A quick guide to the KW4TI layout of the WA2EBY amplifier

This layout of the WA2EBY amplifier is intended to provide a design that can be easily manufactured by low-cost PCB board fabrication houses. Many services such as JLCPCB, Seeedstudio, etc. will fab a 10 by 10 cm 2-layer PCB for $5 or less, and this board is exactly that size. Furthermore, this board is intended to reduce the size of the overall amplifier making it suitable for portable use. Because of this, the components are packet in very tightly. This PCB is laid out to enable some flexibility in obtaining components.

The design is largely the WA2EBY design as given in the March/April 1999 issue of QST. However, some changes have been made to make the design:

- The amplifier and filters are now on a single PCB.
- To make the PCB cheaper to fabricate and the heatsink mounting easier, the MOSFETs and heatsink are placed at the edge of the PCB, rather than needing to route a hole through the PCB to attach the MOSFET drains to heatsinks.
- An overcurrent protection circuit has been added so that if the MOSFET draw too much current, especially if the amplifier is driven into oscillation with a mismatched load, the bias voltage is shut off to the gates to shut down the MOSFETs.
- Various test points and jumpers have been added around the board to help debugging and diagnoses of problems.
- Pads have been added so that the T/R relay can be controlled externally.

Populating the PCB

Populating the PCB is relatively straightforward. It is generally recommended to place the smaller components first, and then add the more bulky components later. L1, L2, and L3 should be placed later as they tend to be fragile. MOSFETs Q2 and Q3 should be placed last to minimize the potential of damage from ESD. Before placing the MOSFETs, but after other smaller components, place transformers T1, T2, and T3. These transformers are bulky and will cover other components on the PCB. In particular, T3 is very bulky and is placed on top of the T/R relay RLY1 so that a little extra lead length is needed to reach the PCB from its position sitting on top of the relay. After winding the transformers, do not trim the leads until you know how much length you will need to reach the pads on the PCB. Try to minimize the lead length, however, an extra cm or two of lead length does not affect operation that much.

The silkscreening for T1 and T2 labels how each of the two pairs of windings should be connected. T1 is 10 bifilar turns of 0.5 mm wire (AWG 24) wound on a FT50-43 or FT82-43 ferrite toroid. T2 is 10 bifilar turns of 0.6 mm wire (AWG 22) wound on two stacked FT50-43 or FT82-43 cores (though a smaller core is better here as its a tight fit). T3 is a binocular core, for example BN43-3312, or one can be made from two larger 43-mix ferrite coax beads with 2 primary turns and 3 secondary turns (to achieve an approximately 1:2 impedance transformation). The primary turns are connected closer to the MOSFETs, and the secondary turns connected closer to the T/R relay, as shown on the silkscreening.

The MOSFETs Q2 and Q3 can be mounted to the PCB either using the through-holes, however, this makes replacement of the MOSFETs more difficult. Alternatively, the leads may be trimmed and the

MOSFET leads surface mounted to the pads. This also makes mounting the heatsink easier, as the MOSFETs are protruding over the edge of the PCB. A common heatsink may be used for Q2 and Q3, however, the drains must be isolated from each other, and so an insulating heatsink pad is needed. A small heatsink is required for Q5, however, under normal use it should dissipate very little power.

The mounting holes of the PCB are connected to ground, and so metal standoffs connecting the corners of the PCB to a grounded case is best.

Description of the jumper blocks:

JP1:	Position 1-2, use attenuator pad (normal position)
	Position 2-3, bypass attenuator pad (but still loads the RF input with the attenuator)
JP2/JP3:	Test points to detect bias voltage on MOSFET gates
JP4:	Position 1-2, disable overcurrent protection
	Position 2-3, enable overcurrent protection
JP5/JP6:	Both position 1-2, bypass filters
	Both position 2-3, place filters in-line
JP7:	Closed to for T/R relay always in transmit position (good for testing).
JP8:	Closed to bypass zener diode, useful for running amplifier from 12-14 volts

J4: Power is applied at J4.

J27/J28 may be connected to a switch and shorted together to force the T/R relay to stay in the receive position. This is useful so that the SWR can be tuned using a rig in bypass mode, and then the amplifier is switched into the path. Alternatively J27 can be connected to an external T/R control +12 V through a 1k resistor. However, D2 should probably be removed if you do this.

Placing and connecting the low-pass filters:

The filter is connected to positions J12 and J13 if JP5/JP6 are set to include the filters in the RF path. Two short lengths of RG-174 cable may be soldered with the centers connected to J12 and J13, and the shields connected to J29 and J31.

The positions to place the inductor/capacitors for each of the five filters are in the following table. The pads for the capacitors are designed for either through-hole (ceramic or mica) or one or two 1206-size SMD capacitors. This is also shown on the schematic, and silkscreening outlines the filters on the PCB.

Input Position	Capacitor 1	Inductor 1	Capacitor 2	Inductor 2	Capacitor 3	Output Position	Ground Position
J10	C23	L4	C24	L5	C25	J11	J25
J14	C26	L6	C28	L8	C30	J16	J26
J15	C27	L7	C29	L9	C31	J17	J24

J18	C32	L10	C34	L12	C36	J20	J23
J19	C33	L11	C35	L13	C37	J21	J22

To connect the filters, a pair of short RG-174 cables may connected to each filter, with the centers connected to each input and output position, and the shields of the cables connected to any ground position (the nearest ground position is labeled, but they are all equivalent).

J12 is connected to one pole of a band selector switch, and J13 is connected to another pole. All of the input positions for all of the filters are then connected to the positions on the band selector switch connected to J12, and the output positions for all the filters connected to the positions on the band selector switch connected to J13. If a two pole band selector switch is not available, DPDT switches may be used with each switch simultaneously connecting J12/J13 to the input/output position of a filter. However, only one filter should be switched into the RF path at a time. The grounds of all the coaxial cables can be joined together on the other side of the switch, and simply serve as shielding. Wires can be used instead of coaxial cables, however, keeping the wires short is important as the wires add extra inductance to the RF path.

Tuning the bias on the IRF510 gates

To tune the bias on the IRF510 gates, the RV1 and RV2 10 turn potentiometers are used. These are usually set so that each of the gates has 50 mA of drain current with no RF applied. The voltage bias needed to do this depends on the particular IRF510s and applied drain voltage. To adjust the bias, first turn the bias down to zero for both of the gates. A milliammeter may be placed in-line with the +28 V supply, and the quiescent current noted with zero gate bias applied. The bias voltage of one of the gates may be slowly increased as to add 50 mA more quiescent current, with the transistor allowed to thermally stabilize for 30 seconds or so, and then the other gate voltage may be increased similarly to add another 50 mA of quiescent current.

Winding the inductors

The inductors are wound similarly to how originally suggested in the original WA2EBY article.

L1: 3 ½ turns of 0.5 mm (24 AWG) diameter magnet wire around 5 mm (0.19”) diameter form.
L2/L3: 9 ½ turns of 0.5 mm (24 AWG) diameter around 6.25 mm (0.25”) diameter form.

The form can be a drill bit or round pen or pencil with a similar diameter.

To wind them, take a piece of waxed paper and wrap it around the form, and wrap a piece of transparent tape around the paper to hold the waxed paper on the form. Then wrap the wire around the form, leaving at least 3-5 cm of extra wire on the end of the inductor. Make sure the turns are packed tightly on the form. Then use a drop of cyanoacrylate (super) glue to hold the turns together. Moisture from breath accelerates curing of the glue. Then you can slide the wax paper and coil off of the form and cut away any extra paper with scissors. A nail file is useful for removing the enamel coating on the wires.

Overcurrent protection

An overcurrent protection circuit has been included that is not in the original WA2EBY design found on the G0KLA web page. It limits the input current to 3 amps and then shuts off the bias to the MOSFET gates. It works by turning on the TIP42 emitter-base junction with about 0.6 volts forward drop when there is 3 A passing through the 0.2 ohm sense load. This then shuts off Q4 which then disconnected the +28 V supply to the zener diode. If this happens, led D8 will shut off, so you could mount D8 on the panel and detect and overcurrent/mismatched load condition this way.