

# Assembly and Bring Up Guide

by Mike Willegal  
www.willegal.net

second edition

## Chapter 1 – Assemble Components, Tools, and Equipment

### 1. Recommended Tools and Equipment

- Quality soldering iron
- Solder
- Wire cutters – for trimming component leads
- Your favorite PCB cleaning agent - Windex has worked well for me
- Ohm meter
- Swiss army climber knife or equivalent – for decal application, a small scissors, tweezers and pick are helpful for decal application
- Testors dullcoat or equivalent – for finishing decals
- Decal setting solution - Solvaset(recommended) or Micro-sol or Micro-set or Decal-set Usually found in small paint sized bottles near the paint section of a hobby shop.
- Small 000 or 0000 modelers brush.
- Fine file - may be needed for memory jumper blocks
- Logic probe or oscilloscope – handy if you are having trouble with bring up
- Wirewrap tool – useful for stripping wire for memory headers
- Apple II schematics – available in reference manuals at <http://www.apple-iigs.info/doc/docii.htm> and elsewhere. The “Red Book” schematics are close to the rev 0 layout, but check my web pages for errors

### 2. Additional Components

- From a scrap Apple II or II plus you can salvage:
  - i. Apple II power supply and power cord
  - ii. Apple II ROM set– either Integer or Applesoft ROMs will work. Though all rev0 boards came originally with integer ROMs, many were later upgraded with Applesoft ROMs
  - iii. Apple II compatible keyboard
  - iv. Apple II compatible speaker
- Locate a TV or monitor that supports video composite input and an appropriate video cable with RCA connectors

### 3. Accessories

- Apple II compatible paddles or joystick. I prefer paddles for many of the early Apple II games such as breakout
- Cassette recorder and tapes – for saving and loading programs

## 4. Compare Received Components With Parts List

Examine and identify all parts provided with the kit. For a few components, equivalent replacement parts may be shipped with your kit. In these cases, both names are listed in the PART column. The first part is the original part number used by Apple. IC's are organized on the anti-static foam in the same order as they are listed here (top to bottom, left to right). Memory and memory select headers are in tubes.

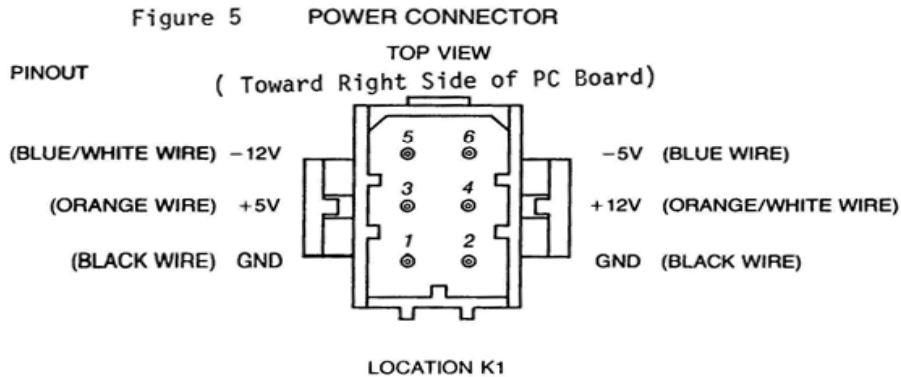
PART	DESCRIPTION	QUANTITY	
PCB	motherboard	1	
PART	DESCRIPTION	QUANTITY	
Decals	for memory jumpers	1	
Wire	wire wrap wire for memory jumpers (jumpers prewired in second edition kits)	6	
PART	DESCRIPTION	QUANTITY	
2513	char ROM	1	
8T28	transceiver	2	
555	timer	1	
741	op amp	1	
74LS00	nand gate	1	
74LS02	or gate	1	
74LS04	and gate	1	
74LS08	quad and gate	2	
74LS11	3 input and gate	1	
74LS139	dual 2-4 decoder	2	
74LS151	8-1 mux	1	
74LS161	4 bit counter	4	
74LS174	hex d flip flop	2	
74LS20	dual 4 input nand gate	1	
74LS251	8 input mux	1	
74LS257	2:1 mux	5	
74LS32	quad 2 input or gate	1	
74LS74	dual d flip flop	2	
Memory select headers		3	
Header cover	mem sel header cover	3	
ROM	not supplied	6	N/A
6502	processor	1	
74LS259	8 bit addressable latch	1	
4116 DRAM	ram 16k*1	24	
74LS138	3 to 8 line decoder	4	
74LS153	dual 4 to 1 selector	4	
74LS194	8 bit shift register	3	
74LS283	4 bit binary adder	1	
74LS51	dual 2 input and-or-invert	1	
74S175	quad d flip flop	1	
558/NTE926	quad timer	1	
74166	8 bit shift register	1	
74S195	4 bit shift register	1	
74S86	quad 2 input XOR	1	
8T97/MC6887	bus driver	3	
<b>Parts (socketed)</b>		<b>89</b>	
<b>Types (socketed)</b>		<b>35</b>	

PART	DESCRIPTION	QUANTITY	
Power	AMP 9-35028-1	1	
Cassette In/Out		2	
Video header	4 pin header	1	
Speaker header	2 pin header	1	
Video jack		1	
50 pin card edge	expansion	8	
GAME I/O	16 pin socket (below)	1	N/A
Keyboard	16 pin socket (below)	1	N/A
PART	DESCRIPTION	QUANTITY	
Resistor sip	1k networked resistors	3	
10 ohm	brown-black-black	1	
27 ohm	red-violet-black	2	
47 ohm	yellow-violet-black	2	
100 ohm	brown-black-brown	5	
150 ohm	brown-green-brown	1	
330 ohm	orange-orange-brown	1	
1K ohm	brown-black-red	1	
1.5K ohm	brown-green-red	1	
2.0K ohm	red-black-red	1	
2.7K ohm	red-violet-red	1	
12K ohm	brown-red-orange	5	
47K ohm	yellow-violet-orange	1	
220K ohm	red-red-yellow	1	
3.3M ohm	orange-orange-green	1	
200 ohm pot	video potentiometer	1	
PART	DESCRIPTION	QUANTITY	
.1uF +80%/-20% capacitor	decoupling caps	44	
47pF cap	video	1	
.022uF	paddle timer	4	
5-50 pf cap	video color	1	
PART	DESCRIPTION	QUANTITY	
1n914 diode		1	
PART	DESCRIPTION	QUANTITY	
27uH choke	be careful to not confuse with 27 ohm resistor which has similar markings	1	
PART	DESCRIPTION	QUANTITY	
Crystal	clock source	1	
PART	DESCRIPTION	QUANTITY	
2n4258/2n3906	clock generation	2	
2n3904 transistor		1	
MPSA13 Darlington transistor	speaker driver	1	
PART	DESCRIPTION	QUANTITY	
16 pin socket		63	
14 pin socket		15	
8 pin socket		2	
24 pin socket		7	
40 pin socket		1	
<b>Types (soldered)</b>		<b>44</b>	
<b>Parts (soldered)</b>		<b>189</b>	
<b>Types (total)</b>		<b>89</b>	
<b>Parts (total)</b>		<b>278</b>	

## Chapter 2 – Solder In Sockets and Components

### 1. Check for Power and Ground Shorts

Easiest way to do this is to use an ohm-meter to make sure that there is no connection between the nets. You can easily probe the at the location of the power connector. The only holes that are connected are the two ground holes at the left side of the connector. Other holes should not be connected.



### 2. Remove Card Edge Connectors

These connectors are mounted on the board during shipment to prevent damage to the pins during shipping. You can carefully remove the connectors for now, as it will be easier to solder in the sockets without the connectors present. Set the connectors in a safe place where the pins will not be damaged. They will be soldered in after the sockets are placed and soldered.

### 3. Sockets

The key thing here is to check orientation and make sure that you don't put a 14 pin socket in a location for a 16 pin socket. Start with the biggest sockets, since you can't put a big socket in a location for a smaller one. Make sure that the socket is oriented correctly with pin 1 of the socket near to the white dot on the PCB.

Make sure the sockets are fully seated. I accomplish this by resting the socket upside down on a small object with the board on top. The weight of the board should keep the socket completely seated. Then tack down a couple of corner pins and recheck orientation and seating. Then finish soldering the rest of the pins.

Don't try to do too much in one sitting. A couple of rows in an evening is plenty.

#### 4. Solder 40 Pin Socket

Pin 1 is to the right; make sure you orient the sockets correctly.

PART	LOCATION	DESCRIPTION	COMPLETE
40 pin socket	H-9	processor - pin 1 to right	

#### 5. Solder 24 Pin Sockets

Pin 1 is to the bottom; make sure you orient the sockets correctly with pin 1 toward the bottom of the board. Note that Pin 1 on the 2513 is to the left, the opposite orientation of the processor soldered in the previous step

PART	LOCATION	DESCRIPTION	COMPLETE
24 pin socket	F-3	ROM-F8	
24 pin socket	F-5	ROM-F0	
24 pin socket	F-7	ROM-E8	
24 pin socket	F-8	ROM-E0	
24 pin socket	F-10	ROM-D8	
24 pin socket	F-11	ROM-D0	
24 pin socket	A-4	2513 - pin 1 to left	

## 6. Solder All 63, 16 Pin Sockets

I wouldn't attempt to do this many sockets in one sitting. After a couple of rows or when you get tired, take a break. Check orientation and solder corner pins. Before soldering remaining pins, double check seating and orientation.

PART	LOCATION	DESCRIPTION	COMPLETE
16 pin socket	J-1	74LS257	
16 pin socket	J-14	GAME I/O	
16 pin socket	H-2	74LS138	
16 pin sockets	H-3 H-4 H-5	8T97	
16 pin sockets	H-10 H-11	8T28	
16 pin socket	H-12	74LS138	
16 pin socket	H-13	558	
16 pin socket	H-14	74LS251	
16 pin socket	F-2	74LS139	
16 pin sockets	F-12 F-13	74LS138	
16 pin socket	F-14	74LS259	
16 pin socket	E-2	74LS139	
16 pin sockets	E-3 to E-10	RAM bank E	
16 pin sockets	E-11 E-12 E-13	74LS153	
16 pin socket	E-14	74LS283	
16 pin sockets	D-3 to D-10	RAM bank D	
16 pin sockets	D-11 to D-14	74LS 161	
16 pin socket	C-1	74LS153	
16 pin socket	C-2	74LS195	
16 pin sockets	C-3 to C-10	RAM bank C	
16 pin socket	C-12	74LS51	
16 pin socket	B-1	74s175	
16 pin socket	B-4	74LS194	
16 pin socket	B-5	74LS174	
16 pin sockets	B-6 B-7	74LS257	
16 pin socket	B-8	74LS174	
16 pin socket	B-9	74LS194	
16 pin socket	A-3	74166	
16 pin socket	A-7	KEYBOARD	
16 pin socket	A-8	74LS257	
16 pin socket	A-9	74LS151	
16 pin socket	A-10	74LS194	

## 7. Solder the 14 Pin Sockets

Make sure that all 16 pin sockets are in place before starting this group. This will prevent you from inadvertently inserting a 14 pin socket into a location that needs a 16 pin socket.

PART	LOCATION	DESCRIPTION	COMPLETE
14 pin socket	J-13	74LS74	
14 pin socket	H-1	74LS08	
14 pin sockets	F-1 E-1 D-1	MEMORY SELECT	
14 pin socket	D-2	74LS20	
14 pin socket	C-11	74LS04	
14 pin socket	C-13	74LS51	
14 pin socket	C-14	74LS32	
14 pin socket	B-2	74S86	
14 pin socket	B-11	74LS74	
14 pin socket	B-12	74LS08	
14 pin socket	B-13	74LS11	
14 pin socket	B-14	74LS02	
14 pin socket	A-2	74LS00	

## 8. Solder In the 2, 8 Pin Sockets

Make sure that all 16 and 14 pin sockets are in place before starting this group. This will prevent you from inadvertently inserting an 8 pin socket in a location that needs a larger socket.

PART	LOCATION	DESCRIPTION	COMPLETE
8 pin socket	K-13	741C	
8 pin socket	B-3	555	

## 9. Repeat Check for Power and Ground Shorts

## 10. Mount Card Edge Connectors

These connectors fit somewhat tightly into the holes on the PCB. If they don't seat correctly, check for bent pins on the connectors. Straighten any bent pins and carefully insert the connectors into the PCB.

## 11. Solder Card Edge Connectors

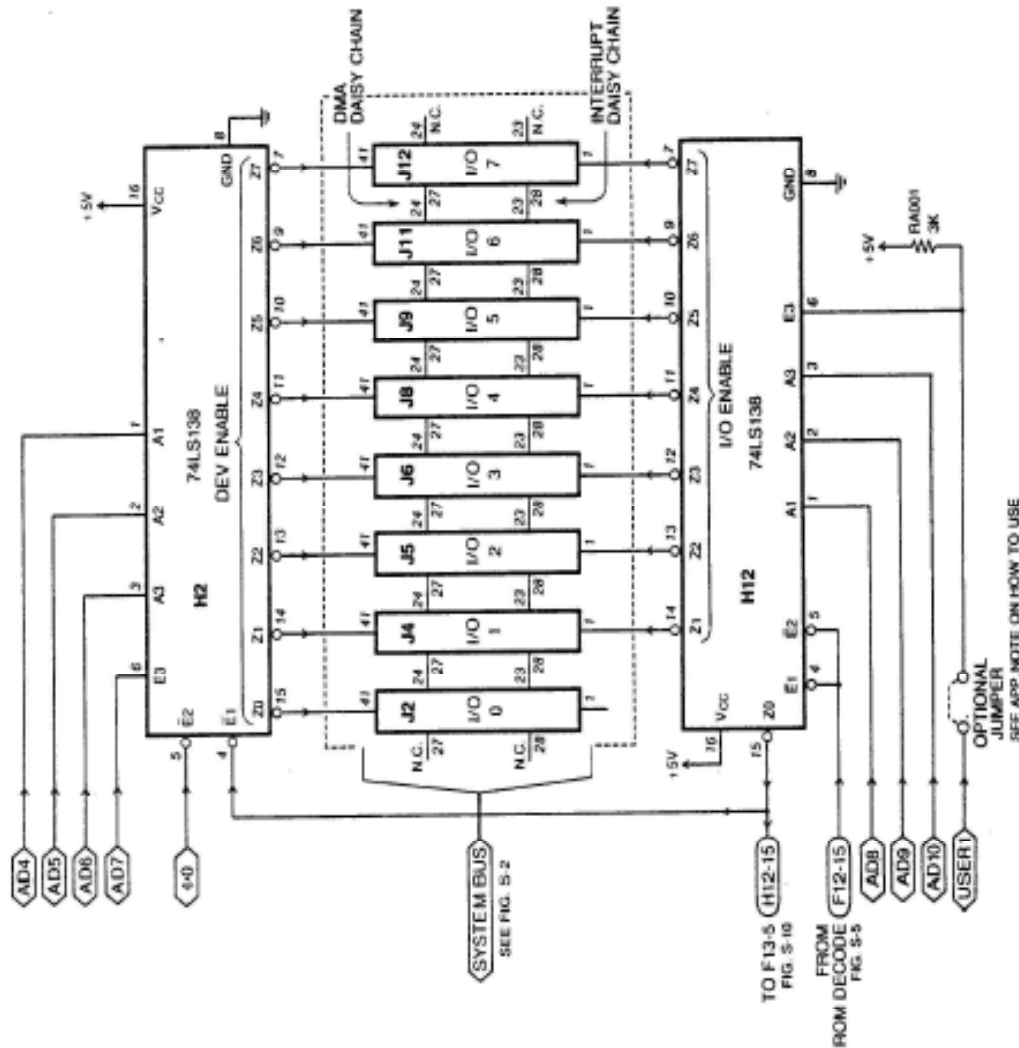
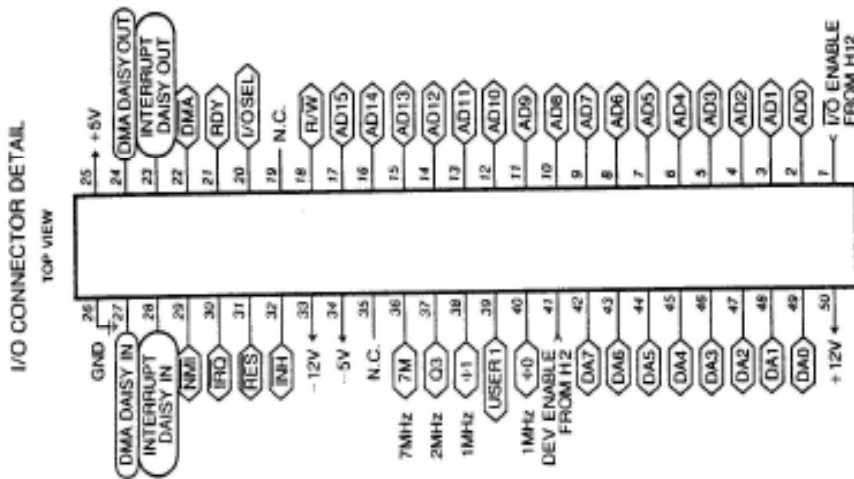
Tack down a couple of pins on each end of the connector and check for good seating of the connector in the PCB. Then proceed to solder the remaining pins.

PART	LOCATION	DESCRIPTION	COMPLETE
Card edge connector	J-2	slot 0	
Card edge connector	J-4	slot 1	
Card edge connector	J-5	slot 2	
Card edge connector	J-6	slot 3	
Card edge connector	J-8	slot 4	
Card edge connector	J-9	slot 5	
Card edge connector	J-10	slot 6	
Card edge connector	J-12	slot 7	

## 12. Repeat Check for Power and Ground Shorts

## 13. Check Bus Connectivity

Use an ohm meter to check bus connectivity. This involves checking connectivity from slot to slot for pins that were used and from each slot to the selector mux for the pins that were not used. DMA and interrupt controls are only connected between adjacent slots. See Apple II schematic for details.





## 14. Solder In the 44 Decoupling Capacitors

I found the easiest way to solder discrete components is to find a way hold the board vertically in a fixture. Place the component in the hole where it should stay. Then solder on one leg and check to make sure that the component is fully seated before soldering on the other leg. Once soldered in, check your work, and then trim the leads using a small wire cutter. Decoupling capacitors have a white line on the silk screen connecting the two holes. Don't mistake vias for component mounting holes. Vias have smaller diameter holes and are not connected to a mate with a white line on the silk screen. Locations are approximate.

PART	LOCATION	DESCRIPTION	COMPLETE
.1 uF Capacitor	K-13 K-13	1 above, 1 right 741C	
.1 uF Capacitor	K-14 K-14	2 above video header	
.1 uF Capacitor	H-2	below 74LS138	
.1 uF Capacitor	H-13	above 558 - <b>don't mix up with timer caps (step 17)</b>	
.1 uF Capacitor	H-14	right of 74LS251	
.1 uF Capacitor	F-2	above 74LS139	
.1 uF Capacitor	F-14	right of 74LS259	
.1 uF Capacitor	E-5	above RAM	
.1 uF Capacitor	E-3 to E-5	below RAM	
.1 uF Capacitor	E-7 to E-9	below RAM	
.1 uF Capacitor	E-11	below 74LS153	
.1 uF Capacitor	E-14	right of 74LS283	
.1 uF Capacitor	D-5	above RAM	
.1 uF Capacitor	D-3 to D-5	below RAM	
.1 uF Capacitor	D-7 to D-9	below RAM	
.1 uF Capacitor	D-11	below 74LS161	
.1 uF Capacitor	D-14	right of 74LS161	
.1 uF Capacitor	C-5	above RAM	
.1 uF Capacitor	C-3 to C-5	below RAM	
.1 uF Capacitor	C-7 to C-9	below RAM	
.1 uF Capacitor	C-14	right of 74LS32	
.1 uF Capacitor	B-1	below 74S175	
.1 uF Capacitor	B-3	above 555	
.1 uF Capacitor	B-7	above 74LS257	
.1 uF Capacitor	B-14 B-14	left above speaker	
.1 uF Capacitor	A-1 A-1 A-1	above, left & below crystal	
.1 uF Capacitor	A-14	corner of board	

## 15. Repeat Check for Power and Ground Shorts

## 16. Solder In Resistors

Use same process as used for capacitors when soldering.

PART	LOCATION	DESCRIPTION	COMPLETE
12K, 12K, 220K ohm	K-13	all three above 741C	
27 ohm	K-14	left video header	
12K, 12K, 100 ohm	J-13	all three above 74LS74	
47K	J-13	right of 74LS74	
10 ohm	J-14	near board edge	
100, 100, 100, 100	J-13	4 left of GAME I/O	
1.5K, 2.0K, 2.7K	J-14	3 right of GAME I/O	
1K ohm	F-14	right of 74LS259	
12K, 3.3M ohm	B-3	above 555	
27 ohm	B-14	above spare	
47, 47, 150 ohm	A-1	above crystal	
330 ohm	A-1	below crystal	

## 17. Solder In Remaining Electrical Components

Use same process as used for resistors and capacitors when soldering. Take special note of the position of the transistors in the clock circuit. The silkscreen on the original Apple rev 0 is wrong and so is my replica. The flat side should face the crystal- see the cover of this manual for proper orientation.

PART	LOCATION	DESCRIPTION	COMPLETE
1K resistor sip	K-12	bus pull ups. End of package with dot goes toward end of board with expansion slots.	
1K resistor sip	D-10, C-10	ram bus termination. End of packages with dots goes toward end of board with keyboard connector.	
200 ohm pot	J-14	video adjustment	
.022uF cap	4 parts at J-13	4 game port timer caps	
47pF cap	H-14	47pF mica cap	
5-50 pf cap	F-14	color trim	
1n914 diode	J-14	speaker circuit	
27uH choke	H-14	27 micro henry choke	
Crystal	A-1	master timing crystal	
2n4258/2n3906	A-1, A-1	clock generation- <b>IMPORTANT</b> - Orient according to picture on cover of this manual, not silkscreen. Orient the flat side of the transistor toward crystal. (The board was designed for TO-106 type packages, but Apple ended up using 2n4258s with TO-92 packages which have a different configuration).	
2n3904	J-14	video amp	
MPSA13 transistor	J-14	speaker driver	

## 18. Solder In Remaining Connectors

Resistors use normal resistor codes, which are also shown in the table at the beginning of this manual. Use same process as used for resistors and capacitors. Be careful that the power connector is oriented correctly or you will not be able to properly insert the power plug. One end is keyed and this end must be on the side next to the expansion slots.

PART	LOCATION	DESCRIPTION	COMPLETE
Power	K-1	<b>IMPORTANT: orient correctly or power plug will not be able to be inserted correctly</b>	
Cassette in/out	K-12, K-13		
Video header	K-14	4 pin header	
Speaker header	A-14	2 pin header	
Video jack	K-14		

## 19. Repeat Check for Power and Ground Shorts

Congratulations, you have finished soldering. Once components are placed into sockets you will no longer see zero resistance between various power supplies.

## 20. Clean PCB of Rosin and Byproducts of Soldering

Clean the back of PCB of excess flux and rosin. I discovered that "Windex" window cleaner did a terrific job removing the by-products from the soldering job. Your mileage may vary. Spray it on the back of the board and scrub with a soft brush that will not scratch the surface of the PCB. Next clean up any remaining residue by running warm water over the back of the board while lightly scrubbing with soft brush. Let dry overnight. Position a fan to blow over the board to make sure that all moisture evaporates.

## 21. Check Board for Solder Bridges and Cold Solder Joints

While the board is drying, you should carefully check your work for bad solder joints and solder bridges.

## Chapter 3 – Make Up Jumper Headers for Memory System

### 1. Jumper Headers for Memory System

Current version kits have headers pre-wired for either 48K or 4K memory, depending upon the kit you ordered. These headers have a more authentic look than the jumper blocks provided in 1st generation kits, but require significant modification for the 48K configuration. I have done the modifications and wiring for you. You only need to install decals and install the covers to complete these jumper blocks. Handle the jumper block covers carefully, as they have been painted black to match original Apple jumper block coloring. If you nick the paint, you can touch up with a plastic compatible flat black paint. If you have a current kit, you can skip to step 3.

Older kits have headers, covers, wires and decals for making up your own jumper blocks. Replacements are available from Digikey. Part numbers are A102AE-ND for base and A106-ND for the cover. The wiring of these blocks is as follows:

#### MEMORY SELECT SOCKETS

##### TOP VIEW

##### PINOUT

(0000-0FFF) 4K "0" BLOCK	1		14	RAM ROW C
(1000-1FFF) 4K "1" BLOCK	2		13	RAM ROW D
(2000-2FFF) 4K "2" BLOCK	3		12	RAM ROW E
(3000-3FFF) 4K "3" BLOCK	4		11	N.C.
(4000-4FFF) 4K "4" BLOCK	5		10	16K "0" BLOCK (0000-3FFF)
(5000-5FFF) 4K "5" BLOCK	6		9	16K "4" BLOCK (4000-7FFF)
(8000-8FFF) 4K "8" BLOCK	7		8	16K "8" BLOCK (8000-BFFF)

##### LOCATIONS D1, E1, F1

Examples:

I have provided 48K of DRAM with the kit, for this configuration wire as follows:

##### Pin to Pin

14	10
13	9
12	8

For a 4K system:

##### Pin to Pin

1	14
2	13
3	12

## 2. Solder Jumper Wires on Headers

When soldering, use as little heat as possible, or the headers will melt. I place a piece of the wirewrap wire with the stripped portion into the slot and solder one end. I will then trim the wire to length and strip the other end. Place the second end into the second slot on the header and solder. Then trim ends of wire off as close to the header as possible. If the cover still fits tightly, then file off any excess with a fine file, making sure that any metal filings do not end up in your work.

## 3. Apply Decals

Put the decals on last, so you don't have to worry about the heat of the soldering iron melting them. The key to decals is to apply the setting solution very lightly with a small brush, just so it settles down onto the surface it is being applied to. It must be properly positioned before applying the decal setting solution, as the solution will melt it onto the surface. Apply too much, and the decal will melt too much and lose its shape. Don't touch the decal once the setting solution is applied, at least until it is dry. You may want to practice with a random set of decals that come be purchased at a local hobby shop.

Decals are applied with the following process.

- 1 Decals adhere best to glossy finishes. For this reason, I have already sprayed the provided header covers with a gloss finish.
- 2 Cut out decal. Trimming as close as you feel comfortable to the artwork. Leaving less "flash" will result in a better finish.
- 3 Float the trimmed decal in a small bowl of plain water. Wait until the decal slides off of the backing paper. Then wait another minute. The glue that holds the decal to the paper should be washed off. A decal setting solution is used to "melt" the decal onto the component.
- 4 Use the small tweezers to position the decal on the component.
- 5 Use the edge of a paper towel to wick away as much water as possible.
- 6 Position decal with a toothpick.
- 7 Use a small modelers brush to dab a small amount of decal setting solution around the edges of the decal. The setting solution should wick under the rest of the decal and cause it to melt onto the surface of the component. If you use too much setting solution, you may melt the decal and disturb the finish, so use in moderation.
- 8 If you want a matt finish, wait for the setting solution to dry and then spray the header cap with Testors dull coat to seal the decal to the component. For a glossy finish, use gloss coat.

## **Chapter 4 – Stuff Board**

### **1. Stuff the Board**

Stuff only bank C of DRAM, leaving banks D and E of Ram empty. Also leave ROM sockets empty until later. ROMs are not needed to run the video system, and leaving them out will not harm the board. You should bring up the video system first, which is the most complicated portion of the board.

A few IC's may be replacement parts, with different ID's than the original. All IC's except the processor and the character ROM are placed with pin one toward the bottom of the board. The processor has pin "one" to the right and the character rom has pin "one" to the left. When reading the labeling on a chip, pin one is almost always on the bottom left corner. Refer to parts list, list of socket locations, and scan of my first prototype included on the cover this guide, if you are unsure about placement and orientation of components.

ICs will be easier to insert, if the legs are bent to a angle that precisely aligns with the sockets. To do this, place the IC on it's side on a hard flat surface. One set of pins will be on the surface and pointed towards you. Keeping the IC's legs held firmly down, carefully roll the chip toward you to slightly bend the chip leads just a bit and then repeat with the process with the chip flipped to it's other side. Check for fit against socket and repeat accordingly.

When stuffing chips into sockets, be careful that pins are not inadvertently bent underneath the chip, instead of going into the socket. If you do bend a pin, they can be usually be straightened with a small pliers, if you do it carefully. Pins will usually break, right where they connect with the chip case, so do not bend the pin any more than necessary, especially at the joint, where it mates with the case.

### **2. Review PCB Assembly**

Check for correct component placement, seating and orientation. Check the back of the PCB a second time for solder bridges or cold solder joints.

## **Chapter 5 – Bring Up**

### **1. Initial Power Up**

Connect a power supply. Upon initial power up, immediately feel around the board for hot chips. If any chips are hot, power down immediately and check for solder bridges on circuits connected to that chip. Check +5, -5, +12 and -12 volt power supplies for correct voltage.

### **2. Check for Video Output**

Connect the composite video cable to the monitor. Turn on the monitor and let it warm up. Then turn on the power supply to the replica. If you get no video or bad video, you are going to have to go into troubleshooting mode. First check cabling and adjust horizontal and vertical hold on monitor. Also adjust 200 ohm resistor on motherboard. If assembled and operating correctly, you should be able to see a stable video display of random text characters.

### **3. Power Down and Insert ROMs Into Sockets**

Now power up. Short pin 3 of keyboard to ground to reset the replica. At this point you should get a prompt on the display. Remember that rev0 Apple II's have no reset circuitry, so you must manually reset your machine in order to get a prompt.

### **4. Now Connect an Apple II Compatible Keyboard**

At this point, you should be able to enter and run programs.

### **5. Continue Checkout at Your Own Pace**

Checkout the rest of the systems by connecting and exercising peripherals.

- Rest of memory
- Slots
- Game port
- Speaker port
- Cassette I/O ports

## **Chapter 6 – Troubleshooting and Help**

The complexity of the memory and video systems can make troubleshooting an Apple II a bit involved. A good job of soldering the components into place should eliminate most if not all trouble. First step, in case of trouble, should be to check for bad solder joints or bridges. In fact, except for some initial issues with bad or incorrect components, which I have corrected in the kits I am providing to you, I have had no trouble bringing up my initial prototype.

There are several Apple II repair manuals available that may be of help. These may be found in online auctions or online booksellers.

Refer to my Apple II repair page at [www.willegal.net](http://www.willegal.net) for some troubleshooting hints. Note, that with a properly constructed replica, you should have no trouble with intermittent sockets that are constant issues with vintage Apple IIs.

Feel free to send email to: [mike@willegal.net](mailto:mike@willegal.net) if you run into difficulties