

ELECRAFT KSB2 SSB ADAPTER

Assembly and Operating Instructions

Revision G, July 2, 2011. Copyright © 2011, Elecraft; All Rights Reserved

Introduction

The KSB2 option provides the Elecraft K2 with single-sideband transceive capability. With the KSB2 installed, the operator can use digital communications modes such as RTTY, packet, SSTV and PSK31 in addition to SSB voice.

The KSB2 includes a 7-pole crystal filter optimized for SSB transmit and receive. This filter is always used for SSB transmit. During receive, either the fixed SSB filter or the variable-bandwidth CW crystal filter can be specified for each of the remaining SSB filter settings (FL2-FL4). The SSB filter can also be used for receive in CW mode if desired. The BFO is individually programmable for each filter, allowing considerable flexibility in optimizing settings for SSB, CW, or digital modes. Transmit and receive BFO settings can be adjusted independently in SSB modes if desired.

Other features of the KSB2 include a programmable speech compressor and basic VOX (voice-operated transmit) capability. In addition, the K2 provides a Carrier Balance mode in which the SSB transmit signal is routed directly to the receiver. This mode facilitates carrier balance adjustment, and can also be used with headphones to listen to mic audio whenever the mic gain or compression level is changed.

A wide variety of 8-pin microphones can be used with the KSB2. A mic configuration jumper block is provided on the Front Panel PC board (see **Microphone Configuration** for details).

This manual supercedes relevant sections of the K2 Owner's Manual.

Specifications

Crystal Filter	Bandwidth approx. 2.3 kHz @ -6 dB; 6/60 dB shape factor approx. 2:1
Carrier Rejection	-40 dB or better (typ)
Speech Compressor	Compression ratios: 1:1, 2:1, 3:1, 4:1
Current Drain	10-15 mA
Size	4.1 x 2.2 inches (10.4 x 5.6 cm)



Caution: Some components in this kit can be damaged by static discharge. Before handling any transistors or integrated circuits, always put on an anti-static wrist strap or touch any grounded, unpainted metal surface.

Parts Inventory

The table below lists all parts in the kit. The K2 Owner's manual has photographs of similar parts.

Ref.	Description	Qty.
Components on KSB2 Module		
CB,CN	Capacitor, not used (leave open)	0
CC,CM	Capacitor, 27 pF ("27" or "270")	2
CG,CH,CE,CK, CA,CP	Capacitor, 39 pF ("39" or "390")	6
CF,CJ	Capacitor, 100 pF ("101")	2
CD,CL	Use short wire jumpers in place of these capacitors (see text)	0
C25	Capacitor, 22 pF ("22" or "220")	1
C30, C36	Capacitor, 820 pF ("821")	2
C37	Capacitor, .001 μ F ("102")	1
C1-3,C5-12,C16, C17,C19,C21,C22, C24,C26,C33,C35, C39-44	Capacitor, .01 μ F ("103"), with 0.1" (2.5 mm) lead spacing. Note 1: Quantity shown includes one spare. Note 2: There are also five (5) .01 μ F capacitors with 0.2" (5 mm) lead spacing, listed with Front Panel board components (page 3).	27
C15,C18,C27, C32,C46	Capacitor, 0.1 μ F ("104"), with 0.2" (5 mm) lead spacing	5
C4, C13	Capacitor, 0.1 μ F ("104"), with 0.1" (2.5 mm) lead spacing	2
C20,C23	Capacitor, 0.33 μ F electrolytic ("0.33" or "334")	2
C31,C34,C50,C51	Capacitor, 2.2 μ F electrolytic ("2.2" or "225")	4
C14	Capacitor, 22 μ F electrolytic ("22" or "226")	1
C38	Capacitor, 47 μ F electrolytic ("47" or "476")	1
D1,D2,D6-14	Diode, 1N4007 (black body)	11
D3,D4,D5	Diode, 1N4148 (glass body)	3
L1	RF choke, 22 μ H (red-red-black)	1
P1	Conn., 12-pin male, 0.1" pin spcg	1
P2,P3	Conn., 3-pin male, 0.1" pin spcg	2
Q1,Q2,Q3	Transistor, NPN plastic, PN2222A	3
R8,R10	Resistor, 100 ohms, 5%, 1/4-watt (brown-black-brown)	2
R11	Resistor, 150 ohms, 5%, 1/4-watt (brown-green-brown)	1
R15	Resistor, 180 ohms, 5%, 1/4-watt (brown-gray-brown)	1
R5,R12	Resistor, 470 ohms, 5%, 1/4-watt (yellow-violet-brown)	2
R14	Resistor, 1K, 5%, 1/4-watt (brown-black-red)	1
R6	Resistor, 2.7K, 5%, 1/4-watt (red-violet-red)	1
R2	Resistor, 5.6K, 5%, 1/4-watt (green-blue-red)	1
R9,R16,R23,R24	Resistor, 10K, 5%, 1/4-watt (brown-black-orange)	4
R20	Resistor, 18K, 5%, 1/4-watt (brown-gray-orange)	1
R7	Resistor, 33K, 5%, 1/4-watt (orange-orange-orange)	1
R4	Resistor, 56K, 5%, 1/4-watt (green-blue-orange)	1

Components on KSB2 Module, continued		
R21	Resistor, 68K, 5%, 1/4-watt (blue-gray-orange)	1
R22	Resistor, 560K, 5%, 1/4-watt (green-blue-yellow)	1
R1	Potentiometer, 1 M trimmer ("105")	1
RP3	Resistor network, 2.0 K, 3 R, 6 pins (77063202 or 980663202)	1
RP1,RP2	Resistor network, 2.7 K, 4 R, 8 pins (77083272)	2
RP5	Resistor network, 47K, 5 R, 6 pins (61473)	1
RFC1,RFC2	Toroidal inductor, 19 turns on FT 23 -43 core (0.23")	2
T1	Toroidal transformer on FT 37 -43 core (0.375"), 7:22 turns	1
T2	Toroidal transformer on FT 37 -43 core (0.375"), 4:22 turns	1
U1	IC, Microcontroller, 16F872 or 16F872A	1
U2	IC, Digital-to-analog converter, 8 bits, MAX522	1
U3	IC, Audio amp/speech compressor, SSM2166 (SMD, pre-installed)	1
U4	IC, Dual comparator, LM393	1
U5	IC, Balanced Mixer/Modulator, NE602 (alt: SA602, NE612, etc.)	1
U6	IC, voltage regulator (6 volts), 78L06	1
X1-X7	Crystal, 4.9136 MHz (matched for crystal filter). Note: Save the envelope, which is labeled with a calibration value.	7
Z1	4.0 MHz ceramic resonator w/internal capacitors	1
Components on Front Panel Board		
P1	Conn., dual-row 16p male, 0.1" spcg	1
C4-C8	Capacitor, .01 μ F, 0.2" (5 mm) lead spacing	5
Q3	Transistor, PNP, 2N3906	1
RP3	Resistor network, 10 K, 4 R, 8 pins (77083103)	1
Rbias	Resistor, 10 K, 5%, 1/4 W (optional mic bias; see text)	1
R13	Resistor, 68.1K, 1%, 1/4 W	1
Components on RF Board		
J11	Conn., 12-pin female, 0.1" pin spcg	1
J9, J10	Conn., 3-pin female, 0.1" pin spcg	2
Hardware and Miscellaneous		
HDWR	Socket for U1 on KSB2 module, 28 pins	1
HDWR	#4 split lock washer (quantity shown includes 2 spares)	6
HDWR	4-40 x 1/4" ZN ST phillips machine screw	2
HDWR	Standoff, 3/16" dia. x 3/8" long, round, 4-40 threaded	1
MISC	Wire, #26 enamel, GREEN	2 ft.
MISC	Wire, #28 enamel, RED	5 ft.
MISC	Wire, #24 insulated, solid conductor	2 ft.
MISC	KSB2 PC Board	1

Firmware Upgrades

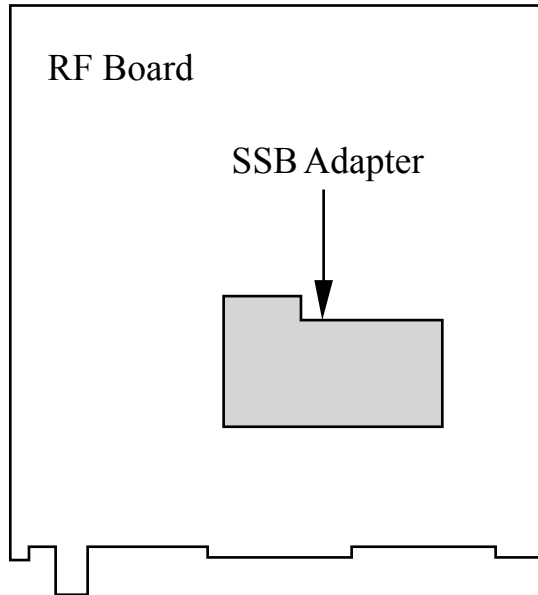
If you received new main-processor firmware (U6 on the K2 control board) along with your SSB adapter, you should install and test it before proceeding with assembly. The SSB adapter requires main processor firmware revision **1.04A** or later. (Hold any button on power-up to check your revision number.) See separate instructions that were supplied with the firmware upgrade.

BFO Crystals

If you have a field-test K2 (s/n 1-100), you should have received two replacement BFO crystals. These are required to allow proper SSB operation. Install the new BFO crystals and any associated components before proceeding with KSB2 assembly. See separate instruction sheet.

Assembly Overview

The KSB2 module plugs into the K2 RF board at approximately the location shown below.



As indicated in the parts list, most of the parts in the kit will be installed on the KSB2 PC board. A small group of parts will be installed on the K2's RF board, and a few on the Front Panel board. The last step in the assembly process is to wire the microphone connector for your particular mic (P1, Front Panel).

KSB2 PC Board Assembly



A fine-point, temperature-controlled soldering iron (700-800 deg. F, 340-370 deg. C) is required to assemble this kit, due to the high density of the PC board layout. A high-wattage iron or one with a wide tip may damage components, pads, or traces. Use a minimum amount of solder to avoid ground shorts.



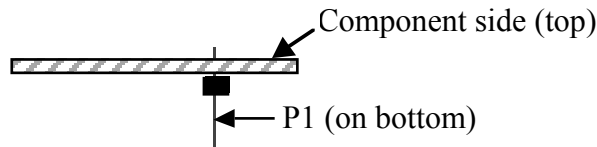
To avoid difficulties in soldering adjacent components, install components only in the order described below. Double-check all values before soldering, since removing small parts from double-sided PC boards can be difficult.



Using the parts list (page 3), identify all of the components that are to be installed on the K2's Front Panel and RF boards and separate them from the remaining items. **Note:** The .01 μF capacitors with small lead spacing (0.1", 2.5 mm) are only used on the KSB2 module, while the .01 μF capacitors with the wider lead spacing (0.2", 5 mm) will be installed on the Front Panel board.



Install 12-pin male connector P1 on the bottom of the PC board in the position indicated by its component outline. Do not solder yet. The drawing below shows how P1 should appear viewed from the left end of the board, with the component side up.



Solder just one pin of P1 on the top of the board, near the middle of the connector (pin 6 or 7). Verify that P1 is now perpendicular to the PC board and is seated completely flat. If not, re-heat the soldered pin and press down on all of P1's pins until the connector drops into place. Once the connector is seated correctly, solder the remaining pins. This connector must not be tilted or installed at the wrong height.



All component leads should be kept short to avoid stray signal coupling. The leads on small capacitors *do not* need to be straightened, but keep their mounted height at about 1/8" (3 mm) or less.



Install C30 and C36 (820 pF, "821"), near P1 on the top side of the board. Be careful not to confuse C30 or C36 with C18, which is farther from P1 and has wider lead spacing.



Install C25 (22 pF, "22" or "220"), which is near the right end of P1 (viewed from the top side).

Install all of the lettered capacitors shown below (CC, CM, etc.). After inserting each capacitor, bend its leads slightly to hold it in place. Limit soldering time to 2 or 3 seconds per lead, using a minimum amount of solder to avoid ground shorts.

- __CC and __CM (27 pF, "27" or "270")
- __CG and __CH (39 pF, "39" or "390")
- __CE and __CK (39 pF, "39" or "390")
- __CA and __CP (39 pF, "39" or "390")
- __CF and __CJ (100 pF, "101")

Install short wire jumpers at CD and CL. Use discarded component leads to form the jumpers. Do not leave any excess lead length above the board.

Capacitors CB and CN are not used and should be left open.

Install the 0.1 μ F capacitors ("104") with **0.1" (2.5 mm)** lead spacing.

- __C4 (near X1) __C13 (near X7)

Install the 0.1 μ F capacitors ("104") with **0.2" (5 mm)** lead spacing.

- __C15 __C18 __C27 __C32 __C46

Install the .01 μ F capacitors ("103") with **0.1" (2.5 mm)** lead spacing (C1-C3, etc.). Use the Parts Placement Drawing to verify the reference designators on capacitors in the crystal filter area that are not labeled.

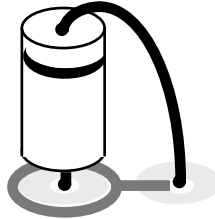
- __C1 __C2 __C3 __C5 __C6
- __C7 __C8 __C9 __C10 __C11
- __C12 __C16 __C17 __C19 __C21
- __C22 __C24 __C26 __C33 __C35
- __C39 __C40 __C41 __C42 __C43
- __C44

Note: You'll have one .01 μ F capacitor of this type left, which has been included as a spare.

Install C37 (.001 μ F, "102"), which is near the microcontroller, U1.



All diodes will be installed vertically as shown below. The anode lead will be inserted into the pad enclosed by a circle. The cathode lead (banded end) must be folded down and inserted into the adjacent pad, which is connected to the first pad by a white line. When installing diodes, check the Parts Placement Drawing as needed to make sure that you're inserting the leads into the correct pads.



- Install D3 and D4 (1N4148), both of which are near U5.
- Install D5 (1N4148), on the left side of the board near C34.
- Install D1 (1N4007), which is located near the middle of the board. As indicated by the short white line, the cathode lead (banded end) goes into the pad to the left of the D1 label. (There are two other pads nearby D1, so be careful to use the correct one.) Push the diode down so no excess lead length is exposed.
- Install D2 (1N4007), to the left of D1. The cathode lead goes into the pad closest to the D2 label.
- Install D6 through D14 (1N4007). Be sure to insert the leads into the correct holes as indicated on the PC board and the Parts Placement Diagram.

__D6	__D7	__D8	__D9	__D10
__D11	__D12	__D13	__D14	

- Install resistor networks RP1, RP2, RP3 and RP5. Pin 1 of each network is identified by a dot. This pin must be inserted into the round pad (the other pads are square). Clip the leads of all resistor networks after soldering to reduce stray signal coupling. **Note: RP3 and RP5 both have six pins, but different values. Check the labels carefully.**

__RP1 (2.7K 8 pins)	__RP2 (2.7K, 8 pins)
__RP3 (2.0K, 6 pins)	__RP5 (47K, 6 pins)

- Transistors Q1-Q3 are all type PN2222A (plastic, TO-92 package). Install these transistors with their flat sides oriented as indicated by their component outlines. Note that Q2 and Q3 will end up with their flat sides facing each other when correctly installed.

__Q1	__Q2	__Q3
------	------	------

- U3 is a surface-mount IC that should already be installed on the top side of the board (SSM-2166). Examine U3 with a magnifying glass to verify that all leads are soldered.
- Install U6, the 78L06 voltage regulator IC. This device has a plastic package like a transistor. The flat side must face the U6 label as indicated by the component outline.
- Install the 28-pin socket for U1. The notched end goes towards the left edge of the board.
- Install the 8-pin DIP ICs, U2 through U5. A portion of the part number of each IC is printed on the board. Compare this number with the number printed on each IC before installation. In all cases, pin 1 of the IC (the notched or dimpled end) goes into the round pad (the remaining pads are square).

__U2 (MAX522)

__U4 (LM393)

__U5 (NE602)

- Clip the leads of U5 after soldering to reduce stray coupling. Other IC leads need not be clipped.
- Install all of the electrolytic capacitors as indicated by their board outlines. The negative lead is identified on the case. The positive lead must be inserted into the pad marked "+". The electrolytic capacitors may all be identical in appearance, so check the values carefully before installation.

__C20 (0.33 μ F)

__C23 (0.33 μ F)

__C14 (22 μ F)

__C31 (2.2 μ F)

__C34 (2.2 μ F)

__C38 (47 μ F)

__C50 (2.2 μ F)

__C51 (2.2 μ F)

- Install L1, a solenoidal RF choke, to the right of P1.
- The carrier-balance control, R1, is located near the front edge of the board. Press R1 down as far as it will go, and make sure it is parallel to the board before soldering. Set R1 to its mid-point after soldering.
- Install ceramic resonator Z1 near the microcontroller (U1).
- Install R5 (470 ohms, yellow-violet-brown), which is located on the far right edge of the board.
- Install the remaining resistors on the bottom side of the board. To avoid lead trimming problems, pre-form and trim each resistor's leads before installation. The leads should be just long enough to be visible on the component side (top). Solder the resistors on the bottom side only. **Note:** R16's leads will be obscured by the socket for U1. Trim the leads of R16 so that it sits flat on the bottom of the board.

__R8, __R10 (100 ohms, brown-black-brown)

__R11 (150 ohms, brown-green-brown)

__R15 (180 ohms, brown-gray-brown)

__R12 (470 ohms, yellow-violet-brown)

__R14 (1K, brown-black-red)

__R6 (2.7K, red-violet-red)

__R2 (5.6K, green-blue-red)

__R16, __R9 (10K, brown-black-orange; see note on lead trimming above)

__R7 (33K, orange-orange-orange)

- R4 (56K, green-blue-orange)
- R20 (18K, brown-gray-orange)
- R21 (68K, blue-gray-orange)
- R22 (560K, green-blue-yellow)
- R23, R24 (10K, brown-black-orange)

Re-check the values of capacitors CG and CH (39 pF). Once the crystals are installed (following steps) it is difficult to gain access to these two capacitors.

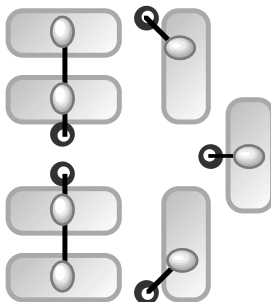
Locate the envelope containing the matched SSB filter crystals (X1-X7). On the outside of the envelope you'll find a calibration number that ranges between **3.2** and **3.9**. Record the number: _____.
Note: If the envelope is unmarked, use **3.6**.

Using the number recorded in the previous step, look up the corresponding **LSB** and **USB** transmit BFO frequencies in the table below. Record these frequencies in **Table 3** (page 20) in the two spaces provided in the **BF1t** column.

Xtal Cal #	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
LSB	4913.1	4913.2	4913.3	4913.4	4913.5	4913.6	4913.7	4913.8
USB	4915.9	4916.0	4916.1	4916.2	4916.3	4916.4	4916.5	4916.6

Install all 7 crystals, making sure that they are flush with the top of the PC board and are not tilted. There should be no excess lead length.

The cases of the crystals should be grounded to the adjacent ground pads using jumpers formed from discarded component leads. The drawing below shows the ground pads and jumpers as viewed from above the board. Solder the jumpers to the board first, then fold them over the crystal cans. Be careful not to overheat the crystal cans when soldering the jumpers in place.

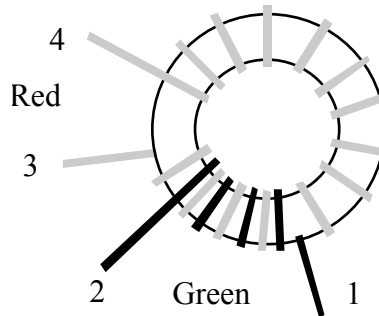


Install 3-pin male connectors P2 and P3 on the bottom of the board. Use the same technique you used when installing P1. These connectors must not be tilted, and must be seated flush with the board.



T1 and T2 are toroidal transformers, with two numbered windings: 1-2 and 3-4. These numbers are printed next to the pads on the PC board, and they also appear on the schematic drawing.

T1 will be wound on a ferrite core (FT37-43, 3/8" [9.5 mm] diameter). For the larger winding, 3-4, use **22 turns** of red enamel wire (13", 33 cm). This winding will occupy about 80 to 90% of the core, as shown in the drawing below. (The drawing shows only 14 turns on the 3-4 winding.) Each pass through the core counts as one turn. Some turns of the 1-2 winding may cross over those of the 3-4 winding.



Carefully strip and tin the leads of T1's 3-4 winding as follows: First, cut the leads to about 1/2" (12 mm) long. Next, completely remove the enamel insulation from the leads to within 1/8" (3 mm) of the core. You can use a small amount of solder on your iron's tip to heat-strip the insulation (preferred method), or use a butane lighter or sand-paper. If you scrape the insulation off, be careful not to nick the wire.

T1's other winding, 1-2, uses **7 turns** of *green* enamel wire (5", 13 cm). (The drawing shows only 4 turns.) Wind the 1-2 winding on top of the 3-4 winding, using about 20% of the core. Strip and tin the leads of the 1-2 winding.

Install T1 vertically as shown by its component outline, with the 1-2 winding facing the edge of the board. Pull the leads taut on the bottom so that the transformer is held firmly in place. Make sure that the exposed part of each lead is shiny and has no remaining insulation.

Trim and solder all four leads of T1. When soldering, make sure that the solder binds well to the leads. If the lead appears to be an "island" in a small pool of solder, chances are it is not making good contact. Measure from leads 1 to 2 and 3 to 4 using an ohmmeter to be sure the leads are making contact.

Wind T2 in the same manner as T1, with **22 turns** on the 3-4 winding (red) but only **4 turns** on the 1-2 winding (green).

Install T2. It will be rotated 180 degrees with respect to T1, with its 1-2 winding (green) facing the closest edge of the board.



Very small ferrite cores are used for RFC1 and RFC2 to minimize stray signal coupling. These cores are a little harder to work with than larger cores, and are also more fragile. If you find it necessary to hold them with a vice, use only plastic or rubber jaws and a minimum of pressure.



Inductor RFC1 is wound with 19 turns of red enamel wire (9" [23 cm]) on an FT23-43 core. Since this winding completely fills the core, you may end up with one or two turns overlapping each other on the ends, which is acceptable. The edges of the core are sharp, so while winding, try to avoid scraping the wire against the core. Prepare the leads as you did with T1 and T2, but leave them long (about 1").



Install RFC1 on the **top** of the board, even though the component outline appears on the bottom (in the crystal filter area). The component outline identifies the proper holes to use. Insert the leads into these holes from the top, then pull the toroid down until it is seated on the board between RP1 and X3. Before soldering, look at the leads with a magnifying glass (if necessary) to make sure that all insulation is removed where the leads intersect the pads. Solder RFC1 on the bottom and clip the excess lead length.



Wind and install RFC2 in the same manner as RFC1.



Use an ohmmeter to verify continuity (< 1 ohm) between the pads for RFC1. Do the same for RFC2.



In the middle of the board, directly above the "C23" label, you'll find two pads connected by a white line. Install a 1/4" (6 mm) tall U-shaped ground jumper between these two pads, on the top side of the board. The jumper can be formed from a discarded component lead. (One of the thick leads from a 1N4007 diode is ideal.) This jumper can be used as a ground point for test instruments.



Re-check the orientation of the following using the Parts Placement drawing:

__ ICs

__ Resistor Networks

__ Diodes

__ Transistors

__ Electrolytic capacitors



Carefully examine both sides of the board for solder bridges and cold solder joints.



Before handling microcontroller U1, touch an unpainted, grounded surface. U1 is a CMOS IC that can be damaged by static discharge.



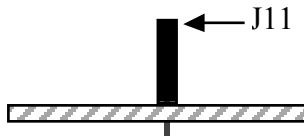
Install U1 in its socket. The notched or dimpled end of U1 should be nearest the left edge of the board. (Pin 1 is indicated by a round pad on the board.)

KSB2 Module Installation

- Remove the top and bottom covers. (Do not remove the heat sink.)
- Disconnect and remove the frequency counter probe.
- Locate the 5-crystal CW filter on the K2 RF board (X7 through X11). If any ground wires are soldered to the *tops* of these crystals, re-locate them to the sides of the crystals, about 1/4" (6 mm) up from the surface of the PC board. **Note:** There are two ground pads for each of these crystals (one on either side). For best performance, solder two wires to each crystal. (Early revisions of the K2 manual called for the use of just one wire each, soldered to the tops of the cans, resulting in worse rejection of out-of-band signals.)
- Locate the 2nd crystal filter on the RF board (X5 and X6). The ground wires on these two crystals should be positioned approximately as shown below to maintain clearance from the SSB adapter. (Grounding of these crystals is non-critical, so either top or side grounding will work.)



- Remove jumpers W2 and W3 on the RF board (near the 5-crystal filter). It is best to de-solder these jumpers and remove them completely rather than just cut them at both ends. If the SSB adapter must be removed later, W2 and W3 can be re-installed, or you can insert jumpers between pins 1 and 3 of J9/J10.
- Desolder and remove C167 from the RF board. C167 is located near the SSB option connector, J11. Save C167 in case you need to remove the SSB adapter at a later date.
- Install the 12-pin female connector on the RF board at J11(labeled "SSB") as shown by its outline. Do not solder yet. The side view of J11, below, shows how it should appear once properly seated.

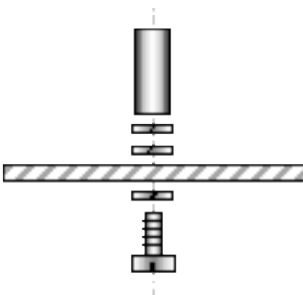


- Solder just one pin near the middle of J11. If the connector is not sitting completely flat against the RF board, reheat this pin and press the connector down. Then solder the remaining pins of J11.
- Install 3-pin female connectors on the RF board at J9 and J10, using the same technique used with J11.

Install the 3/8" (9.5 mm) standoff on the top of the RF board as shown below, using three split lock washers and a 1/4" (6 mm) machine screw. The hole for the standoff is near the BFO test point (TP2).



If you have difficulty getting the screw threads started into the standoff, hold the standoff with pliers on one side while pushing and turning the screw from the other with a phillips screwdriver. Once the lock washers start to compress, the screw will mate adequately with the standoff.



If your K2 serial number is 2999 or lower, you should make the 2nd XFIL modification to the K2 RF board at this time. This equalizes the pitch of LSB and USB signals on receive, and provides optimal sensitivity in all operating modes. (It has no effect on transmit.) The parts for the modification can be purchased from Elecraft (part #XFILMDKT). Instructions can be found in this PDF document:

http://www.elecraft.com/Apps/new_fil_docs/k2_2nd_xfil_ssb_mod.pdf

If you don't have web access, call or write for a printed copy of the instructions.

Note: The modification has already been incorporated into K2's with serial number 3000 and higher. You may also have made this modification already if you upgraded your K2 to revision B.

Plug the SSB module into the RF board. P1 on the SSB module mates with J11 on the RF board, and P2-P3 on the SSB module mate with J9-J10. Note that J11 will be obscured by the SSB adapter as you plug it in, so you won't be able to see whether the pins of P1 are mating correctly. However, if you line up the pins on P2-P3 with J9-J10, the alignment of P1 and J11 should also be correct. Also look at the hole labeled "TP2" on the SSB module: you should see the BFO test point centered below this hole.

Secure the SSB adapter to the RF board standoff using a 4-40 screw and one split lock washer.

Re-install the bottom cover (6 screws).

Initial Test

- Turn on the K2 and verify that you see the usual **ELECRAFT** display. If you see **INFO 080** or no display, you may have the SSB adapter plugged in incorrectly. If it appears to be installed correctly, unplug the adapter and look for a short to ground on one of the pins of P1.
- Tap the **MENU** button, then use the **BAND+** / **BAND-** buttons to get to the **SSBA** and **SSBC** menu entries. If you see "--" displayed for **SSBA** and **SSBC**, the SSB adapter's microcontroller is not communicating with the main processor on the Control board. Make sure U1 on the SSB adapter is not plugged in backwards. Also verify that R12 is installed (470 ohms).
- Tap **MODE** to select CW mode. Set the RF GAIN to max; AF GAIN, mid-way; preamp ON.
- Switch to 40 meters using **BAND+** / **BAND-**. Connect an antenna and headphones or speaker.
- Verify that the K2 performs the same on CW receive as it did prior to installing the SSB adapter. The filters you had set up should sound the same, and there should be no loss of signal strength. If signals appear to be weaker, see **Troubleshooting**.

BFO Test

- Connect the K2's internal frequency counter cable to TP2 (BFO) through the hole labeled "TP2" near the center of the SSB module. Tap the **MENU** button and scroll to the **CAL** menu entry. Then hold **EDIT** and scroll the **CAL** parameter until you see **CAL FCTR**. Hold **EDIT** a second time to activate the frequency counter display. You should now see a BFO frequency reading between 4910 and 4918 kHz on the LCD. The last digit may flicker. If the reading is 0000.00 or out of range, the SSB adapter may be loading down the BFO signal. Check C42, RP3, L1, C25, and C26 on the adapter. Look for shorts or opens in this part of the circuit. Also see **Troubleshooting**.

Receive-Mode SSB Filter Test

Selecting the Fixed-Bandwidth SSB Filter

- If you're still in **CAL FCTR** mode, tap **MENU**. Select 40 meters using **BAND+** / **BAND-**.
- Switch to LSB mode using the **MODE** button, and use **XFIL** to select FL1.
- Use the menu to select **CAL FIL** and activate the filter setup display. You'll see filter FL1's setting displayed. If a bandwidth number appears after FL1, e.g. **FL1 2.20L**, it indicates that the variable-bandwidth CW filter is presently being used for SSB receive. The small "L" indicates LSB mode.
- Use the VFO knob to change the setting for FL1 to **FL1 OP1L**. (**OP1** is the next available setting after **2.49**. "OP1" refers to the first *option* filter, in this case the fixed filter on the SSB adapter.) You should hear a pronounced difference in the receiver's audio when you go from **2.49** to **OP1**, since this causes the SSB adapter to switch between the CW filter and the SSB filter. Leave the filter set for **FL1 OP1L**. **Note: OP2 - OP5** also select **OP1** since only one fixed filter is available on the KSB2.

BFO Setup for LSB/USB

- Tap the **BAND-** button to see the BFO setting for the first SSB filter (BF1). You should see a display similar to **BF1t120L**. The BFO frequency control parameter (in this case **120**) has a range of 000-255. (A lower-case letter **t** appears in the BFO display for BF1, e.g. **BF1t120L**. This is a reminder that on transmit, BFO setting **BF1** is always used, regardless of how you set the BFO for FL2 through FL4.)
- Tap **DISPLAY** to show the present LSB BFO frequency in kHz. Adjust the VFO knob until the BFO is as close as possible to the **LSB/BF1t** freq. from **Table 3**. Then tap **BAND-** to return to the BFO parameter display.
- Tap **MODE** to select USB mode. You should now see a display similar to **BF1t200u**.
- Tap **DISPLAY** to show the present USB BFO frequency in kHz. Adjust the VFO knob until the BFO is as close as possible to the **USB/BF1t** freq. from **Table 3**. Tap **BAND-**.
- Exit the menu by tapping **MENU**.
- Using only FL1, listen to a few SSB stations. (Use LSB on 40 meters and below, and USB on 20 meters and above.) In later sections we'll describe various ways to set up FL2, 3, and 4 on receive (see Table 3). You'll also be able to fine-tune the transmit BFO settings, if necessary, to match your voice. **Note:** Use CAL FIL only on 17 meters and below. The BFO settings for LSB and USB are swapped on 15, 12 and 10 meters due to the K2's frequency mixing scheme.

Front Panel Board Components

- Remove the two screws that hold the Control board to the Front Panel board. Remove the four chassis screws that hold the Front Panel assembly to the chassis, then carefully unplug the Front Panel assembly.
- Remove the knobs, optical encoder hardware, and the flat-head screw to the left of the encoder shaft. (Do not remove the screw holding the associated standoff to the Front Panel PC board.) Separate the Front Panel from its PC board.



The front-panel SSB components will be installed in a small area located between the four potentiometers on the left-hand side of the board.

- Install the following components on the Front Panel board:
 - __ C4-C8 (all .01 μ F) __ Q3 (2N3906)
 - __ RP3 (10 K, 8 pins) __ R13 (68.1K, 1%)
- Turn the Front Panel board upside down and install the microphone configuration connector, P1. The short ends of the pins go into the board, and the connector must be soldered on the front side. Be very careful when soldering the pins of P1, which are very close to pushbutton switch S6.
- Re-assemble the Front Panel board (including knobs and hardware), but leave it unplugged.

Microphone Configuration

Follow the steps below to configure the K2 for your microphone.

1. If the Front Panel assembly is plugged in, remove the appropriate screws and unplug it. There are two screws holding the Front Panel board to the Control board, and four chassis screws that hold the Front Panel assembly to the chassis.
2. Place the Front Panel board upside-down on a soft cloth, with P1 to your right. P1's left-hand pins are the K2 signal lines, while those on the right correspond to the 8 pins of the microphone jack.
3. Determine the proper P1 wiring for your mic. First look in **Table 2** (following page) to see if your mic is listed. (Also check our web site, www.elecraft.com, which lists additional microphones). If you have a mic that is not listed, use **Table 1** in conjunction with your microphone's schematic to determine which wires to use. If your mic has the wrong connector type, you can use a Radio Shack #274-025.
4. Connect each of the required signal lines using hookup wire, wire-wrap wire, or discarded component leads. (You can optionally use 2-pin computer "jumper blocks" for connections that tie adjacent P1 pins together.) Some mics also require a bias resistor between the **AF** and **5V** lines, as described in Table 1 or Table 2.
5. Plug the Front Panel assembly into the RF board. Secure it to the chassis (4 screws) and control board (2 screws).

Table 1. P1 Signal Descriptions. (Also see Table 2.)

Signal	Description	Notes
AF	Mic audio, Low-Z (approx. 600 ohms). Approx. 100 mVp-p audio level.	With some mics it is necessary to connect 5V to AF through a resistor. The kit includes a 10 K resistor (Rbias) for use with many condenser mics. Some mics may require a much smaller resistor to supply operating current for a buffer stage. Consult the transceiver and microphone schematics.
PTT	Push-to-talk	Contact closure to ground when PTT button pressed. The PTT signal is the same as the DOT key line, making it easy to use a foot switch or other method of enabling xmit.
DN	"Down" button (optional)	Contact closure to ground when button pressed, otherwise open (infinite resistance). You can activate the VFO A/B switching function using any contact closure to ground (UP, DN, FUNC). The present version of the KSB2 firmware does not support other mic button functions.
UP	"Up" button (optional)	
FUNC	Function button (optional)	
5V	5 volts DC (10 mA max.)	Some microphones will work well with 5 volts even though the schematic calls for a higher voltage.
GND	Ground	Signal, logic, or shield ground.
GND		

Table 2. P1 Wiring for Selected Microphones (NC = no connection).

Elecraft MH2, MD2, Proset-K2		Kenwood (MC-43,47,48,60), Alinco EMS-11		Icom (HM-7,12,22,23,36)	
Mic kit includes 8 jumper blocks for use at P1, plus a 5.6-k resistor. Install the jumpers first, <i>then</i> solder the resistor from pin 1 to 6. Note: Do not attempt to disassemble the microphone.		Do not connect pin 5 unless mic has internal preamp. Touch-tone ICs may be sensitive to stray RF. CAUTION: 5V goes to pin 5, not pin 6 (not straight across). Leave pin 6 of the mic unconnected.		Do not connect pin 2 unless mic has internal preamp. Touch-tone ICs may be sensitive to stray RF. Resistor, AF to 5V: HM-7, 820 ohms; HM-12/22/23/36, 10 K	
Signal	Mic pin	Signal	Mic pin	Signal	Mic pin
AF	1 (resistor to pin 6)	AF	1	AF	1 (see resistor, above)
PTT	2	PTT	2	PTT	5
DN	3	DN	3	DN	3
UP	4	UP	4	UP	NC
FUNC	5	FUNC	NC	FUNC	NC
5V	6	5V	5 (see note above)	5V	2 (see note above)
GND	7	GND	7	GND	6
GND	8	GND	8	GND	7
Yaesu (MD-1, MH-1, 27, 31, YM-35, MD-100)		Radio Shack (mic supplied with HTX-100)			
The MD-100 is slightly different from the other mics in the list: connect 5V to pin 2					
Signal	Mic pin	Signal	Mic pin	Signal	Mic pin
AF	8	AF	1	AF	
PTT	6	PTT	2	PTT	
DN	3	DN	3	DN	
UP	1	UP	4	UP	
FUNC	NC	FUNC	NC	FUNC	
5V	NC (MD-100: pin 2)	5V	NC	5V	
GND	2 (all but MD-100)	GND	7	GND	
GND	5, 7	GND	8	GND	

Alignment

- If your K2 serial number is 2999 or lower:** Locate the PA Bias control, R60, on the K2's RF board near the PA transformer. Set R60 fully counter-clockwise. (Newer K2s have a fixed resistor at R60.)
- Locate the carrier balance control, R1 on the KSB2 module. Set it close to the center of its range.
- Turn on power to the K2. **Select 40 meters, LSB mode, and filter FL1. Set RF GAIN = max.**

Coarse Carrier Balance Adjustment

- Disconnect the microphone.
- Select **SSBC** in the menu, and set the parameter to **2-1** (2:1 compression).
- Select **SSBA** in the menu, and set the parameter to **BAL** (carrier balance). Then exit the menu. You may see an S-meter indication, since the low-level SSB signal is now being fed back into the receiver.
- Adjust R1 on the KSB2 slowly for a *minimum* indication on the S-meter. This should occur close to the center of R1's range. If R1 has no effect, see **Troubleshooting**.
- Select **SSBA** in the menu and set the parameter to **3**. This will disable carrier balance mode.

Fine Carrier Balance Adjustment

A ham-band receiver is required to do fine carrier balance adjustment.

- Use the menu to set **SSBA** to **3** and **SSBC** to **2-1**.
- Connect a microphone to the K2. **Select LSB mode and FL1.** Set power to 5 watts.
- Connect a dummy load to the K2.
- Verify that pushing the PTT (push-to-talk) switch on the mic puts the K2 into transmit mode.
- Press PTT, but do not talk into the mic. Locate the K2's transmitted signal on the external receiver. The VFO setting you use on the external receiver to listen to your K2's carrier will be different from that used to tune in the SSB voice signal. If you're tuned to a setting that allows you to hear the voice signal, you'll be at the *zero-beat* frequency of the carrier and will not be able to hear a tone.
- With the PTT switch pressed, adjust R1 on the SSB adapter for *minimum* carrier signal amplitude using the receiver's S-meter. This should occur near the middle of R1's range (typically slightly to the right). Repeat the adjustment using USB. Find the best compromise setting between LSB and USB.

Filter Setup

- Connect the K2's internal frequency counter probe to TP2 (BFO).
- Select **40 meters, LSB mode, and filter FL1**. (It's important to always do filter setup on 17 m or below to avoid confusion due to the K2's sideband inversion above 17 m. The settings apply to all bands.)
- Set up your filters exactly as shown in Table 3 (below), using CAL FIL. Both the filters (FL1-4) and BFOs (BF1-4) must be set up for each operating mode. The BFO settings are given as actual frequencies (4912-4917 kHz) rather than as BFO control values (0-255). As described earlier, the **DISPLAY** button is used in CAL FIL to setup the BFO frequencies. You may not be able to set the frequencies to exactly those shown, but try to get as close as possible. The 10 Hz digit may flicker, which is normal.
- Read all of pages 21 and 22 carefully to become familiar with SSB operation.
- Set POWER for 5 watts and select LSB mode. Monitor your transmitted voice signal in another receiver, or contact a nearby station and have them listen critically. Then, as explained on page 22 (**SSB Transmit BFO Optimization**), adjust the **LSB BF1** value for best transmitted signal quality.
- Switch to USB mode and adjust the **USB BF1** value for best transmitted signal quality.
- Optional: For receive-mode BFO fine-tuning (BF2-BF4) you can use an audio spectrum analysis program such as *Spectrogram*, which runs on PC-compatible computers. This is described on our web site.

Table 3. Suggested Filter and BFO Settings. (Also see notes below.)

Mode	FL1	BF1 ^t (note 1)	FL2	BF2	FL3	BF3	FL4	BF4
CW	OP1	4913.6	0.70	4913.1	0.40	4913.1	0.20	4913.0
CW Rev.	(note 2)	4916.0		4914.3		4914.3		4914.2
LSB	OP1	(_____) From Page 10	OP1	4913.5	1.80	4913.0	OFF or 0.70 (note 3)	4912.7
USB		(_____) From Page 10		4916.1		4915.5		4914.7

Table 3 Notes

- The LSB and USB BFO settings are derived from the filter crystal frequency (see page 10) to ensure good SSB transmit performance. The lower-case **t** after **BF1** is a reminder that these BFO settings are always used on transmit, regardless of which filter you select for receive.
- FL1** on CW is set for OP1 since the SSB filter is ideal for casual CW tuning. The remaining CW filters provide narrower bandwidths, and are centered at approximately 600 Hz.
- FL4** on LSB/USB is shown set to OFF, which means it will not be accessible with the **XFIL** button. (Any filter can be turned off except for FL1.) To use this filter for PSK-31 or other data modes, set FL4 to 0.70 or narrower. The BF4 settings shown provide a center frequency of about 1000 Hz.

Using The SSB Adapter

Basic SSB Setup

Mode Selection: To use SSB, select LSB or USB using the **MODE** button. Tap **AGC** to select **SLO** AGC (recommended for all data modes).

Filter Selection and Setup: Use the **XFIL** button to select the desired receive-mode crystal filter. In SSB modes you'll usually select **FL2**, since the BFO settings for this filter have been optimized for receive (see Table 3). In transmit, the BFO settings for **FL1** are always used, regardless of what receive filter is selected. This allows you to fine-tune the way your voice sounds on transmit (see *SSB Transmit BFO Optimization*). For receive purposes, you can set up FL2, 3, and 4 according to Table 3 or modify these settings for particular applications. For example, FL4 is shown set to OFF in the table (for SSB modes), but it could be set to any desired bandwidth for voice or data.

Mic Gain: SSBA controls the mic's audio gain. Level **1** attenuates the mic audio by about 10 dB and is useful when operating outdoors or mobile. (You can change R15 on the SSB adapter if you want a different attenuation level.) Level **2** turns the mic attenuator off and is the recommended setting for normal indoor operation. Level **3** is similar to level **2**, but provides slightly better VOX sensitivity. **BAL** is used for carrier balance adjustment, routing the SSB adapter's output directly to the receiver's I.F. input.

Speech Compressor Level: SSBC controls the speech compressor. **1-1** turns speech compression off. This minimizes audio distortion for digital data modes. **2-1** is the recommended setting for normal voice operation. **3-1** and **4-1** may be useful for contest or DX work.

Power/ALC Metering: On power-up, the K2 bargraph LED defaults to RF output metering. To select ALC metering (automatic level control), hold **RF/ALC**. You'll see **ALC** flashed on the LCD. In ALC metering mode, the LEDs illuminate from the *right* end of the display to distinguish ALC readings from RF power readings. ALC readings are always shown in BAR mode. (See **Power Control and ALC**, below.)

Using PTT (SSB and CW modes): On power-up, the K2 defaults to **PTT** mode. You can also use a foot switch connected to the DOT input (key jack). In CW mode, the mic button can be used as a hand key by setting **INP** to **HAND** in the menu.

Using VOX: Using voice operated transmit (VOX), you can simply talk into the microphone to transmit. To select VOX mode, hold the **VOX** button. You'll see **SPCH 0.2** flashed on the LCD. ("SPCH" means "speech," and "0.2" means an 0.2-second hold time.) Holding the **VOX** button again selects **SPCH 0.4** (0.4 second hold time), and holding again selects **SPCH 1.0** (1 second). The mode letter flashes slowly as a reminder that the mic is "live." You'll need to keep the mic away from the K2's speaker, since the K2 does not provide "anti-vox" circuitry. This is usually not a problem since the K2's speaker faces upwards. For mobile use or in other high-noise situations, you can set **SSBA** to **1** to reduce mic gain.

MIC Buttons: Either an UP or DOWN button on your mic can be used to switch between VFOs A and B, assuming you have these lines connected. You'll hear one beep when VFO A is selected, two for VFO B.

Power Control and ALC

Tracking ALC: SSB transceivers use Automatic Level Control (ALC) to reduce transmit drive if output exceeds a desired level. Many transceivers require that you adjust the mic gain manually until the ALC indication is in a certain range. The K2's ALC is different: the drive level is automatically adjusted, over time, to keep ALC close to the optimal level. This *tracking ALC* (TALC) eliminates the need to adjust mic gain in most cases. You can set the POWER control, mic gain, or speech compression to any level, and the ALC level will average between 1 and 3 bars (in ALC meter mode) as you talk.

POWER control: This control is used to set the desired SSB peak power output. The maximum is about 10 to 15 watts PEP, depending on the band, antenna impedance, and power supply voltage.¹ The minimum power output in SSB modes is about 1 watt, even if you set the POWER control below this level. (If you set the POWER level near maximum, the ALC indication will typically be between 0 and 2 bars. Low power settings (3 watts or less) will result in about 3 bars on average.) Other POWER considerations:

1. **Don't set the POWER control any higher than the transmitter is capable of.** For example, if you hold TUNE and find that you can only get to 9 watts on 10 meters even with the POWER control all the way up, you should use POWER settings of 9 watts or less on 10 meters, in *all* modes.
2. **Use lower power when using a battery.** Don't use > 10 watts unless you're running from 13-15V.
3. **Set CAL CUR to no more than 3.5 amps.** This will allow the K2 to remind you when the PA transistors are drawing too much current, so you can reduce power before they get too warm. If you see a HI CUR warning message, reduce power until the warning goes away.
4. **If you get a mic burn or a report that your signal is distorted:** This is usually an indication that you have high RF voltage on the K2 chassis due to the use of an end-fed or poorly-matched antenna. The problem can be solved by using an RF Isolator, available from Elecraft and other manufactures.
5. **Use 5 watts or less for digital data modes,** since the duty cycle for digital modes can approach 100%. Use 1:1 or 2:1 speech compression for minimum data distortion (**SSBC 1-1** or **2-1**).

SSB Transmit BFO Optimization (Important)

When you transmit using SSB mode, the fixed filter on the SSB adapter is always used (OP1). The way your voice sounds to other stations depends on the BFO settings for this filter (i.e., BF1 in CAL FIL). Table 3 provides BF1 values for LSB and USB based on the measured crystal filter frequency (from page 10). However, you may have to experiment with these settings, adjusting them slightly to obtain best voice quality. You can use another ham-band receiver, or ask a nearby station listen to your signal as you vary BF1. Use CAL FIL, moving the BFO as much as +/- 200 Hz from the frequencies shown in Table 3. Start with lower sideband, then upper. Moving the BFO too close to the filter will worsen carrier rejection, so be sure to re-check carrier amplitude whenever you change the BFO setting.

Note: The BFO settings for LSB and USB are swapped on 15, 12 and 10 meters due to the K2's frequency mixing scheme. If you use 17 m or below for making BFO changes, the following rules apply:

LSB: moving the LSB BFO *lower* in frequency will raise the voice pitch and improve carrier rejection.

USB: moving the USB BFO *higher* in frequency will raise the voice pitch and improve carrier rejection.

¹ Operation above 10 watts PEP output may result in a small increase in transmit IMD.

Troubleshooting

If you have difficulty during test or alignment, do the following:

1. Check the orientation of all ICs, diodes, transistors, electrolytic capacitors and resistor networks.
2. Look for unsoldered pins, solder splashes, or shorts to ground, especially in the area of the crystal filter.
3. Measure resistances to ground in the crystal filter area, checking each crystal, both resistor networks, all diodes, numbered capacitors, and R5. Leads of these components should show not low resistance to ground.
4. Do the IC and filter switching diode voltage checks listed below. Be sure to set up the K2 exactly as described.

DC Voltage Charts

ICs: Voltages were measured under the following conditions: LSB mode, filter FL1 selected (OP1), VOX = PTT, POWER set to 0.1W. Menu: SSBA = 3; SSBC = 2-1. Some IC ground pins are not listed.

IC/PIN	RX(V)	TX(V)	IC/PIN	RX(V)	TX(V)	IC/PIN	RX(V)	TX(V)	IC/PIN	RX(V)	TX(V)
U1-1	6.0	6.0	U1-17	6.0	5.6	U2-6	5.6	5.6	U3-14	6.0	6.0
U1-2	5.9	5.3-5.9	U1-18	6.0	6.0	U2-7	6.0	6.0	U4-1	0.0	0.0
U1-3	2.3	2.3	U1-19	0.0	0.0	U2-8	6.0	5.4	U4-2	2.2	2.2
U1-4	0.0	0.0	U1-20	6.0	6.0	U3-1	0.0	0.0	U4-3	0.6	0.6
U1-5	0.0	0.0	U1-21	5.8	0.1	U3-2	0.2	0.2	U4-5	2.2	2.2
U1-6	5.1	0.0	U1-22	0.2	0.0	U3-3	2.5	2.5	U4-6	5.1	0.0
U1-7	0.0	0.0	U1-23	0.0	0.0	U3-4	2.5	2.5	U4-7	0.0	0.0
U1-8	0.0	0.0	U1-24	0.0	0.0	U3-5	2.2	2.2	U4-8	6.0	6.0
U1-9	0.0	2.3	U1-25	0.0	0.8-1.2	U3-6	2.2	2.2	U5-1	0.0	1.4
U1-10	0.0	3.1	U1-26	0.0	0.0	U3-7	1.5	1.5	U5-2	0.0	1.4
U1-11	0.0	0.0	U1-27	0.0	0.0	U3-8	0.36	0.44	U5-4	0.0	3.4
U1-12	0.0	0.0	U1-28	5.6	2.4	U3-9	5.2	5.6	U5-5	0.0	4.8
U1-13	0.0	5.9	U2-1	6.0	5.6	U3-10	0.0	0.0-2.0	U5-6	0.0	5.9
U1-14	6.0	5.9	U2-2	6.0	5.9	U3-11	5.4	5.4	U5-7	0.0	5.1
U1-15	0.0	6.0	U2-3	6.0	6.0	U3-12	0.0	0.0	U5-8	0.0	5.9
U1-16	6.0	5.4	U2-5	0.6	0.6	U3-13	2.3	2.3			

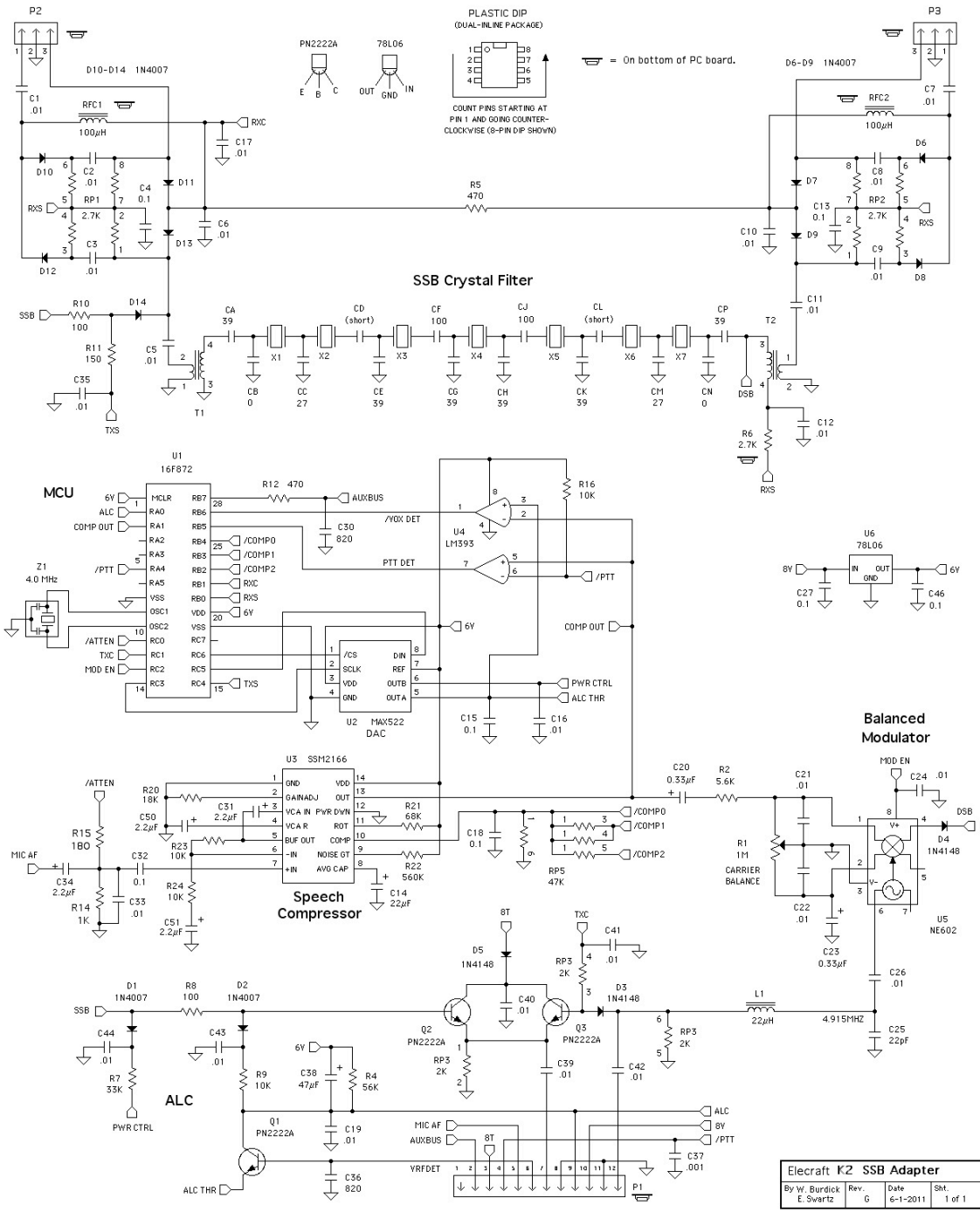
Filter Switching Diodes: Voltages were measured at the *cathode* (banded end) of each diode, in receive mode only. For CW, use FL = 0.00-2.49 (selects variable bandwidth filter). For SSB, use FL = OP1 (selects fixed SSB filter).

Diode	CW(V)	SSB(V)	Diode	CW(V)	SSB(V)	Diode	CW(V)	SSB(V)	Diode	CW(V)	SSB(V)
D10	5.4	6	D12	6	0	D6	4	6	D8	4.6	1.4
D11	6	0	D13	5.4	6	D7	4.6	1.4	D9	4	6

Circuit Details

RF Circuits: X1-X7 form an optimized, fixed-bandwidth SSB filter. T1 and T2 match the SSB filter's 1500-ohm input/output impedance to the 150-ohm I.F. path. D6-D13 select either the fixed SSB filter or the CW filter, and also provide T-R signal routing. D1 sets the overall TX gain via firmware (see Tracking ALC, above), while D2 provides fast-attack ALC. Q2 and Q3 are emitter followers, buffering the transmit signal on either SSB or CW, respectively.

Audio and Control: Mic audio is amplified and compressed by U3. D-to-A converter U2 controls the ALC threshold (via Q1), power scaling (D1), and VOX detection threshold (U4). U1 configures the SSB adapter under control of the K2's main processor, via the 1-wire AuxBus network.



Elecraft K2 SSB Adapter			
By	Rev.	Date	Sht.
W. Burdick	G	6-1-2011	1 of 1
E. Swartz			