Elecraft KAT100 Automatic Antenna Tuner

Revision C, March 12, 2003

KAT100-1 shown above. See page 3 for photo of full-height version (KAT100-2).

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Introduction

The KAT100 automatic antenna tuner (ATU) is designed for use with the Elecraft K2/100 transceiver, as well as the basic K2. It can match loads with SWRs in excess of 10:1, and can easily handle 150 watts of transmit power. Ten front-panel LEDs provide an accurate, real-time SWR indication during transmit. The KAT100 also includes *two* antenna jacks–the equivalent of two auto-tuners connected to the rig.

Because of its tight integration with the K2, the KAT100 offers many advantages over generic external auto-tuners:

- Automatic power reduction to 2 or 20 watts (in low- and high-power modes) when the K2's `TUNE` switch is pressed; auto-tune is possible with as little as 0.2 watts in low-power mode
- Direct display of power, SWR, and other data on the K2 LCD
- ATU can be configured using the K2 menu
- K2's POWER control setting indicated by two LEDs
- K2's `ANT1/2` switch selection indicated by two LEDs
- L/C settings stored in EEPROM for both antennas on all bands
- SWR LEDs can use bar or dot mode (set by **GRPH** menu entry)
- All LEDs have two brightness levels (set by **LCD** menu entry)

The ATU comes in two enclosure styles, both of which match the K2:

- The **KAT100-1**, shown on the cover of this manual, is housed in a low-profile cabinet, intended to be placed *beneath* the K2. Two anti-slip brackets are provided, so the K2 will remain in position even if the KAT100-1 is tilted up. (Also see **Tilt-Stand Options** at right).

- The **KAT100-2**, shown in the photo at right, is intended for *side-by-side* arrangement with the K2. It includes front and rear panels that match our K2-sized **EC2** enclosure kit. (The EC2 is sold separately.) The EC2 cabinet provides plenty of room in the top cover for your own accessories.

Both KAT100 types are covered in this manual.

Tilt-Stand Options

Two different matching tilt stands are available, one for each KAT100 type. The **ETS2** is our standard, full-height tilt stand (2.5"), and is recommended for use with the KAT100-2. The **ETS15** is identical to the ETS2 but is only 1.5" tall. It's ideal for use with the low-profile KAT100-1, providing the optimum viewing angle during operation.

Pre-Wound Toroids Available

The toroids in the KAT100 kit are not difficult to wind, and detailed instructions are provided (beginning on page 13).

If you prefer not to wind the toroids yourself, you can obtain a full set of pre-wound toroids (with leads stripped and tinned) from an Elecraft-qualified source. Ordering information is at www.elecraft.com.

You do not need to send your cores or wire to the winding service. You can keep your set for replacements or for use in your own projects.

KAT100-2

Parts Inventory

You should do a complete inventory, and if you find anything missing, contact Elecraft.

⚠ **i** Leave painted panels wrapped until they are needed during assembly. This will protect the finish.

☐ **Items supplied only with the KAT100-1 (with low-profile enclosure).**

Picture	Ref. Designator(s)	QTY	Description	Part #
	MISC	1	KAT100-1 Front Panel	E100138
	MISC	1	KAT100-1 Rear Panel	E100139
	MISC	2	KAT100-1 Side Panel	E100140
	MISC	1	KAT100-1 Top Cover	E100146
	MISC	1	KAT100-1 Bottom Cover (note: includes holes for optional feet/tilt-stand)	E100147
	The items below are in a small bag labeled "Misc., KAT100-1" (p/n E850132)			
	HDWR	28	Screw, 4-40 x 3/16" Panhead Phillips, black (includes several spares)	E700015
	HDWR	8	2-D Fastener	E100078
	MISC	4	Rubber foot, self-adhesive	E700024
	MISC	2	Anti-slide bracket	E100150

☐ **Items supplied only with the KAT100-2 (for use with an EC2 enclosure).**

Picture	Ref. Designator(s)	QTY	Description	Part #
	MISC	1	KAT100-2 Front Panel, EC2-compatible	E100142
	MISC	1	KAT100-2 Rear Panel, EC2-compatible	E100143
	The items below are in a small bag labeled "Misc., KAT100-2" (p/n E850136)			
	P3, P6	2	Connector, 2 pin male, 0.156"spacing (Aux 12V In and Aux RF Out)	E620012
	P4	1	Connector, 10 pin (5x2) male, 0.1" spacing (Aux Control)	E620040

☐ **Items in the KAT100 main parts bag (E850094), supplied with both KAT100-1 and -2.** Color codes and markings are shown in parentheses. Reference designators from 101 up refer to Front Panel components. Refer to Appendix A of the K2 owner's manual for more parts photos.

⚠️ **Some components in this kit can be damaged by static discharge. Before handling diodes, transistors, and ICs, touch a grounded, unpainted metal surface, or use a wrist strap grounded through a 1 megohm resistor.**

Picture	Ref. Designator(s)	QTY	Description	Part #
	C1	1	Capacitor, 12 pF, 2000V ceramic (3 KV caps may be substituted for any 2KV)	E530107
	C2	1	Capacitor, 22 pF 2000V ceramic	E530108
	C3	1	Capacitor, 39 pF 2000V ceramic	E530109
	C4	1	Capacitor, 82 pF 2000V ceramic	E530110
	C5,C6A,C6B,C7A-7D	7	Capacitor, 150 pF 2000V ceramic ("151")	E530111
	C8	1	Capacitor, 1200 pF, 1600V polypropylene film ("122")	E530112
	C32	1	Capacitor, 100 pF, 200V ("101")	E530034
	C33-36,C47	5	Capacitor, .001 µF, 50 V ("102")	E530001
	C37,C38,C39,C45, C46 C50,C51,	7	Capacitor, .01 µF, 50 V ("103")	E530009
	C44,C49,C101,C102, C56	5	Capacitor, .047 µF, 50V ("473")	E530025
	C9-30,C40,C41,C43, C48,C52-55,C57-60	34	Capacitor, 0.1 µF, 50V ("104")	E530020
	C42	1	Capacitor, 10 µF, 35 V electrolytic	E530045
	C31	1	Capacitor, 5-30 pF trimmer	E540001
	D1,D2	2	Diode, 1N5711 (small glass body)	E560004
	D3,D4	2	Diode, 1N5817 (large black body)	E560008
	D110,D111,D112	3	Rectangular LED, Red (long lead is anode -- see text)	E570007
	D101,D103,D104, D105,D106,D113	6	Rectangular LED, Green	E570008
	D102,D107,D108, D109,D114	5	Rectangular LED, Yellow	E570009
	E1	1	Screw terminal, right-angle PCB mount	E700012

J1	1	Connector, DC barrel jack, 2.1mm, right-angle PCB mount	E620026
J2	1	Connector, BNC, right-angle PCB mount, with finishing nut and washer	E850134
J3	1	Connector, DB9-F (female), right-angle PCB mount	E620058
J4,J5,J6	3	Connector, SO239	E620064
J7	0	Connector, 6-pin female, 0.1" (not supplied; for future use)	N/A
J101	1	Connector, 12-pin female, 0.1" spacing, PCB mount	E620008
K1-K18	18	Relay, SPDT, 10A rating	E640012
L1,L2,L3,L4	4	Toroidal inductor on T80-0 core (brown, 0.8" dia.); see text	E680020
L5,L6,L7,L8	4	Toroidal inductor on T94-2 core (red, 0.94" dia.); see text	E680018
P1,P2	0	Connector, 2 pin male, 0.1" spacing (not supplied; for future use)	N/A
P 5	1	Connector, 12 pin male, 0.1" spacing, right-angle mount	E620065
Q1	1	Transistor, PNP, modified TO-92 package, Zetex ZTX789A **Note:** Q1's labeling may be hard to read. The part number should be marked on the silver-colored side.	E580019
Q2,Q3	2	Transistor, MOSFET, TO-92 package, 2N7000	E580002
Q101,Q102	2	Transistor, NPN, TO-92 package, PN2222	E580001
R5,R101-R114	15	Resistor, 120 ohms, 1/4W, 5% (brn-red-brn)	E500022
R2	1	Resistor, 200 ohms, 1W, 5% (red-blk-brn)	E500074
R115	1	Resistor, 220 ohms, 1/4W, 5% (red-red-brn)	E500002
R116	1	Resistor, 470 ohms, 1/4W, 5% (yel-vio-brn)	E500003
R11	1	Resistor, 680 ohm, 1/2 W, 5% (blue-gray-brn)	E500085
K2 CTRL-R12	1	Resistor, 820 ohm, 14 W, 5% (gray-red-brn)	E500001
R1,R8,R9	3	Resistor, 3.3K, 1/4W, 5% (org-org-red)	E500017
R12,R16,R17,R18	4	Resistor, 10K, 1/4W, 5% (brn-blk-org)	E500015
R3,R4	2	Potentiometer, 100K trimmer ("104")	E520001
R6,R7,R13	3	Resistor, 8.45K, 1/4W, 1% (gray-yel-grn-brn)	E500071
R15	0	Resistor (not supplied; for future use)	N/A
RFC1	1	RF choke, 15µH (brn-grn-blk) **NOTE: may be in bag with toroid cores**	E690012
RFC2	1	Toroidal inductor on FT37-43 core (gray, 0.37" dia.); see text	E680003
RP1	1	Resistor pack, 3.9K, 4 individual resistors, 8 pins	E510000
T 1	1	Transformer on FT50-43 toroidal core; see text	E680008
U1	1	IC, Programmed microcontroller for KAT100, PIC16F877 or PIC16F877A	E610012
U2,U3,U4, U101,U102	5	IC, octal driver, TPIC6B595	E600032
U5	1	IC, op-amp, LM358	E600010
U6	1	IC, high-current op-amp, EL5146C	E600041
U7	0	IC, EEPROM, 25LC320 (not supplied; reserved for future use)	E600009
U8	1	IC, 5V regulator, TO-220 package, 78M05 or 7805	E600024
W1-W7	0	Wire jumper (leave open except as specified in text)	N/A
Z1	1	Ceramic resonator, 4.0MHz, 0.2% tolerance (orange, with 3 leads)	E660001

	HDWR	2	L-bracket, front panel retainer, 4-40 threaded	E700073
	HDWR	14	Screw, 4-40 x 3/16" Panhead Phil, black (2 spares)	E700015
	HDWR	15	Screw, 4-40 x 5/16" Panhead Phil, zinc plated (2 spares)	E700077
	HDWR	1	Thumb screw, 6-32 x 1/2", with black plastic knob	E700070
	HDWR	1	Nut, 6-32	E700069
	HDWR	2	Flat washer, #6	E700067
	HDWR	24	Split lock washer, #4 (2 spares)	E700004
	HDWR	15	Nut, 4-40 (2 spares)	E700011
	HDWR	3	Solder lug	E700062
	HDWR	2	Standoff, hex male-female (for DB9 connector, J3)	E700078
	MISC	1	Connector, 2.1 mm mating plug for J1 (DC barrel jack)	E620032
	MISC	1	Connector, 9-pin, DB9M (male), solder cup terminals (for control cable)	E620049
	MISC	3 ft.	Cable, 4-conductor shielded	E760009
	MISC	1	DB9 backshell and hardware (for control cable)	E620050
	MISC	1	40-pin socket for U1	E620017
	MISC	1 ft.	Hookup wire, #20, black insulation	E760006
	MISC	1 ft.	Hookup wire, #20, red insulation	E760007
	MISC	4 ft.	#26 enamel wire for T1 and RFC2, red	E760002
	MISC	2 ft.	#26 enamel wire for T1, green	E760004
	MISC	20 ft.	#20 enamel wire for L1-L8, red	E760022
	MISC	10	Cable ties (for L1-L8; 2 spares)	E980002
	MISC	1	Sand paper	E850090
	MISC	1	KAT100 RF PC Board	E100144
	MISC	1	KAT100 Front Panel PC Board (may be wrapped with one of the panels)	E100145

RF Board Assembly

☐ Place the KAT100 RF PC board in front of you, with the **bottom side** up and the **front edge** facing you as shown in the Parts Placement Drawing, Appendix B.

☐ On the bottom of the board, along both edges, you'll find **six** locations for *2-D fasteners*. These are used to secure the RF board to the chassis panels. In the next few steps, just **four** 2-D fasteners will be attached, and the remaining two locations will not be used. Which four locations to use depends on whether you're building a KAT100-1 or KAT100-2:

KAT100-1: Use the two 2-D locations near the front edge, and the two near the back edge.

KAT100-2: Use the two 2-D locations near the front edge, and the two located about two-thirds of the way back. (The 2-D fasteners are supplied with the EC2 enclosure kit, not the KAT100-2.)

☐ Locate a 2-D fastener and hold it vertically (Figure 1a). Looking at a side with two holes, note that the holes are offset from the center. The PC board outlines for the 2-D fasteners have a matching offset, which will aid in installing them in the next step.

Holes offset from center

(a)   (b)
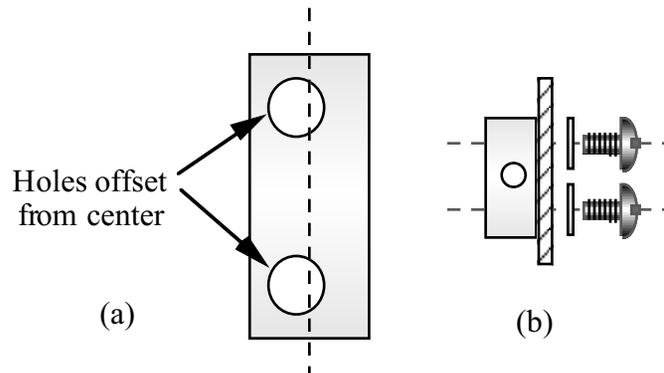
Figure 1

☐ Install 2-D fasteners at the four locations identified earlier, on the *bottom* of the RF board. Secure each fastener from the top side of the board with 3/16" (4.8 mm) pan-head screws (black) and #4 split lock washers (Figure 1b).

☐ Make sure the 2-D fasteners line up with the edges of the PC board and do not hang over. If they hang over or do not match their component outlines, they are installed backwards.

⚠ **The leads on small capacitors are fragile. Do not pull on the leads or bend them excessively.**

☐ Sort all capacitors into groups by physical appearance (size, color, and lead spacing). Within these groups, sort them by capacitance value.

☐ Locate the component outline for capacitor C55, on the top side of the board near the front edge.

☐ Install a 0.1-µF capacitor (labeled "104") at C55. Keep the lead length as short as possible. (If the leads are pre-formed, the capacitor may sit slightly above the board.)

☐ Bend C55's leads outward on the opposite side of the board to keep it from falling out or shifting position. Then solder the capacitor and trim the leads.

Note: Components may be soldered one at a time or in groups. Leads can be trimmed either before or after soldering. After soldering, trim leads to about 1/16" [1.5 mm] or less in length.

⚠ **If your solder joints are not clean and shiny, your iron may not be hot enough, or you may be using the wrong type of solder. These "cold" solder joints will likely result in poor performance, reliability problems, or component failure. You may wish to consult our web site for additional soldering instructions and tool recommendations.**

⚠ℹ In the steps that follow, you'll be installing groups of components. When working from a long list, install all of the items on one line before moving on to the next. Arrows (⇒) appear in the list to remind you of this order. In general, assembly proceeds from left to right and front to back across the board.

☐ Install the capacitors listed below. Start with C29, which is to the left of C55, near relay K16. **Check each capacitor's labeling carefully (shown in parentheses).**

__ C29, 0.1 (104)   ⇒   __ C26, 0.1 (104)   ⇒   __ C25, 0.1 (104)
__ C24, 0.1 (104)   __ C23, 0.1 (104)   __ C22, 0.1 (104)
__ C21, 0.1 (104)   __ C20, 0.1 (104)   __ C19, 0.1 (104)
__ C60, 0.1 (104)

__ C51, .01 (103)   __ C50, .01 (103)   __ C39, .01 (103)
__ C40, 0.1 (104)   __ C38, .01 (103)   __ C46, .01 (103)
__ C37, .01 (103)   __ C48, 0.1 (104)   __ C43, 0.1 (104)

__ C9, 0.1 (104)   __ C18, 0.1 (104)   __ C17, 0.1 (104)
__ C16, 0.1 (104)   __ C15, 0.1 (104)   __ C14, 0.1 (104)
__ C13, 0.1 (104)   __ C12, 0.1 (104)   __ C11, 0.1 (104)
__ C10, 0.1 (104)   __ C52, 0.1 (104)   __ C53, 0.1 (104)

__ C45, .01 (103)   __ C54, 0.1 (104)   __ C36, .001 (102)
__ C35, .001 (102)   __ C41, 0.1 (104)   __ C58, 0.1 (104)
__ C44, .047 (473)   __ C49, .047 (473)   __ C56, .047 (473)
__ C57, 0.1 (104)   __ C47, .001 (102)   __ C59, 0.1 (104)

__ C33, .001 (102)   __ C34, .001 (102)

__ C32, 100 pF, **200V** (101)

__ C28, 0.1 (104)   __ C30, 0.1 (104)

__ C27, 0.1 (104)   Near K17, middle of board

☐ Install the high-voltage capacitors listed below.

Note: Save a few of the clipped leads from these capacitors for use as ground jumpers in later steps.

__ C1, 12 (12)   ⇒   __ C2, 22 (22)   ⇒   __ C3, 39 (39)
__ C4, 82 (82)   __ C5, 150 (151)   __ C6B, 150 (151)
__ C6A, 150 (151)   __ C7D, 150 (151)   __ C7C, 150 (151)
__ C7B, 150 (151)   __ C7A, 150 (151)

__ C8, 1200 pF (122)

☐ Install the electrolytic capacitor, C42 (10 µF), near the back-right corner of the board. The (+) lead must be installed in the hole marked with a "+". The (+) lead is usually longer than the (–) lead, and the (–) lead is identified by a black or white stripe.

☐ Install the 5 to 30 pF ceramic trimmer capacitor, C31, near the back edge of the board. Orient the flat side of the trimmer as indicated.

☐ Using a small flat-blade screwdriver, set the trimmer to its midpoint (screwdriver slot perpendicular to the flat side).

☐ Sort all of the resistors by value. The color bands on 1% resistors (which usually have a blue body) can be difficult to read, so you should use a DMM (digital multimeter) to verify their values. Tape them to a piece of paper with the values labeled.

☐ Install the resistors below. Start with R18, which is at the front edge of the board, near the microcontroller, U1 (the only 40-pin IC).

__ R18, 10k, 5% (brn-blk-org)   ⇒   __ R17, 10K, 5% (brn-blk-org)
__ R5, 120, 5% (brn-red-brn)   __ R9, 3.3k, 5% (org-org-red)
__ R8, 3.3k, 5% (org-org-red)

__ R7, __ R6, and __ R13,   8.45k, 1% (gray-yel-grn-brn)

__ R16, 10k, 5% (brn-blk-org)
__ R11, 680, 5% (blue-gray-brn), **1/2-watt**

__ R12, 10k, 5% (brn-blk-org)   __ R1, 3.3k, 5% (org-org-red)

☐   Install the 200-ohm, 1-watt resistor (red-blk-brn) at R2, on the *bottom* of the board. Make sure R2 is flat against the board before soldering.

☐   Install resistor network RP1 (3.9k). RP1 is located on the right side of the board, near relay K9. The dotted (pin 1) end of RP1 should be oriented to the left. (RP1 is symmetrical and can be reversed, but this orientation will help you visually identify the pin 1 end.)

☐   Install trimmer potentiometers R3 and R4 (100 k, "104"), in the back right corner of the board. The trimmers will sit a small distance above the PC board on the pin shoulders.

☐   Set both trimmer potentiometers to their midpoints.

⚠ⁱ   The subminiature RF choke to be installed in the step has very fragile leads. Do not pull on them. Keep soldering time to a maximum of 2 seconds.

☐   Locate the miniature 15-μH RF choke, RFC1 (brn-grn-blk), which is the same bag as the toroidal cores. Install the choke in the back-right corner of the board, near J3.

☐   Check the resistance across RFC1 using the lowest resistance scale of your DMM. This will ensure that the choke was not damaged during soldering. The reading should be under 5 ohms.

☐   Install the ceramic resonator, Z1, near the microcontroller. Z1 looks like a capacitor with three leads.

☐   Near the "KAT100 RF" label in the front-left corner, you'll find a short jumper location, identified by a ground symbol (⏚). Use a discarded high-voltage capacitor lead to make a 3/4" (19 mm) U-shaped wire for this jumper. Mount the jumper on the top side of the board, with the top of the U-shape approx. 1/4" (6 mm) above the board. Solder it from the bottom side.

☐   Install a similar jumper in the back-right corner, near relay K1.

☐   Install diodes D1 and D2 (1N5711) near connector J3 at the back edge of the board. Make sure the banded end of each diode is oriented toward the right as indicated by its component outline.

☐   Install diodes D3 and D4 (1N5817), both located along the right edge. Note that the banded ends of these diodes point in opposite directions.

⚠ⁱ   **Before handling transistors in the next two steps, touch an unpainted, grounded metal surface. Electrostatic discharge can cause transistors to become damaged or intermittent.**

☐   Using a magnifying glass if necessary, identify the three different types of TO-92 package transistors (small black body, three leads). They will look like one of the two types shown in Figure 2.
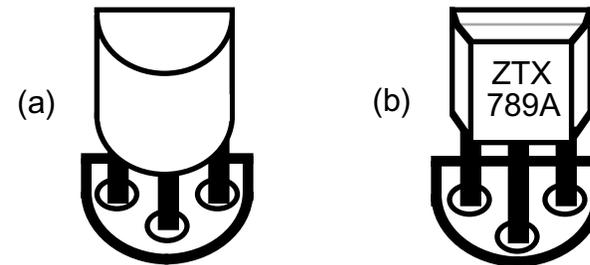
Figure 2

☐   Locate the two 2N7000 transistors. Install these at Q2 and Q3 as shown in Figure 2a. Q2 is near the center 2-D fastener on the right edge, and Q3 is near the microcontroller, U1. The flat side of each transistor should be aligned with the flat side of its component outline.

☐   Locate the ZTX789A transistor, which is labeled on its smaller flat side. Install Q1, located near D4. Orient the transistor as shown in Figure 2b.

⚠️ **i** **If you're building a KAT100-1, skip the remaining steps in this column. Connectors P3, P4, and P6 are only supplied with the KAT100-2 kit.**

☐ Install the 10-pin, dual-row (5x2) male connector at P4, but **do not solder yet**. Figure 3a shows P4 as viewed from right side of the board. The plastic part of the connector must be on the **top** side of the board, with the long end of the pins pointed up. The short ends are inserted into the board.
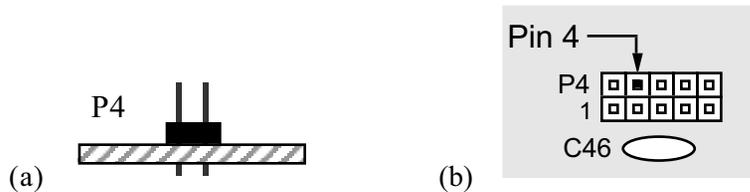

Figure 3

☐ Solder just one pin of P4. **Note:** P4's plastic body can melt if too much heat is applied. Limit soldering time to 2 to 3 seconds.

☐ Examine P4 closely. If it is not flat against the board, re-heat the soldered pin while pressing down on the plastic body of the connector.

☐ Solder the remaining pins of P4. Do not trim the leads.

☐ Cut pin 4 of P4 as indicated in Figure 3b, as close as possible to the connector's plastic body.

☐ Locate a 2-pin, high-current male connector (0.156" lead spacing) for use at P3.

☐ Install P3 at its indicated location on the right side of the board, but **do not solder yet**. Make sure the polarizing tab is oriented as indicated by its component outline.

☐ Press P3 down until it is flat against the board, then solder.

☐ Install P6 (in the back-right corner) in the same manner as P3.

☐ Install the 40-pin IC socket at U1. Orient the socket so the end with the open notch is toward the right edge of the board.

⚠️ **i** **In the following steps you'll be installing connectors at the back edge of the PC board. These connectors must be installed correctly in order for the rear panel to fit onto the board.** Figure 13 (page 20) shows how the rear-panel connectors will appear once installed.

☐ Install the DC input jack, J1, at the back edge. The 3 leads on the jack must be lined up with the slot-shaped holes in the component outline. If the holes are a tight fit, press firmly until the connector snaps into position, flat against the board. Solder all three pins.

☐ Install the AUX RF jack, J2 (BNC), in the back-right corner. Solder one of the large ground mounting pins first. If J2 then appears to be tilted or twisted, reheat this ground pin while pushing J2 down onto the board. Once it is seated properly, solder the remaining pins.

☐ Install J3, the 9-pin "D" connector, as indicated by its component outline. **Do not solder yet**.

☐ Solder one of the 9 pins (near the center). Examine J3 closely. If it is not flat against the board, re-heat the soldered pin while pressing down on the connector. Then solder the remaining pins.

☐ Solder J3's mounting tabs. Use a minimum of solder (do not fill the entire hole).

☐ Locate screw terminal E1. If it was supplied with a screw, remove it. The screw will not be used.

☐ Place E1 in its indicated position, with the threaded hole facing the rear edge of the board. **Solder just one pin.** CAUTION: This part will get hot; don't touch it with your finger while soldering.

☐ If necessary, reheat the soldered pin of E1 and adjust it so that all four pins are pressed down on the board as far as they'll go. Then solder all pins.

☐ Locate voltage regulator U8 (78M05 or 7805). Bend the leads of U8 to match its component outline (see Figure 4). Form the leads around the shaft of a small screwdriver to create smooth rather than sharp bends.
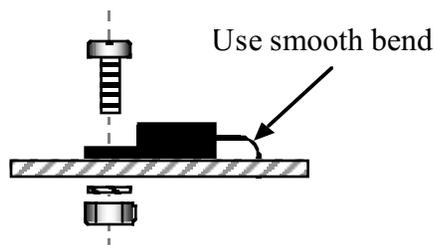
Use smooth bend

Figure 4

☐ Insert U8's leads into the proper holes. Secure U8 with a 4-40 x 5/16" (8 mm) machine screw (zinc plated, not black), #4 lock washer, and 4-40 nut.

☐ Solder all three leads. Trim the leads on the bottom side.

Note: The pin 1 end of ICs can be identified by a notch or dimple as shown in Figure 5. This end must be oriented toward the notched end of the component outline.

Notch
Pin 1

Dimple
Pin 1
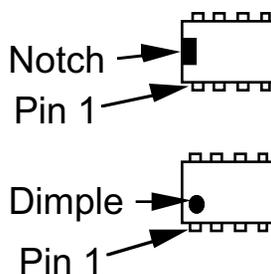
Figure 5

☐ Install U5 (LM358, 8 pins), which is located in the back-right corner. A portion of the part number is printed on the board under the IC ("358"). **Do not solder yet.**

☐ Bend two opposite corner pins on the bottom side to hold the IC in place. Solder all 8 pins (about 1 to 2 seconds per pin).

⚠️ **U2, 3, and 4 (TPIC6B595) are especially sensitive to electrostatic discharge. Touch a grounded surface before handling each of them.**

☐ Install the remaining ICs. Compare the part number on each IC to the number printed on the board, and make sure that the pin 1 end is oriented correctly.

__ U2, __ U3, and __ U4, TPIC6B595 (or similar number ending in "595")

__ U6, EL5146

Note: U7 is not used.

☐ Remove the relays from their tube. If any of the pins are bent, straighten them carefully using long-nose pliers.

☐ Place relays at locations K1-K18. The relays can only be installed one way. **Do not solder the relays yet, and do not clip or bend the relay leads.**

☐ Using a thin hardcover book to hold the relays in place, flip the PC board and book over together.

☐ Solder just two diagonally opposite corner pins on each relay.

☐ Turn the board back over. If any relay is not flat against the board, re-heat its corner pins one a time while pressing down on the relay.

☐ Once all relays are properly seated, solder the remaining pins. Do not trim relay leads, which can cause mechanical stress, reducing the life of the relay.

Inductor Winding and Installation

A number of toroidal inductors are used on the RF board.[1] The first four inductors to be wound use type T80-0 cores. *80* specifies the outside diameter in hundredths of an inch, in this case 0.80 inches (20.3 mm). The *-0* suffix refers to the core type, in this case **phenolic**. In addition, four T94-2 cores are used (0.94", 24 mm). The *-2* refers to an **iron powder** core type.

There are also two ferrite toroidal cores used, one of type FT37-43 and one of type FT50-43. In this part number, *FT* identifies the core as ferrite, and *-43* identifies the type of ferrite. The number in the middle again specifies the outside diameter. *37*, the smaller size, is 0.37" (9.5mm). *50*, the larger size, is 0.50" (12.7mm). Both ferrite cores are dark gray in color and can only be differentiated based on their size.

Three types of enamel wire are supplied with the kit: #20 red, #26 red, and #26 green. #20 wire is much larger in diameter than #26. Be sure to use only the type called for in the instructions; do not substitute other wire types. Cut wires to the specified lengths to avoid running out of wire.

☐ Sort the large toroidal cores into two groups: brown (T80-0, .80" [20 mm]) and red (T94-2, 0.94" [24 mm]).

⚠ **#20 enamel wire is quite stiff. After winding it tightly onto the core, you may find that there's a small gap between the wire and the core's flat surfaces. This will not affect performance. If you try to wind the this wire so that it "hugs" the core all the away around, you may have to pull the wire too hard, resulting in hand fatigue.**

☐ A T80-0 core (brown phenolic) will be used for L1. Cut 9 inches (23 cm) of **#20 red** enamel wire. To wind L1, "sew" the long end of the wire through the core. *Each pass **through the core** counts as one turn.* Exactly 6 turns are needed, as shown in Figure 6. The enamel insulation will be removed in a later step.

Figure 6

☐ Place L1 on top of its photo (Figure 6). Adjust the turns until the spacing is similar to that shown. If the spacing cannot be matched, it may be because you have one turn too few or too many.

☐ Trim L1's leads to about 3/4" [19 mm] long as shown.

---

[1] Pre-wound toroids are available from an Elecraft-approved source; see page 3.

⚠️ **In the next two steps, the leads of L1 will be stripped and tinned. Toroid leads must be prepared correctly to maintain reliability at the high voltages and currents seen by the tuner.**

There are three commonly-used methods to remove the enamel coating from the leads: (1) heat-stripping, (2) burning/sanding, or (3) scraping with a sharp tool. These methods are covered below.

(1) To heat-strip the enamel wire:

- Place a small amount of solder (a "blob") on the end of your soldering iron
- Insert the clipped end of the wire into the hot solder. If the iron is hot enough, you should see the insulation bubble and begin to vaporize after 4 to 6 seconds.
- Add more solder and feed more of the wire into it as the enamel melts. Continue tinning the wire up to the edge of the core. Then slowly pull the wire out of the solder.
- If any enamel remains on the lead, scrape it away using your thumbnail or a sharp tool.

(2) The insulation can be burned off by heating it with a butane lighter for a few seconds. Use sandpaper to remove the enamel residue.

(3) You can scrape the insulation off using a razor blade or other sharp tool. Avoid nicking the wire.

☐ Strip the leads of L1 as described above. Remove the enamel from the leads up to the edge of the core (see Figure 6).

☐ Tin L1's leads with fresh solder. If the solder on the leads looks dull or is not adhering very well, remove any residual enamel and re-tin the lead.

☐ Install L1 flat on the board as shown by its component outline near relays K1 and K2. **Do not solder yet**.

☐ Secure L1 to the PC board using a cable tie. Two holes are provided for this purpose, one inside the core and one outside. The cable tie should be installed such that its "head" (thick end) ends up on the *bottom* side, pressed tightly against the board (Figure 7).
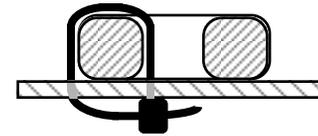
Figure 7

☐ Using a ruler, make sure that the head of the cable tie does not extend more than 0.25" (6 mm) below the bottom of the board. This would prevent proper installation of the bottom cover.

☐ Trim off excess cable tie length.

☐ Solder the leads of L1. When soldering, make sure that the solder binds well to the leads. **If the lead appears to be an "island" in a pool of solder, it is not making good contact; remove the toroid and prepare the leads as described above.** (For further information, look for "Soldering Tips" on our web site.)

⚠️ Do not apply adhesives or fixatives of any kind to toroids.

☐ Using your DMM on a low resistance scale, check for continuity between L1's pads (not the leads) on the bottom of the board. If the reading is over 1 ohm, re-strip the leads. **Note:** Your DMM probes will have some residual resistance. Short them together to measure this amount, and subtract it from your continuity readings.

☐ Toroidal inductors L2-L8 are shown in the photos at right (Figure 8). Wind each of these toroids using the indicated cores, either T80-0 (brown, phenolic) or T94-2 (red, iron powder). All are wound using **#20** enamel wire. Use the wire length and number of turns shown.

☐ Place each toroid on its photo and adjust the turns spacing so it is similar to that shown. Re-check turns counts. (Recall that each pass *through* the core counts as one turn.)

☐ Prepare the leads of these toroids as you did for L1.

⚠**i** The T94-2 cores (red) have one side which is painted a darker color than the rest of the core. To improve the appearance of the completed RF board, we suggest mounting all four of these cores with the dark side down.

☐ Install L2-L8, using cable ties as you did for L1. Match each toroid to its reference designator carefully. Exchanging any of them will make tune up erratic and may prevent the ATU from finding a match.

Note: Once in position, some of the toroids may be very close to each other, and may even be touching. This will not affect performance.

☐ Solder L2-L8.

☐ On the bottom side of the board, check for continuity between the pads of L2-L8. If you get a reading of over 1 ohm, remove the toroid from the board and prepare the leads again.

__ L2: 10 T, **T80-0**
13" (33 cm)
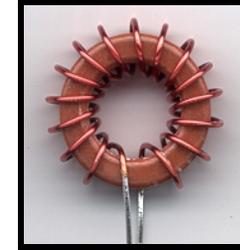
__ L3: 16 T, **T80-0**
19" (48 cm)
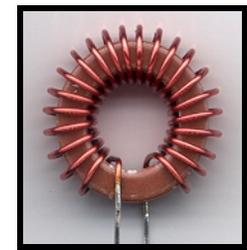
__ L4: 23 T, **T80-0**
26" (66 cm)

__ L5, 12 T, **T94-2**
18" (46 cm)

__ L6, 17 T, **T94-2**
24" (61 cm)
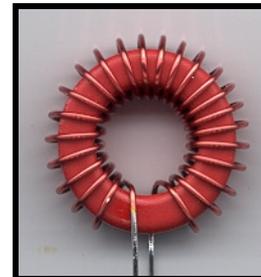
__ L7, 24 T, **T94-2**
34" (86 cm)

__ L8, 34 T, **T94-2**
46" (117 cm)

Figure 8

☐ Locate the two dark gray (ferrite) toroid cores. The smaller of the two (type **FT37-43**) has an outside diameter of 0.37" (9.5 mm). This core will be used in the following steps.

☐ RFC2 is wound on an FT37-43 core using 16 turns of **#26** red enamel wire (14", 36 cm). Wind and prepare this inductor in the same manner as L1.

☐ Install RFC2 vertically as indicated by its component outline near relay K1.

⚠ Toroidal transformer T1 uses a *bi-filar* winding, which means that two wires are wound on the core together. The wires will be twisted together loosely before they're wound onto the core.

☐ Cut two 11" (28 cm) lengths of **#26** enamel wire, **one red and one green**.

☐ Twist the red and green wires together over their entire length. The wires should cross over each other about every 1/2" (1 cm).

☐ Wind 12 turns of the twisted wires onto the large ferrite core (FT50-43). The turns should cover about 80-90% of the core, as shown in Figure 9 (a white core was used to highlight the winding).

☐ Separate T1's leads as shown in Figure 10. The numbers on the leads correspond to numbered pads on T1's PC board outline.
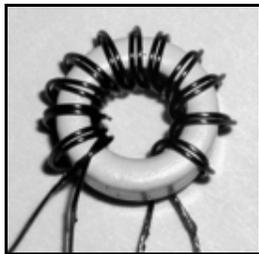
Figure 9

☐ Strip and tin the leads of T1.

☐ Using a magnifying glass, examine the red/green lead pairs to make sure that the leads are not shorting together.
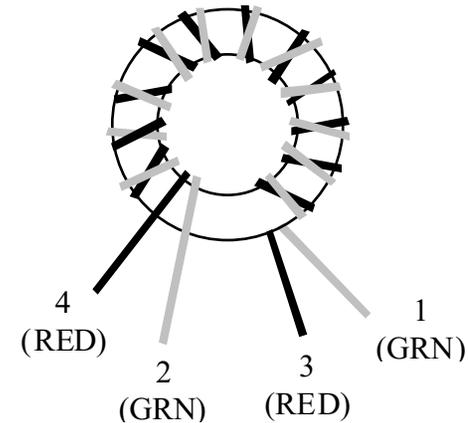

4
(RED)

1
(GRN)

2
(GRN)

3
(RED)

Figure 10

☐ Install T1 vertically on the PC board as indicated by its outline near the back edge of the board. Insert the red and green leads into their numbered holes (see lead numbering above).

☐ Verify continuity between the #1 and #4 pads of T1.

Uninstalled Components

☐ Verify that these locations on the RF board are not filled:

Top side:

__ U1 (microcontroller, 16F877), should not be installed in its socket yet.
__ U7, front edge
__ W1-W6, front edge
__ W7, back edge
__ J7, right front corner
__ P7, right side, near L2

Top side, KAT100-1 only:

__ P6, __ P3, __ P4   (all along the right edge)

Bottom side:

__ R15   __ P1   __ P2   __ P5

P5 will be installed in the next section. The other uninstalled components are reserved for future use.

Visual Inspection

⚠️ **Nearly all problems with kits are caused by poorly-soldered component leads or incorrectly-installed components. You can locate and correct most assembly errors ahead of time with a simple visual inspection.**

☐ Using a magnifying glass, examine the bottom of the PC board closely for all of the following: cold solder joints (dull rather than shiny appearance), solder bridges, and leads that are not soldered. Re-heat any suspect joints.

☐ Using the parts placement drawing at the end of the appendix, re-check the orientation of all __ Diodes, __ Transistors, __ ICs.

Resistance Checks

☐ Make the resistance measurements listed below, touching the DMM's (+) and (-) leads to the indicated points. The schematic may be helpful in troubleshooting any incorrect readings.

⚠️ The symbol **>** means *greater than*. Your DMM may indicate infinite resistance (all digits flashing) for readings in the table that include this symbol. Other readings should be +/- 10 %.

KAT100 Test Points (+, -)	Resistance
Between pins 2 and 5 of relays K1-K18 (on bottom of board, marked)	380-450 ohms
U8 (voltage regulator) "12V" pin, ground	1-30 k
U8 (voltage regulator) "5V" pin, ground	1-30 k
U2 (6B595) pin 2, ground	1-30 k
U2 (6B595) pin 3, ground	> 100 k
U2 (6B595) pin 9, ground	< 2 ohms
U2 (6B595) pin 12, ground	> 100 k
U2 (6B595) pin 13, ground	> 100 k
U2 (6B595) pin 18, ground	> 1 k
U6 (EL5146) pin 2, ground	1-30 k
U6 (EL5146) pin 3, ground	> 1 k
U6 (EL5146) pin 6, ground	> 1 k
U6 (EL5146) pin 7, ground	1-30 k
U6 (EL5146) pin 8, ground	> 100 k
U5 (LM358) pin 1, ground	> 100 k
U5 (LM358) pin 2, ground	> 100 k
U5 (LM358) pin 3, ground	45-55 k
U5 (LM358) pin 5, ground	45-55 k
U5 (LM358) pin 6, ground	> 100 k
U5 (LM358) pin 7, ground	> 100 k
D3 (1N5817) cathode[2], ground	> 100 k
D3 (1N5817) anode, ground	> 100 k
D4 (1N5817) cathode, ground	> 100 k
D4 (1N5817) anode, ground	> 100 k

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[2] The banded end is the cathode.

Front Panel Board Assembly

☐ Place the Front Panel PC board in front of you with the "KAT100 FP" label at the left.

☐ Install the following two resistors at the right edge:

__ R115, 220, 5% (red-red-brn)
__ R116, 470, 5% (yel-vio-brn)

☐ Install 120-ohm resistors in all remaining resistor locations (R101 through R114).

☐ Install the following components on the bottom side of the board:

__ Q101 and __ Q102, PN2222A (align flat side as indicated)
__ C101 and __ C102, .047 (473)

⚠ **TPIC6B595 ICs are very sensitive to static discharge. Touch a grounded, unpainted metal surface before handling them.**

☐ Place a TPIC6B595 IC at U101, but **do not solder yet**. Note the pin 1 location. The labeling on U101 should read upside-down with respect to the "KAT100 FP" label.

☐ While holding U101 firmly against the PC board, bend the four corner pins on the IC outward to hold it in place. **The front panel metal piece will not fit correctly unless U101 is seated flat on the board.**

☐ Re-check the orientation of U101, then solder.

☐ Install U102 in a similar fashion.

⚠ **Follow all LED installation instructions carefully to preserve the appearance of your KAT100's front panel.**

☐ Sort the rectangular LEDs into groups according to color.

☐ Install a **green** LED at D101, at the left end of the Front Panel board, but **do not solder yet**. **As indicated on the board, the long lead (anode) goes to the right.**

☐ Hold the LED flat against the board (not tilted). Bend the leads outward on the bottom side to hold it in place. Then trim both leads.

☐ Solder one lead of the LED, keeping soldering time to 1 to 2 sec.

☐ If the LED is tilted or is not pressed flat against the board, re-heat the lead while pressing the LED down.

☐ Once the LED is correctly positioned, solder the other lead, again keeping soldering time to 1-2 seconds.

☐ Install a **yellow** LED at D102. **Make sure the long lead is to the right.** Before soldering, adjust the LED's position as with D101.

☐ Install **green** LEDs at D103, D104, D105, and D106. Make sure the long lead is to the **right** for these and all remaining LEDs.

☐ Install **yellow** LEDs at D107, D108, and D109.

☐ Install **red** LEDs at D110, D111, and D112.

☐ Install a **green** LED at D113.

☐ Install a **yellow** LED at D114.

☐ Using a discarded component lead, make a 3/4" (19 mm) U-shaped wire for the ground jumper (⏚), near R101. Mount the jumper with the top of the U-shape no more than **1/8" (3 mm)** above the board. Solder from the bottom side.

☐ Trim all leads as short as possible on both sides of the board.

Final Assembly

☐ Straighten the leads of microcontroller IC U1 (PIC16F877) as shown below. The rows of pins must be straight and parallel to each other to establish the proper pin spacing. To straighten the pins, rest one row of pins against a hard, flat surface. Press down gently on the other row of pins and rock the IC forward to bend the pins into position as shown below.
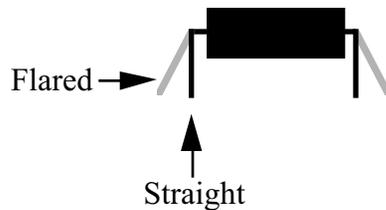

Figure 11

☐ Insert U1 into its socket, with the notched or dimpled end of the IC aligned with the notched end of its socket and outline. (The labeling on the IC should be upside down with respect to the "KAT100 RF" label at the left side of the board.)

☐ Examine U1 closely. If any pins are bent, remove the IC and straighten them. (To remove U1 from its socket, pry it up gently on each end using a small flat-blade screwdriver.)

⚠️**i** **The right side view at Figure 12 shows how the Front Panel and RF boards will be joined in the following steps.** J101 is a 12-pin female connector on the Front Panel board. P5 is a 12-pin right-angle male connector on the RF board. Also shown is one of two L-brackets that secure the assembly and keep the Front Panel board in a vertical position.

☐ Locate the two small L-brackets. Identify the *shorter* side of the "L", which will be attached to the RF board.

☐ Place an L-bracket at one of the indicated locations at the front edge the RF board. Align it with the component outline. If it's not flush with the front edge, the short and long sides may be reversed.

☐ Secure the L-bracket loosely to the RF board using a 4-40 x 3/16" [4.7 mm] screw (black) and #4 lock washer.

☐ Install the second L-bracket in the same way.
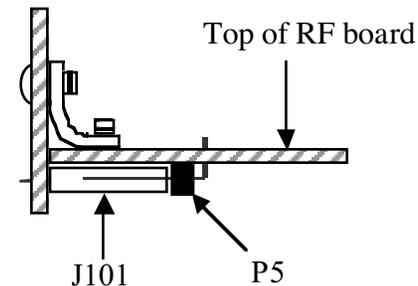
Figure 12

☐ Slide the 12-pin female connector (J101) onto the pins of the 12-pin male connector (P5). There should be no gap between them.

☐ Locate P5's outline on the *bottom* of the RF board. Insert P5's right-angle pins into their holes. **Do not solder yet**.

☐ Position the Front Panel board as shown above. The pins of J101 should be inserted into their holes, and the two L-brackets should be aligned with their outlines on the back of the Front Panel board.

☐ Secure the L-brackets loosely to the Front Panel using two 4-40 x 3/16" [4.7 mm] screws (black) and two #4 lock washers.

☐ If the Front Panel is not aligned with the RF board along its front edge, adjust the L-brackets positions.

☐ Tighten the all four L-bracket screws.

☐ Solder all pins of J101 and P5.
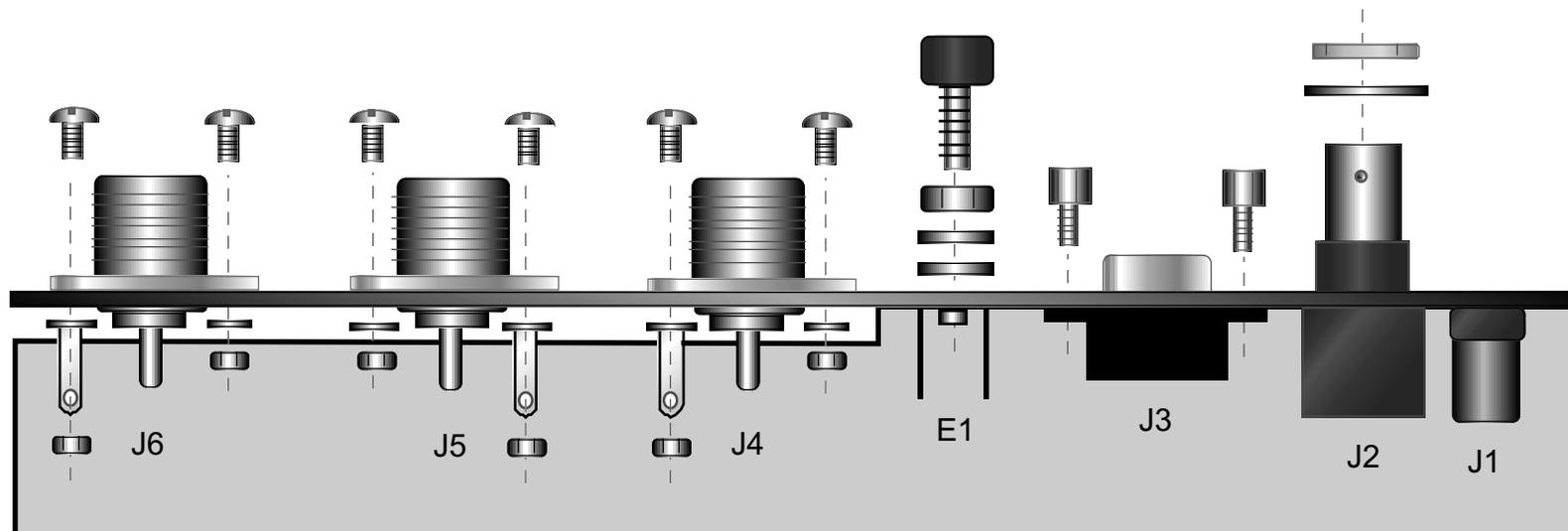
Figure 13

Unwrap the rear panel piece, and place it with the labeling facing away from you. Review Figure 13, which shows the vertical portion of the panel, along with all of the panel- and PCB-mounted connectors. Do not attach the rear panel to the RF board at this time.

Using the supplied sandpaper or a sharp tool, scrape away any residual paint from around the hole for the ground terminal, E1. **Do this on the *inside* surface of the rear panel.**

Sand or scrape residual paint from around at least one mounting hole for each of the three SO239 connectors (J4, J5, and J6). Again, this should be done on the inside surface.

Position J6 on the rear panel as shown. The connector's flange should be on the *outside* of the panel. The center pin's solder cup should be facing *up* to facilitate soldering in a later step.

Secure J6 with four 4-40 x 5/16" (8 mm) pan head screws, #4 split lock washers, and 4-40 nuts. A solder lug takes the place of one lock washer at the indicated corner, closest to the top edge of the rear panel. **Do not overtighten the hardware.**

Position J5 and J4 on the rear panel in the same way as J6, with the solder cups facing up.

Attach J5 and J4 to the rear panel using the same hardware. Note the position of the solder lug on J5, which differs from J4 and J6.

Cut six lengths of #20 stranded hookup wire (vinyl insulated):

__ three **black**, 1.25" (3.2 cm) long
__ two **red**, 1.5" (4 cm) long
__ one **red**, 2.5" (6.3 cm) long.

Remove 1/4" (6 mm) of insulation from each end of all six wires.

Twist the strands of each wire tightly. Tin the wires using a small amount of solder.

KAT100-1 Enclosure Assembly

⚠️ **The instructions on the next two pages apply only to the KAT100-1 (tuner with low-profile enclosure). If you're building a KAT100-2, turn to page 23.**

☐ Solder the three **black** wires to the lugs on J4-J6 (Figure 14).

☐ Solder the three **red** wires to the center terminals of J4-J6. The longest of the three red wires should be soldered to J4 (RF IN).

☐ Slide the rear panel assembly onto the back edge of the RF board. The connectors mounted on the RF board (E1, J3, J2, and J1) should line up with their holes. **Do not secure the rear panel or connectors yet.**

☐ Locate the three pads labeled GND at the back edge of the RF board. Pull the rear panel assembly back a short distance from the board so that these pads can be soldered from the bottom side of the board.

☐ Solder one end of each of the three **black** wires to each of the GND pads. The black wires and the approximate locations of their associated GND pads can be seen in Figure 14.

☐ Trim excess lead length from the GND wires on the bottom of the RF board.

☐ Slide the rear panel assembly full into place. The connectors mounted on the RF board should press up against the inside of the panel.

☐ Secure the rear panel to the bottom of the RF board at the 2-D fasteners using two 4-40 x 3/16 [4.7 mm] screws (black).

Note: If the holes on the bottom portion of the rear panel do not line up with the holes in the 2-D fasteners, you may not have the rear panel pressed all the way onto the RF board.

☐ Secure E1 (ground terminal) to the rear panel with the 6-32 thumbscrew, 6-32 nut, and two #6 flat washers (Figure 13). The nut must be installed between the washers and thumb screw as shown to ensure good electrical contact.

☐ Secure J3 (9-pin D connector) to the rear panel using two male-female standoffs (see Figure 13). **Do not overtighten the standoffs, as they can easily be stripped.**

☐ Secure J2 (BNC) to the rear panel using the supplied finishing nut and lock washer.

☐ Pass the longest **red** wire, which is soldered to J4's center terminal, through the center of toroidal transformer T1.

☐ Solder one end of this wire to the pad labeled RF IN.

☐ Solder one end of each of the two remaining **red** wires to the pads labeled ANT1 and ANT2.

☐ Trim excess lead length from the wires just soldered on the bottom of the RF board.

Figure 14

☐ Unwrap the front panel piece. Slide it over the LEDs on the Front Panel board, then secure it to the 2-D fasteners on the bottom of the RF board using two 4-40 x 3/16 [4.7 mm] screws (black).

☐ Unwrap the side panels, and lay them on soft cloth with the painted side down. The sides that are oversprayed (lightly painted) should be facing up.

☐ Sand or scrape away the overspray in the area of all four mounting holes on both side panels. Be careful not to nick or sand too close to the edge of the panel.

☐ Place 2-D fasteners on the inside surface of the side panels at the two locations shown in Figure 15. The panels are symmetrical, so either edge can be considered the top.

☐ Secure each 2-D fastener to the side panel using **one** 4-40 x 3/16" [4.7 mm] screw (black). **The fasteners must be oriented as shown in the detail drawing, Figure 16.**

Holes offset away from panel
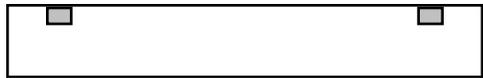
Figure 16

Figure 15

☐ Attach the side panels to 2-D fasteners already installed on the RF board. Use **one** 4-40 x 3/16" [4.7 mm] screw (black) per fastener.

☐ Secure the side panels to top surfaces of the front and rear panels. Use **one** 4-40 x 3/16" [4.7 mm] screw (black) per fastener.
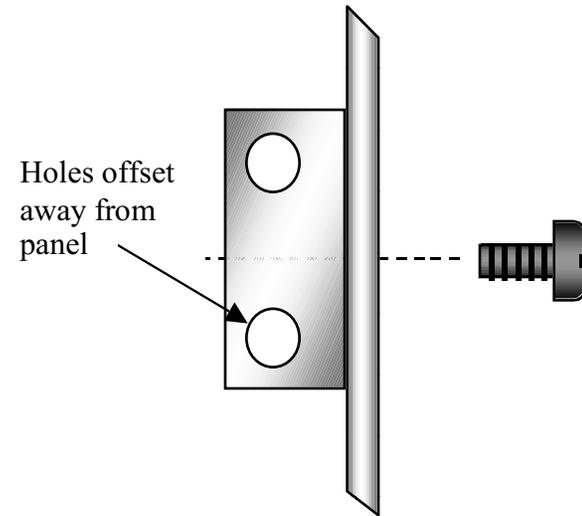
☐ Unwrap the bottom cover piece, which can be distinguished from the top cover by the presence of mounting holes for a tilt stand and rubber feet. It is painted on both sides.

☐ If you have purchased a tilt-stand kit for use with the KAT100, install the stand and front/rear feet now, following the instructions supplied. Otherwise, install the four self-adhesive, low-profile rubber feet supplied with the KAT100-1. Position them near the corners of the bottom cover.

☐ Install the bottom cover. Secure it to the RF board in four places using 4-40 x 3/16" [4.7 mm] screws (black).

⚠ⓘ Continue with **K2 Firmware Installation** on page 24.

KAT100-2 Enclosure Assembly

⚠ **The instructions on this page apply only to the KAT100-2 (EC2 version of the ATU). If you're building a KAT100-1, use the instructions starting on page 21.**

☐ Solder one end of each of the three **black** wires to the three pads labeled "GND" at the back edge of the RF board. The black wires and the approximate locations of their GND pads can be seen in Figure 14 (page 21).

☐ Solder one end of the **longer red** wire to the pad labeled RF IN.

☐ Solder one end of each of the two remaining **red** wires to the pads labeled ANT1 and ANT2.

☐ Trim excess lead length from all of the #20 wires on the bottom of the RF board.

☐ The ETS2 tilt stand option for the EC2 enclosure includes two large, round back feet for the enclosure. If you have an ETS2, install these feet on the rear panel using the supplied hardware.

☐ Slide the rear panel assembly onto the back edge of the RF board. The connectors mounted on the RF board (E1, J3, J2, and J1) should press up against the inside of the panel.

☐ Secure the rear panel to the bottom of the RF board at the 2-D fasteners using two 4-40 x 3/16 [4.7 mm] screws (black). **Note:** If the holes on the bottom portion of the rear panel do not line up with the holes in the 2-D fasteners, you may not have the rear panel pressed all the way onto the RF board.

☐ Look carefully at the locations of the screws holding the feet in place. If the screws are near any component pins on the bottom of the RF board, clip the component pins. This may require temporary loosening of the rear panel hardware.

☐ Secure J3 (9-pin D connector) to the rear panel using two male-female standoffs (see Figure 13). **Do not overtighten the standoffs, as they can easily be stripped.**

☐ Secure J2 (BNC) to the rear panel using the supplied finishing nut and lock washer.

☐ Secure E1 (ground terminal) to the rear panel with the 6-32 thumbscrew, 6-32 nut, and two #6 flat washers (Figure 13). The nut must be installed between the washers and thumb screw as shown to ensure good electrical contact.

☐ Solder the three **black** wires to the solder lugs on J4-J6 as shown in Figure 14.

☐ Pass the long **red** wire that is soldered to the "RF IN" pad through the center of toroidal transformer T1.

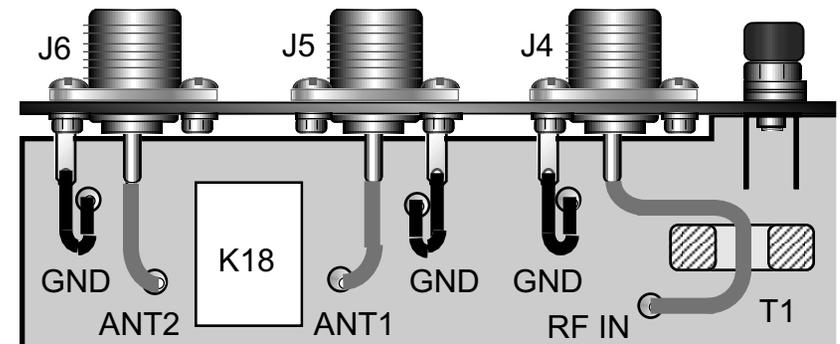☐ Solder the three **red** wires to the center terminals of J4-J6 as shown.

☐ Unwrap the front panel piece. Slide it over the LEDs on the Front Panel board, then secure it to the 2-D fasteners on the bottom of the RF board using two 4-40 x 3/16 [4.7 mm] screws (black). (These screws were supplied with the EC2 enclosure kit.)

☐ Attach the bottom cover and side panels that came with the Elecraft EC2 project enclosure. (If you also have an ETS2 tilt stand, attach that to the bottom cover first.) The EC2 kit provides the needed hardware. The EC2 top cover will be installed later.

K2 Firmware Installation

☐ **To use the KAT100, your K2 firmware must be revision 2.03d or later, and the IOC must be revision 1.07 or later.**
To determine what revision you have, turn the K2 on while holding any switch pressed. You'll see a display such as this: **2.03d 1.07**. The number on the left is the revision of the K2 main microcontroller firmware, U6 on the K2 Control board. It includes a letter suffix which may be either upper or lower case. The other number is the revision for the I/O controller (IOC), U1 on the K2 RF board. Record both of the numbers here: **K2 _____   IOC _____.**

☐ If you determine from the above that your firmware must be replaced, or if new firmware was supplied by Elecraft, complete the remaining steps on this page. Otherwise, turn to page 25.

1. If you will be replacing your IOC, record all of your primary menu settings. (If your old K2 firmware was revision 2.00 or later, also record your secondary menu settings.) Next, use **CAL FIL** to obtain and record all of your filter and BFO settings for all modes. Finally, record the settings for **CAL CUR**, **CAL S HI**, and **CAL S LO**. (**CAL tPA** is stored by the KPA100, not the K2. Do not run **CAL PLL** at this time.)

2. Turn the K2 off and remove the top cover or KPA100 module.

3. Remove the two screws that hold the control board to the front panel. Also remove the KAF2 if present. Remove the control board using the long-handled Allen wrench (supplied with the K2).

4. **Touch an unpainted, grounded metal surface.** Remove the old K2 firmware, U6 (Control board), using a small screwdriver to pry it gently out of its socket at both ends. Store it in a safe place.

5. Straighten the leads of the new microcontroller (PIC18C452).

6. Install the new microcontroller. Orient the notched or dimpled end of the IC with the notched end of its component outline.

7. Install R12 and remove C44 as described on page 26, right column.

8. Reinstall the Control board. Also reinstall the KAF2 if applicable.

9. If your I/O controller firmware is revision is 1.05 or earlier, remove U1 on the RF board and install the replacement IOC here.

10. Turn on the K2. You may see **INFO 201** (for about 11 seconds) if you have installed a new IOC.

11. If you saw **INFO 201**, you will need to re-enter all of your menu and filter parameters (saved in step 1).

12. Test your sidetone using the **ST L** menu entry. If the sidetone is missing, **EDIT** the **ST L** parameter, then tap **DISPLAY** to change the sidetone source. The default is **U8-4**, compatible with the KPA100 and KIO2.

13. If you have the K60XV option installed (60 meter adapter), set the **D19** secondary menu entry to **Y** (see K60XV manual).

☐ If you are upgrading from K2 Rev. 2.01 or earlier, you must perform the VFO calibration steps below. This procedure is done only on 40 meters. It does not have to be repeated on each band.

1. **Allow the K2 to warm up at normal operating room temperature for at least five minutes.**

2. Plug the K2 frequency counter cable into P6 on the Control board. Connect the probe end to test point TP1 on the RF board (VCO).

3. Switch to 40 meters and set the VFO to about 7100 kHz.

4. Tap **M ENU** and locate the **CAL** entry. Hold **EDIT**, then change the parameter to **PLL**. Hold **EDIT** again to begin the calibration procedure. You'll see a frequency in the 12 MHz range displayed, and the letter "**d**" will flash as the firmware records calibration data. After approximately 5-10 minutes, you'll hear a short tone, and **END** will be displayed. Tap any switch to clear this message.

⚠ If you see **INFO 232** at any time during VFO calibration, verify that you were on 40 m, with the counter cable at TP1**.**

5. You can check the VFO's accuracy using a signal at a known frequency (see page 98 of the K2 manual). **Note:** In the Revision C K2 manual, steps 8 and 11 on page 98 are incorrect for the new firmware. **CAL PLL** is now run only once, and only on 40 m.

6. Move the K2 counter cable to the BFO test point, TP2 (or remove the cable and store it).

7. Re-install the top cover or KPA100 module.

☐ If you installed new firmware, read the K2 Revision 2 Firmware manual to become familiar with any new features or changes.

KAT100 (MALE)   **KAT100 CONTROL CABLE**   **K2 OR K2/100 (MALE)**   **OPTIONAL RS232 CABLE TO PC (SEE K2/100 or KIO2 MANUAL)**   **PC (FEMALE)**
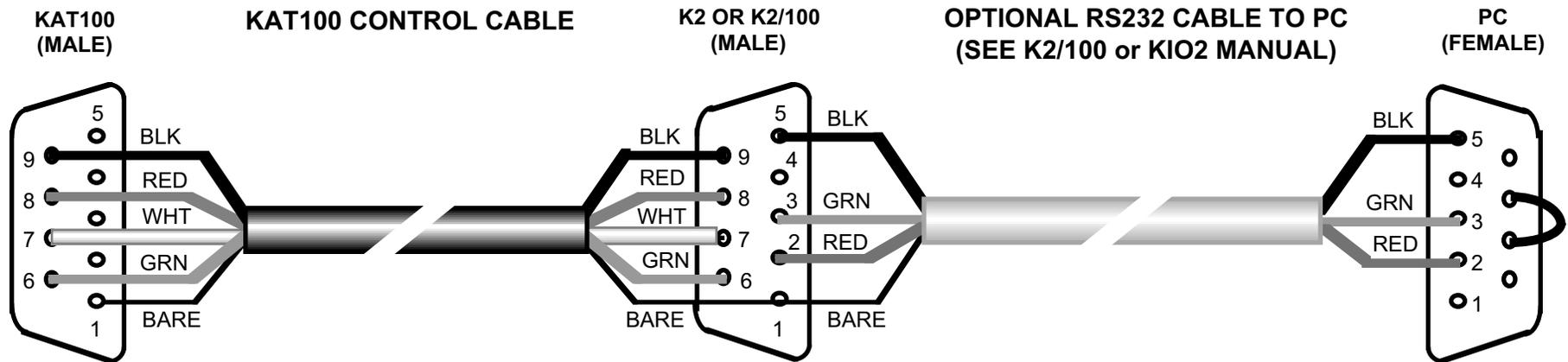
Figure 17

Control Cable Assembly

☐ Locate the 4-conductor cable. Cut a 2' (60 cm) length. **Note:** A shorter cable can be used as long as it accommodates the physical orientation of the K2 and the ATU. A longer cable can also be used, but it will have to be tested to ensure that it is not subject to RF interference. A more heavily-shielded control cable may be required.

☐ Remove 1/2" (12 mm) of the jacket from the cable at each end. Be very careful not to nick the individual wires.

☐ Peel back and cut away the foil shield.

☐ Strip off 3/16" (5 mm) of insulation from each insulated wire.

☐ Twist the strands of each wire together. Tin lightly with solder.

☐ If you previously built an RS232 control cable for use with the KPA100 or KIO2, remove the backshell from the K2 end. Orient the cable as in Figure 17, with the PC end (female) to the right.

☐ If you have not built an RS232 control cable, you should have an unused DB9M (male) connector that was supplied with the KIO2 or KPA100 kit. Locate this connector for use in the next step.

☐ You should now have two DB9M (male) connectors: one that was supplied with the KAT100, and one from the KIO2 or KPA100. (The latter may already be part of an RS232 cable.) Orient the two male connectors as shown in the left side of Figure 17. The solder cups should be facing up, and the 4-pin rows should be to the left.

☐ Clamp the left-most male connector into a padded vise, if available.

☐ Solder the BARE (shield), GREEN, WHITE, RED, and BLACK wires to the indicated connector pins at the KAT100 end of the cable. It may be helpful to melt some solder into each solder cup on the connector first.

☐ Remove the left male connector from the vise (KAT100 end), and insert the other male connector (K2 or K2/100 end).

☐ Solder the wires to this connector as shown. If there are RS232 interface wires already connected, you'll need to solder the bare wires from both the KAT100 control cable and the RS232 cable to pin 1.

☐ Remove the connector from the vise.

☐ Locate the connector housing (backshell) and associated hardware. **Note:** A single hinged backshell may be provided rather than a two-piece backshell.

☐ Attach a backshell to the male connector at the KAT100 end of the cable. Figure 18 shows how the backshell appears when assembled. Use the provided cable clamp to hold the cable in position, then secure the clamp with two screws. The jackscrews must be retained by the shells. Secure the backshell halves with the provided hardware (or, if the shell is hinged, snap the backshell closed).

JACK SCREW

CLAMP
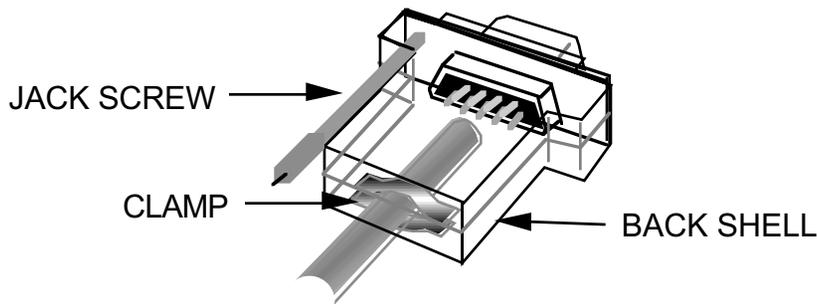
BACK SHELL

Figure 18

☐ Attach a backshell to the connector at the K2 end. If you have not built an RS232 cable, you should have an unused backshell from the KIO2 or KPA100 kit. If you did build an RS232 cable, re-install the backshell you removed earlier. The hole in the backshell should accommodate both 4-conductor cables.

Power Cable Assembly

☐ The KAT100 requires a source of 10-15 V DC. A mating plug is supplied for the KAT100's power jack, J1. You can make a separate cable for the KAT100, or build a "Y" cable to share power with the K2 or K2/100.

☐ If your power supply does not have a fuse, you may wish to add a 1-amp fuse of any type in-line with the KAT100's DC input.

K2 Control Board, R12

If your K2 is s/n 2999 or lower, you'll need to install a resistor in series with the VRFDET line on the K2 Control board as described below. This will protect the K2's microcontroller from accidental damage if you have a short in the KAT100 control cable. (K2s s/n 3000-up already have this resistor, designated R12.)

☐ Remove the two screws that hold the K2 control board to the front panel. Also remove the KAF2 if present. Remove the control board using the long-handled Allen wrench (supplied with the K2).

☐ Locate the trace on the top side of the K2 Control board that runs between resistors R8 and R9 (see drawing below). Cut the trace.

☐ On the bottom of the board, solder an 820-ohm resistor (gray-red-brown) between the two vias. You'll need to pre-trim the resistor's leads since it isn't possible to cut the lead that falls between R8 and R9.

R8 R9

Cut

R12 (on back)
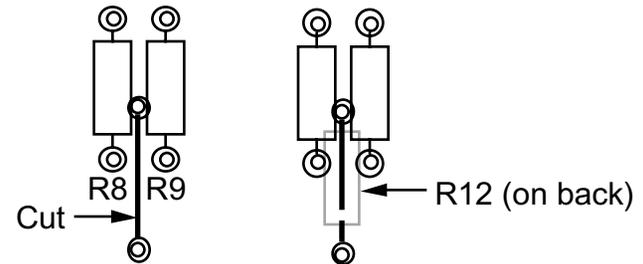
K2 Control Board, C44

☐ Remove the Control board, if necessary (see above).

☐ C44 (0.1 µF) on the K2 Control board, if present, must be removed (it causes inaccuracy in current measurement). On the revision B Control board, C44 is located near microcontroller U1. On earlier Control boards, C44 is not on the board, but in lieu of this you may have soldered a capacitor directly across R7. Remove it in either case.

Alignment and Test

Initial Tests

⚠️ **Do not transmit during these tests.**

☐ Turn the K2 and all power supplies **OFF**.

☐ Reinstall the K2 Control board and KAF2 if not installed.

☐ Connect the KAT100 to a source of 10-15 V DC (J1).

☐ Connect the control cable between the KAT100 **CONTROL** jack (J3) and the **AUX I/O** jack on the K2 or K2/100.

⚠️ **In the following steps, if you see or smell smoke, turn off the K2 and all power supplies and refer to Troubleshooting.**

☐ If the KAT100 is powered from a separate supply, turn it on first. **The LEDs on the KAT100 should remain <u>off</u> and you should not hear any relays switching yet.**

☐ Turn on the K2's power supply, then turn on the K2. This should cause the KAT100 to turn on as well. Only two KAT100 LEDs should turn on: **ANT1** or **ANT2**, and **LOW** or **HIGH** power. You may also hear one or more relays switch.

☐ Tap the ANT1/2 switch a few times. Each tap should activate the KAT100 antenna relay, K18. The **ANT1** and **ANT2** LEDs, as well as the ANT2 annunciator on the K2, should agree.

☐ Switch to a different band, and select the other antenna. Changing back and forth between these two bands should now recall the selected antennas. Turn power off and back on and verify that the appropriate antenna is still selected for each band.

☐ If you have a KPA100 installed, rotate the POWER pot through its full range. The **LOW** power LED on the KAT100 should turn on at 10 W and below. The **HIGH** power LED should turn on above 10 W.

Menu and Relay Test

☐ Tap MENU, then use BAND+ / BAND- or the VFO knob to locate the **ATU** menu entry. Hold EDIT to modify the parameter. If the **ATU** parameter appears as two dashes (**--**), refer to **Troubleshooting**.

☐ Using the VFO knob, scroll through the **ATU** menu parameters. You may hear relays turning on and off as you select various entries. You should see **CAL**, **AUTO**, etc. Each menu entry will be explained in the **Using the KAT100** section.

☐ Set the **ATU** parameter to **L0**. You should hear a relay switch when you move from **L0** to **L1**, then to **L2**, etc., up through **L8**. The same should be true for **C0** through **C8**, as well as **N1** and **N2**. These menu selections can be used to identify failing relays or other components. This is covered in the troubleshooting section.

☐ Set the **ATU** parameter to **CAL**. Tap MENU once to return to menu scroll mode, and a second time to exit the menu.

☐ Turn the K2 off and back on. Use the menu to verify that the **ATU** parameter is still set to **CAL**, then exit the menu.

Preparing the KAT100 for Alignment

⚠️ **If you're planning to install any accessories of your own in the top cover of the full-height KAT100-2, do not connect them until after the KAT100 is aligned.** Do not connect anything to P3, P4, and P6 on the KAT100 RF board at this time.

☐ Turn the K2 off.

☐ Disconnect the KAT100's DC power cable. **It must be left *disconnected* during all alignment steps.**

☐ Disconnect the control cable between the KAT100 and the transceiver. **This cable must be left disconnected during all alignment steps.**

⚠️ℹ️ During the first two parts of ATU alignment, the transmitted signal will be fed through the ATU <u>backwards</u> from the normal direction. That is, the transceiver will be connected to the KAT100's ANT1 jack, and the dummy load will be connected to the KAT100's RF IN jack. This provides a more accurate SWR bridge null, and will also allow direct calibration of the REFL potentiometer (R4).

☐ Connect the KAT100's **ANT1** jack (J5) to the appropriate antenna jack on the K2 or K2/100. There are three possibilities:

- K2/100: use the SO239 jack on the back of the KPA100 module

- Basic (10-watt) K2 *without* a KAT2 (20-W ATU) installed: use the K2's normal BNC antenna jack on the lower rear panel

- Basic (10-watt) K2 *with* a KAT2 installed: use the KAT2's ANT1 jack on the upper rear panel

☐ Connect a 50-ohm dummy load to the KAT100's **RF IN** jack (J4) using a short coax cable. The dummy load should have a rating of at least 5 watts. If you have a K2/100, we recommend that you do all alignment at higher power (20 watts) to improve calibration accuracy. In this case you'll need a higher-wattage dummy load.

☐ Turn on the K2, and switch to the 40-meter band.

☐ If you have a KPA100 installed and a dummy load rated at 20 watts or higher, set the POWER control for 20 watts. Otherwise, set the POWER control for 5 or 10 watts. Use 10 watts if your dummy load can handle this level, at least for short transmissions.

☐ Set the KAT100's FWD and REFL power potentiometers (R3 and R4) to about the middle of their range.

SWR Bridge Null Adjustment

☐ Make sure the KAT100 is set up exactly as described on page 27 (**Preparing the KAT100 for Alignment**). The signal must be routed *backwards* through the ATU, and the KAT100 DC and power cables must be *disconnected*.

☐ Locate a non-metallic tuning tool suitable for adjusting the SWR bridge trimmer capacitor, C31.

☐ You can use a DMM or an analog volt meter to null the SWR bridge. Set the meter for 2 or 3 volts DC full-scale. Connect the (-) lead to the ground jumper near the front of the KAT100 RF board. Use an alligator clip so you won't have to hold the lead in place.

☐ Touch the voltmeter's (+) lead to **pin 3** of U5 (see Figure 19). **Note:** There will be a DC voltage on this pin during transmit, even though the KAT100 is not connected to a power supply.

Pin 5 ⟶ ⟵ Pin 3

Figure 19

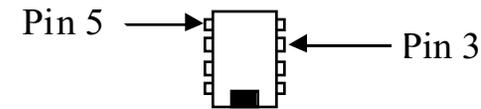☐ Enter tune mode by holding **TUNE**. Adjust C31 for a ***minimum*** reading on the voltmeter (0 volts, or close to it). Hold **TUNE** again when finished.

⚠️ℹ️ **You may see an indication near 0 volts over a small range of C31's rotation. It is very important to position C31 in the <u>middle</u> of this range. Repeat the null adjustment step until you're sure that C31 is positioned correctly.**

Power Calibration (R3 and R4)

☐ Make sure the KAT100 is set up exactly as described on page 27 (**Preparing the KAT100 for Alignment**). The signal must be routed *backwards* through the ATU, and the KAT100 control and power cables must be *disconnected*.

Power Calibration Voltage Table: During power calibration, a DC voltage will be present at pin 3 or 5 of U5 (LM358) even though the KAT100 is not connected to a power supply. The table below shows target voltages at U5 corresponding to 5, 10, and 20 watts output. One of these power levels will be used in the steps below.

Power Level	Voltage at U5
5 W	1.3 V
10 W	1.8 V
20 W	2.7 V

☐ Select one of the power levels indicated in the table above. If you have a K2/100, 20 watts is recommened. Otherwise, use 10 watts (if you have a 10 watt dummy load) or 5 watts. You will only need to do calibration at one power level.

☐ Use a DMM for power calibration (20 or 30 V DC full-scale). The (-) lead should be connected to a the KAT100's ground jumper.

☐ Touch the DMM's (+) lead to **pin 5** of U5 (see Figure 19).

☐ Enter tune mode by holding **TUNE**. Adjust **R4 (REFL)** until the DMM reads close to the target voltage from the table. Hold **TUNE** again when finished.

Note: In high-power mode, the power shown on the LCD should stabilize near the desired level (20 watts) after a few seconds. On a basic K2, power may drift upwards. Repeat the adjustment if needed.

☐ Disconnect the cables at the KAT100's RF IN and ANT1 jacks and reverse them.

☐ Touch the voltmeter's (+) lead to **pin 3** of U5 (Figure 19).

☐ Enter tune mode, overriding the power limit if applicable. Adjust **R3 (FWD)** until the target voltage is reached. Hold **TUNE** to exit.

☐ With power and control cables still disconnected from the KAT100, measure the resistance from **pin 5** of U5 to ground. Record the value here: _____ k.

☐ Multiply this amount by 1.2 (example: if the reading is 50 k, multiplying by 1.2 yields 60 k). Your calculated value: _____ k.

☐ Adjust **R4 (REFL)** until the resistance measured at **pin 5** equals your calculated value. (This step improves the accuracy of reflected power and SWR measurements.)

Top Cover Installation

☐ Turn off the K2 and KAT100.

☐ Unwrap the KAT100 top cover. Set it upside down on a soft cloth to protect the finish. **Note:** The top cover is fabricated from steel, not aluminum, to minimize interaction between the ATU and the K2 when the two are stacked. Since it is steel, the top cover is painted on both sides to protect against rust. Either side can be used as the top surface.

☐ Sand or scrape away the paint around all four mounting holes on one side of the top cover.

☐ Install the top cover using four 4-40 x 3/16" (4.7 mm) black screws.
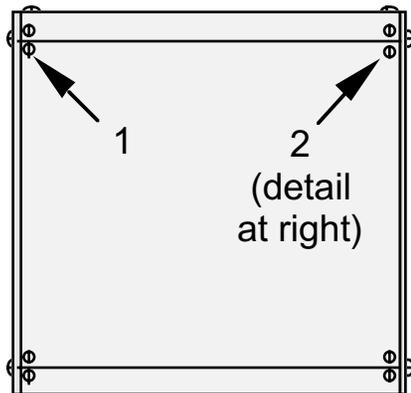
Anti-Slide Brackets (KAT100-1 only)

The KAT100-1 is designed to be placed beneath the K2. If the two are then tilted, using the optional ETS15 tilt stand or a slanted operating surface, the K2 tends to slide off during operation. To keep the K2 in place, you can install the two supplied anti-slide brackets. The K2's rear feet slip over the short standoffs on the brackets.

☐ Identify rear-corner locations *1* and *2* on your top cover (Figure 20a).

☐ Install an anti-slide bracket at location *2* using the two screws already present at this location (see detail, Figure 20b).

☐ Install the second anti-slide bracket at location *1*. It should be rotated 180 degrees in relation to the bracket at location *2*.

(a)
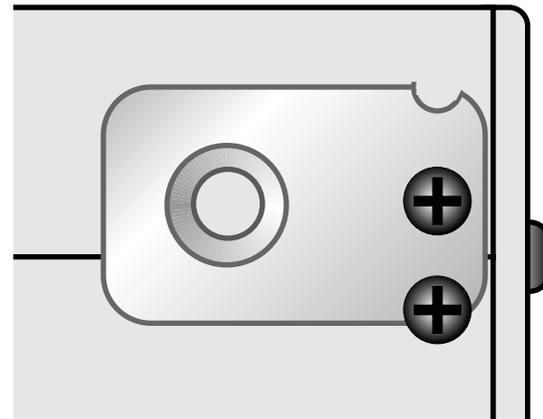
(b)

Figure 20

Using the KAT100

CAUTION: Never touch an exposed antenna wire when transmitting. If you ever receive an RF burn, stray RF may be the cause (see Antenna Considerations, page 33).

Rear Panel Connectors

12VDC (J1)

The KAT100 must be connected to a 10-15 V DC source**. The KAT100's power supply must be turned on <u>first</u> if it is separate from the transceiver's power supply.** Typical current drain is 200-300 mA, but it can be as high as 700 mA in the unlikely event that all relays and all LEDs are turned on simultaneously[3].

AUX RF (J2)

This connector is not used by the KAT100 itself. It could be used for RF signal routing to an accessory module built into the ATU.

J2 is connected internally to 2-pin male connector P6 via series capacitor C49. P6 is supplied only with the KAT100-2. A mating female connector may be purchased from Elecraft if required (#E620013 housing, plus two #E620014 crimp pins).

CONTROL (J3)

The KAT100 requires control signals from the transceiver's **AUX I/O** port to operate. The AUX I/O port is included with the K2/100. In the case of the K2, the **KIO2** option is required.

Assembly instructions for the KAT100 control cable can be found on page 25.

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[3] All relays and LEDs on. This is very unlikely to occur; in normal use, the maximum will be closer to 400-500 mA. If you're concerned about current drain, you can use the K2's **GRPH** menu entry to select **DOT** mode for the LED bargraphs on both the K2 and the KAT100, or install KAT100 jumper W1 to force DOT mode for just the KAT100 regardless of the **GRPH** menu setting.

GND (E1)

A good ground should be connected to the KAT100. This is especially important with high power (K2/100). See **Antenna Considerations**.

RF IN (J4)

J4 must be connected to the appropriate antenna jack on the K2 or K2/100 via a short 50-ohm coaxial cable. There are three possibilities:

- K2/100: use the SO239 jack on the back of the KPA100 module
- Basic (10-watt) K2 *without* a KAT2 (20-W ATU) installed: use the K2's normal BNC antenna jack on the lower rear panel
- Basic (10-watt) K2 *with* a KAT2 installed: use the KAT2's ANT1 jack on the upper rear panel

Note: If both a KAT100 and KAT2 are in the system, the KAT2 will be switched to **CALP** mode, and its ANT1 jack selected. The `ANT1/2` switch and **ATU** menu entry will control only the KAT100.

ANT1 (J5) and ANT2 (J6)

Unbalanced antenna jacks (a balun is required with balanced feed lines). The K2's `ANT1/2` switch selects the antenna.

Front Panel LEDs

ANTENNA (1 and 2): These indicate which antenna is selected. If ANT 2 is selected, the K2's ANT2 LCD annunciator will be turned on.

SWR (1-5): SWR indication, 1:1 to 5:1 (or higher), during transmit.

POWER (LOW and HIGH): If the KPA100 is enabled and set for over 10 W, the **HIGH** LED will turn on. Otherwise, **LOW** will be on.

Jumpers (W1-W7)

Installing W1 forces **DOT** mode for the SWR LEDs, regardless of the K2's **GRPH** setting. W2 forces **BAR** mode. W3-W7 are not used.

Normal ATU Operation (AUTO Mode)

For normal operation, set the **ATU** menu entry to **AUTO**.

Hold **TUNE** to start auto-tune. Power will be decreased to 2 W (basic K2) or 20 W (K2/100) if set above these levels. Power and SWR will be displayed on the LCD during tune-up (e.g. **20 1.5-1**). The SWR portion of the display may flash occasionally if you're using high power. SWR will also be shown on the KAT100's SWR LEDs.

The ATU itself will terminate **TUNE** after 1-5 seconds.

The ATU's L and C settings are stored in EEPROM, then recalled instantly when you change bands or antennas. If you move significantly off frequency, you may need to retune in order to keep SWR low (especially at high power). The SWR LEDs on the KAT100 are activated during transmit to alert you to SWR changes.

Important ATU Operating Tips

- **If the KAT100 uses a separate power supply from the transceiver, the KAT100 supply must be turned on <u>first.</u>**
- Erratic behavior of either the KAT100 or K2 may be observed during auto-tune if excessive RF gets into the cables or circuitry. If this happens at high power, reduce power to 10 watts or less for auto-tune purposes. See **Troubleshooting** for other suggestions.
- Holding **TUNE** + **DISPLAY** overrides the tune-mode power limit (2 watts for a basic K2, 20 watts for the K2/100), and temporarily suspends **AUTO** mode. This is useful when you want to check power output with the present L and C settings.
- A very low SWR is not necessary for good antenna performance, but it *will* allow operation of the K2/100 at maximum power output (see **Antenna Considerations**).
- If you tap **DISPLAY** to show the voltage/current display, then hold **TUNE**, you'll see the K2's transmit-mode voltage and current drain, not power output and SWR. The tune-mode power limit will be overridden, and the ATU's L and C settings will not change.
- The ATU menu entry can display current values of L and C, network type, and other data. See **ATU Menu Settings** at right.
- Sometimes a slightly lower SWR can be found by repeating **TUNE**.

Bypassing the Matching Network (CAL mode)

You can bypass the matching network by setting the **ATU** menu entry to **CAL**. This sets the L and C values in the matching network to zero. However, there will still be considerable stray reactance present within the ATU. This stray reactance may de-tune any antenna or dummy load connected to the ATU's antenna jacks.

As an alternative to **CAL**, you can tune up the ATU into a 50-ohm dummy load on each band using **AUTO** mode. This will cancel out the tuner's stray reactance. After tuning up on all bands, put the ATU into SWR (**x.x-1**) mode, which will preserve the L and C settings.

ATU Menu Settings

The table below lists all settings for the **ATU** menu entry. **AUTO** mode is used most of the time. In this mode the ATU terminates **TUNE** automatically. The other modes are primarily used for calibration and test. When you switch between **CAL** and **AUTO** mode, you may hear a few relays switching, since in **CAL** mode, L and C are set to 0. You'll also hear relays switch if you select the **L0-L8**, **C0-C8**, or **N1-N2** modes (see **Troubleshooting**).

Mode	Description	Mode	Description
CAL	Bypass (L/C = 0)	**Exxx**	0-199 = error code; see Troubleshooting
AUTO	Auto-tune mode	**INIT**	Resets all L/C to 0 on next power-up
x.x-1	Auto-tune SWR (present band/ant.)	**Fx.xx**	KAT100 firmware revision, e.g. F1.03
Lxx.x	Inductance, µH (present band/ant.)	**L0-L8**	Individual inductor selection
Cx.xx	Capacitance, nF (present band/ant.)	**C0-C8**	Individual capacitor selection
NETx	1=Cin, 2=Cout (present band/ant.)	**N1**	Selects Cin network; L/C set to 0
Txxx	Combinations tried (last auto-tune)	**N2**	Selects Cout network; L/C set to 0

Antenna Considerations

An antenna tuner will not *improve* your antenna–it can only tune out the antenna's reactance. Use the longest, highest antenna you can put up, keep the antenna away from other objects, and use a good ground system.

Stray RF

At high power, you may experience RF feedback problems when using electrically short antennas, end-fed antennas, very short feedlines, or any combination of these. Improved RF isolation or grounding may be required, as discussed below.

Ground System

A ground system will provide efficient radiation, better antenna loading characteristics, less RF on the chassis, and safer operation. A buried ground rod and a large array of radials is best, but connections to plumbing and house electrical ground wiring will often suffice.

SWR Requirements

A low SWR (less than 1.5:1) won't necessarily contribute to a better radiated signal. For example, if the SWR is 2:1, the loss in transmitted signal strength will only be around 0.5 dB relative to 1:1. However, a low SWR *can* be important at higher power levels. The K2/100, like other full-power transceivers, will automatically limit maximum power output to protect the final transistors if reflected power is too high.

Of course the KAT100 always *tries* to hit 1.0:1, and with most antennas it will find an SWR below 1.5:1 on most bands. On antennas or bands where this is not possible, you may want to reduce the POWER setting manually.

Resonant and Multi-Band Antennas

The KAT100 will tune up nearly any antenna cut for 40 or 80 meters on all bands. With multi-band antennas such as beams or verticals, the KAT100 will typically improve the match on each band used. It will also allow operation on additional bands.

Random-Length Antennas

A wire antenna, end-fed or fed with balanced line, is an excellent choice for use with an ATU. Nearly any piece of wire over about 30 feet long and end-fed can be tuned up on 80-10 meters (preferably working against a good ground or at least two radials). A longer wire or additional inductance in series will be needed to cover 160 meters.

For portable operation (Field Day, etc.) a good strategy is to put up *two* wire antennas. You can then do quick comparison tests as often as necessary using $\boxed{\text{ANT 1/2}}$. With two long-wires oriented in different directions, differences of from one to three S-units may be observed on some signals.

Using Baluns and RF Isolation Chokes

A balun is a device that converts a balanced antenna or feedline to unbalanced (one side grounded) to work with your ATU. A balun can also perform an impedance transformation, and may help isolate the antenna from the tuner to reduce RF pickup. You may need a balun if: (1) you're using balanced feedline; (2) you're having trouble matching an antenna on one or more bands; (3) you notice RF feedback or get an RF burn. A low-loss, broad-band, 4:1 balun is a good choice, and may solve all three problems. A 9:1 balun is often used with 450 or 600-Ω open-wire line, but since the tuner can handle a wide range of impedances, 4:1 may work just as well. A 1:1 balun will also work in most cases. All baluns exhibit some loss, but the loss may be negligible if the balun is used properly.

RF isolation or "choke" baluns can be very effective at reducing RF feedback. These baluns use a large number of ferrite beads or cores slipped onto coax, and can be used between the transceiver and the ATU, or between the ATU and antenna (if the antenna is coax-fed). Commercially-built units (usually in the form of large tubes) can be obtained from many different suppliers.

Troubleshooting

IMPORTANT: If you take any corrective action for a KAT100 problem, be sure to turn off all power supplies, then turn on the KAT100's power supply <u>first</u> (if it is separate from the K2's power supply). Otherwise, the K2 may not be able to establish communication with the ATU. If it is not convenient to turn the KAT100's power supply off, disconnect its power input (J1) for a few seconds.

General Troubleshooting

If your specific symptoms are not covered below, do a complete visual inspection of the KAT100 circuit boards. Look for reversed diodes, leads not soldered (or not clipped), backwards ICs, and broken wires or components. Make the resistance measurements from earlier sections, and test all diodes in-circuit. Check continuity between the *pads* of all toroids (not the leads themselves).

Control or Menu Problems

KAT100 not recognized by the K2 (ANT1/2 switch not working, or ATU menu parameter missing): This could be due to a power supply problem; some switching power supplies show a "bounce" downward in voltage a few hundred milliseconds after being turned on or when loaded by attached equipment. This could prevent the K2 from sending its initial auxBus message to the KAT100. If the power supply is OK, make sure the KAT100 microcontroller, U1, is fully seated in its socket and is not installed backwards. Look for bent pins (you may need to remove U1 from the socket to find them). Make sure the control cable is wired correctly. Also check Z1 (ceramic resonator) and R5 (auxBus series resistor). Check both the RF and Front Panel boards for shorts to ground, solder bridges, and unsoldered connections.

INFO messages: If you see **INFO 080** or a similar message on the LCD, refer to the K2 Owner's Manual, Appendix E.

Missing sidetone: You may have the wrong sidetone source selected. Select the **ST L** menu entry and **EDIT** its parameter, then tap **DISPLAY**.

Transmit or TUNE problems

Erratic tuning in AUTO mode: This is much more likely to occur at high power, and could be due to high RF voltages on the K2 chassis, mic, key, power supply leads, or KAT100 control cable. First, try reducing power to 10 watts or less. This will force auto-tune to be done at 2 watts. <u>If this cures the problem</u>, you may need to add RF bypassing to your power supply, key, or mic; improve your ground system; move the antenna farther away; or use a "choke balun" between the ATU and the transceiver. <u>If this doesn't cure the problem</u>, you may have a defective L-network inductor, capacitor, relay, or relay driver IC (U2-U4). You can use the KAT100 menu to troubleshoot the problem to the component level (see **Testing Relays, Inductors, and Capacitors**, below).

Even though SWR reads 1:1, K2/100 power is limited: The SWR displayed on the K2's LCD and the KAT100 SWR LEDs originates from the KAT100's SWR bridge. The KPA100 module has its own SWR bridge, which could be seeing a higher SWR reading than the KAT100. In this case the KPA100 may request power reduction. If power seems to be getting limited to an artificially low level, re-check the KPA100's SWR bridge alignment. You could also have any of the RF feedback problems listed under **Erratic tuning in AUTO mode**.

Erratic power control with K2/100: During key-down, the K2/100 power output should follow the setting of the POWER control, with only minor adjustments every second or so to correct for upward drift of the power level. If the power level indicated on the K2's LCD or bargraph seems to "jump" continuously and never settle down, it is probably due to RF getting into the KAT100 control cable. This is usually just an aesthetic issue, and will not cause trouble. However, you can try soldering a .01 µF capacitor from pin 7 to ground (inside the backshell).

HI CUR message: This LCD message indicates that the K2's 10-watt stage is drawing too much current. You should have **CAL CUR** set for at least **3.50** amps. You may have a general problem with the K2 transmitter or the KPA100 (see Appendix E of the K2 manual).

HI REFL message: This LCD message will be flashed if the KPA100 (100-watt final stage) has detected high SWR. When this happens, the K2 reduces power output until reflected power is back to a safe level. **HI REFL** warning may occur as low as an SWR of 1.5:1 at 100 watts, and at higher SWRs for lower power levels. The warnings are disabled during auto-tune mode because power is reduced to 20 watts.

"Distorted audio" signal report in SSB mode: You could have any of the RF problems discussed earlier, or your microphone may be sensitive to RF. Some mics have a DTMF generator IC that can be activated by stray RF. Try disabling this IC. You may be able to simply disconnect the DC supply voltage to the mic at the Front Panel mic configuration connector. Also try grounding the mic jack.

Can't null the SWR bridge: Examine all components and connections in the SWR bridge, especially T1's windings (which may be reversed or not making contact).

SWR inaccuracy: This is probably due to incorrect nulling of the KAT100's SWR bridge. C31 must be adjusted so that it is in the middle of the parts of its range where the voltmeter reads 0 volts.

Inability to achieve low SWR: Write down the **ATU** menu parameters after the TUNE attempt, including SWR, L, C, NET, Exxx, Txxx, and the ATU firmware revision. Send this data to Elecraft for analysis. Also try **ATU INIT**, which will reset all the ATU L and C settings to 0 on the next power up. You could have a single defective relay or component on the L-C board. (See **Testing Relays, Inductors, and Capacitors**, below.)

ATU error message (E001-E199): Please report this to Elecraft. Normally the ATU's **Exxx** parameter will be from **E200-E255**, indicating what type of match the KAT100 firmware achieved.

Testing Relays, Inductors, and Capacitors

The KAT100 menu parameters provide a way to do component-level troubleshooting of the L network. Start by slowly scrolling through ATU parameters L0 through L8, C0 through C8, N1, and N2. At each setting you should hear relays switching. If you find one that doesn't, this may pinpoint a bad relay. If the relays are all working but you suspect an inductor or capacitor, you can test each L and C by noting their effect on SWR, one at a time. Start on 10 meters. Connect a 50-ohm dummy load to one of the antenna jacks, select L0, hold TUNE, and note the SWR reading. Then select L1 and hold TUNE again; the SWR should change by a small amount. L2 should have a larger effect, etc. When the inductance selections cause the SWR to go off the scale (9.9), switch to a lower band (say 30 meters), go back to L0, then test the remaining inductors. Similarly, you can test all 8 capacitors, starting on 10 meters with C0, C1, etc. You'll know you have found the bad component if it has too large or small an effect (or no effect) on SWR, in relation to the others tested.

Specifications

All measurements were made using a 13.8 V, 1-amp power supply. Numeric values are typical; your results will be somewhat different. Specifications are subject to change without notice.

L - C Ranges	L: approx. 0-20 µH in 256 steps; C: approx. 0-2400 pF in 256 steps
Network Type	L-network (series L, shunt C); C switchable to transceiver or antenna side
Antenna outputs	2, Unbalanced
SWR Range Matched	Up to 10:1 typ. (varies with band; smaller range on lowest bands)
Tuning time	1 to 5 seconds typical for initial tune-up; < 1/2 sec. to recall stored settings
SWR Display	1.0:1 to 9.9:1 (on K2 LCD); 1:1 to 5:1 on 10 front-panel LEDs
Enclosure Size	1.3" (H) x 7.8" (W) x 8.3" (D) (3.3 x 19.8 x 21.0 cm)
Weight	Approx. 3 pounds (1.4 kg)
Supply voltage	10 to 15 VDC
Current Drain	200-300 mA typical; 700 mA max[4]

---

[4] All relays and LEDs on. This is very unlikely to occur; in normal use, the maximum will be closer to 400-500 mA.

Circuit Details

Refer to the schematic, Appendix A.

RF Board

The ATU uses eight series inductors and eight parallel capacitors, configured as an L-network. Both the inductors and capacitors have very high voltage and current ratings to prevent malfunction in the presence of high SWR and high power. For this reason, the KAT100 can easily handle 150 watts, even with SWRs in excess of 10:1.

The capacitance can be placed at the transmitter or antenna end of the network by relay K17. Each inductor and capacitor has its own relay, and a final relay (K18) controls the antenna switch. The relays can handle about 10 amps. The inductor relays short their respective inductors when not needed. Based on lab tests, this technique does not degrade Q or cause unwanted magnetic coupling.

The relays are selected under control of the ATU's microcontroller. Open-drain shift-registers U2-U4 actually drive the relays. Data is sent to U2-U4 by the microcontroller via a serial interface. L, C, and network in/out values are stored in the microcontroller's on-chip EEPROM. An external EEPROM (U7) is provided for possible future expansion.

T1 and associated circuitry form a Bruene-style bridge used for SWR and power measurement. The output from the bridge is buffered by op-amp U5. The /FSCL and /RSCL lines are pulled low by two open-drain outputs on U3 when high power is used (K2/100, 11 watts or greater). This scales the bridge outputs by a factor of 3.16 (square root of 10) to keep SWR and power measurements in the appropriate range. The scaling is turned off at lower power levels to improve SWR-measurement accuracy.

If the KAT100 needs to provide a closed-loop power control signal back to the K2 via the VRFDET line, an additional high-current buffer, U6, is turned on (VRFEN = 5V). This is only required if there is no KPA100 connected (i.e., if a basic K2 is connected to the KAT100 via a KIO2 module).

The KAT100 can be powered from either J1 (external) or P3 (internal), providing flexibility for builders who wish to add accessory modules into the top cover (this applies to the KAT100-2 only).

Q1 and Q2 provide automatic turn-on capability for the KAT100, eliminating the need for an on-off switch. Whenever a K2 is connected to the KAT100 and is turned on, the 12CTRL line from either J3 (external) or P4 (internal--KAT100-2 only) turns on Q2, which in turn pulls Q1's base low. Q1 has a very low C-E saturation voltage, so it can easily provide the needed operating current for the KAT100 even though it is a TO-92 plastic device.

U8 provides regulated 5 volts to the logic circuits and front-panel LEDs.

The microcontroller sleeps during receive mode, with its oscillator disabled. This completely eliminates any RFI. The microcontroller will wake up on transmit (8R line going low) or when an auxBus message is received.

Jumpers W1-W7 and connectors P1, P7, and J7 are provided for future firmware/hardware expansion.

Front Panel Board

LED drivers U101-U102 are shift register/driver ICs of the same type used to control the relays. Individual resistors are used to establish the current for the LEDs, which would allow the builder to adjust individual LED intensity if desired. However, this should not be necessary since the LEDs are generally well-matched.

Q101 and Q102 provide one of two fixed voltages to LED array. If the /NIGHT line is pulled low, the voltage drops to reduce brightness for nighttime use. The transistors are wired in parallel to increase current-handling capability.

L IN

L1 .08µH	L2 .16µH	L3 .32µH	L4 .64 µH	L5 1.3 µH	L6 2.6 µH	L7 5.2 µH	L8 10.4 µH

K1 K2 K3 K4 K5 K6 K7 K8

L OUT

C

C1 12	C2 22	C3 39	C4 82	C5 150	C6A 150	C6B 150	C7A 150	C7B 150	C7C 150	C7D 150	C8 1200

K9 K10 K11 K12 K13 K14 K15 K16

K1 K2 K3 K4 K5 K6 K7 K8

K18 (Sheet 2) C30 0.1 C27 0.1 K17 (Sheet 2)

* R15

12VRY

K9 K10 K11 K12 K13 K14 K15 K16

C29 0.1

C9 0.1

C13
C12
C11
C10
0.1

C14
C15
C16
C17
0.1

C28 0.1

C18 0.1

C22
C21
C20
C19
0.1

C23
C24
C25
C26
0.1

C54 0.1

(Sheet 2)
/RSCL /FSCL

/EOT
(Sheet 2)

C59 0.1

U4 6B595

U3 6B595

RFC2 47 uH

12V

C52 0.1

C53 0.1

U2 6B595

SRTEST

5V

C48 0.1

RYCK RYLOAD

C55 0.1

RYDATA

* = Components not supplied; for future use.

= On bottom of PC board.

Note: All relays are shown in the N.C. position.

Elecraft	KAT100 RF Board		
By W. Burdick E. Swartz	Rev. B	Date 1/4/03	Sht. 1 of 2

Appendix A

SWR Bridge / KAT100 RF Board Schematic

J4 RF IN
GND
RFIN
T1 FT50-43
C31 30pF
SWR Bridge
C32 100
R1 3.3K
R2
200 1W
D1 1N5711
D2 1N5711
C33 .001
C34 .001
R3 R4 100K
FWD
REFL
C35 .001
C36 .001

* P 1
* P 7
L IN (Sheet 1)
K17
L OUT (Sheet 1)
C (Sheet 1)

JUMPERS: W1-W2: Both open = Auto. LED control; W1 = DOT; W2 = BAR
W3-W7: Leave open except as required (see manual).

Ant. Switch
K18
J5 Antenna 1
ANT1
GND
J6 Antenna 2
ANT2
GND

W6 W5 W4 W3   W2 W1
R17 10K
R18 10K
5V

/8R
AUXBUS
C37 .01
R5 120

U5B
TP4
R7 8.45K 1%
VREFL
5V
C40 0.1
C51 .01
VRFEN

12V
R6 8.45K 1%
VFWD
RP1 3.9K
C50 .01
U6 EL5146C
EN
VRFDET
C39 .01
C38 .01
R9 3.3K
R8 3.3K

U5A LM358
RP1 3.9K
/FSCL
/RSCL

U1 16F877 MCU
RB7 RB6 RB5 RB4 RB3 RB2 RB1 RB0 VDD VSS RD7 RD6 RD5 RD4 RC7 RC6 RC5 RC4 RD3 RD2
MCLR RA0 RA1 RA2 RA3 RA4 RA5 RE0 RE1 RE2 VDD VSS OSC1 OSC2 RC0 RC1 RC2 RC3 RD0 RD1
40 /SW /CD 5V FPLOAD FPCK FPDATA 25 21 * *
5V
35 30
15 20
VPS VFWD VREFL AD1 CT AD2 VRFEN SRTEST RYLOAD RYCK RYDATA IDAT ICLK
VSW

Z1 4.0MHz

* U7 25LC320
/CS VCC
SDO /HOLD
/WP SCK
VSS SDI

** Test output -- n/c

E1 Ground Post
J2 Aux RF In
C49 .047
P 6 Aux RF Out
J3 (BACK VIEW)
1 2 3 4 5
6 7 8 9

J3 Control

C60 0.1
P 5 Front Panel
ICLK IDAT /SW FPLOAD FPCK FPDATA
1 2 3 4 5 6 7 8 9 10 11 12

* P 2
J1 12V DC
C44 .047
D4 1N5817
Q1 ZTX789A
12V
R13 8.45K 1%
VPS
RP1 3.9K
C42 10 µF
IN OUT
U8 7805
5V
C43 0.1

Aux. 12V
+ -
P 3
D3
C41 0.1
R12 10K
R11 680 1/2 watt
D G S
Q2 2N7000
/ON
12CTRL

* J7
AD1 CT AD2 /CD
1 2 3 4 5 6

/8R
D
Q3 2N7000
G S
RP1 3.9K
C46 .01

P 4 Aux Control
AUXBUS
VRFDET
RFC1 15µH
C47 .001
W7
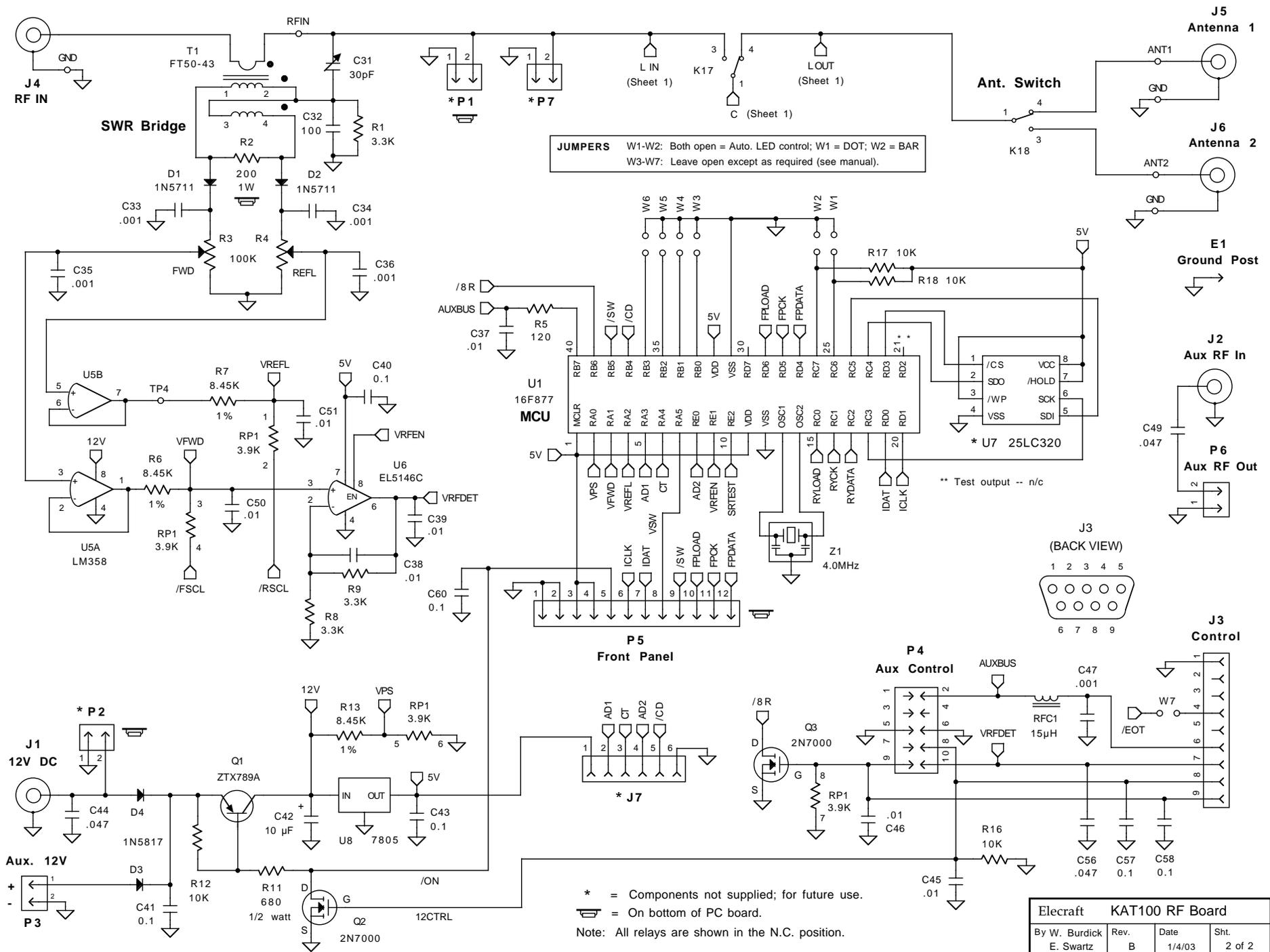/EOT
R16 10K
C45 .01
C56 .047
C57 0.1
C58 0.1

* = Components not supplied; for future use.
☐ = On bottom of PC board.
Note: All relays are shown in the N.C. position.

Elecraft KAT100 RF Board
By W. Burdick
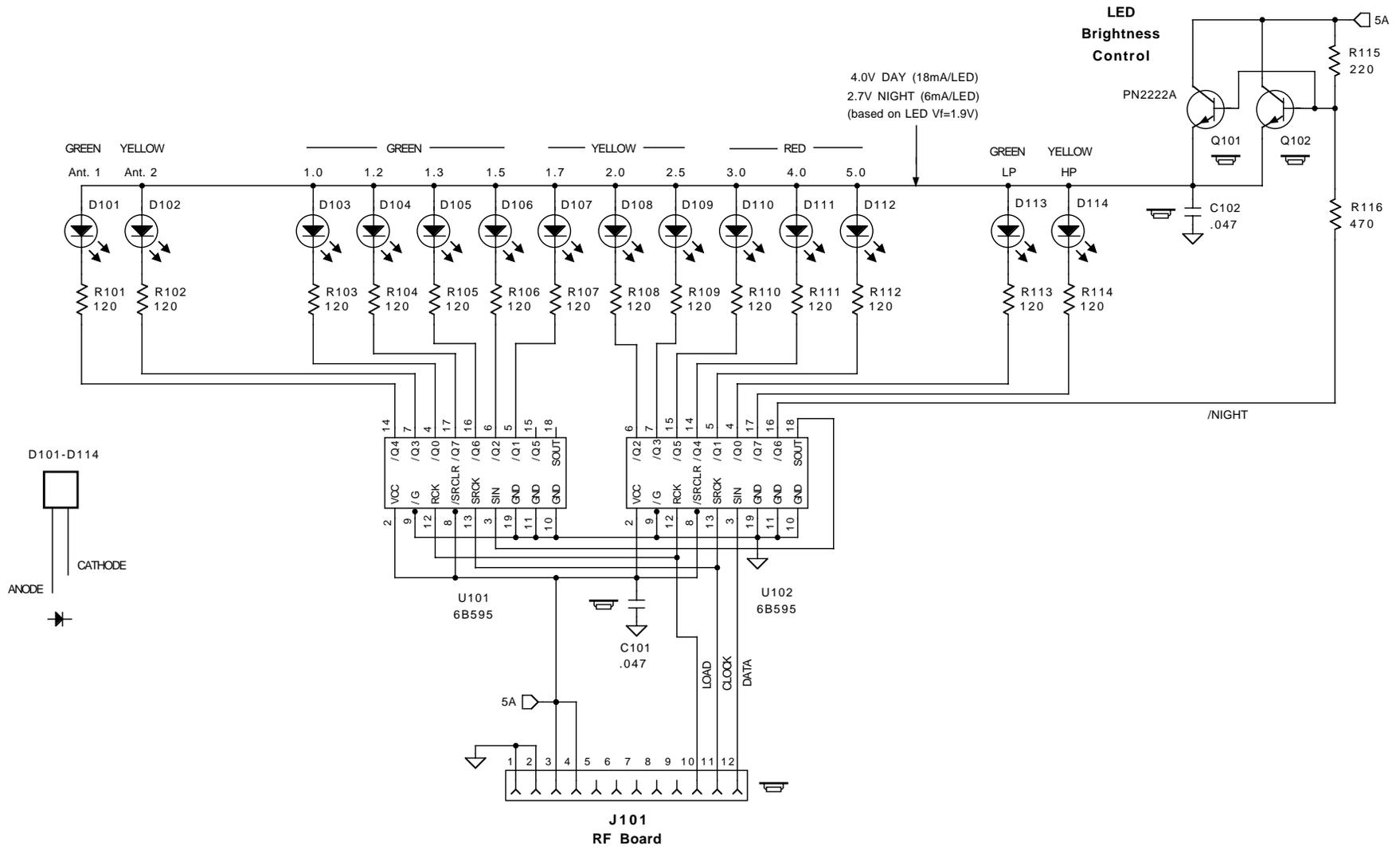E. Swartz
Rev. B
Date 1/4/03
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Appendix A

LED Brightness Control

4.0V DAY (18mA/LED)
2.7V NIGHT (6mA/LED)
(based on LED Vf=1.9V)

D101-D114

CATHODE
ANODE

= On bottom of PC board.

Elecraft KAT100 Front Panel Board			
By W. Burdick E. Swartz	Rev. B	Date 1/4/03	Sht. 1 of 1

Appendix A

KAT100 RF
Rev. B
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KAT100 FP
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