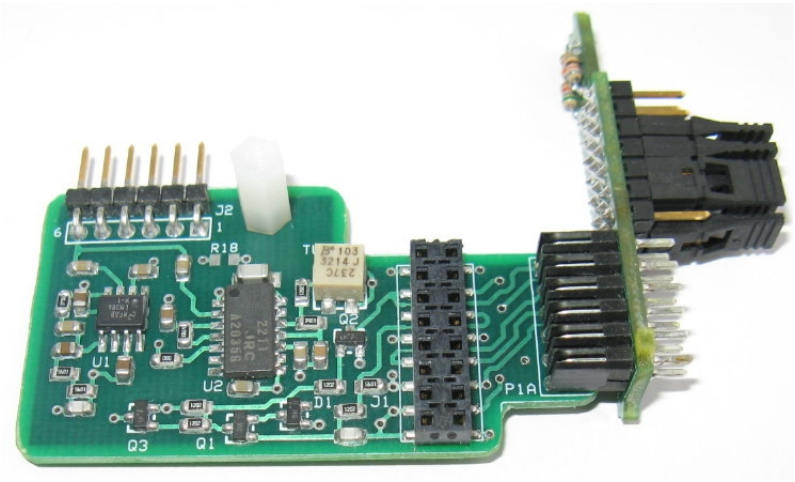
The K2 Miscellaneous Accessory Board (MAB)



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Introduction

The Elecraft K2 amateur radio transceiver kit[1] was first introduced in the late 1990's. At the time of this writing it is still in production, with well over 7,000 units sold. Its performance is excellent even by today's standards.

One of the key features of the K2 is the flexibility with which it can be configured. Users can purchase various modules to obtain the options most important to them. In addition to options from Elecraft, a number of aftermarket and homebrew accessory circuits have been developed and installed.

The K2 microphone connector wiring can be configured to match the wiring of a number of popular microphones. This feature is implemented via a dual-row header on the K2 front panel board. One row of pins is connected to the radio's internal circuits and the other row of pins is connected to the individual microphone connector pins.

Accessing this header for reconfiguration requires some disassembly. Ken Kaplan, WB2ART, and Gary Hvizdak, KI4GGX, developed an innovative product that greatly streamlines the process, the K2 Internal Mic Adapter (IMA.)[2] With the IMA installed, the microphone connector wiring can be reconfigured by simply removing the left side panel, rearranging some plug-in jumpers, and replacing the panel.

Another popular addition is a fixed-level audio output circuit[3] developed by Don Wilhelm, W3FPR. This circuit provides an audio signal to the soundcard input of a computer for data communications or for decoding Morse code (CW). The audio level is not affected by the volume control setting.

Yet another popular accessory is a CW tuning indicator circuit[4] developed by Bob Wolbert, K6XX. This circuit provides a visual indication when the K2 is tuned to within approximately 25 Hz of a received CW signal.

A circuit that enables a computer to key the K2 for transmitting CW is another popular addition. Page 99 of the K2 owner's manual[5] shows an example circuit that can be used to accomplish this.

Physically mounting the various additional circuit boards to implement all these functions in the K2 can be challenging. Another issue is the need for one or more connectors to make the necessary signals available outside the radio, preferably without drilling any additional holes.

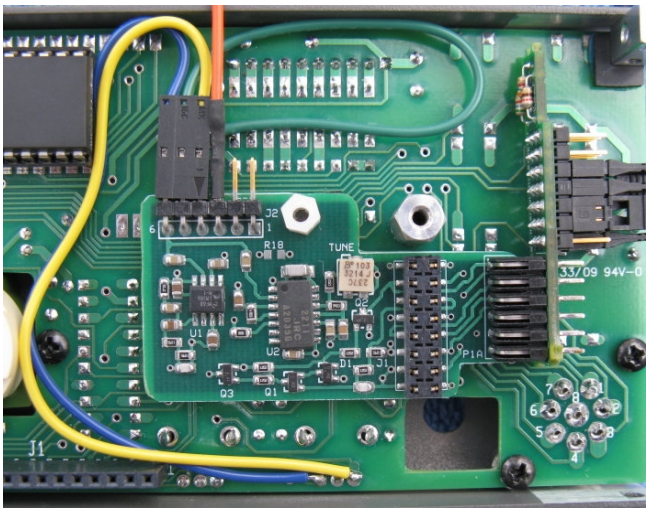
From recent discussions on the Elecraft reflector[6], a spare pin on the microphone connector can be used for bringing out the fixed-level audio output signal. Why not use an additional pin for the computer-generated CW keying signal? Then there would be no need for any additional connections outside the radio.

Carrying it a step further, why not consolidate all these circuits and features into one place? That is the purpose of this project, the K2 Miscellaneous Accessory Board, or MAB for short.

Description

The MAB hosts the W3FPR fixed-level audio output circuit, the K6XX tuning indicator circuit, and a CW keying circuit for use with a computer or straight key. The MAB can be configured for installation in the K2 either with or without the IMA option.

The MAB plugs onto the microphone configuration header P1 located on the K2 front panel board as shown below. This is the same installation method used by the IMA.



Four additional wire connections are needed by the MAB. Three of these wires are attached to the K2 front panel board, and the fourth wire is attached to the K2 control board.

The MAB is designed to replace the Mic Extender Board of the IMA, and it retains that board's J1 and P1A connector types and locations for interface compatibility with the rest of the IMA.

If the IMA function is desired, the IMA must be purchased to obtain the necessary additional components unique to the IMA.

Whereas the original IMA Mic Extender Board was approximately 0.9 inches wide, the MAB board is 2.2 inches wide with the growth towards the center of the radio.

If the MAB is configured without the IMA, the microphone wiring is constrained to the default Elecraft microphone wiring convention.

Circuit Description

A schematic diagram of the MAB is provided in Appendix A and should be referred to in the following discussion.

J1 and P1A perform the same functions as on the original IMA Mic Extender Board.

J2 is a right-angle 0.1-inch header plug mounted on the top side of the board. A three-pin receptacle plugs in for connections to the K2 front panel board. A single wire terminal plugs in for the /DASH connection to the K2 control board. This wire terminal is insulated with heat-shrink tubing.

Note there are two configuration options. One, and only one, of these options must be installed.

If the IMA is not used (Option A), then resistors R14 through R18 are installed. Jumper JP1, a 0.1 inch shunt, is optional and is installed only if the microphone requires a bias voltage.

If the IMA is used (Option B), jumper JP1 and resistors R14 through R18 are not installed, and the IMA connector P1 is installed at P1A. The microphone connections are then configured in accordance with the IMA instructions.

The W3FPR fixed-AF-level output and K6XX tuning indicator circuits are basically unchanged from their published forms. Surface mount components are used to reduce size.

The CW keying circuit uses two open-collector transistors instead of the simpler two-diode example circuit shown in the K2 owner's manual. The two-diode circuit has some potential for unreliable keying if the diodes have high leakage or if the keying input does not provide a hard switch to ground. Although slightly more complicated, the transistor circuit is more robust.

Microphone connector pins 3 and 4 have been selected for the CW keying input and fixed-level audio output signals, respectively. Previously, these pins were used for the UP and DOWN signals from microphones that have this capability. Since these pins are now dedicated, they can no longer be used for other functions.

Microphone connector pin 5 has been previously used by others for the fixed-level audio output signal. Unfortunately, this pin is also used by various major manufacturers for microphone functions of primary importance[7]: Icom: PTT, Kenwood: 8V, Ten Tec: GND, Alinco: 5V or 8V, Yaesu: various. As the primary function of the IMA is to enable usage of microphones from many manufacturers, dedicated usage of pin 5 was rejected for this project.

Parts Procurement

A Bill of Materials for the MAB is provided in Appendix B.

All parts can be obtained from Mouser Electronics[8] with the exception of the printed circuit board, J1, and P1.

J1 is a special low-profile bottom-entry connector. It may be possible to obtain this connector directly from Samtec, its manufacturer.

Alternately, an IMA kit can be ordered from unpcbs.com as the kit includes a J1 connector. This would be my preference as I consider the IMA kit to be a worthwhile addition that is reasonably priced.

Additional information pertaining to the IMA, including ordering information, can be found at the following link:

http://www.unpcbs.com/adaptor/

P1 is installed at the P1A location on the MAB. It is provided as part of the IMA. P1 is not needed if the IMA is not used.

To simplify the ordering process, a project has been created at Mouser Electronics. It can be accessed via the following link:

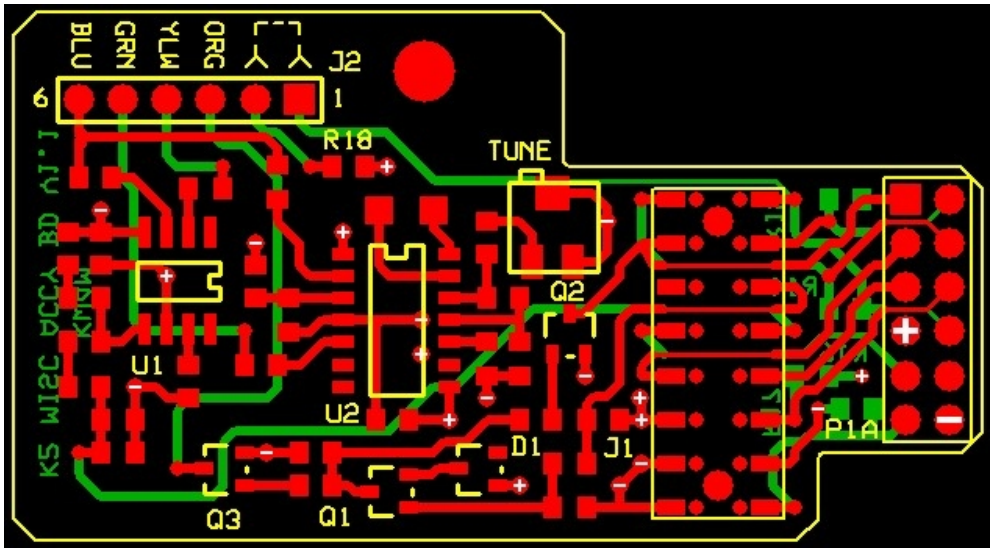
http://www.mouser.com/ProjectManager/ProjectDetail.aspx?AccessID=4954c48ac1

The 22AWG hookup wire was not included in this Mouser project as the costs associated with minimum order requirements were excessive in relation to this project.

At the time of this writing, the total Mouser project cost is $16.91.

Printed Circuit Board

The MAB printed circuit board layout is shown below.



The layout is for a four-layer board with internal 5V power and ground planes. It was prepared using the free ExpressPCB[9] software.

One limitation of the ExpressPCB service is that all holes must be plated-through. The bottom-entry through-holes for J1 must be unplated or plugged to prevent filling up with solder during assembly. Accordingly, it is necessary to manually drill these holes to enlarge them and remove the plating prior to assembly.

With the exception of R14-R17, all components are installed on the top side of the printed circuit board. Component leads protruding through the K2 front panel board do not allow sufficient clearance for other components to be mounted on the bottom of the board.

The ExpressPCB schematic and circuit board layout files can be freely downloaded[10] so those who choose to do so can have their own circuit boards made.

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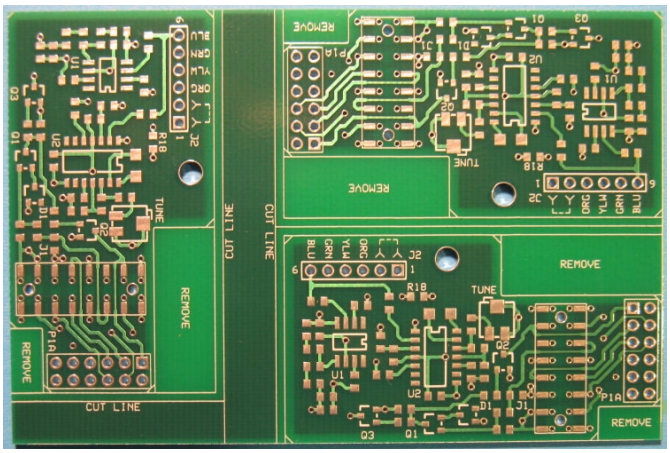
The ExpressPCB MiniBoardPro 4-Layer Service was utilized for the prototype boards. With this service, three 2.5 x 3.8 inch 4-layer MiniBoards are provided at one fixed price.

As this photo illustrates, three MAB boards fit on one MiniBoard.



Each J1 connector location has sixteen small plated-through holes that must be drilled out using a #60 size drill bit. The bit must be large enough so the header pins will clear, but small enough that the internal planes are not cut as this could cause a short. Therefore, substitution of the bit size should be avoided.

A new bit is recommended to produce a clean cut. A drill press or similar should be used to ensure the enlarged holes are drilled perpendicular to the board surface. I used a Dremel tool mounted in its accessory drill press holder.

Next, the individual MAB boards are cut out from the MiniBoards using a shear. They are then trimmed with a router or equivalent. I used the same Dremel tool arrangement but with a carbide burr installed in place of the drill bit. Final trimming can be done with a small file.

At this point the boards should be inspected to verify there was no damage induced. The drilled hole areas deserve special attention. It would be a good idea to test-fit the board by sliding it over the K2 front panel board header. Any mistakes are much easier to correct at this point instead of later after the board is assembled with components.

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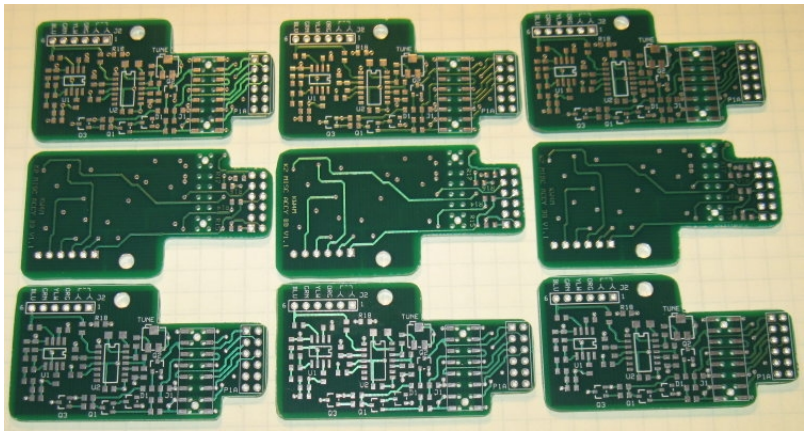
This photo shows the individual MAB boards after drilling, cutting, trimming, and cleaning. At this point they are ready for assembly.



Assembly

The MAB is designed to use surface-mount components of size 0805 or larger so that a small soldering iron can be used for assembly. The surface-mount components can therefore be installed using either a small soldering iron or a hot air tool intended for surface mount work.

No matter which assembly method is used, ESD precautions such as those described on page 12 of the K2 owner's manual must be observed.

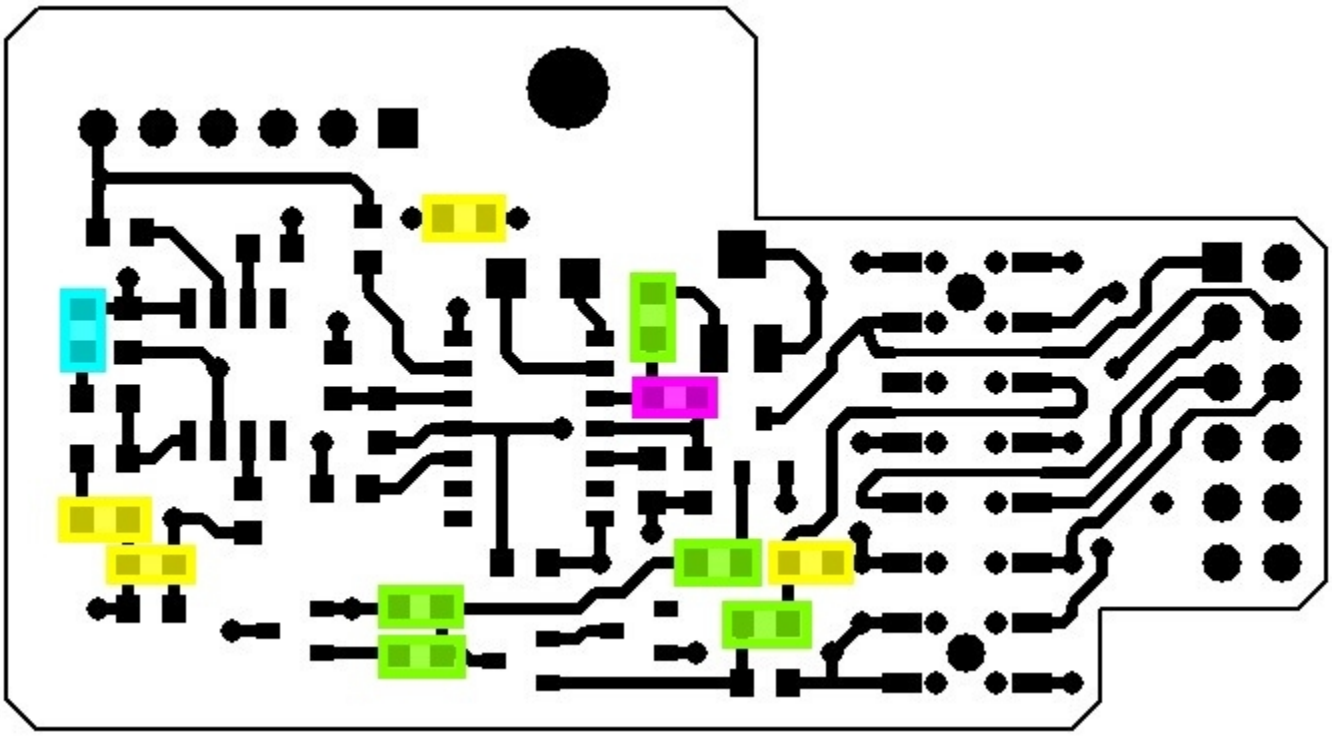
On two of the three boards I assembled, excessive current drain was noted after power had been applied for about an hour. An ohmmeter check revealed a resistance in the tens of ohms between the +5V supply and ground. I suspect this was due to either an excessive quantity or insufficient melting of the solder paste at U2.

In both cases, U2 was removed, the board cleaned, and U2 re-soldered using a soldering iron to correct the problem. After many hours of subsequent use no further problems have been observed.

It would be wise to pay special attention to the soldering at U2, especially if solder paste is used.

Color-coded diagrams on the following pages illustrate where the various components are installed.

The number to the left of the colon indicates the quantity of that particular part.

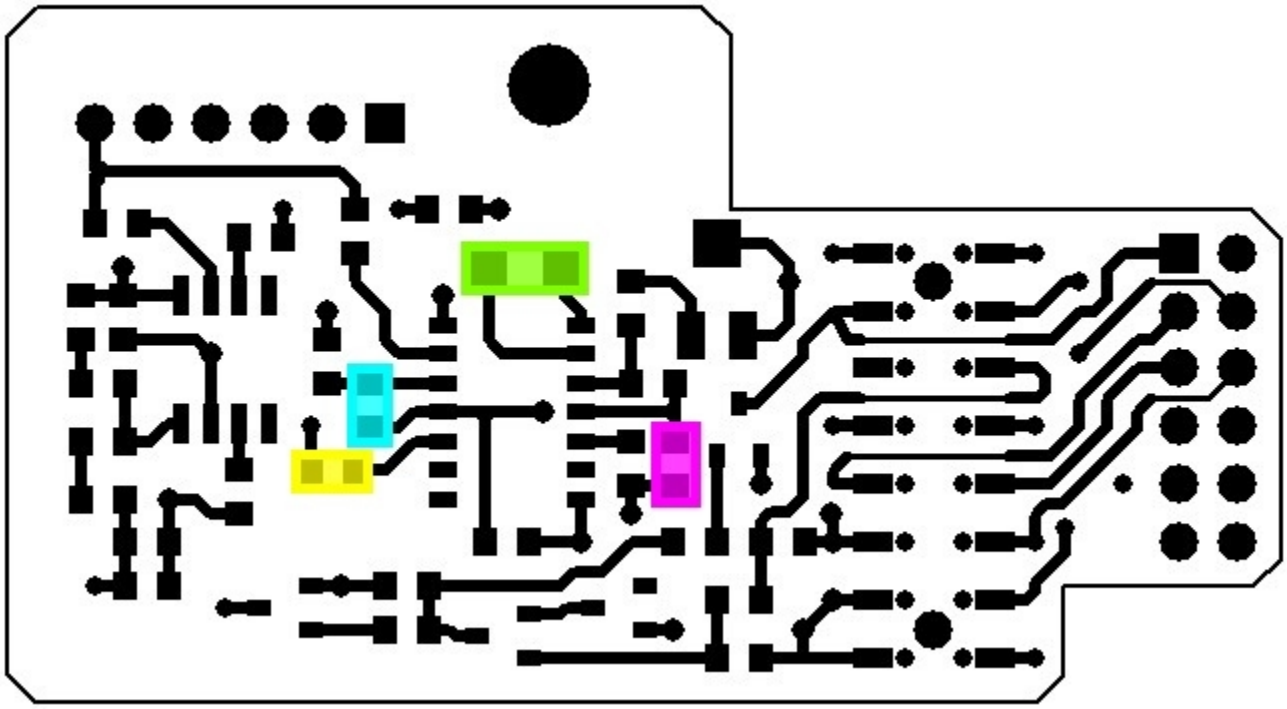


1: R1 = 10 ohms

4: R2,R3,R9,R18 = 5.6K ohms NOTE: R18 is only installed if the IMA option will not be used.

5: R4,R10,R11,R12,R13 = 12K ohms

1: R6 = 390K ohms

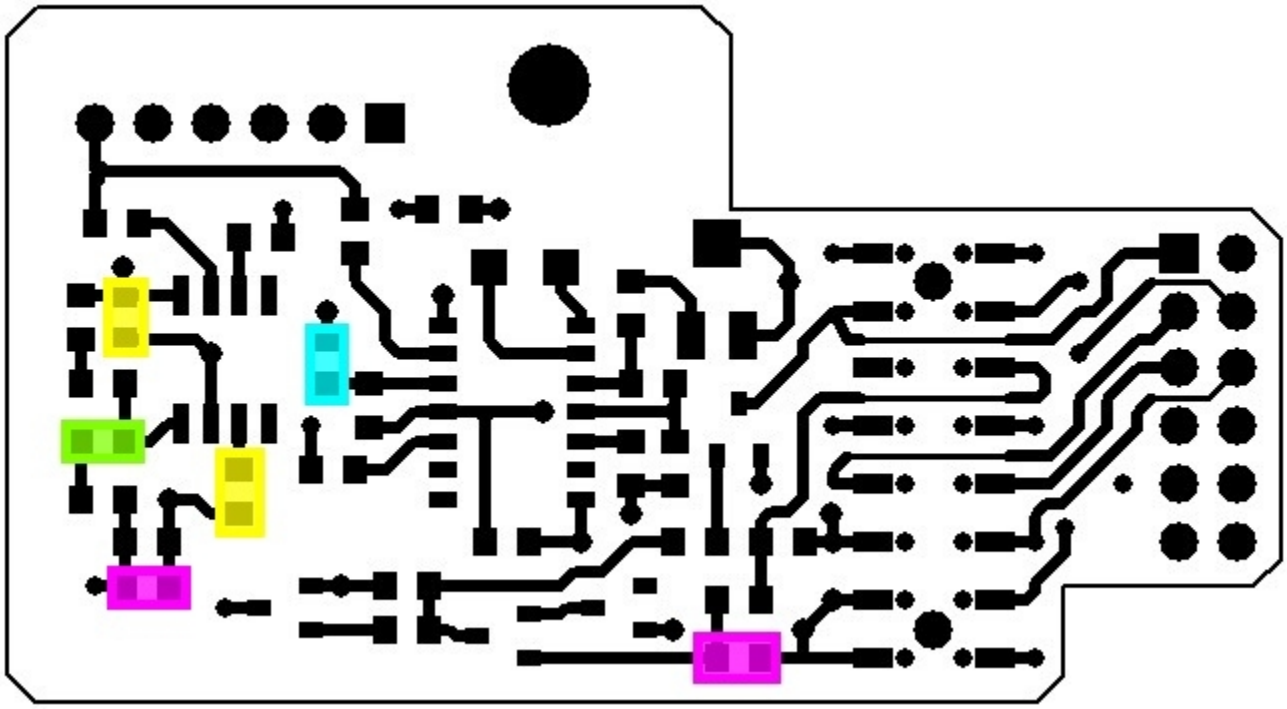


1: R8 = 470K ohms

1: R7 = ZERO ohms

1: C10 = 0.1 uF, 5%, C0G, GRM31C5C1E104JA01L

1: C11 = 22 nF, C0805C223K5RACTU

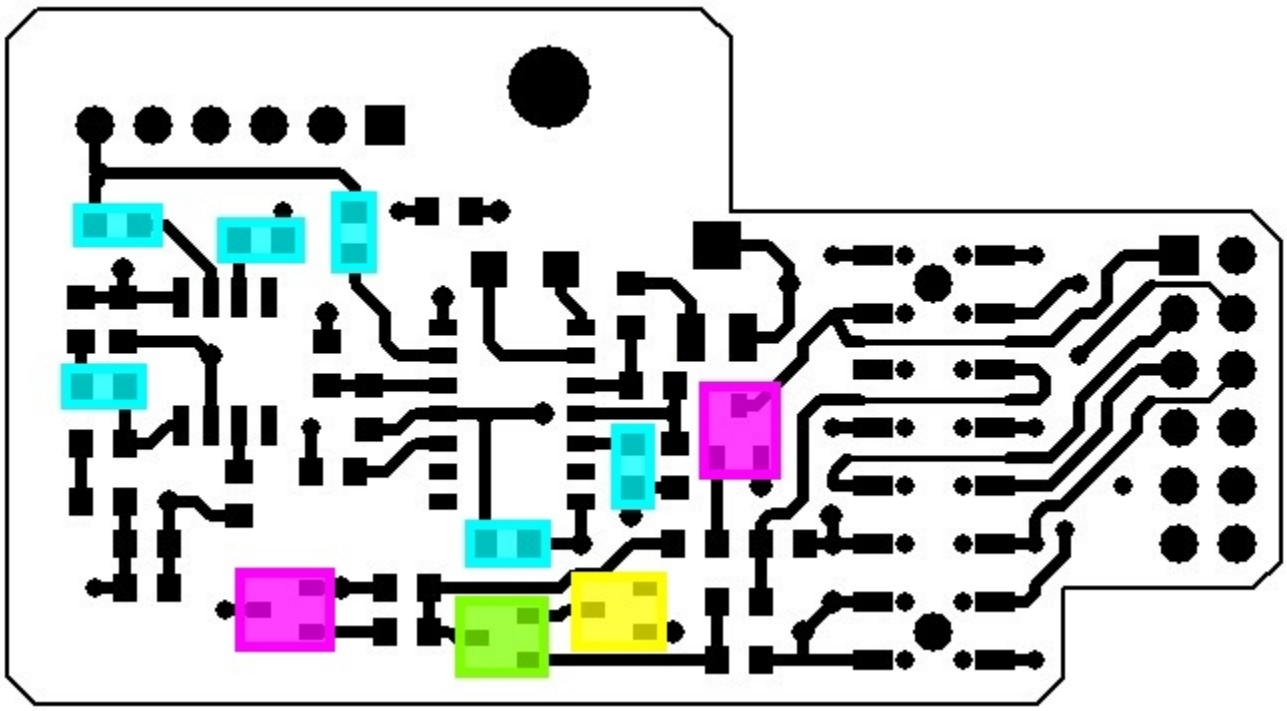


1: C13 = 0.33 uF, GRM219R71H334KA88D

2: C3,C4 = 22 uF, C2012X5R1C226M125AC

1: C6 = 1 uF, C0805C105K4RACTU

2: C7,C14 = 1 nF, C0805C102J5GACTU

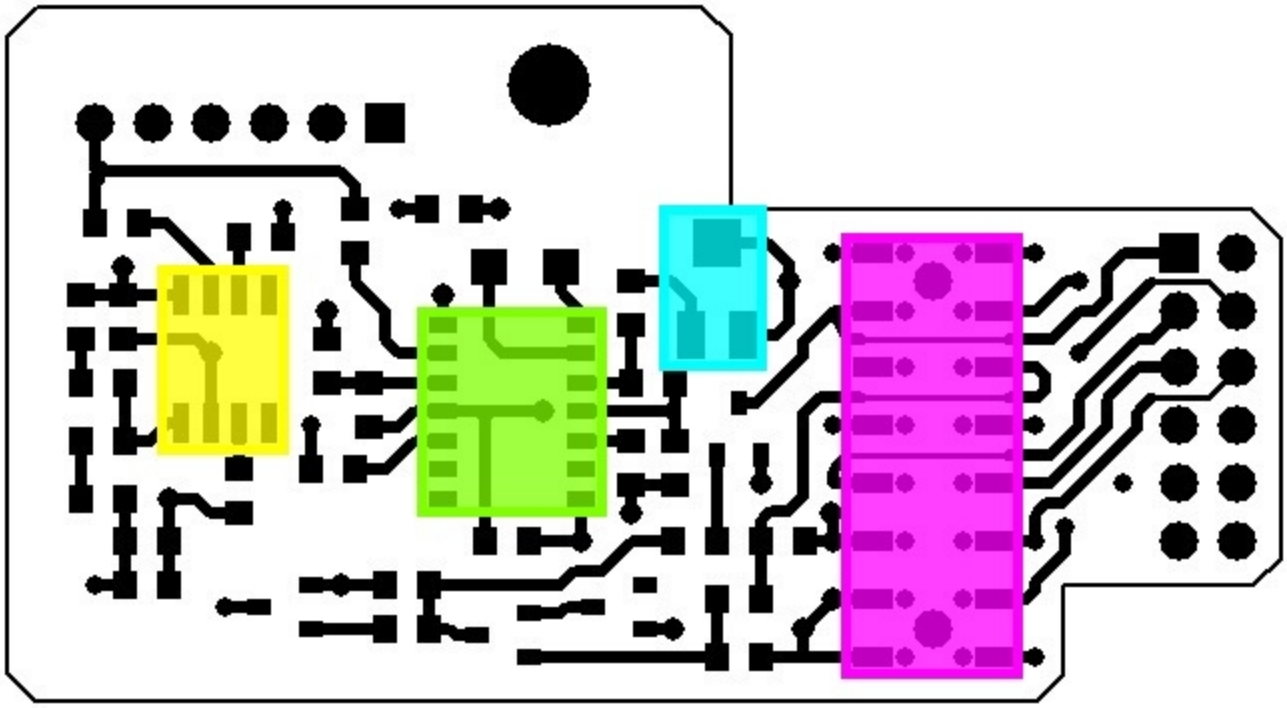


6: C1,C2,C5,C8,C9,C12 = 0.1 uF, C0805C104K5RACTU

1: D1 = MMBD4148

1: Q1 = MMBT3906

2: Q2,Q3 = MMBT2222A

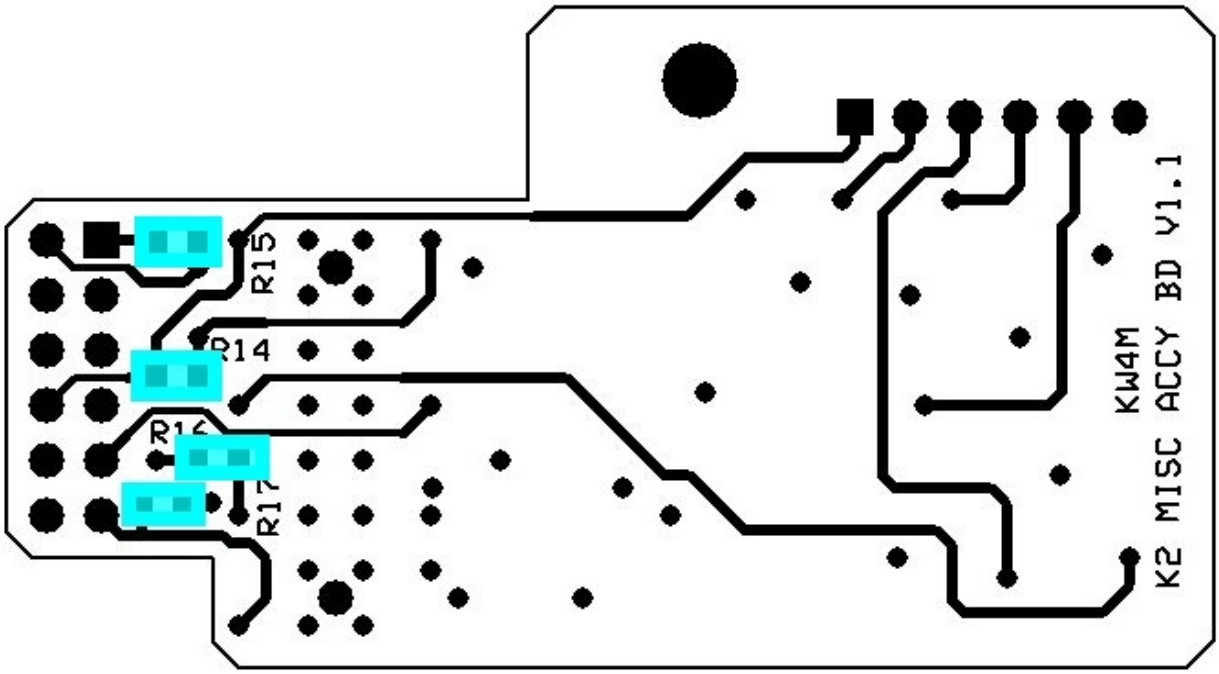


1: R5 = 10K trimpot

1: U1 = LM386M-1 Orient component according to the board silkscreen outline.

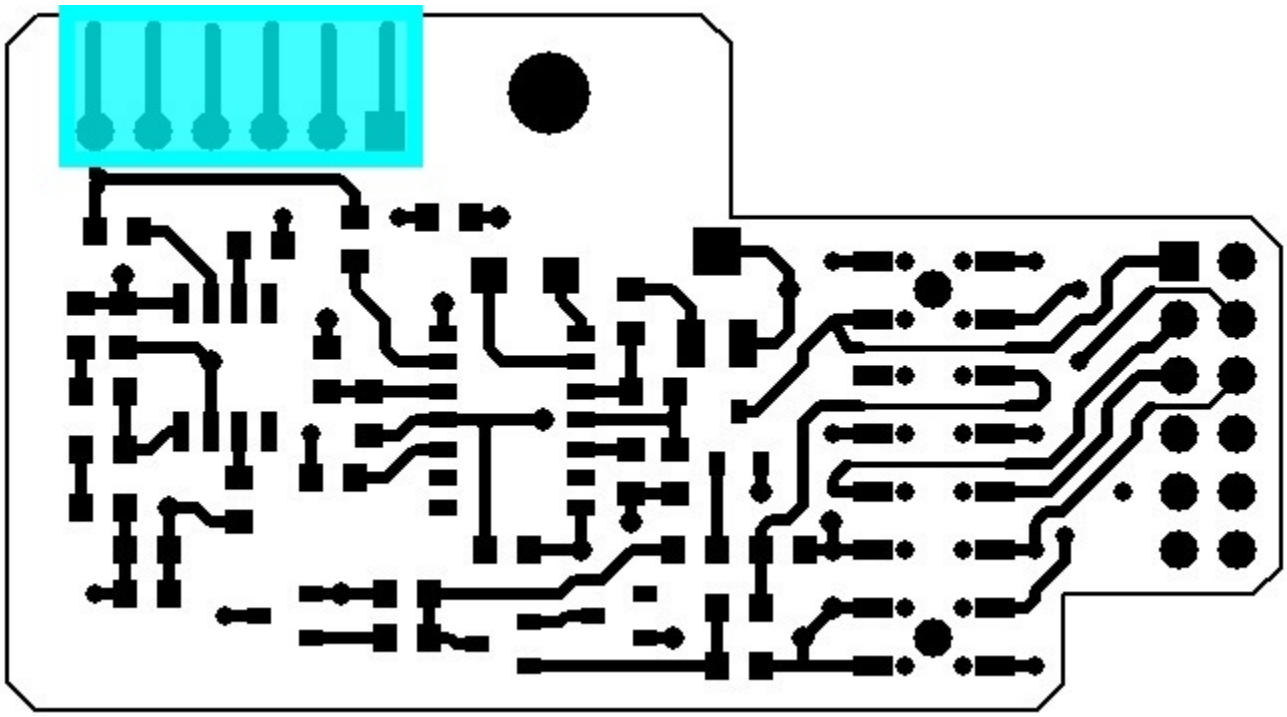
1: U2 = NJM2211M Orient component according to the board silkscreen outline.

1: J1 = special bottom-entry connector Ensure J1 is seated completely and flush with the board prior to soldering.



4: R14,R15,R16,R17 = ZERO ohms

NOTE: These four resistors are only installed if the IMA option will not be used.



1: J2 = right-angle 6-pin connector

The J2 leads that extend through the board need to be trimmed flush with the rear surface of the board to prevent potential shorts with component leads on the K2 front panel board.

It is easier and less likely to cause damage if the leads are trimmed prior to soldering. Slide J2 into place and then trim the through-hole leads flush with the rear of the board.

Ensure J2 is aligned parallel with the board surface and then solder.

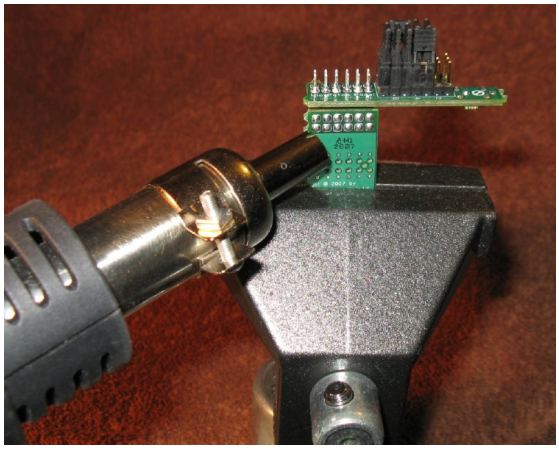
IMA Installation

This section is only applicable if the IMA will be used.

If the IMA has not been assembled yet, its Mic Extender Board should be located first and set aside. It will not be used as the MAB will take its place.

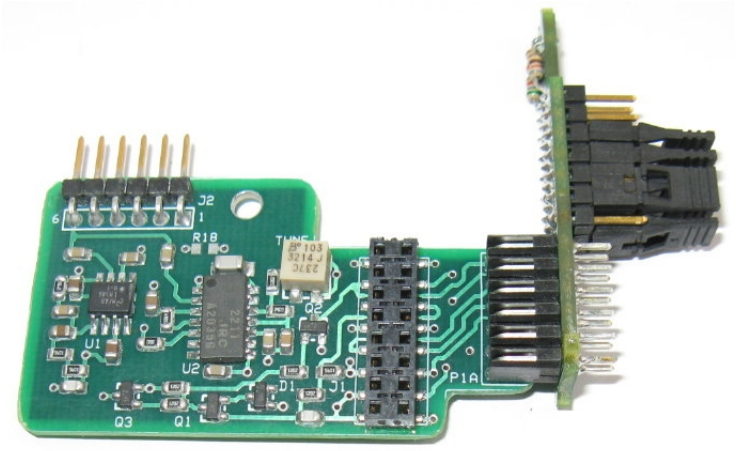
The IMA should then be assembled in accordance with its instructions, minus the Mic Extender Board.

If the IMA is already assembled, the P1 connector should be carefully removed from the Mic Extender Board. I used a hot air tool as shown in this photo. It is advisable to shield the P1 plastic body from direct airflow to reduce the risk of melting.



Once the solder melted it was easy to remove P1 with no damage while it was still soldered to the other board.

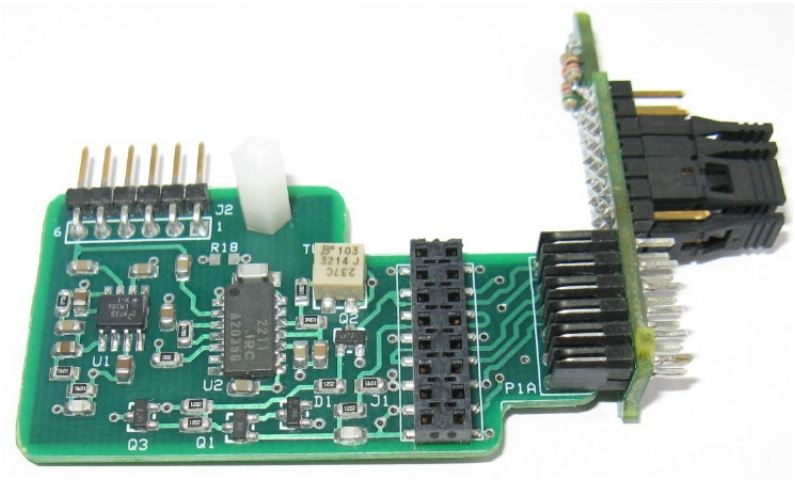
The IMA was then mounted to the MAB as shown below.



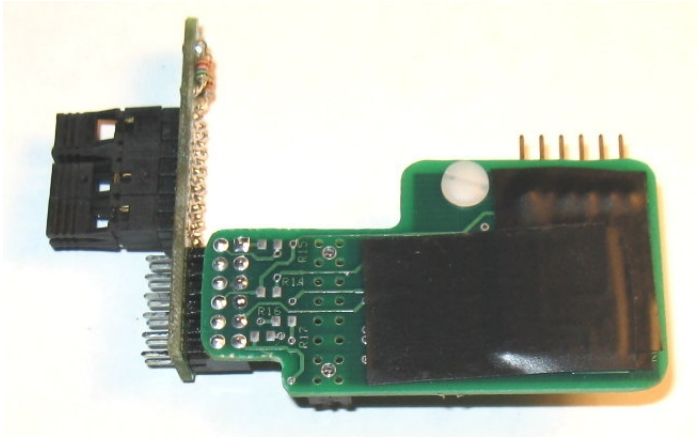
Final Assembly

If not done previously, the J2 leads extending through the MAB circuit board should be trimmed nearly flush with the bottom board surface to prevent potential shorts after installation.

A 4-40 x 3/8 inch nylon spacer is then installed at the mounting hole using a 4-40 x 1/4 inch nylon machine screw. A nylon screw is used to prevent potential shorts should the screw head come in contact with component leads on the K2 front panel board.



Finally, electrical tape is applied to the rear of the board for additional protection from potential shorts.

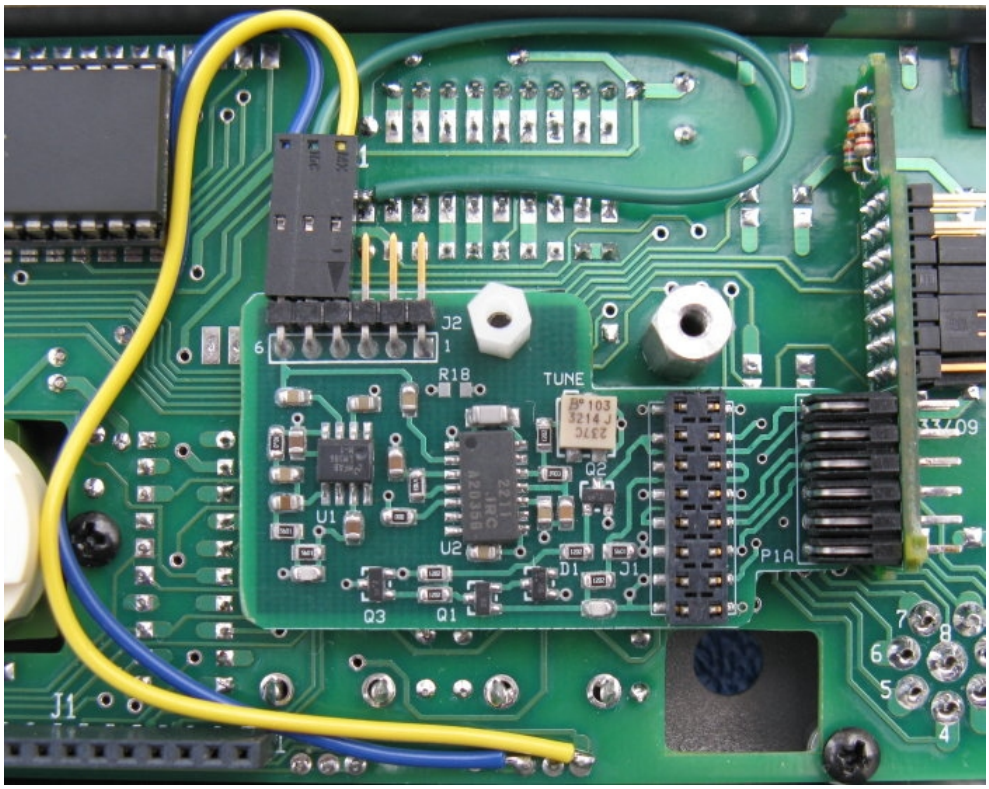


Installation

The K2 front panel board should be removed and placed on a soft towel or similar as a precaution against scratches during MAB installation.

Component leads extending through the K2 front panel board in the vicinity of the MAB should be trimmed to be nearly flush with the board surface to prevent potential shorts.

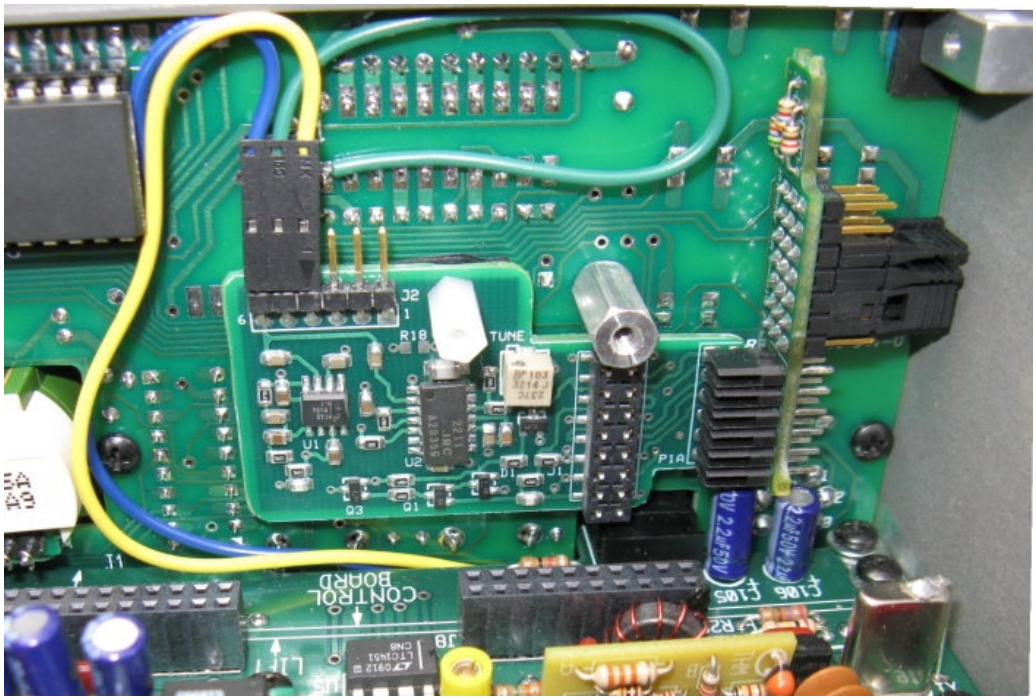
The MAB is installed by plugging it onto the K2 front panel board microphone configuration header.



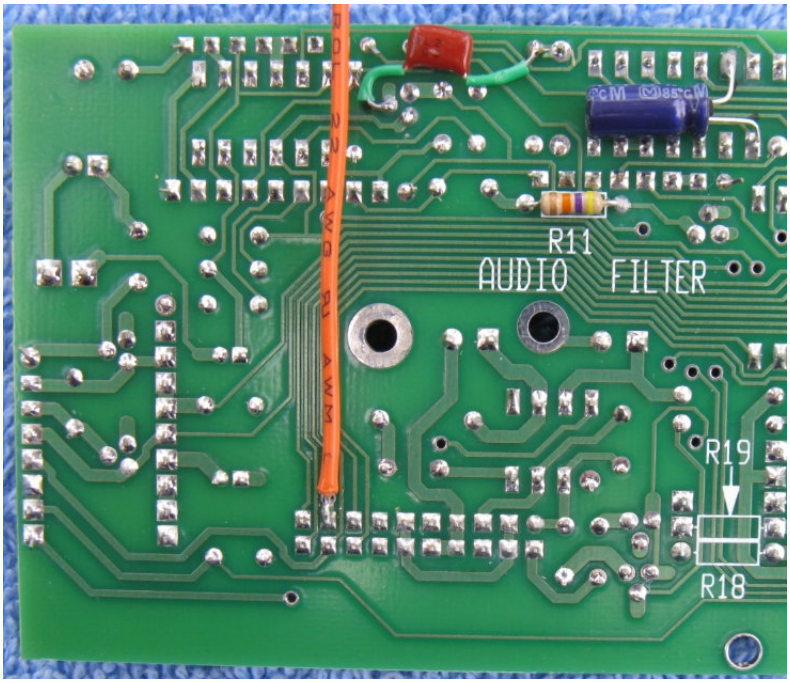
The three-wire front-panel-board cable assembly is prepared and installed as shown above. The wire colors were selected in accordance with the standard resistor color code and which J2 pin they are connected to, e.g. the yellow wire goes to pin 4, the green wire goes to pin 5, etc.

Enough slack should be left such that the wire connector can be unplugged from J2 without causing the wires to be placed under strain.

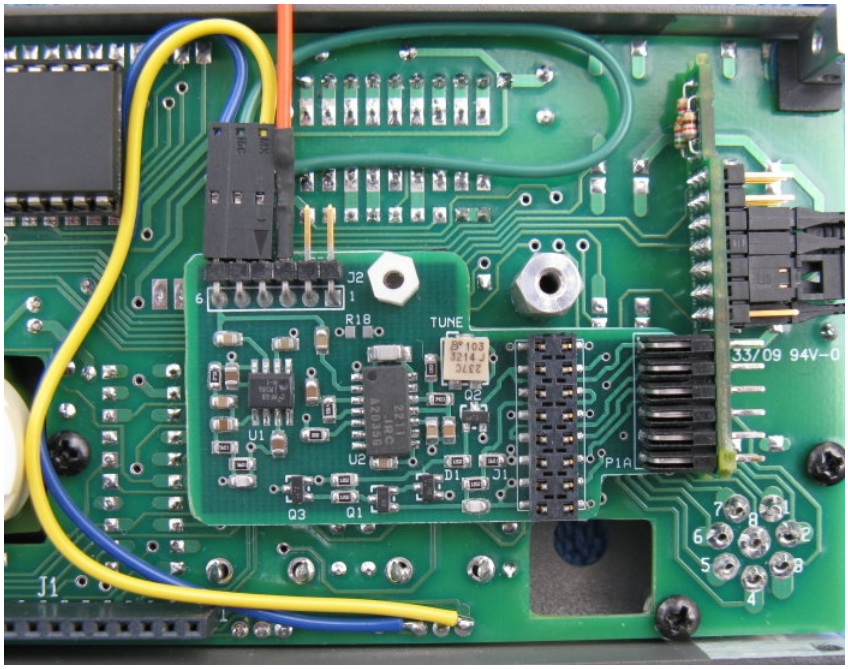
Next, the K2 front panel board is re-installed. The blue and yellow wires need to be carefully routed to avoid being pinched against the K2 RF board.



An orange wire is soldered to the K2 control board as shown.

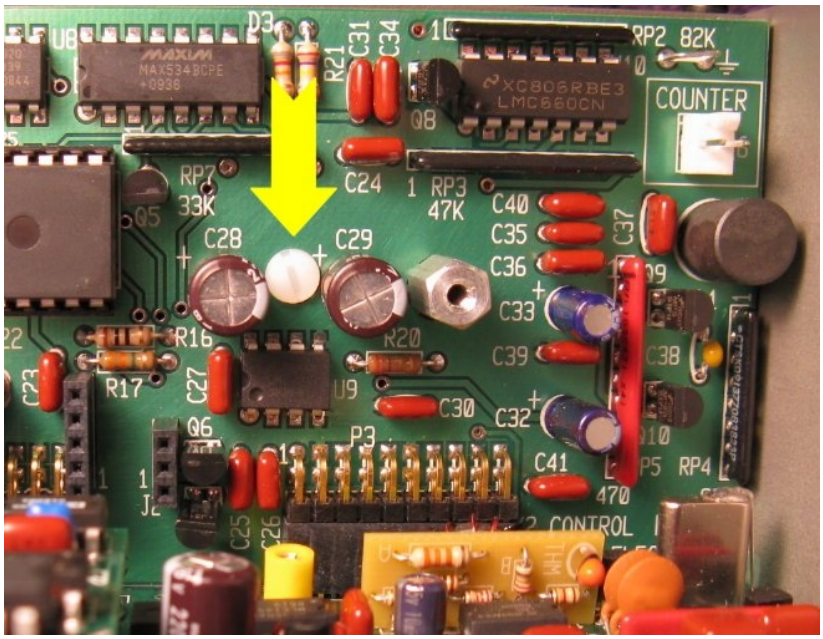


The other end of this wire is connected to pin 3 of J2 using a wire terminal and a small piece of heat-shrink tubing.



The K2 control board is then installed.

A nylon machine screw is used to secure the MAB to the K2 control board.



This last step is optional and likely not needed by most users. It is intended mostly for K2's that may experience excessive levels of shock and vibration.

This completes installation of the MAB. Any K2 options that were removed should be re-installed now.

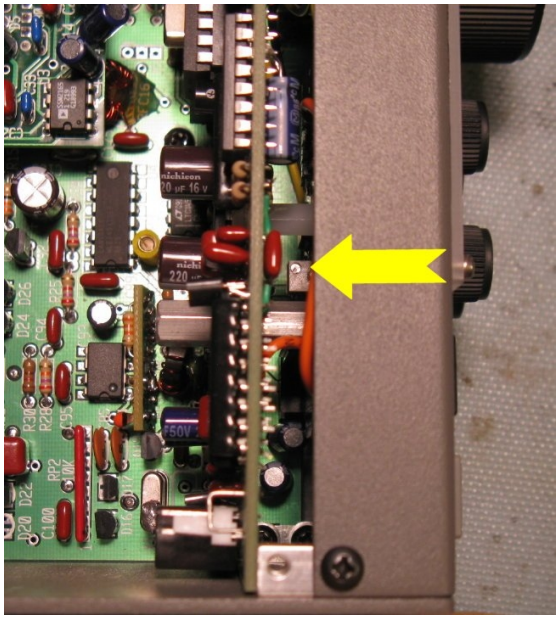
Tuning Indicator Adjustments

S-Meter Adjustment

The tuning indicator uses the most-significant segment of the S-meter LED bargraph array if the MAB wiring is installed in accordance with the preceding instructions. Strong signals can also cause this LED segment to be lit. To reduce the likelihood of this occurring, the S-meter calibration procedure described on page 90 of the K2 owner's manual can be performed. But instead of adjusting until the right-most bargraph segment is barely turned on, use the segment next to it.

Tuning Indicator Frequency Adustment

The small trimpot on the MAB is used to adjust the tuning indicator frequency. It can be accessed from the top as indicated in the photo.



Tom Hammond (SK), N0SS, wrote an excellent procedure for setting the K6XX tuning indicator frequency[11]. For convenience, his instructions are reproduced here:

"42) Select the 80M band and tune in the birdie which appears just at 4.000 MHz.

43) Press-hold [SPOT] to enable the sidetone.

44) If the SPOT tone is significantly stronger (or weaker) than the tone being received from the 4.000 MHz birdie, adjust the AF GAIN control to make the two tones about the same level. Note that you may also wish to use MENU | ST L to change the SIDETONE level, though merely adjusting the AF GAIN may be sufficient.

45) With the VFO tuning rate set to 10 Hz resolution, slowly tune the VFO to being the tone from the 4.000 MHz birdie to the same tonal frequency as that of the SPOT tone. You will know when you have accomplished this as the tone from the 4.000 MHz birdie will seem to 'disappear' behind the SPOT tone, and you may hear a slow 'beat' note (pulsing of the two tones). If you hear a beat note, continue to tune the VFO until the speed of the beat note is as slow as possible. Press [SPOT] to turn the SPOT tone off.

46) Using a very small-bladed screwdriver, slowly adjust the 5-turn trimpot until the 10th LED of the K2 S-meter just starts to flash, and then turns on solidly (brightly). Note the rotational position of the screwdriver (place a mark, or a 'flag', on the screwdriver if necessary). Continue to turn the screwdriver in the same direction. The LED will remain brightly lit for about 40 Hz of VFO adjustment and then again return to flashing slowly as you tune past the point of maximum LED brilliance. STOP TUNING HERE, and reverse the VFO tuning until the LED again just lights solidly.

Note this second point of rotation of the screwdriver, which should occur about 1 to 2 turns past the point where the LED first started blinking slowly.
47) Reverse the direction of the screwdriver and set it to midway between the two points at which the LED flashed slowly.

48) Set the K2 to the 40M band, and the weak birdie at 7.000 MHz.

49) Refer to steps 43 thru 45, and zero beat the 7.000 MHz birdie against the SPOT tone. NOTE the VFO frequency on paper.

50) With the VFO still set to 10 Hz resolution, tune back and forth, across the zero beat frequency you wrote on paper in the above step. You should note that the LED changes from solid (bright) illumination to flashing at about 20-30 Hz either side of the center frequency, and that it lights more solidly the closer you get to being dead-on zero beat with the SPOT tone.

51) This completes alignment of the CW Tuning Indicator.”

References

1. Elecraft website, "K2 and K2/100 All HF Band CW/SSB Transceiver Kits," http://www.elecraft.com/k2_page.htm .
2. unpcbs.com website, "K2 Internal Mic Adaptor," http://www.unpcbs.com/adaptor/ .
3. W3FPR website, "Add Fixed Audio Out to the K2," http://www.w3fpr.com/ .
4. K6XX website, "Visual CW Tuning Indicator," http://www.k6xx.com/ikanrite.html .
5. Elecraft website, "K2 Manual," http://www.elecraft.com/K2_Manual_Download_Page.htm#K2 .
6. Elecraft reflector, http://www.elecraft.com/elist.html .
7. G4WPW website, "Microphone Connections," http://homepage.ntlworld.com/rg4wpw/date.html
8. Mouser Electronics website, http://www.mouser.com/ .
9. ExpressPCB website, http://www.expresspcb.com/ .
10. K2 Miscellaneous Accessory Board project website, http://www.genebitsystems.com/david/K2MiscAccessoryBoard/index.htm .
11. N0SS' Amateur Radio Page mirror, "K2 – Assembly, Alignment & Installation Suggestions for the K6XX CW Tuning Indicator," http://www2.opparc.org/mirrors/n0ss/www.n0ss.net/index_k2.html .

Acknowledgements

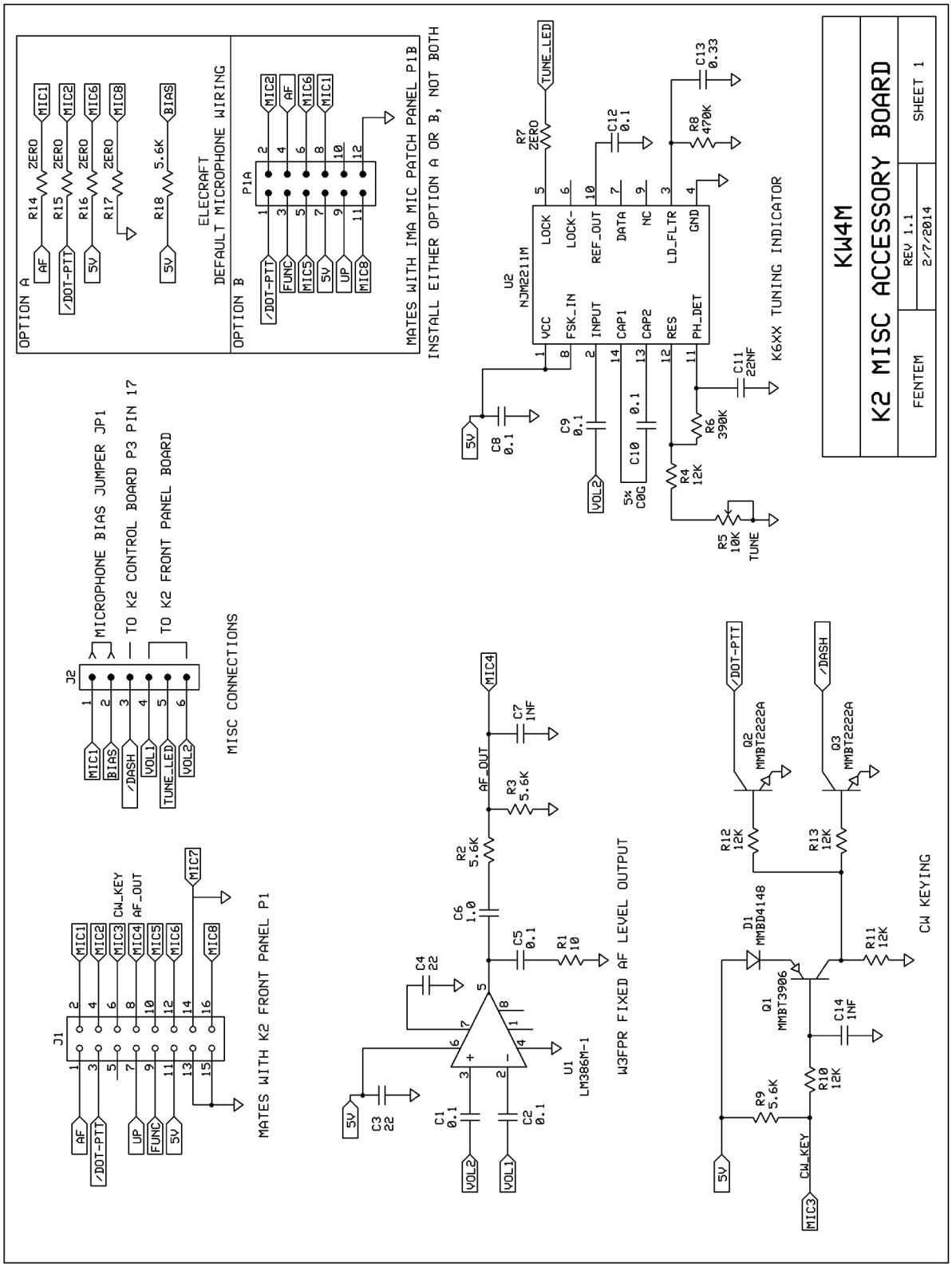
Don Wilhelm, W3FPR, provided numerous helpful comments and suggestions from the initial conceptual idea through the design phase. The project is much-improved due to his insights.

Gary Hvizdak, KI4GGX, and Ken Kaplan, WB2ART, provided additional suggestions and help with obtaining hard-to-find parts, particularly the J1 connector. This project is in fact an extension of their IMA concept.

Thank you all!

Trademarks and Copyrights

Appendix A - Schematic Diagram



Appendix B – Bill of Materials

Quantity	Ref Des	Package	Part Number	Manufacturer	Value	Tolerance	Rating
6	C1,C2,C5,C8,C9,C12	0805	C0805C104K5RACTU	KEMET	0.1	10%	50V
1	C10	1206	GRM31C5C1E104JA01L	MURATA	0.1	5% C0G	25V
1	C11	0805	C0805C223K5RACTU	KEMET	22NF	10%	50V
1	C13	0805	GRM219R71H334KA88D	MURATA	0.33	10%	50V
2	C3,C4	0805	C2012X5R1C226M125AC	TDK	22	10%	16V
1	C6	0805	C0805C105K4RACTU	KEMET	1	10%	16V
2	C7,C14	0805	C0805C102J5GACTU	KEMET	1NF	5%	50V
1	D1	SOT23	MMBD4148	FAIRCHILD			
1	J1	SPECIAL	HLE-108-02-L-DV-BE-LC	SAMTEC			
1	J2	SIP6-RA-TH	22-28-8062	MOLEX			
1	P1A	DIP12-RA-TH			USE P1 CONNECTOR FROM IMA KIT		
1	Q1	SOT23	MMBT3906	FAIRCHILD			
2	Q2,Q3	SOT23	MMBT2222A	FAIRCHILD			
1	R1	0805	ERJ-6ENF10R0V	PANASONIC	10	1%	0.125W
4	R2,R3,R9,R18	0805	ERJ-6ENF5601V	PANASONIC	5.6K	1%	0.125W
5	R4,R10,R11,R12,R13	0805	ERJ-6ENF1202V	PANASONIC	12K	1%	0.125W
1	R5	10K TRIMPOT	3214J-1-103E	BOURNS	10K		
1	R6	0805	ERJ-6ENF3903V	PANASONIC	390K	1%	0.125W
1	R8	0805	ERJ-6ENF4703V	PANASONIC	470K	1%	0.125W
5	R7,R14,R15,R16,R17	0805	ERJ-6GEY0R00V	PANASONIC	ZERO		0.125W
1	U1	TI_SOIC8_NARROW	LM386M-1	TI			
1	U2	DMP14	NJM2211M	NJR			
1		3-PIN WIRE HOUSING	50-57-9003	MOLEX	MATES WITH J2 PINS 4-6		
4		WIRE CONTACT, 22-24AWG	16-02-0104	MOLEX	MATES WITH J2		
1 FT		ORANGE WIRE, 22AWG	3051 OR005	ALPHA			
1 FT		YELLOW WIRE, 22AWG	3051 YL005	ALPHA			
1 FT		GREEN WIRE, 22AWG	3051 GR005	ALPHA			
1 FT		BLUE WIRE,22AWG	3051 BL005	ALPHA			
1 INCH		1/8 INCH DIA HEATSHRINK TUBING	19267-0123	MOLEX	USED FOR WIRE TERMINAL AT J2 PIN 3		
1	JP1	0.1 INCH SHUNT	15-29-1026	MOLEX	MICROPHONE BIAS JUMPER, MATES WITH J2 PINS 1-2		
1		4-40 X 3/8 HEX NYLON STANDOFF	2055-440-N	RAF ELEC HDWE			
2		4-40 X 1/4 NYLON MACHINE SCREW	9327	KEYSTONE			
1		PRINTED CIRCUIT BOARD	TBD	TBD			

R14-R18 AND JP1 ARE ONLY USED IF OPTION A (ELECRAFT DEFAULT MICROPHONE WIRING) IS INSTALLED.

P1 IS PART OF THE IMA KIT AND IS ONLY USED IF OPTION B IS INSTALLED.

INSTALL EITHER OPTION A OR OPTION B, NEVER BOTH AT ONCE.