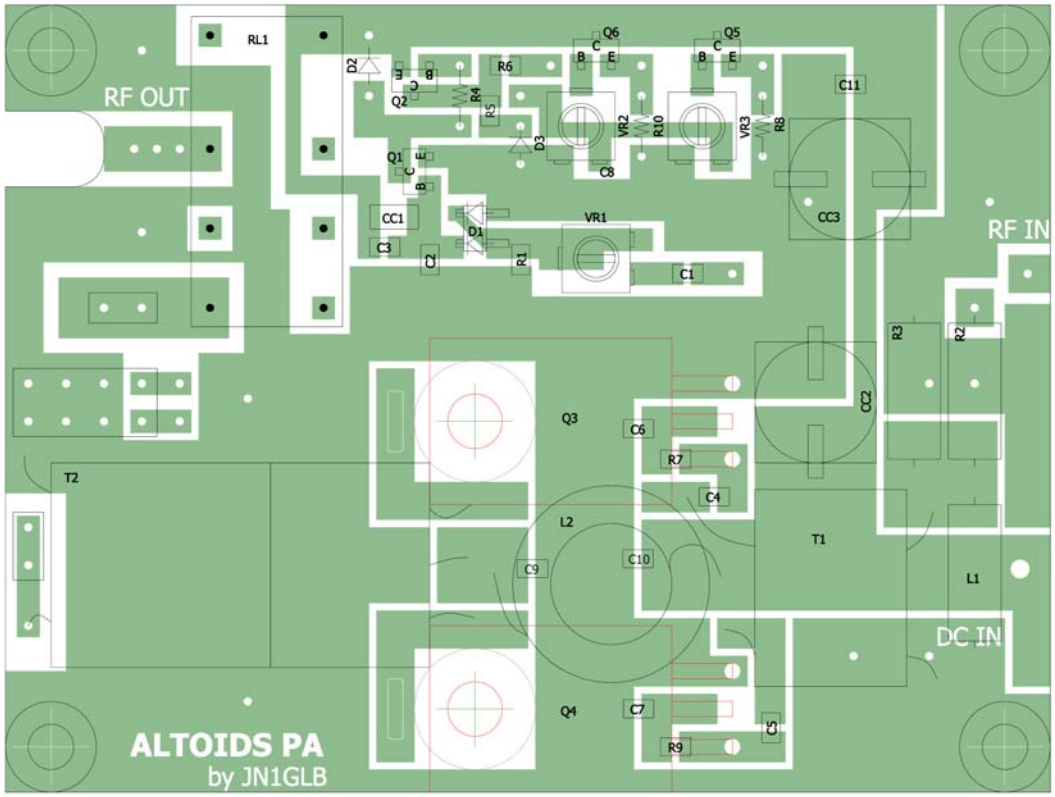
Circuit Schematic



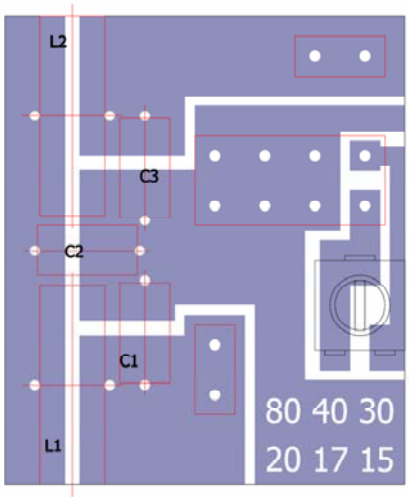
Parts placement

(Components in RED are mounted on the bottom of the main board)

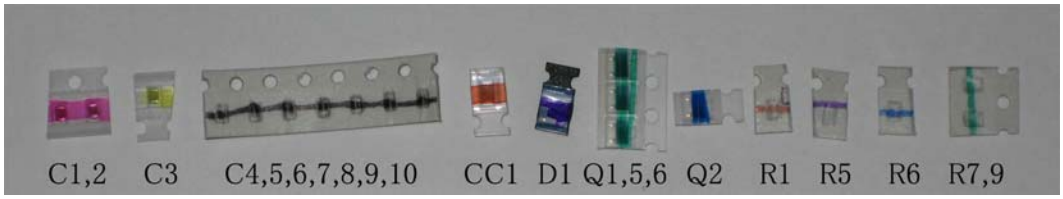
PA Main board



LPF board (solder side)

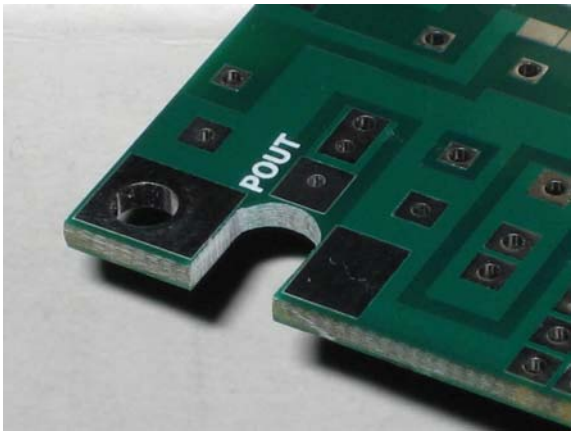


Check the bill of materials to verify no parts are missing. There should be one main board, and a 6-section LPF board, as pictured below.



The PCBs

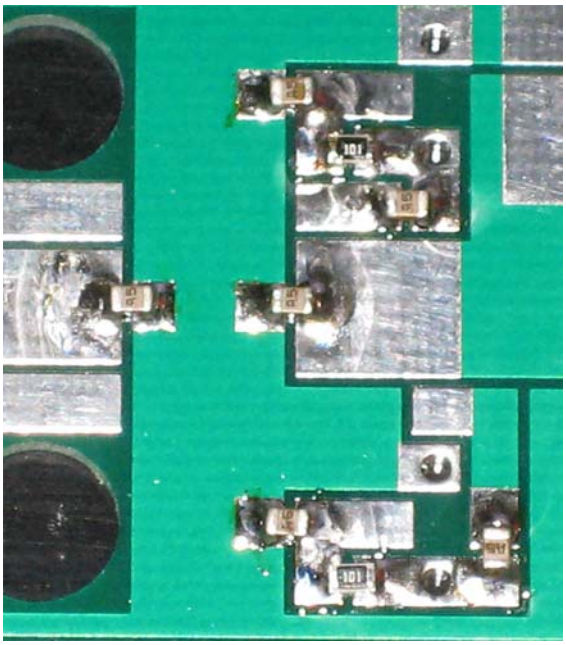
The 6-piece LPF boards can be snapped down the center if pressed carefully into a V-depression. Then, the serrated pieces should be broken with care, preferably not with bare hands (the edges can be quite sharp.) File all PCB edges flat and smooth with a regular file or sandpaper. The hole in the main board marked “POUT” should be opened into a “U” as below with a fret saw or rat-tail file and smoothed as pictured to accommodate the center pin of the output connector.



Soldering

If component installation seems difficult, this is a possible indication that the part is not properly installed. Careful reference to this manual will assure proper parts placement and success with the Altoids PA.

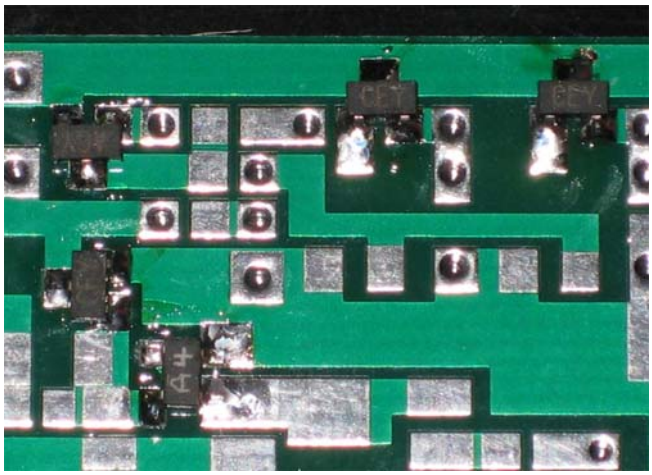
SMD soldering practice



Install capacitors C9 (0.1uF), and C10 (0.1uF). If this is your first time soldering SMDs, these are the best two to start with, as precision placement and microscopic size are not an issue. Using the SMD soldering steps detailed above, first place the part, solder one end, double-check placement and adjust by re-heating the solder. When you are certain of the components location and orientation, solder the remaining end. Check your work carefully before proceeding.
Next, install C6(0.1uF) and C7(0.1uF). This placement is a little tight, so take particular care. Then C4(0.1uF) and C5(0.1uF), as well as resistors R7 (100 Ω), and R9 (100 Ω) should be installed.

Soldering the SMD diode and transistor

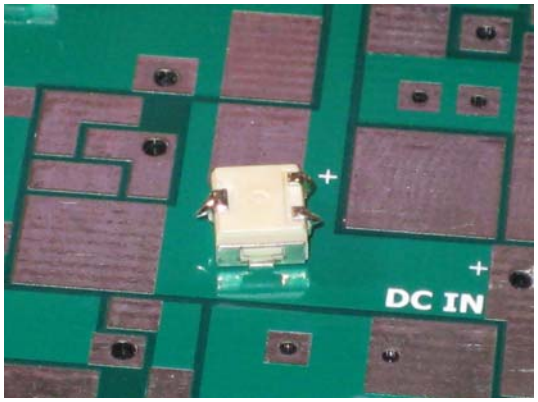
Install diode D1 (1SS319), paying careful attention to its orientation. Then, install transistors Q1 (2SC3325), Q5 (2SC3325), Q6 (2SC3325), and Q2 (2SA1313) in the same way. Try not to linger with the soldering iron tip on these heat-sensitive components.

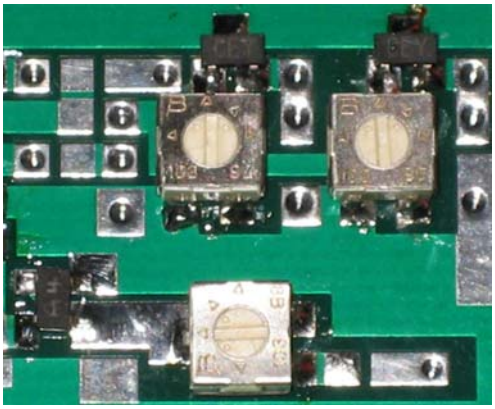


SMD trimpot installation

The small SMD trimmers VR1, VR2, and VR3 (all 10K Ω) are mounted next. There is a trick to this, because the leads are under the component, without much of a tab beyond the flush edge. This procedure makes it simple: First, tin the terminals of the component, taking care not to

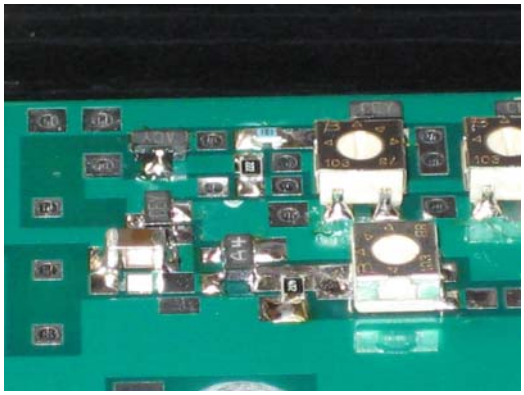
overheat the trimpot. With the tip of the soldering iron leave a little 'tail' of solder that leads slightly outward from the body of the component. (You can practice this technique on a piece of scrap.) Then, tin the pads on the main board, place the component, and solder in place as you would other SMDs. As always, take care not to wick too much solder under the trimpot.





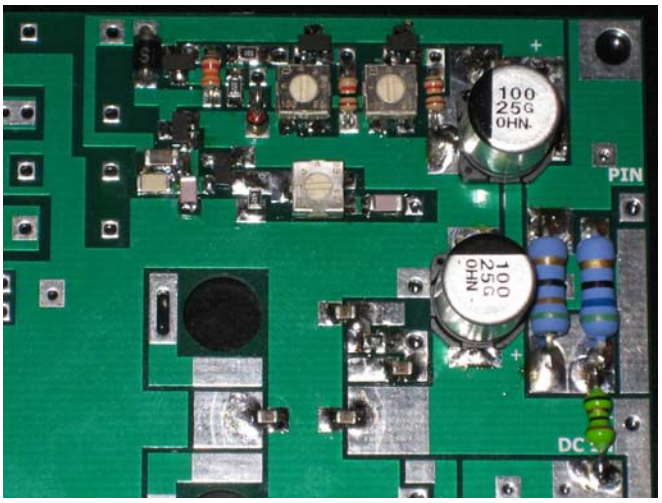
SMD capacitor and resistor soldering

Next C1(0.0022uF) and C2(0.0022uF)are installed. Continue with R1(4.7KΩ), R5(2.2KΩ), and R6(10KΩ). Then C3(0.01uF) and CC1(10uF/25V) are positioned, double-checked, and installed. These are in particularly close quarters so be sure to "check twice, solder once."



Soldering through-hole components, etc.

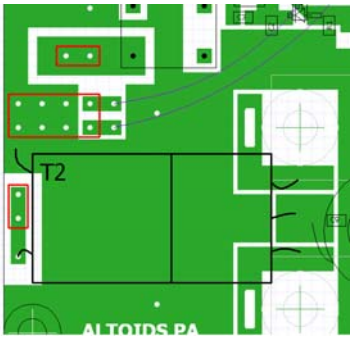
Resistors R4 (3.3K Ω), R8 (1K Ω), R10 (1K Ω), and diode D2 (1S10) are installed next. Zener diode D3 (5.6V) is installed "hairpin style" with the cathode (dark stripe) end UP, as pictured below. After bending the cathode lead, solder the component in place. R2 (56 Ω /1W) and R3 (51 Ω /1W) are soldered in place next. Note that only one end of R2 is through-hole. Next, inductor L1 (1uH) should be soldered in place. CC2 and CC3 (cylindrical 100uF/25V electrolytics) are mounted next. Carefully noting their polarity and orientation solder them in place utilizing the



same method as with the trimmers VR1-3. At this point, RL1 should also be installed, the body of the relay resting snug against the board.

Installing Pin Sockets

Pin sockets are now installed in the main board(Red place of right figure). Make certain they are snugly set in the board and are as perpendicular to the plane of the PCB as possible.



Preparing and installing the input transformer

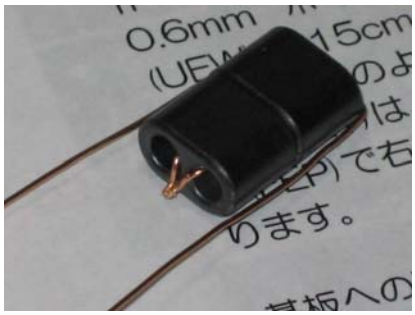
The input transformer is wound on a BN43-302 2T binocular core with the supplied 0.5mm polyurethane electric wire (UEW). There are two windings of two turns each. Preparing the transformer core is simple: cut 2-10cm lengths, winding two loops in one direction on the center of the core, then two loops in the opposite direction on the same core. Take care not to remove the insulation while winding the core (it's not likely, don't worry.) Strip and tin the four leads as shown in the photo below and solder to the main board.

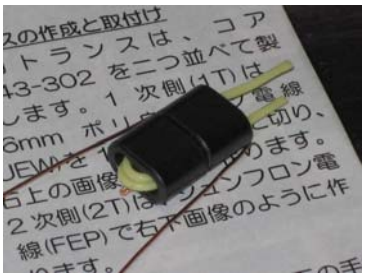
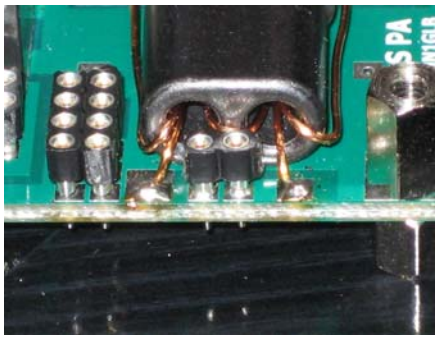
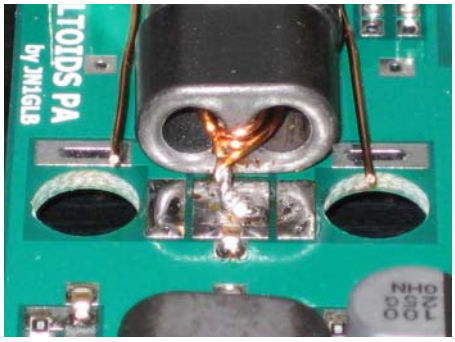
Preparing and installing the output transformer

The output transformer uses two of the same BN43-302 binocular cores placed end-to-end. The primary side is a single turn (1T: the wire passes a single time through each hole of the stacked cores). This is basically just a hairpin "U" of wire soldered to the main board at each end as shown in the photographs — tapped in the center.

Begin by cutting 15cm of the 0.6mm polyurethane coated

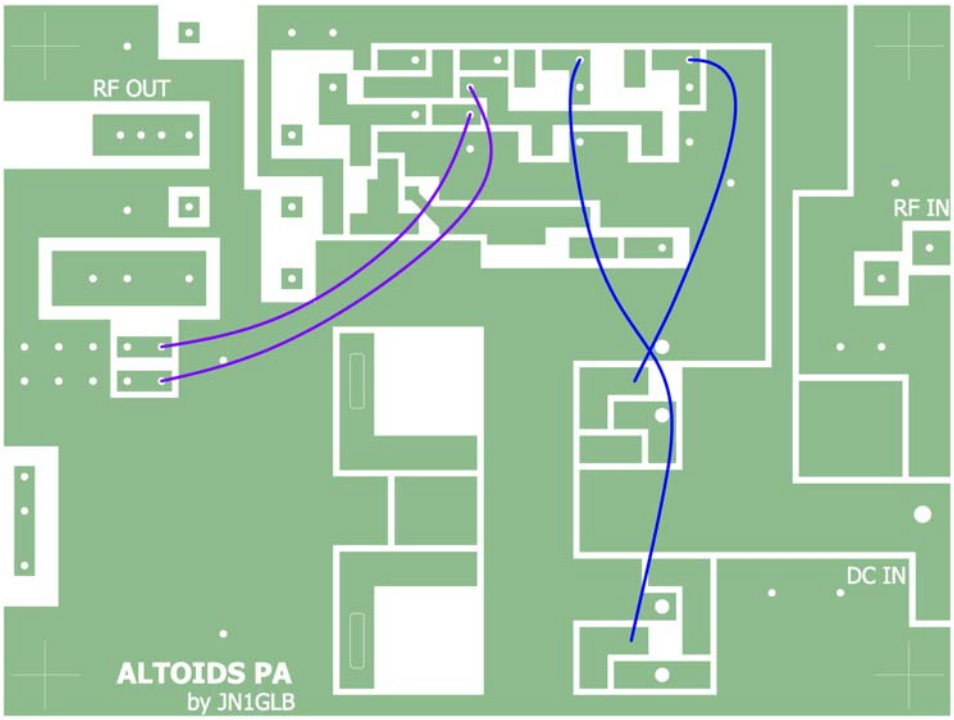
wire supplied, putting a sharp bend in the center, and form it into a tab as shown in the photograph. After each end is inserted into the coil and dressed back along the outside of the stacked cores, they may be tinned and prepared to solder. Remember to tin and scrape the center tap as well. The remaining secondary winding is simply two turns of the heat-proof wire provided, wound just as you did with each of the input transformer turns. Wind two turns, tin and prepare the ends. Compare your wound toroid to the photographs and then mount in place, soldering in the five points designated on the main board. Check for shorts and solder bridges as usual.

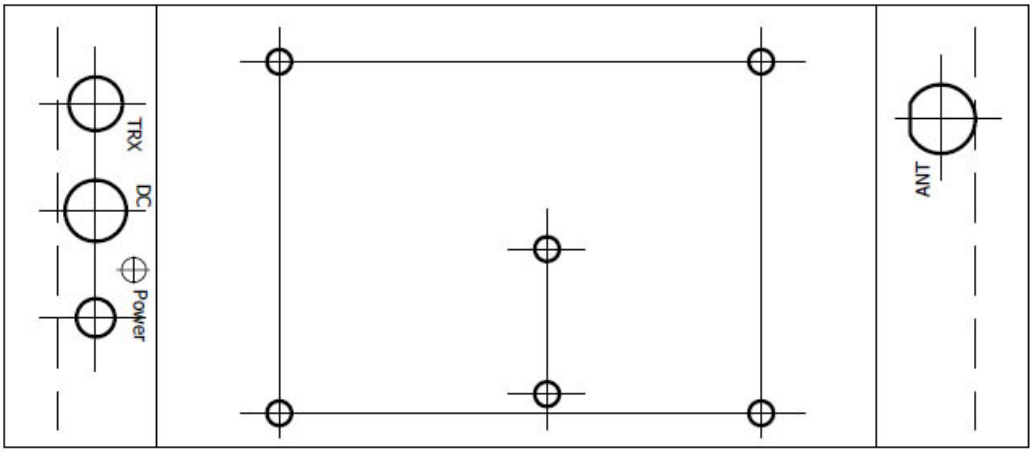
Wiring jumpers

Now four main board insulated wire jumpers should be installed exactly as indicated in the diagram and photo below. Note that two points are not through-hole joints.



Preparing the case

The template below is suitable for a standard "Altoids" breath mint tin. Print, cut out, and fold this template to serve as a guide in making the appropriate holes for the "stock" Altoids PA. This part of the project is highly customizable, as appropriate holes must be made for either RCA or BNC connectors and the builder's choice of cooling fan and heatsink. As before, a Google search of "preparing altoids tin" or similar will bring up scads of drilling and cutting techniques for your chosen enclosure. For those who desire the minty-fresh look of a "GLB Factory Stock" Altoids PA, the template will serve as a perfect guide in alignment of connectors, switches and other peripherals.



Heat Sink Construction

Using the above template as a reference, prepare appropriate M3-size holes for FET heat sink installation—depending on your choice of cooling device. Nylon heat sink screws are supplied for heat sinking the FETs. If other fasteners, screws or bolts are used they must not be metallic. Various mechanical accommodations must be made at this point, specifically that the case, PCB, and the user-specific heat sink and fan do not bump into or interfere with each other.

(This is where you can be creative and resourceful.)

Connector and switch preparation

Please refer to the photos below for BNC output connector placement. If you have chosen an RCA or other connector, make appropriate accommodations.

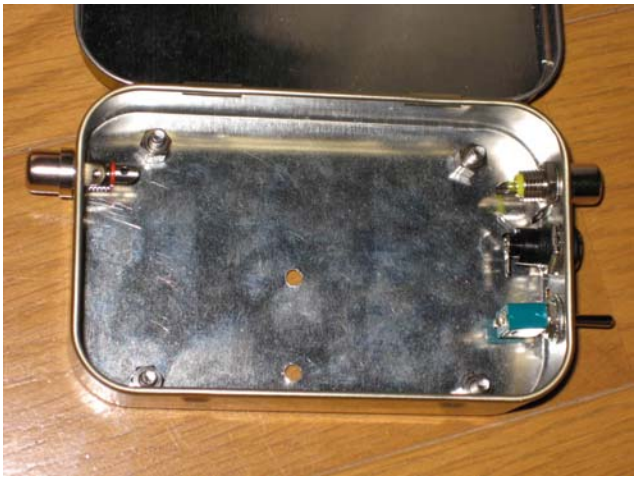
Please tighten connectors securely and make sure there is appropriate clearance for LPF filter board coils, once they are installed and assembled. This will probably involve spreading the switch and jack contacts as pictured, making more room for the main board.
In likewise form install the DC power jack, input RCA jack and switch as pictured below.





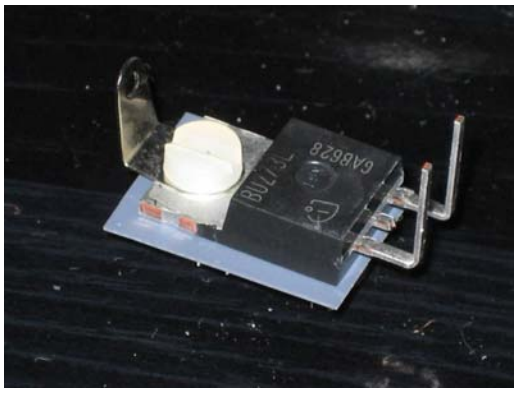
Putting the board in the Altoids tin

The M3X10mm screws that secure the main board, also mount the assembly into the Altoids tin. If your cooling fan interferes with the screw heads, you might want to provide more clearance with a piece of 1-2mm tin or other material—or use countersunk heads. This part of the design is really up to your own ingenuity and creativity. Please use the photos as a starting point for your own work.



Temporary securing of the Power MOS FETs

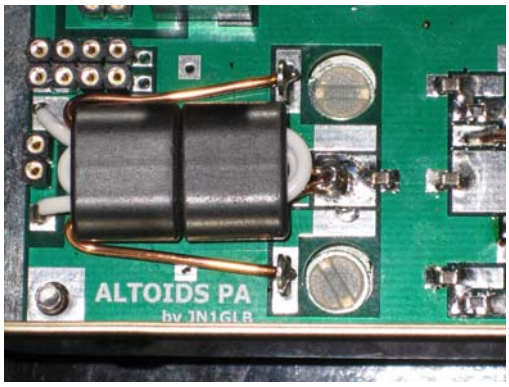
Form the FET leads as pictured below, nipping off the unneeded center drain lead. Bend them right the first time; they will probably not withstand more than that, but will be plenty strong as pictured below.



Form the lug as pictured, assembling the plastic film insulator to each FET with a nylon bolt lightly as pictured. This assembly will be finished later.

PA Main Board Installation

After verifying that the FET leads and the tab of each bent lug extend cleanly through their respective holes in the main board, carefully lower the whole assembly into your Altoids tin. You may find that this process is easier by assembling the board bottom-up, with the FETs on top, then placing the Altoids tin over everything, guiding the nylon screws through their holes—then flipping the whole works over. By whatever means, both ends of the output transformer primary windings should be inserted in the lugs as pictured, and trimmed. Install the nylon nuts under the Altoids tin, taking care nothing is shorting or binding. Verify that the FET drains and the Altoids tin are not shorted together, and then solder the lugs to the board and to the output transformer leads. This process is a good one to 'rehearse' before soldering, as any mistakes will be difficult to desolder and disassemble. Verify snugness of all connectors and check again for shorts before proceeding.



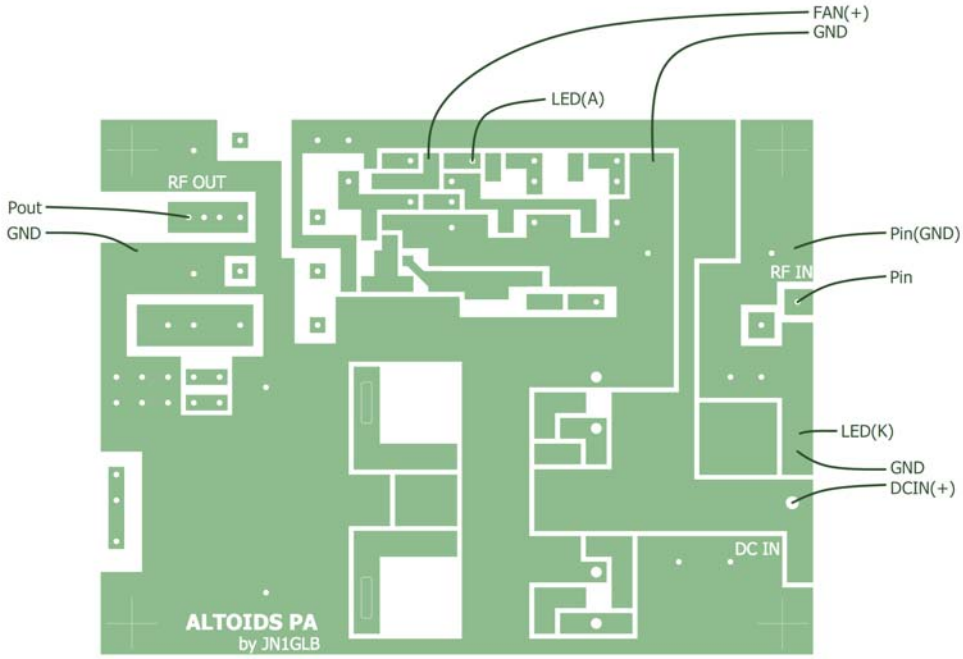
The position of the Altoids tin FET heatsink relative to the plane of the main board is fixed by the soldered lugs. Care in this process will ensure easy removal and replacement of the main assembly from the Altoids tin in the future.

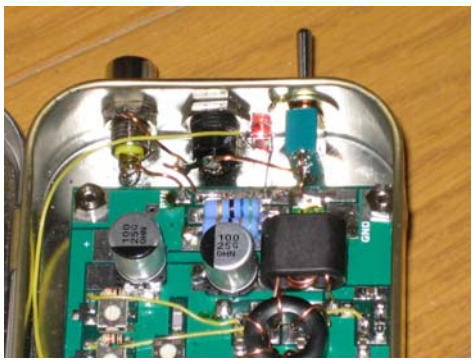
Assembly and installation of RF chokes

Wind five turns of the 0.6mm polyurethane coated wire (UEW) on a T50-43 core and mount this on the main board as pictured.

Wiring it all up

You should have a hole in the case to accommodate the LED. Solder the shorter (anode) lead to the main board ground. Bending the longer (cathode) lead of the LED vertically to clear the DC connector body, solder a jumper around the edge of the case to the appropriate pad on the main board. Insulate as necessary, referring to the diagram and photos below.

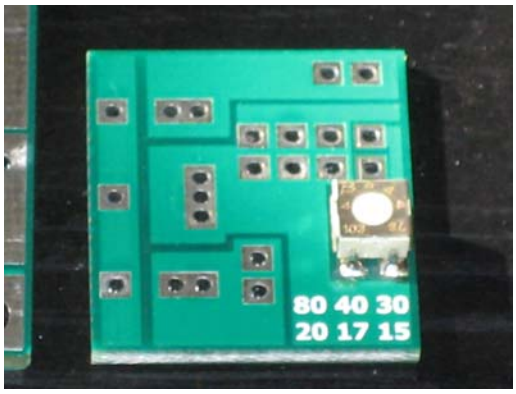


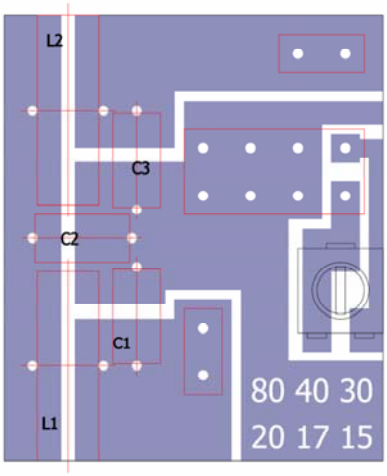


Thus completes the main board. Let's move on to the LPF boards.

Making the LPF boards

Using the technique employed previously in this project, install the SMD trimpot on one of the LPF modules as shown. Verify orientation and position by comparing the diagram with your PCB.

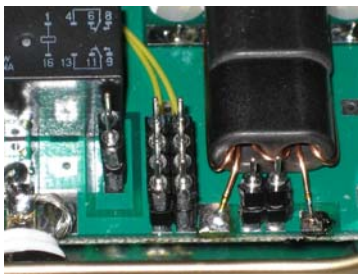


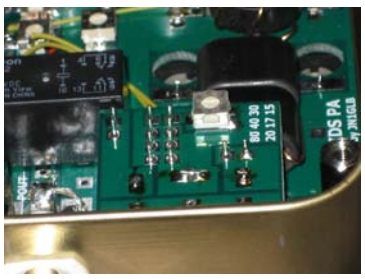


Install C1, C2, and C3 according to the chart below. Inductors L1 and L2 are wound with the supplied 0.5mm wire and installed in turn.

BAND	C1	C2	C3	L1	L2	Aprx wire length
3.5M	820pF	1800pF	820pF	T37-2(red) 23T	T37-2(red) 23T	30cm(12inch)
7M	470pF	1000pF	470pF	T37-2(red) 17T	T37-2(red) 17T	24cm(10inch)
10M	330pF	680pF	330pF	T37-2(red) 14T	T37-2(red) 14T	20cm(8inch)
14M	220pF	470pF	220pF	T37-6(yel) 14T	T37-6(yel) 14T	20cm(8inch)
18M	180pF	390pF	180pF	T37-6(yel) 12T	T37-6(yel) 12T	18cm(7inch)
21M	150pF	330pF	150pF	T37-6(yel) 11T	T37-6(yel) 11T	18cm(7inch)
24M*	120pF	270pF	120pF	T37-6(yel) 10T	T37-6(yel) 10T	16cm(6inch)
28M*	100pF	220pF	100pF	T37-6(yel) 10T	T37-6(yel) 10T	16cm(6inch)

The pin headers are installed last. Make very certain of placement before melting any solder. First, the header is inserted securely in the holes of the mainboard, the LPF board is placed over the pins, placement is verified, and soldered in place. Note that there are two pin thicknesses—the thinner pins go on top of the thicker ones.





Carrier Control Adjustment

VR1 should have been installed with the control somewhat centered. The relay should just trip on keydown. Make certain that the relay just switches with the slightest key down situation. The relay should click along with the key going down. If it makes a humming or any other sound in this state, there isn't enough drive current. When adjusting, keep in mind that turning VR1 clockwise increases the drive current.

Output Adjustment

The following adjustments will require an RF power meter or multitester that reads RF voltage. The 80m band, being the least efficiency is the first to be calibrated. With the 80m LPF module installed, rotate the trimpot on that module completely counterclockwise. VR2 and VR3 on the main board should be roughly centered to begin with. While transmitting 2.5~3 watts in to the Altoids PA, adjust VR2 and VR3 in the same direction to get an output of 15W. When you are satisfied with this adjustment, power down and complete the same procedure with every LPF board for each of the six bands. You adjust as the linear amplifier case, please consider sufficiently in the linearity. Furthermore, transfer characteristic of power MOS FET has become like below. As with any linear amplifier adjustment, your results may follow the graph below, showing MOS FET power transfer characteristics for the Altoids PA.

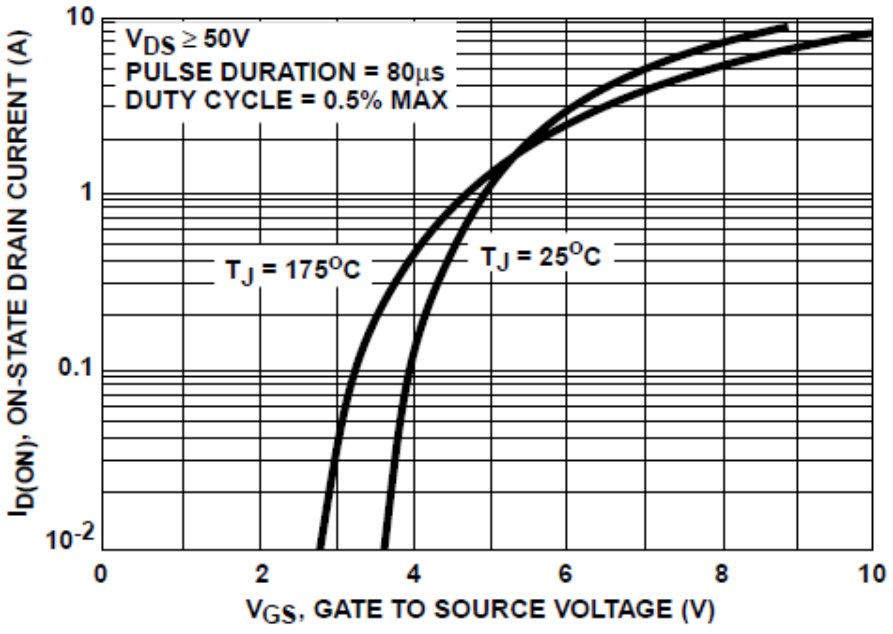


FIGURE 7. TRANSFER CHARACTERISTICS

In order to fit a standard Altoids Curiously Strong Breath Mint tin, the template below should be printed exactly to 58mm X 134mm. Align the right side of the template to the right edge of the case to locate the appropriate holes. The care and feeding of an Altoids tin is part applied science, part alchemy, and part sheer luck. Keep a spare on hand, and a spirit of adventure as you bend, fold and spindle. Have fun!