Apple 1 VMA Signal Activation
February 13, 2015

The VMA signal is a signal needed for the 6800 microcomputer but is not used on the 6502, the pin is a no-connect on the 6502 and a shorting connection area is provided on the Apple 1 board to short it to +5V. The signal is of interest because it is available on the I/O connector. The signal goes to the NAND gate at B1 where it is combined with refresh and the result goes to the 74514 decoder disable pins 18 and 191 disabling all the decoded addresses whenever there is either a refresh or the VMA is low. The signal also goes to a chip select pin on the 6820 PIA which is redundant because the 6820 is disabled whenever the decoder is disabled. The VMA signal can be restored to availability again by replacing the short at approximately A8 labelled 6502 with a pull up resistor. A 2200 ohm resistor in parallel with a 100 pf capacitor should be used, the capacitor controls some crosstalk that has been observed on the signal. When small surface mount parts such as the 0402 parts shown in Figure 1 are used the alteration is nearly invisible.

An alternate implementation is to remove the short at the location and put the added parts under the board between pins 5 and 8 of the 6502 at location A7 or pins 12 and 14 of the DIP at location B1. The capacitor must be connected to the +5V rail instead of GND.

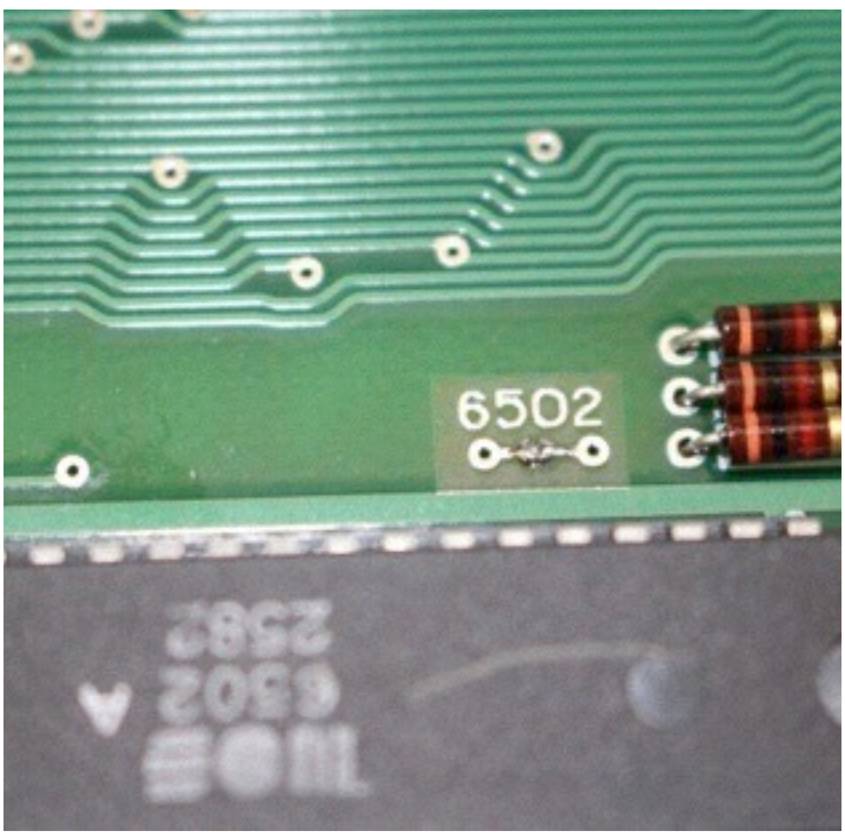

Figure 1

This modification makes available a signal on the peripheral connector that can be used to disable anything accessed using the decoder on a cycle by cycle basis. This includes the 6820 PIA, all on board RAM, the boot ROM and any peripheral using the R, S, or T signals. This permits a peripheral to perform hardware substitution for any of those functions.

Apple 1 Expansion Board
May 31, 2015

The Apple 1 Expansion Board can expand the Apple 1 peripheral card capacity to up to 4 additional board and additional expansion boards can be added to provide for even more peripheral boards.

Figure 1 shows the Expansion Board, the board plugs into the edge connector on the side of the Apple 1 as seen in Figure 2. The connectors on the expansion chassis match the Apple 1 connector so the ACI can be moved to the expansion chassis. Also a card can be plugged on the end of the expansion chassis and even an additional expansion chassis can be plugged on the end as shown in Figure 3.

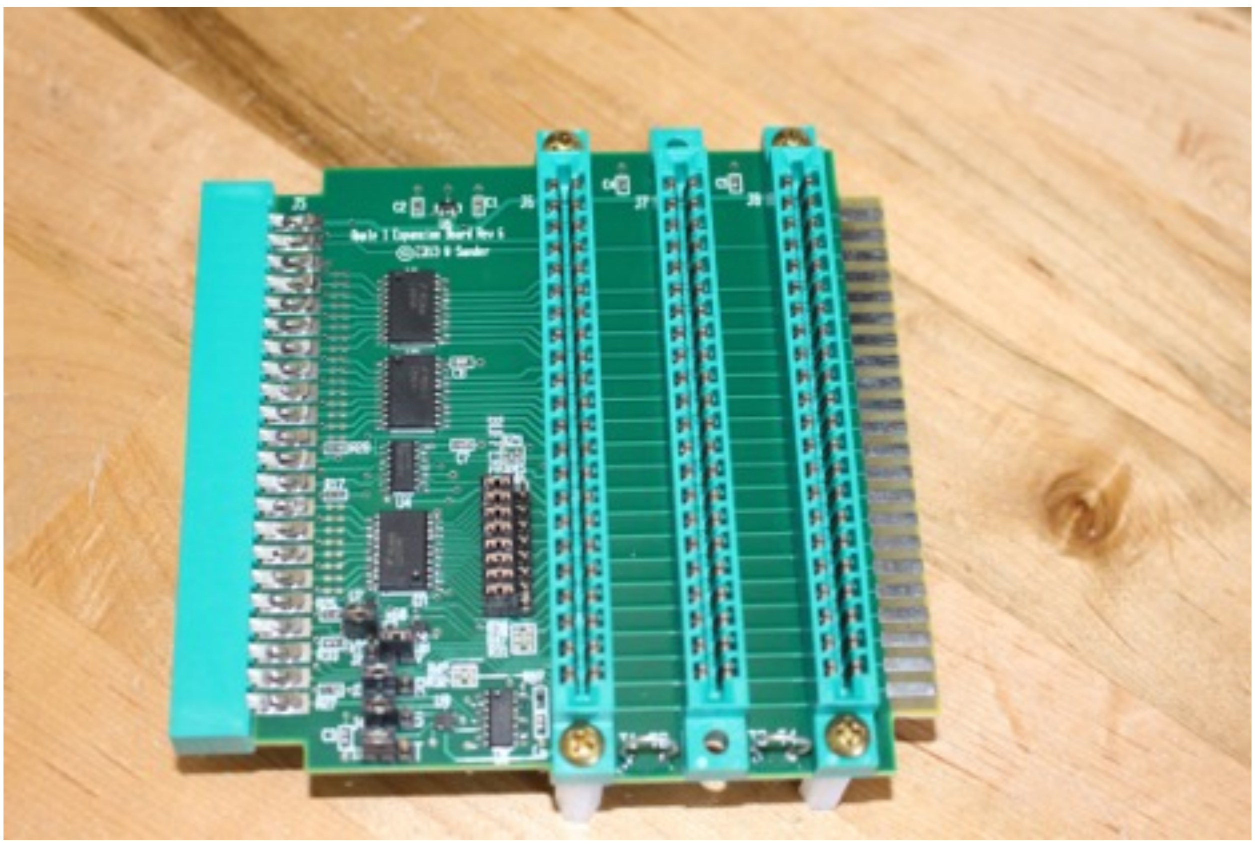

Figure 1

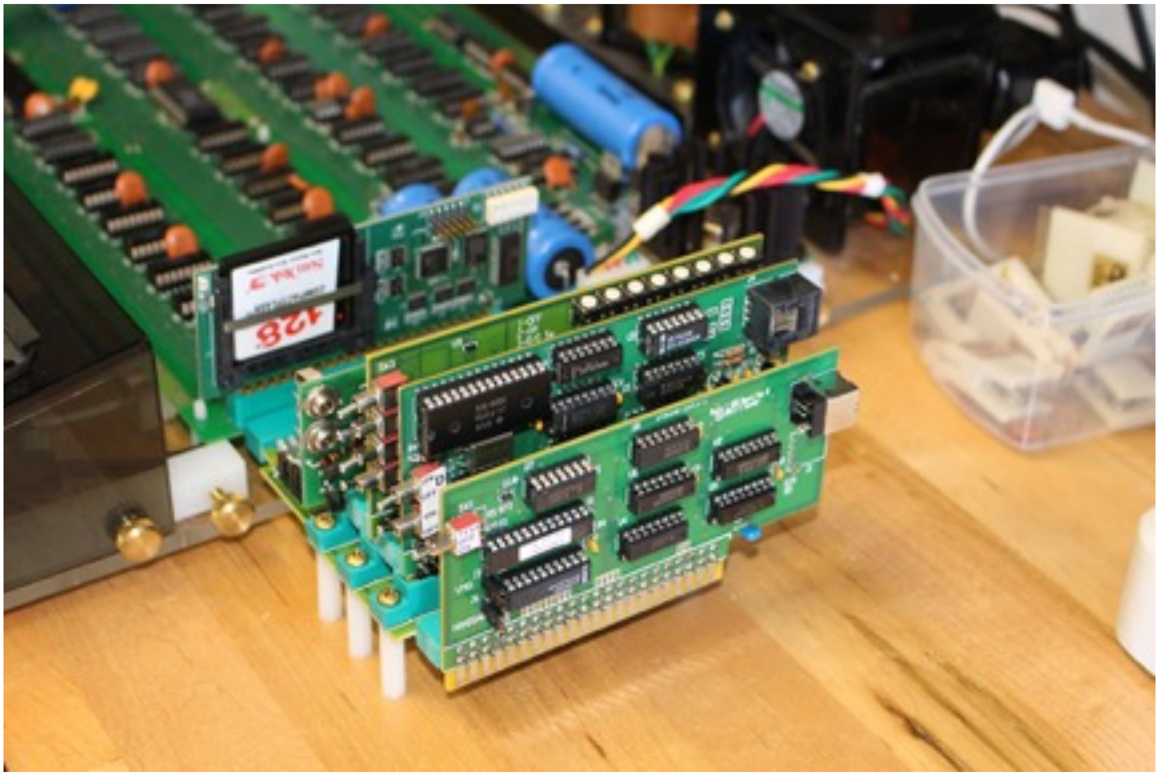

Figure 2

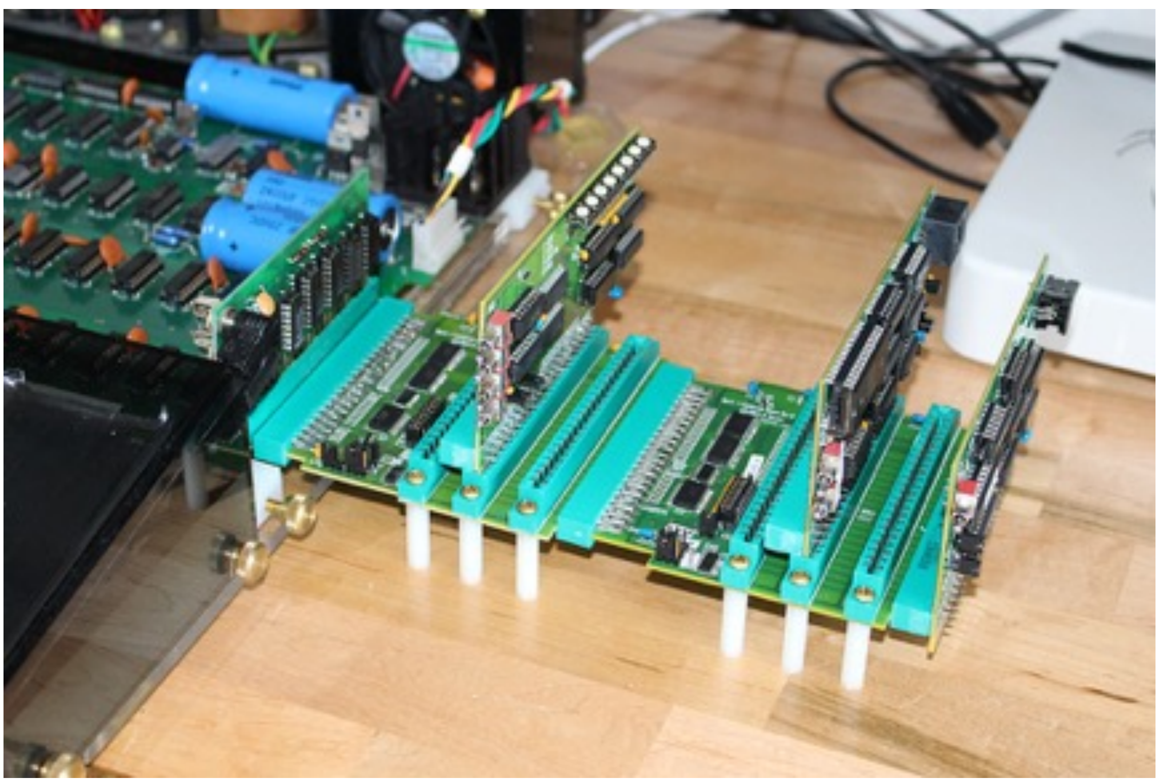

Figure 3

The Apple 1 is a fairly noisy environment because of the large size of the board and being only 2 layers. This makes designing peripheral cards challenging. Figure 4 shows more detail on setting the configuration options. This expansion board design provides buffering on the board so that the signals are restored before use by the peripheral cards. Buffering the address lines is very straight forward but buffering the Data lines is more complicated. There are jumpers on the board for activating the buffer if a board using R, S, or T lines are on the Expansion board. If more than one Expansion board is used then any downstream boards using buffering need to be active but upstream boards need to be inactive. The VMA line has active isolation so that upstream boards are not a problem but downstream Expansion boards need to be activated. Peripheral boards that decode their own address cannot be buffered. The expansion boards have the option to bypass the data buffer using an 8 element jumper. There is also a jumper that connects the VMA line so that it can be left unconnected if using the Expansion Board with an unmodified Apple 1 board.

There are also options for the clock line, Ø0, Ø1 and Ø2 that can be chosen by resistor options. Ø0 and Ø2 can be buffered or unbuffered and Ø1 can be buffered, unbuffered or Ø2 inverted. Each choice provides slight timing differences and buffering reduces noise risk.

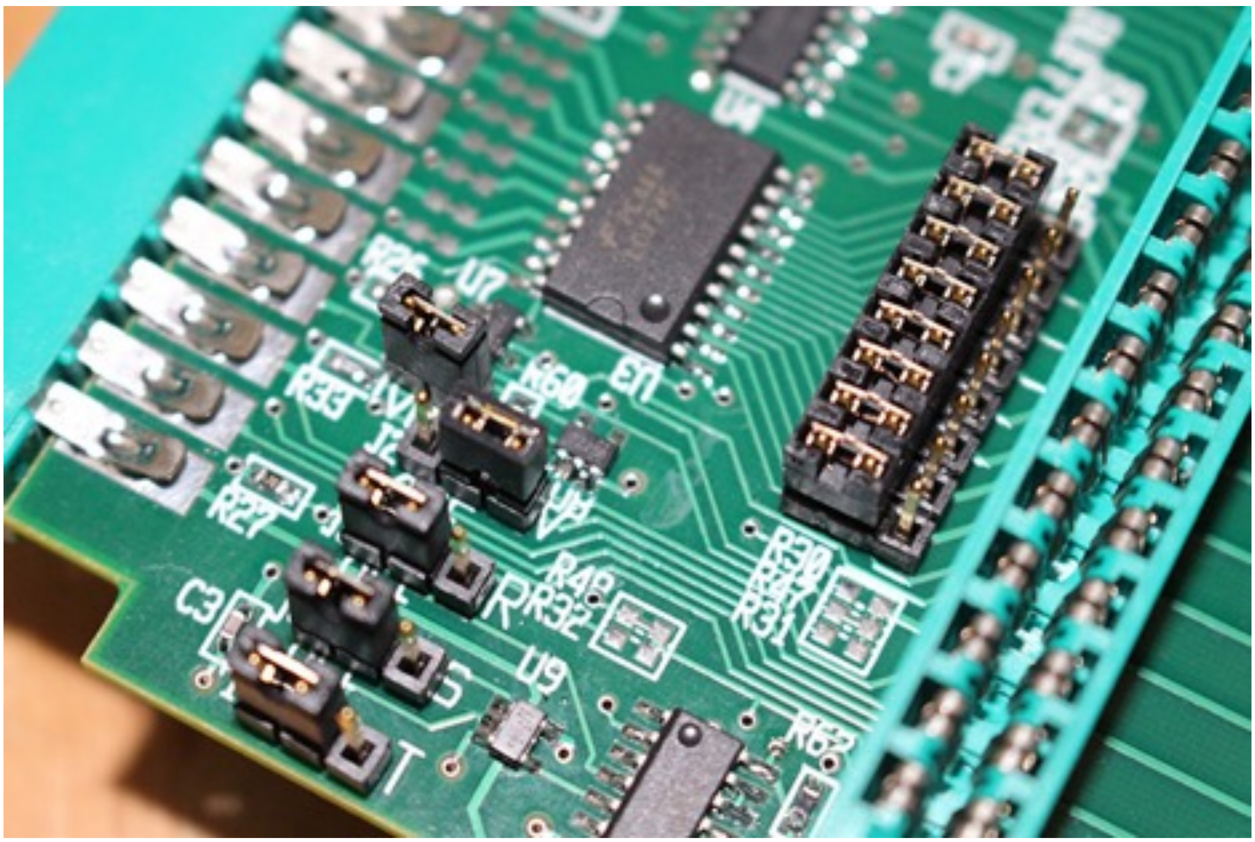

Figure 4

Using a CFFA1 Board

The CFFA1 Board should be installed in the on board socket of the Apple 1 and the ACI board moved to the Expansion Board as shown in Figure 5. If the CFFA1 were placed on the Expansion Board then data buffering could not be used since the CFFA1 maps directly to the data bus and data buffering is needed to add many boards.

Figure 5

For the ACI to function properly then the Expansion board jumpers should be configured as shown in Figure 6.

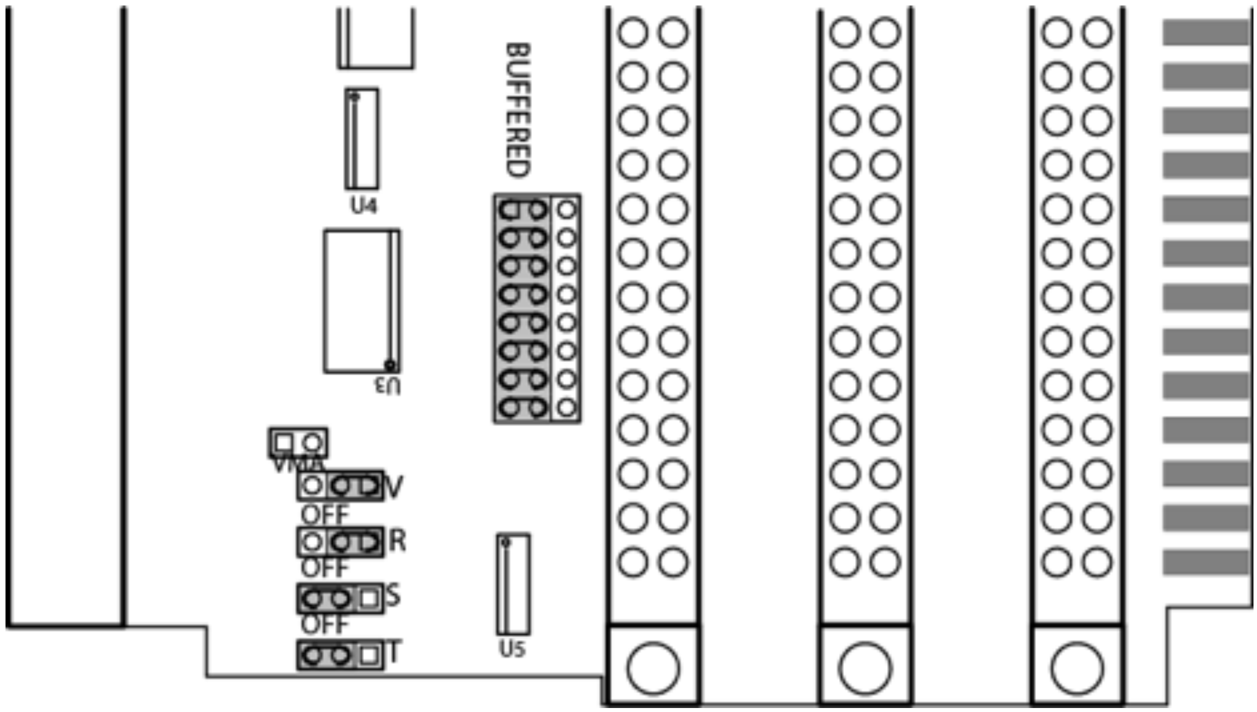

Figure 6

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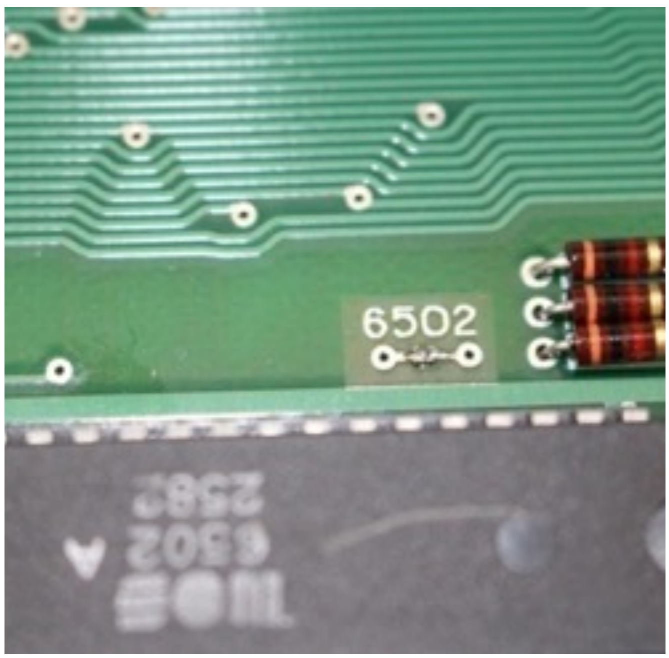


Figure 1

This modification makes available a signal on the peripheral connector that can be used to disable anything accessed using the decoder on a cycle by cycle basis. This includes the 6820 PIA, all on board RAM, the boot ROM and any peripheral using the R, S, or T signals. This permits a peripheral to perform hardware substitution for any of those functions.

For testing the Expansion Board the Apple 1 or Clone is assumed to contain 8K of RAM mapped into the $0XXX and $EXXX space. The VMA Mod is not required for this testing. If the board has been modified for additional memory then that space should be avoided in the memory testing below. The Apple 1 ACI Board should be plugged into the on-board PCB Connector.

Configure the Expansion Board as shown in Figure 7.

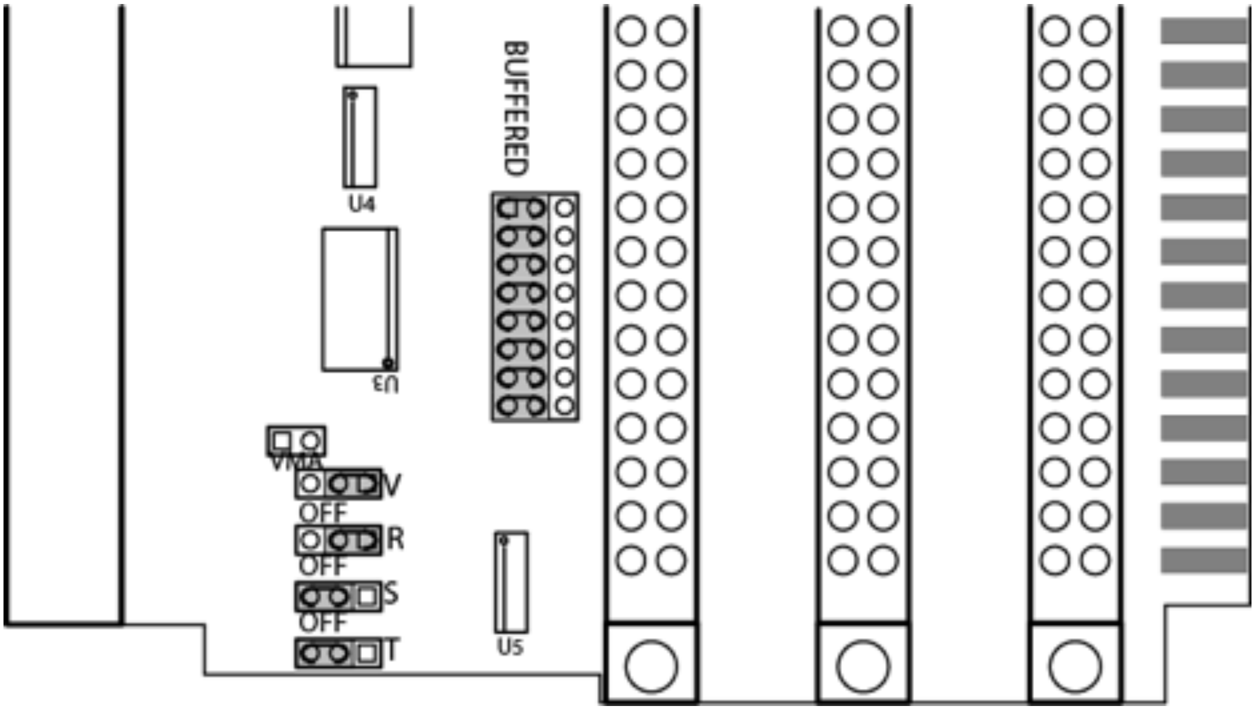


Figure 7

With no boards plugged into the Expansion Board Power ON and make sure the computer resets.

Reset \

Power OFF and install the ACI board in one of the Expansion Board slots

Power ON and Reset

Reset \
Type: `C100.C104` Read $C100 to $C104

`C100: A9 AA 20 EF FF` Result should match this.

If no FRAM board is available then verify that the ACI can Read and Write media.

Configure a known good FRAM board as shown in Figure 8

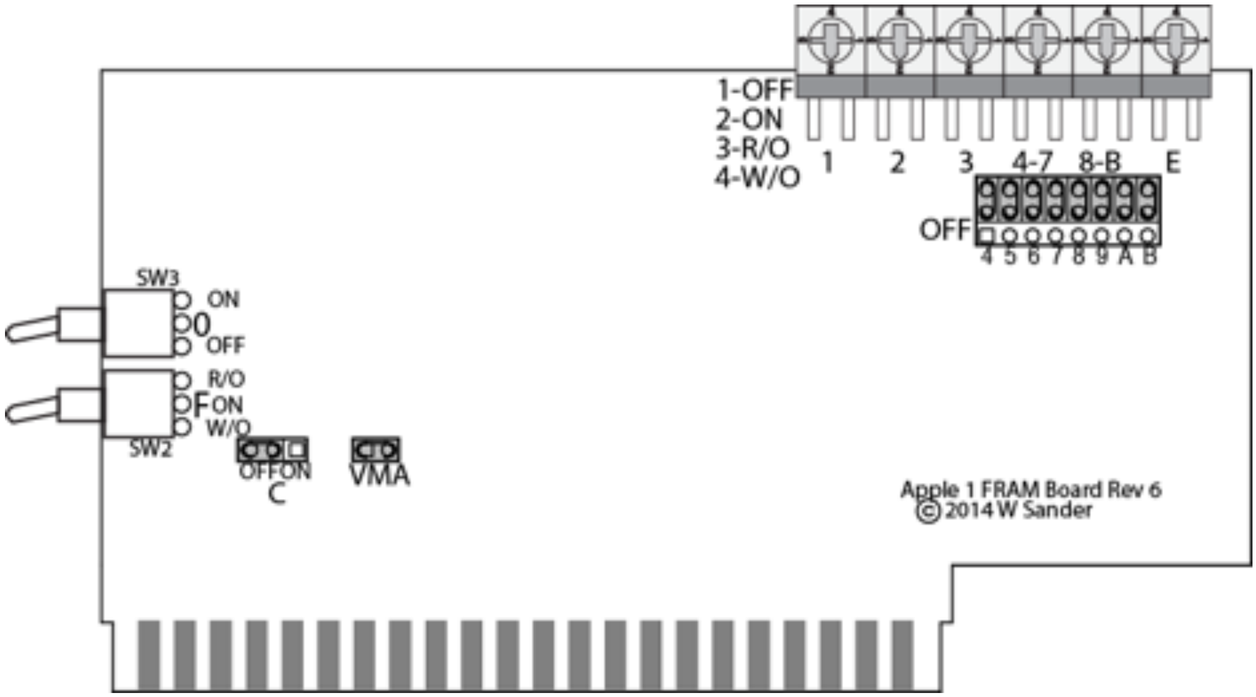


Figure 8

Power off and install the FRAM board in one of the available Expansion Board slots.

Apply power and make sure the computer still resets
Reset \

To test for basic operation:

Type:	`1000:AA`	Write $AA to $1000
	`1000: ??`	Read undefined at $1000
Type:	`1000`	Read $1000
	`1000: AA`	$1000 = $AA
Type:	`1000:55`	Write $55 to $1000
	`1000: AA`	$1000 Was $AA
Type:	`1000`	Read $1000
	`1000: 55`	$1000 = $55

This verifies that the FRAM can read and write all data bits.

The next test uses a RAM test program from Mike Willegal. This program is documented on his web site "www.willegal.net" as "6502 Memory Test".

Apply the following test sequence.

Memory Test

Load the file “Memory Test” from an iPod or equivalent using the ACI Board. The program will load into the Apple 1 on-board memory at $280 to $3A1.

Type:	`C100R`	Run the ACI at $C100
	`C100: A9*`	
Type:	`280.3A1R`	Load Range
	`\`	Load Complete
Type:	`0:00 10 00 C0`	Sets the test range from $1000 to $BFFF
	`0000: ??`	Read undefined at $0000
Type:	`280R`	Run at $280
	`0280: A9PASS 01`	Test Completed 1st Pass
	`PASS 02`	Test Completed 2nd Pass
	`PASS 03`	Test Completed 3rd Pass
	`PASS 04`	Test Completed 4th Pass
Reset	`\`	

End of Memory Test

Power OFF and move the FRAM board to the open slot on the Expansion Board

Power ON, Reset and repeat the Memory Test section.

Power OFF and exchange the positions of the ACI Board and FRAM Board.

Power ON, Reset and repeat the Memory Test section.

Power OFF and reconfigure the jumpers on the Expansion Board as shown in Figure 9.

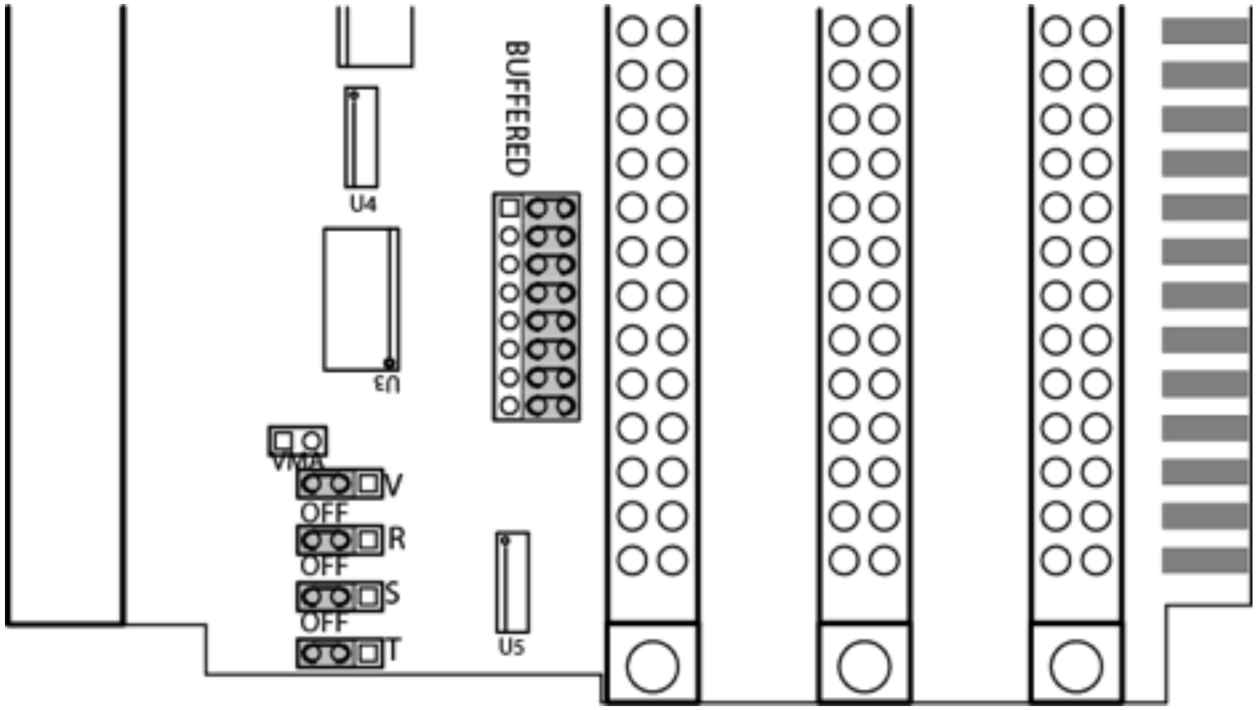
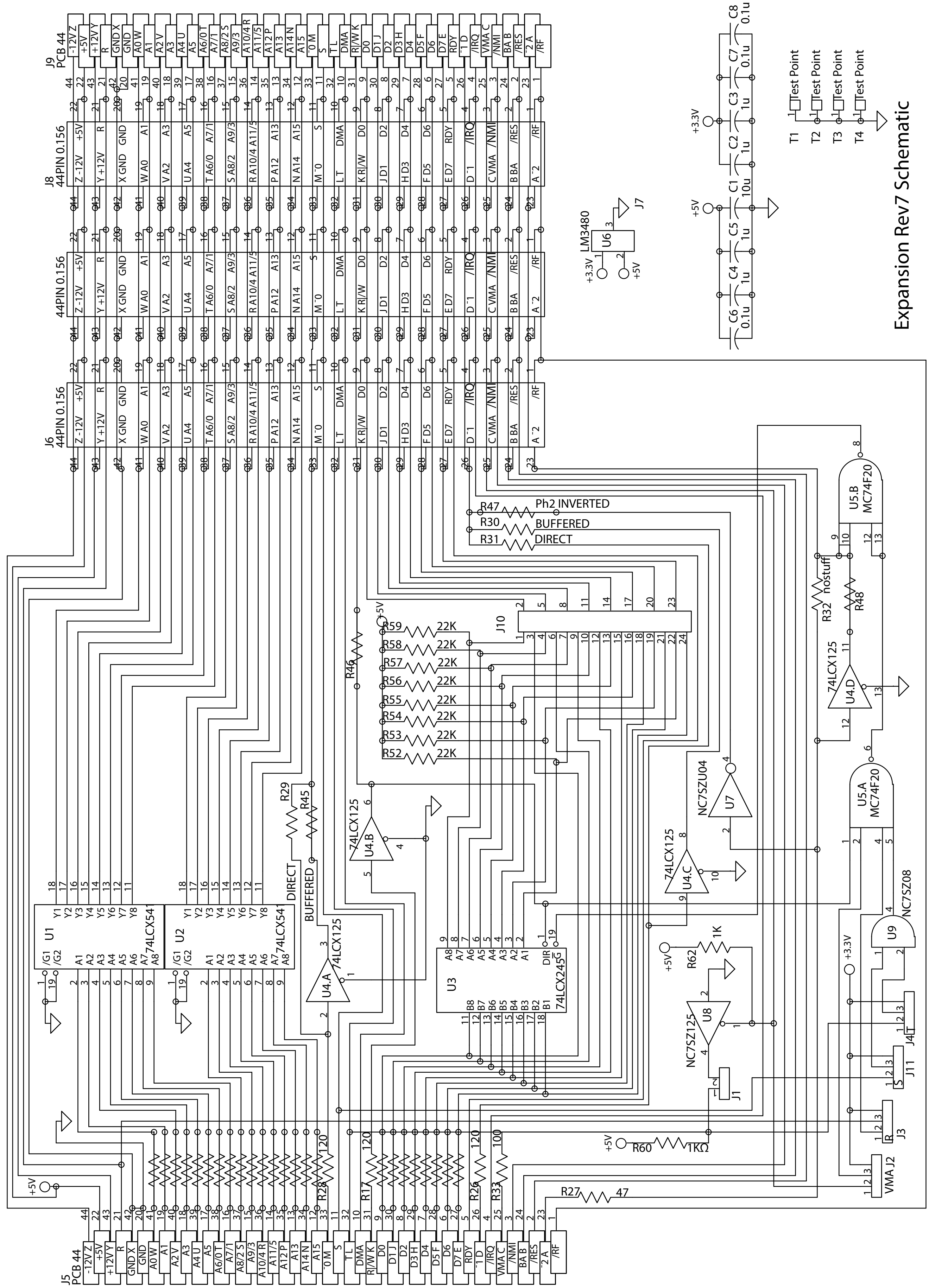
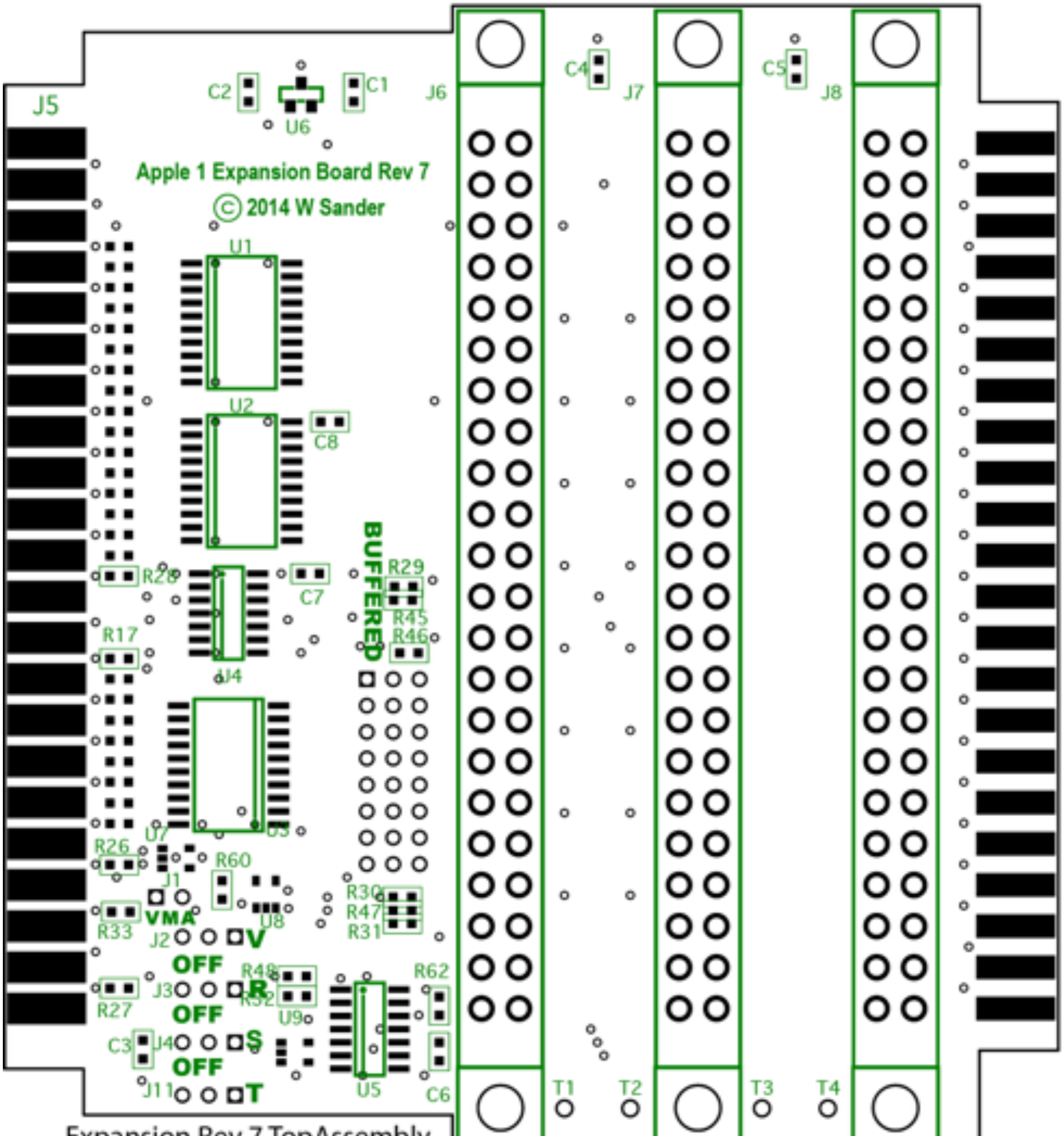


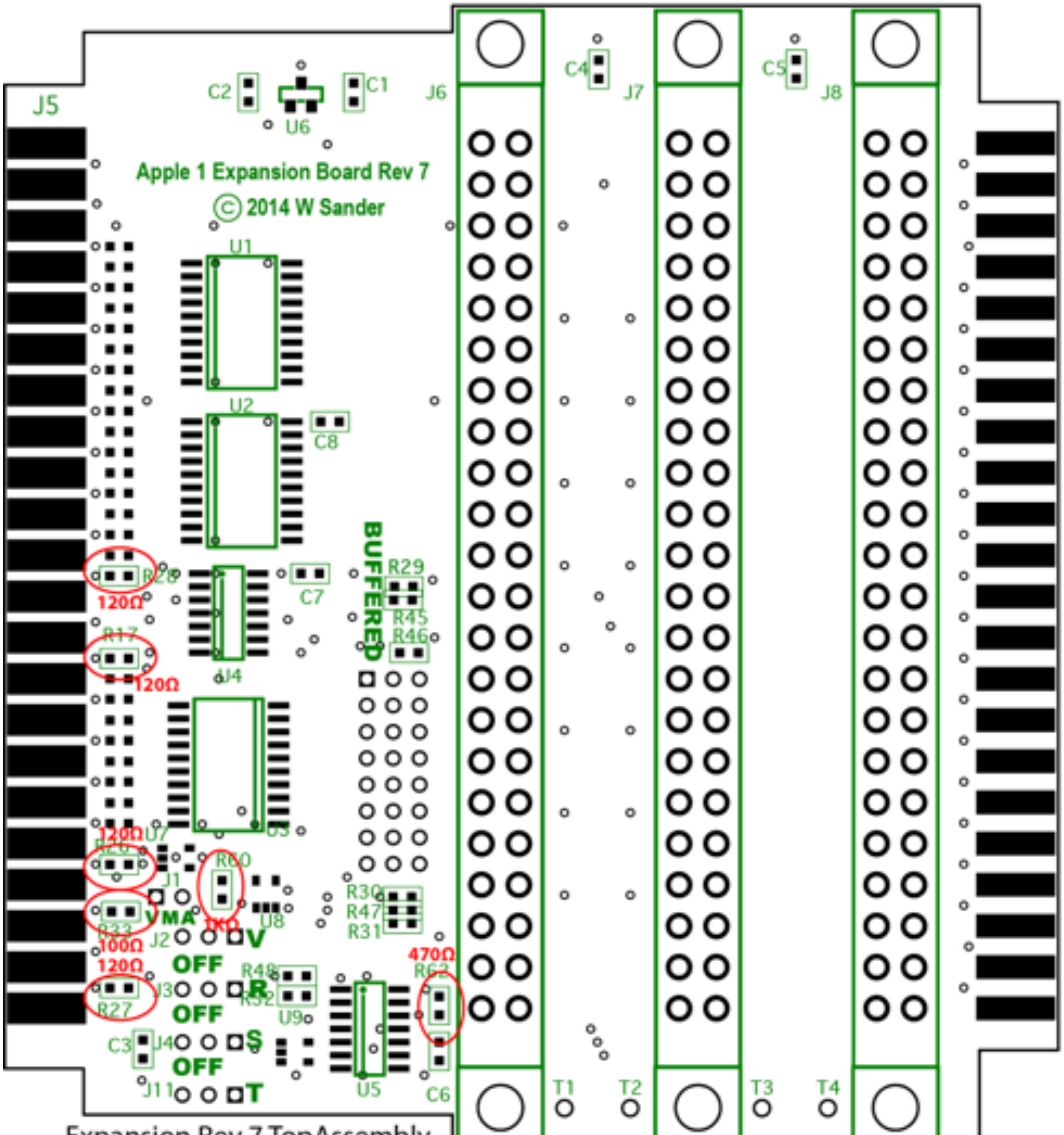
Figure 9

Power ON, Reset and repeat the Memory Test section.


Expansion Rev7 Schematic

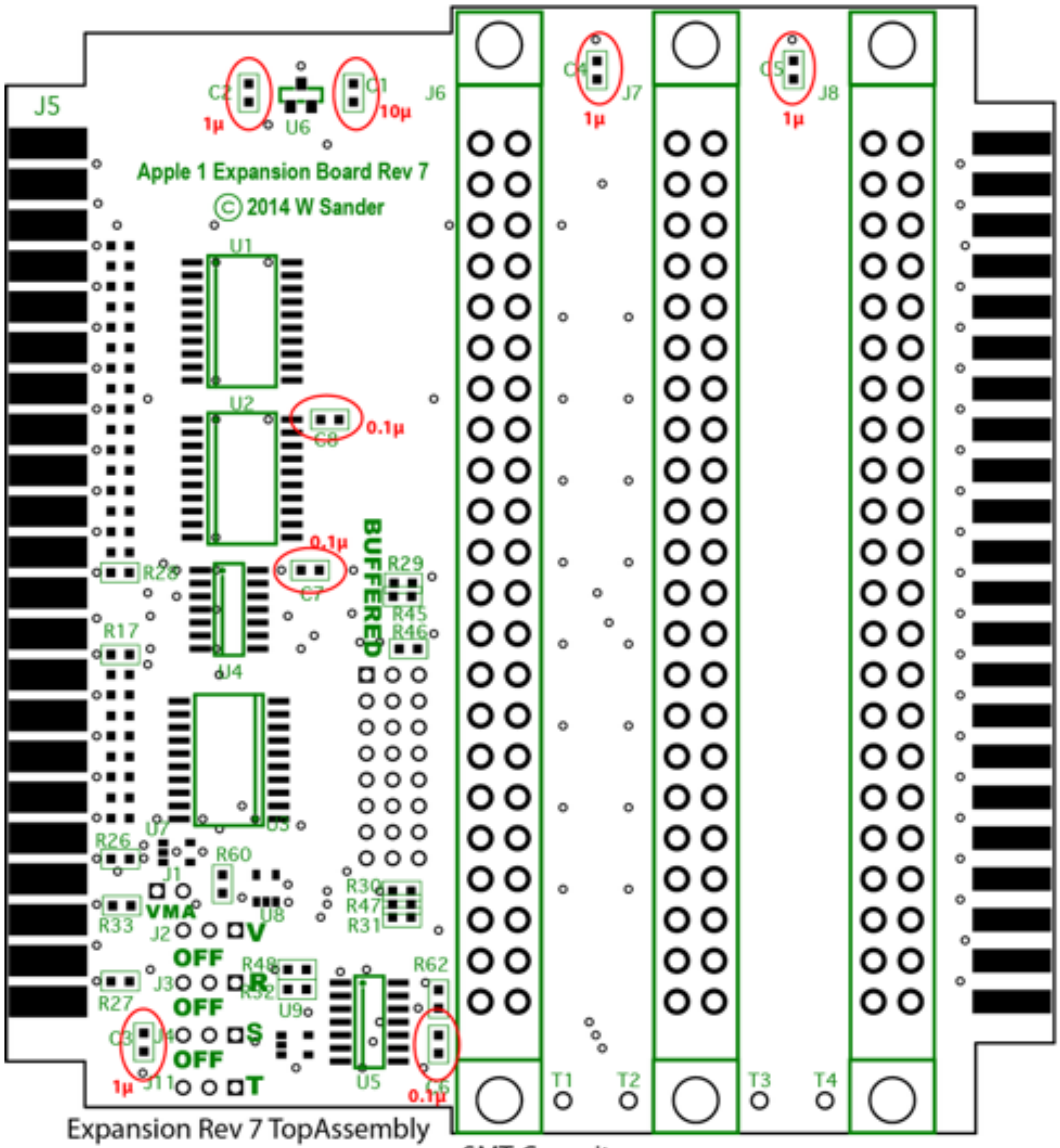


Expansion Rev 7 TopAssembly



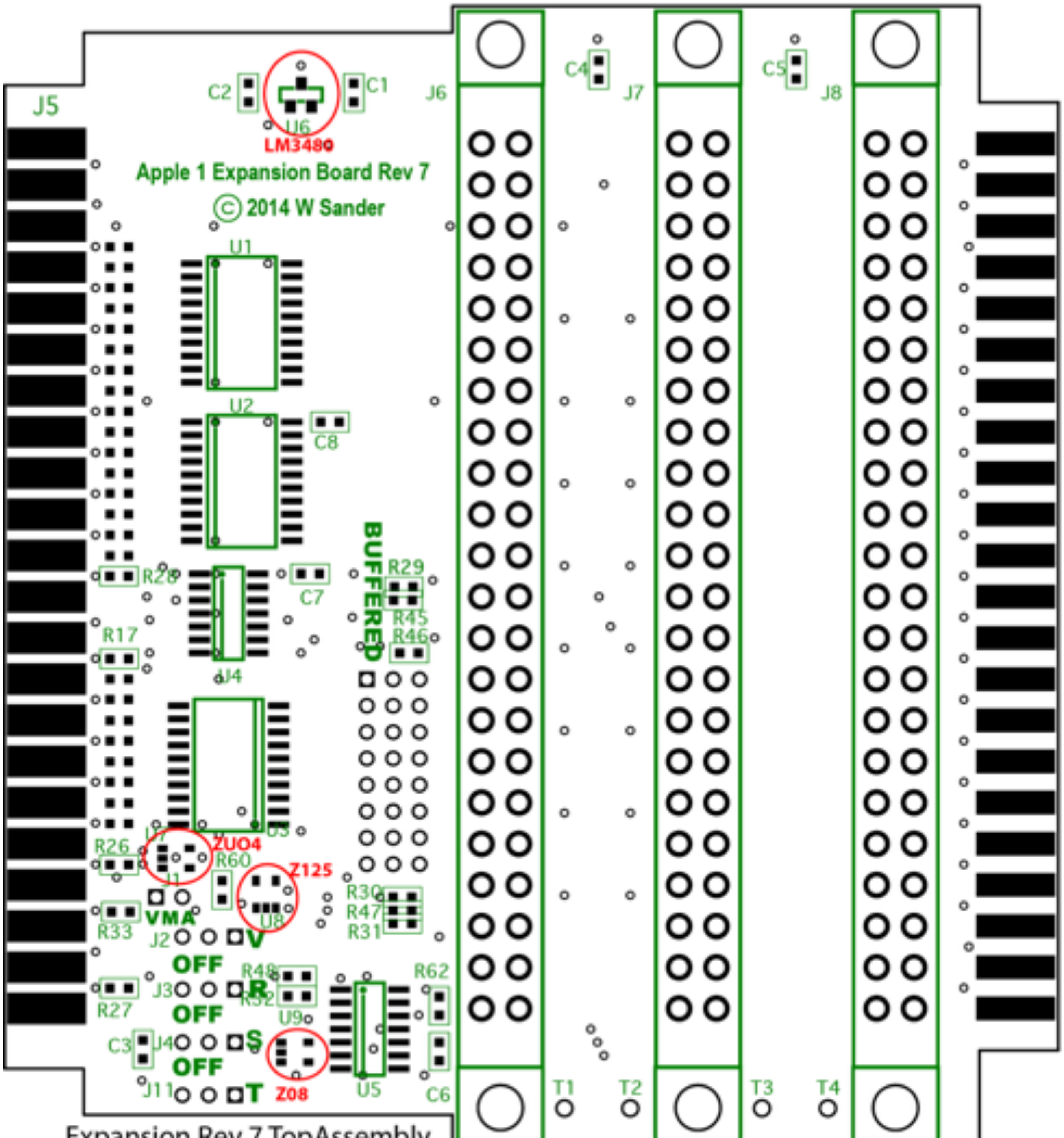
Expansion Rev 7 TopAssembly

SMT Resistors



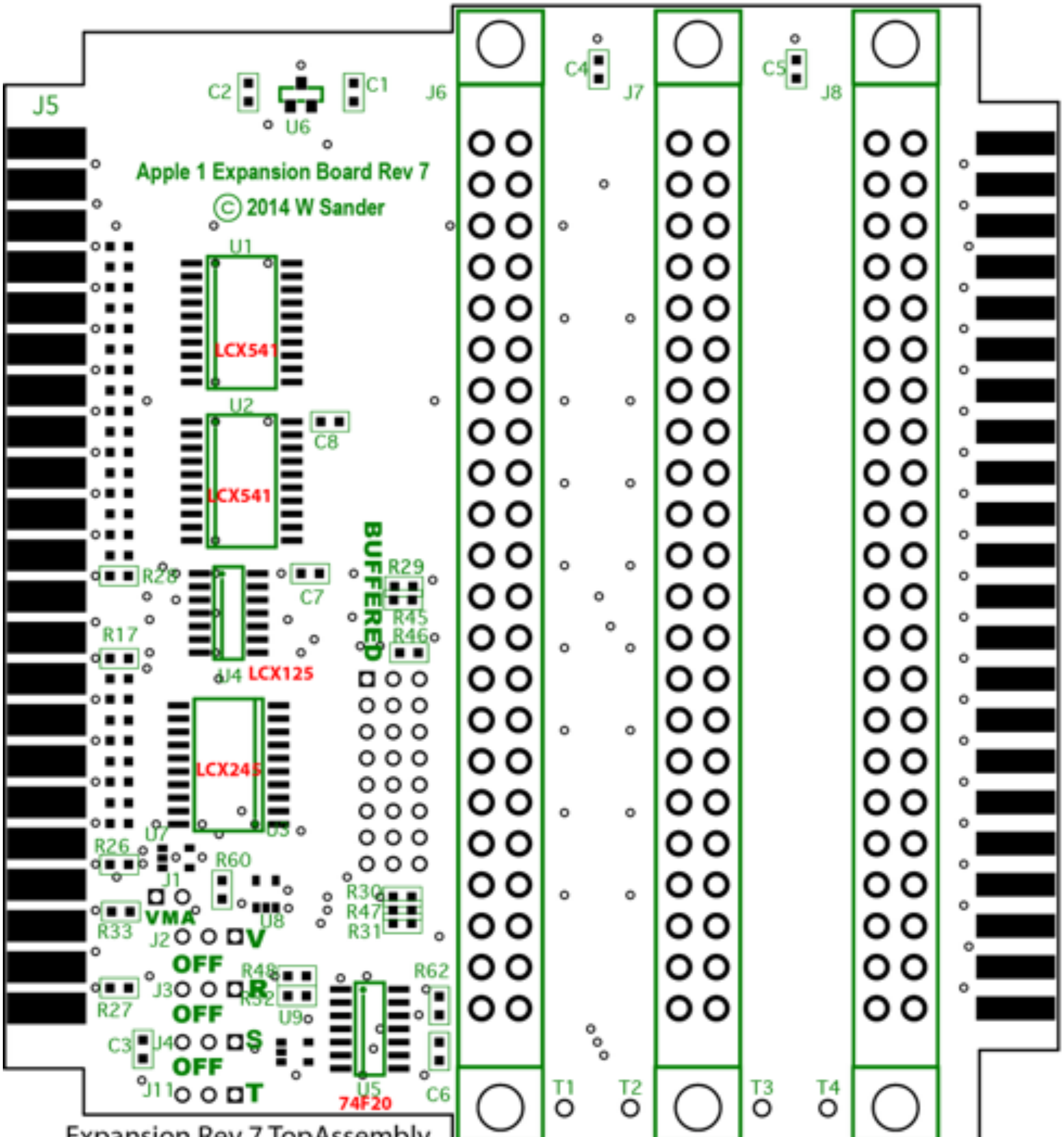
Expansion Rev 7 TopAssembly

SMT Capacitors



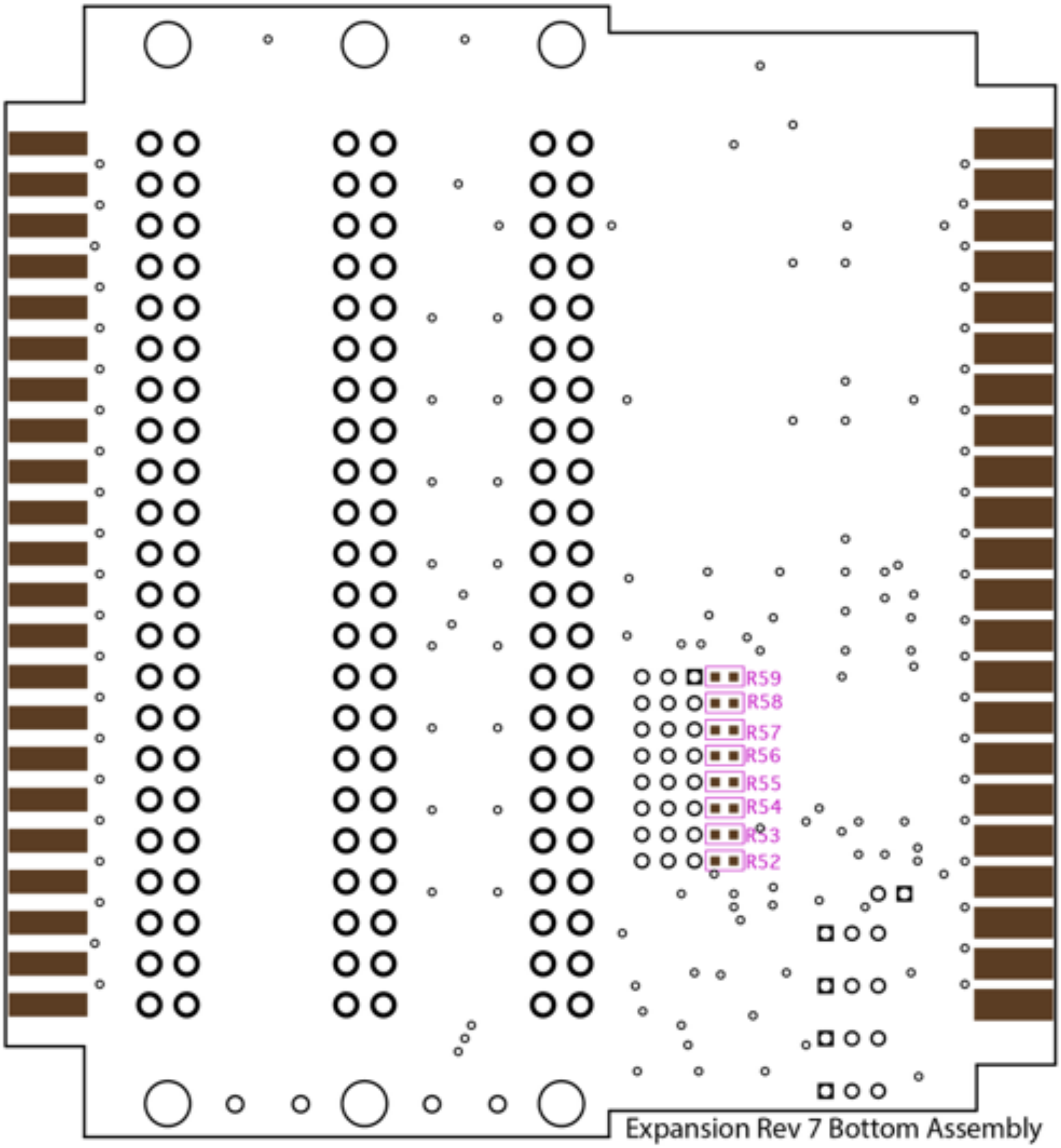
Expansion Rev 7 TopAssembly

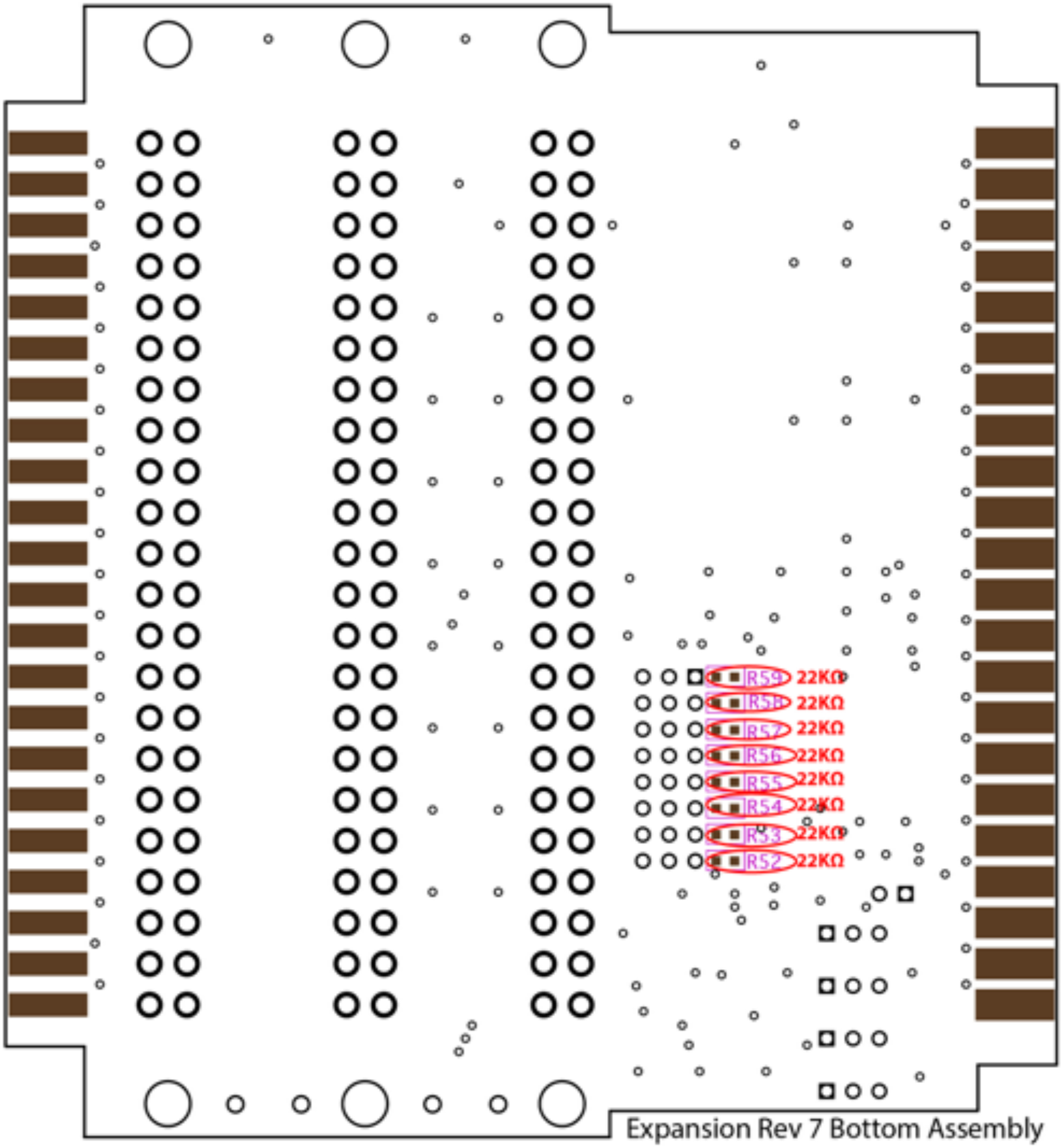
SOT ICs



Expansion Rev 7 TopAssembly

ICs


R59
R58
R57
R56
R55
R54
R53
R52
Expansion Rev 7 Bottom Assembly



SMT Resistors

Expansion Board Rev 7 Parts List

Designator	Part	Value	Manufacturer	Mfg Part No.	Description
C1	CAPACITOR	10u	TDK	C1608X5R1A106M080AC	0603 CAPACITOR
C2	CAPACITOR	1u	TDK	C1608X7R1A105K080AC	0603 CAPACITOR
C3	CAPACITOR	1u	TDK	C1608X7R1A105K080AC	0603 CAPACITOR
C4	CAPACITOR	1u	TDK	C1608X7R1A105K080AC	0603 CAPACITOR
C5	CAPACITOR	1u	TDK	C1608X7R1A105K080AC	0603 CAPACITOR
C6	CAPACITOR	0.1u	TDK	C1608X7R1E104K080AA	0603 CAPACITOR
C7	CAPACITOR	0.1u	TDK	C1608X7R1E104K080AA	0603 CAPACITOR
C8	CAPACITOR	0.1u	TDK	C1608X7R1E104K080AA	0603 CAPACITOR
J1	HEADER	1X2	SAMTEC	TSW-102-07-L-S	1X2 0.1 In Header
J2	HEADER	1X3	SAMTEC	TSW-103-07-L-S	1X3 0.1 In Header
J3	HEADER	1X3	SAMTEC	TSW-103-07-L-S	1X3 0.1 In Header
J4	HEADER	1X3	SAMTEC	TSW-103-07-L-S	1X3 0.1 In Header
J5	Card Connector	44 PIN 0.156	EDAC	305-044-555-201	44 Pin .156 Extender
J6	Card Connector	44 PIN 0.156	EDAC	305-044-520-202	44-Pin .156 Connector
J7	Card Connector	44 PIN 0.156	EDAC	305-044-520-202	44-Pin .156 Connector
J8	Card Connector	44 PIN 0.156	EDAC	305-044-520-202	44-Pin .156 Connector
J10	HEADER	3X8	SAMTEC	TSW-108-07-L-T	3X8 0.1 In Header
	Shorting Block	Octal	FCI	69145-216	Octal Shorting Block
J11	Header	1X3	SAMTEC	TSW-103-07-L-S	1X3 0.1 In Header
R17	RESISTOR	120Ω			0603 RESISTOR
R26	RESISTOR	120Ω			0603 RESISTOR
R27	RESISTOR	120Ω			0603 RESISTOR
R28	RESISTOR	120Ω			0603 RESISTOR
R29	RESISTOR	nostuff			0603 RESISTOR
R30	RESISTOR	nostuff			0603 RESISTOR
R31	RESISTOR	nostuff			0603 RESISTOR
R32	RESISTOR	nostuff			0603 RESISTOR
R33	RESISTOR	100Ω			0603 RESISTOR
R45	RESISTOR	nostuff			0603 RESISTOR
R46	RESISTOR	nostuff			0603 RESISTOR
R47	RESISTOR	nostuff			0603 RESISTOR
R48	RESISTOR	nostuff			0603 RESISTOR
R52	RESISTOR	22KΩ			0603 RESISTOR
R53	RESISTOR	22KΩ			0603 RESISTOR
R54	RESISTOR	22KΩ			0603 RESISTOR
R55	RESISTOR	22KΩ			0603 RESISTOR
R56	RESISTOR	22KΩ			0603 RESISTOR
R57	RESISTOR	22KΩ			0603 RESISTOR
R58	RESISTOR	22KΩ			0603 RESISTOR
R59	RESISTOR	22KΩ			0603 RESISTOR
R60	RESISTOR	1KΩ			0603 RESISTOR
R61	RESISTOR	47Ω nostuff			0603 RESISTOR
R62	RESISTOR	470Ω			0603 RESISTOR
T1	Test Point	GND			Test Point
T2	Test Point	GND			Test Point
T3	Test Point	GND			Test Point
T4	Test Point	GND			Test Point
U1	74LCX541	Octal Buffer	FAIRCHILD	74LCX541WMX	SOIC 20-PIN
U2	74LCX541	Octal Buffer	FAIRCHILD	74LCX541WMX	SOIC 20-PIN
U3	74LCX245	Octal Bidirectional Buffer	FAIRCHILD	74LCX245WM	SOIC 20-PIN
U4	74LCX125	Quad Tri-State Buffer	ON SEMI	MC74LCX125DG	SOIC 14-PIN
U5	MC74F20	Dual 4-Input NAND	FAIRCHILD	74F20SCX	SOIC 14-PIN
U6	LM3480-3.3	3.3 V LDO	TI	LM3480IM3	SOT23
U7	NC7SZU04M5X	TinyLogic Inverter	FAIRCHILD	NC7SZU04M5X	SOT23-5
U8	NC7SZ125M5X	TinyLogic Tri-State Buffer	FAIRCHILD	NC7SZ125M5X	SOT23-5
U9	NC7SZ08M5X	TinyLogic And Gate	FAIRCHILD	NC7SZ08M5X	SOT23-5

Apple 1 FRAM Board
May 31,2015

The FRAM board uses 2 FM1808B 32KX8 FRAM memory parts made by Cypress Semiconductor that are a non-volatile static rams using a ferrous memory cell. These memory cells do not have the fatigue problems of other memories and can be used safely like a standard SRAM. This board can use a mod to the Apple 1 where the VMA line short to +5 is replaced by a resistor and capacitor so the VMA can be become active. Using this modification any onboard memory including the Boot PROM can be disabled on a cycle by cycle basis by pulling down the VMA line and the FRAM board function can be enabled in its place. The board has no on board firmware and no additional software is needed for the boards operation. The board has switches to manage the memory by 4K blocks with the F, and 0 blocks managed by toggle switches and the 1 through B and E blocks managed by 4 position switches and and jumpers. Figure 1 is a photo of the board showing the switch locations and Figures 2 and 3 show details of the 4 position switches. One 4 position switch is used for the 4-7 spaces and another for the 8-B spaces when the jumpers are in the shown position. The spaces 4, 5, 6, 7, 8, 9, A, and B can be individually disabled by moving the jumper to the OFF position or individually enabled by removal of the jumper using the jumpers below the 4 position switches.

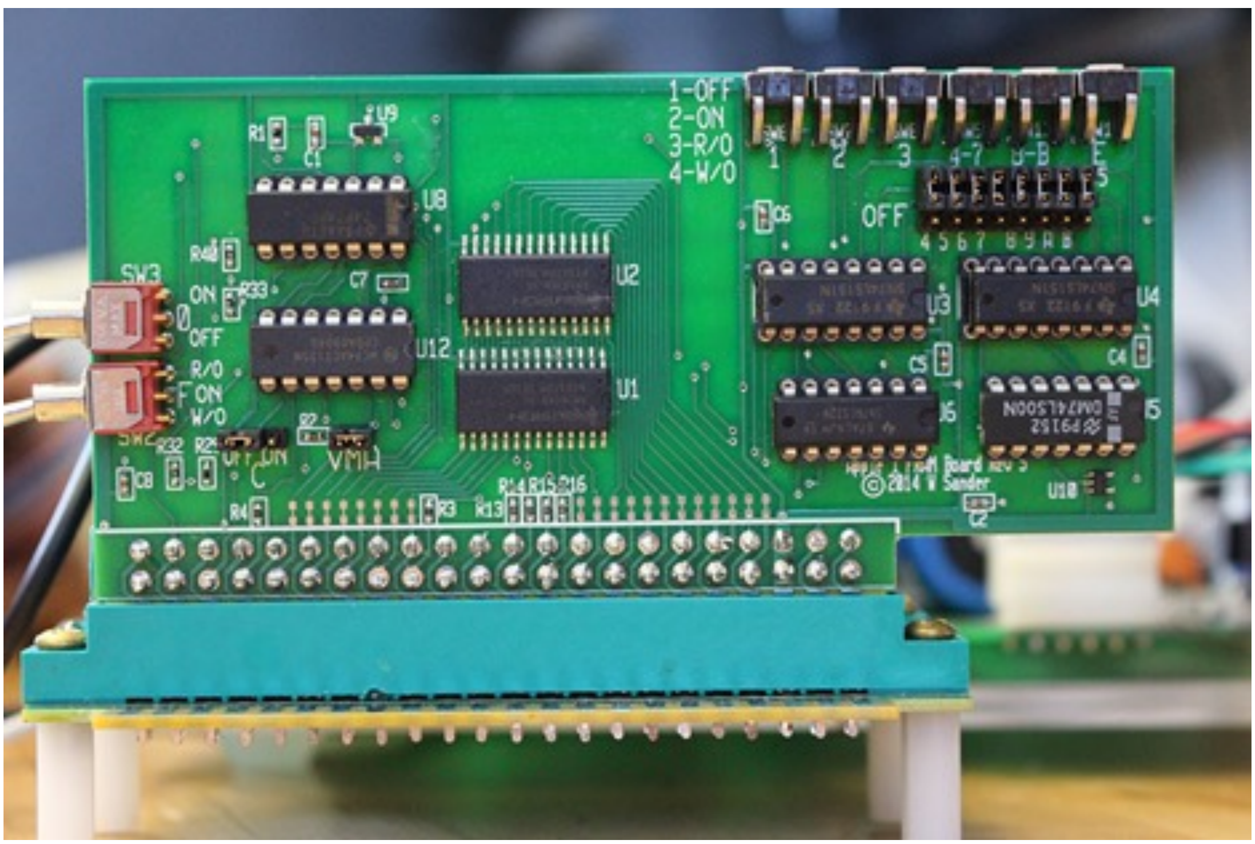


Figure 1

Table 1 shows the function of the 2 toggle switches. Of note is the switch down on switch F where the Read operations are from the on board Apple 1 PROM but the write operations go to the FRAM. This works well because writes to a PROM are not meaningful and the FRAM becomes a Write-Only-Memory. People have joked about WOM's but here is a useful application! This function is only available if the VMA mod has been made.

Switch	Address Range	Up	Middle	Down
0	$0000 to $0FFF	FRAM R/W	NA	Apple 1 RAM
F	$F000 to $FFFF $C000 to $CFFF*	FRAM Read Only	FRAM R/W	Read from PROM Write to FRAM
* $C000 to $CFFF active only if jumper J4 is in the Right Most position				

Table 1 Toggle Switches

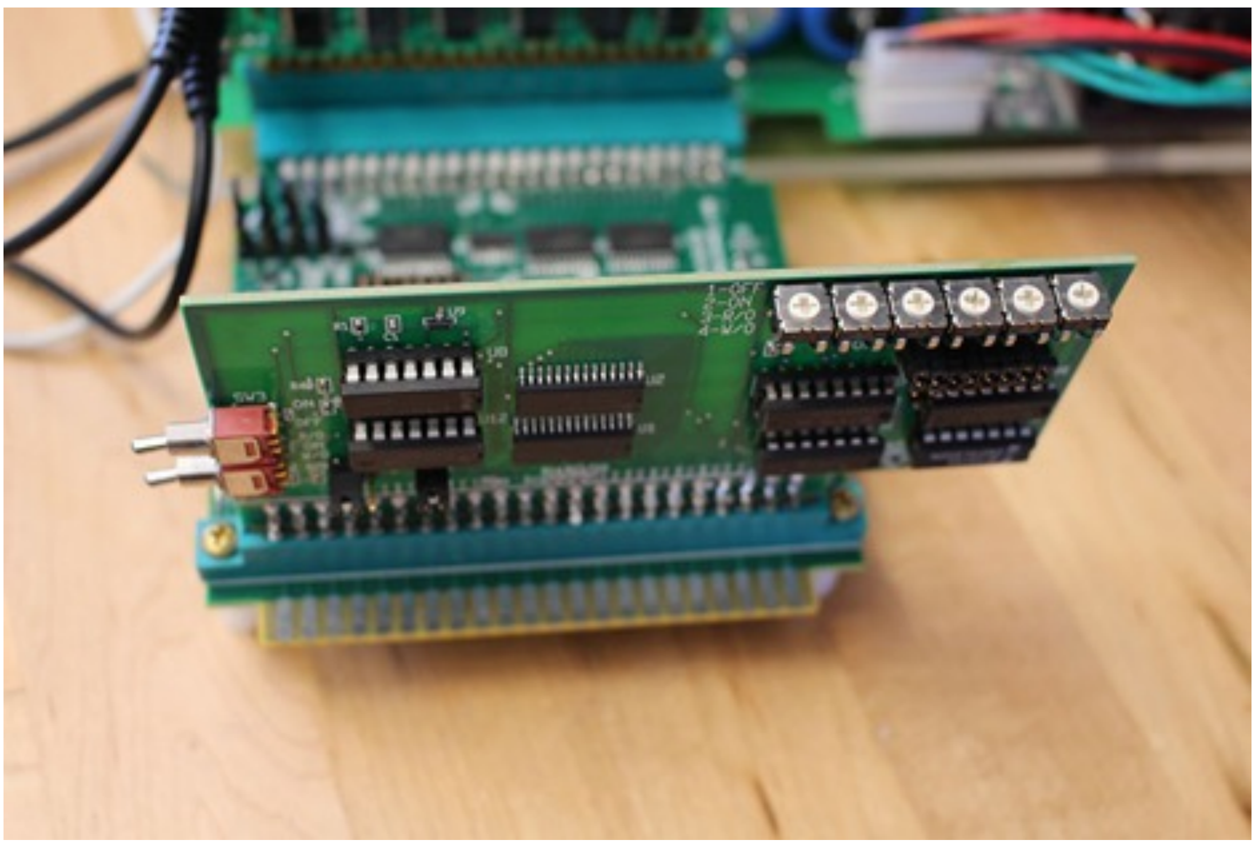


Figure 2

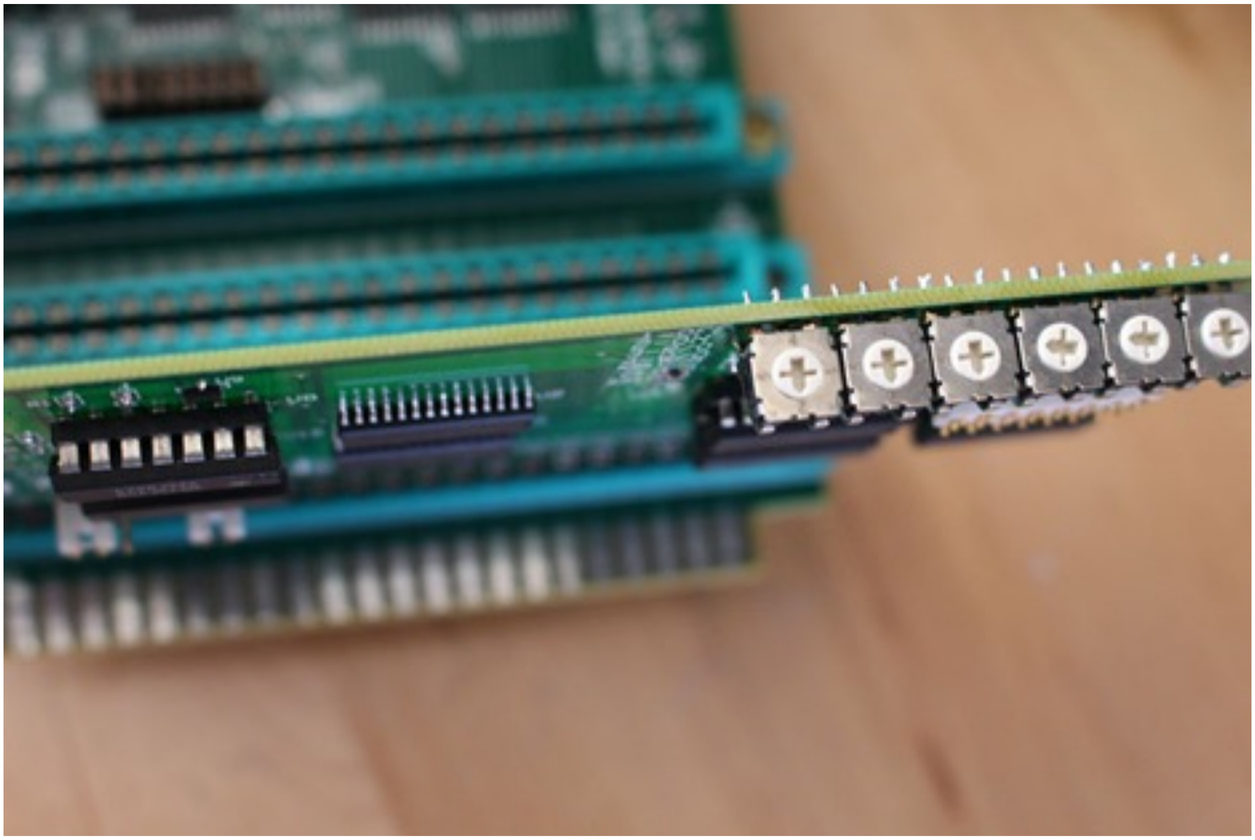


Figure 3

Table 2 shows the function of the 4 position switches. Memory ranges can be switched so that the FRAM can be disabled, enabled for either Read and Write, Read Only , or Write Only. Normally the VMA line will be pulled low on any FRAM access. If Jumper J3 is removed VMA operation is disabled and the VMA mod on the Apple 1 board is not needed. If operated in this mode care must be taken that the FRAM board not be active at the same time as the Apple 1 addressing. If space is to be used as permanent storage it is very important to Write Protect (set as Read Only Memory) that space as loose programs can easily modify writeable space. For some reason ROR and ROL ops often appear in unused space.

Switch Label	Address Range	Switch Position			
		1	2	3	4
1	$1000 to $1FFF	Apple 1 Memory	FRAM R/W	FRAM RO	FRAM WO
2	$2000 to $2FFF	Apple 1 Memory	FRAM R/W	FRAM RO	FRAM WO
3	$3000 to $3FFF	Apple 1 Memory	FRAM R/W	FRAM RO	FRAM WO
4 - 7	$4000 to $7FFF	Apple 1 Memory	FRAM R/W	FRAM RO	FRAM WO
8 - B	$8000 to $BFFF	Apple 1 Memory	FRAM R/W	FRAM RO	FRAM WO
E	$E000 to $EFFF	Apple 1 Memory	FRAM R/W	FRAM RO	FRAM WO

Table 2 4 Position Switches

The FM1808B operates a little differently than a normal SRAM in that it needs a clock for each memory cycle similar to a DRAM. One of the concerns with a non-volatile RAM is to be sure that no unexpected memory cycles take place during power up and power down. The best way to protect against that with these parts is to make sure no clock cycles occur during power up and power down. The circuit formed by U8, U9 and U12C prevent clocks from occurring on power up until there has been an Apple 1 reset or the U8 (a power-on reset circuit) has timed out whichever is later. On power down the clocks are stopped when the voltage goes below about 4.2 volts. The clocks are gated synchronously so that a narrow clock will not occur which could also be a problem.

Using a CFFA1 Board

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Figure 5

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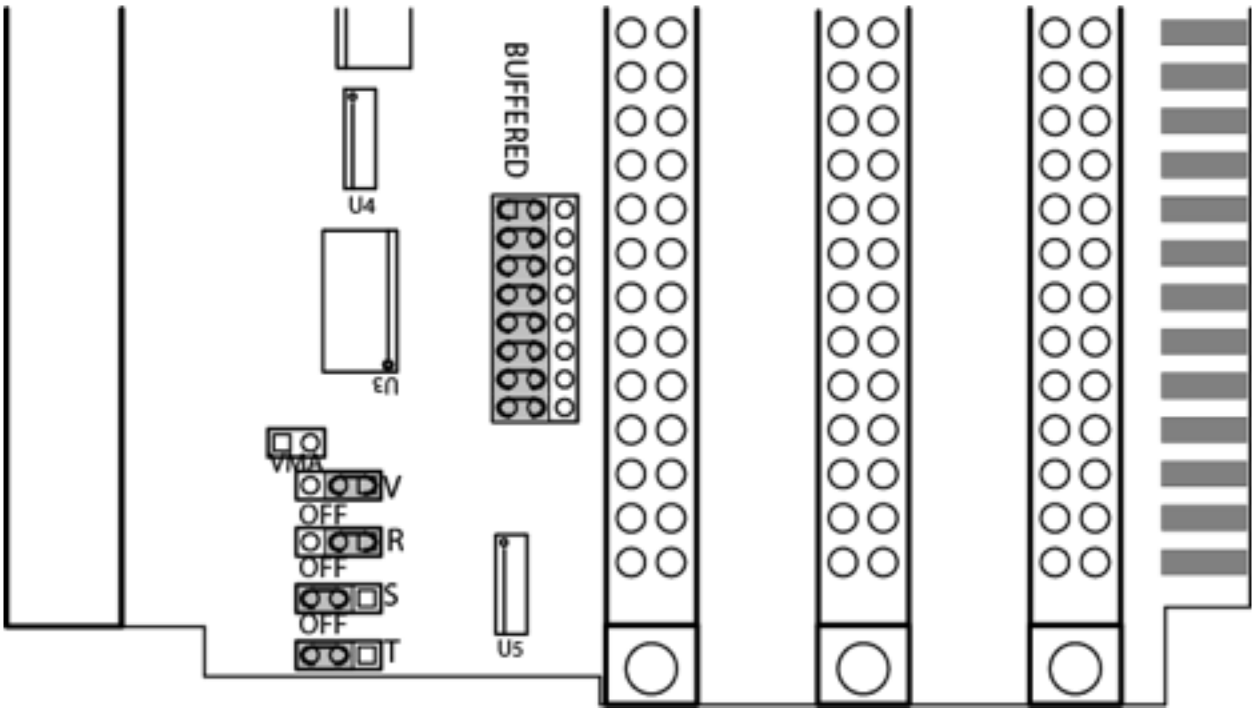

Figure 6

The CFFA1 board switches should be configured as shown in Figure 7 and the FRAM address jumpers should be configured as shown in Figure 8 to allow maximum use of the FRAM space without interfering with the CFFA1 address space.

Figure 7

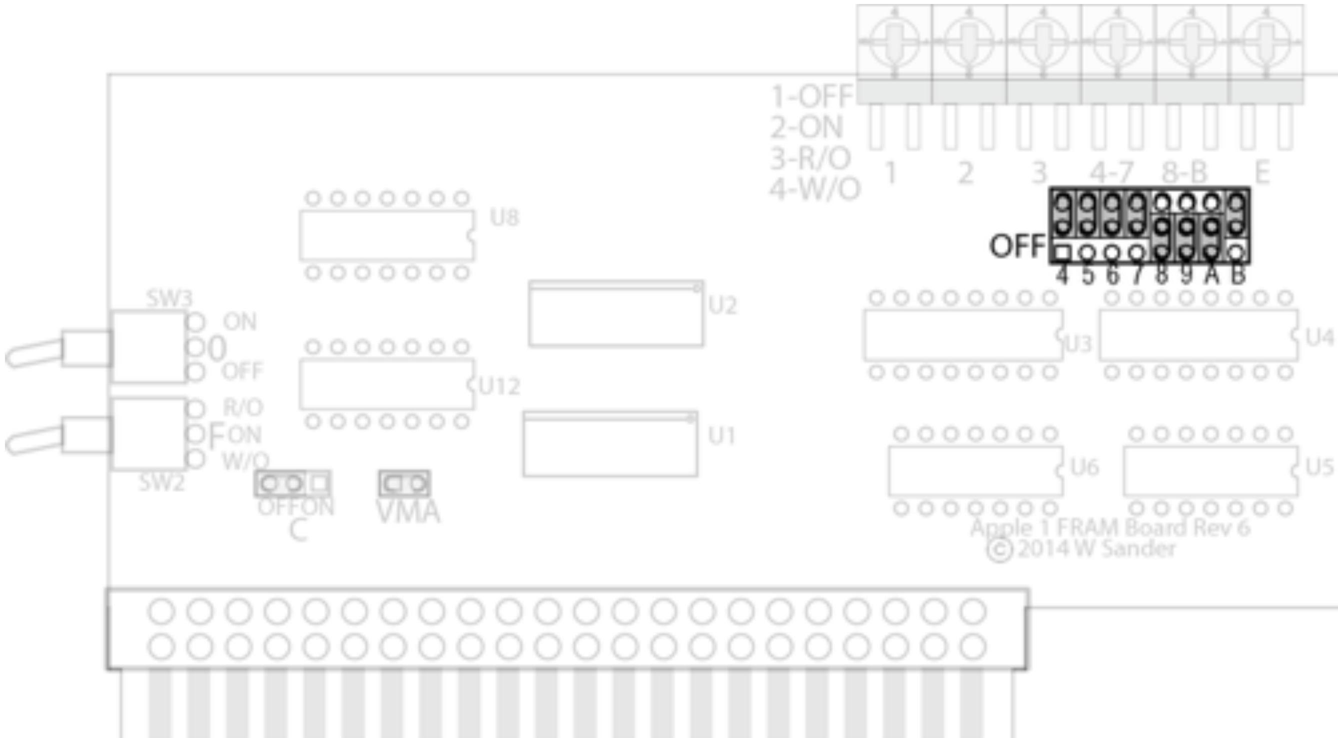
1-OFF
2-ON
3-R/O
4-W/O
1
2
3
4-7
8-B
E
OFF
4 5 6 7 8 9 A B
U8
U2
U12
U1
U3
U4
U6
U5
SW3
ON
OFF
R/O
ON
W/O
SW2
OFF ON
C
VMA
Apple 1 FRAM Board Rev 6
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Figure 8

VMA Activation

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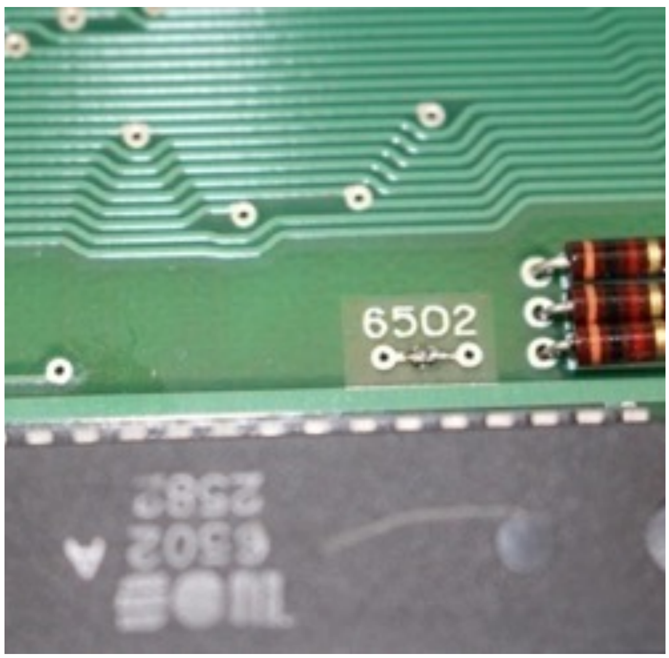

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This modification makes available a signal on the peripheral connector that can be used to disable anything accessed using the decoder on a cycle by cycle basis. This includes the 6820 PIA, all on board RAM, the boot ROM and any peripheral using the R, S, or T signals. This permits a peripheral to perform hardware substitution for any of those functions.

FRAM Board Test

For testing the FRAM Board the Apple 1 or Clone must have the VMA mod performed meaning that the short on the Apple 1 labeled “6502” near the 3 3K resistors and near pin 1 of the 40 pin socket at A7 should be removed and replaced by a 100pf Capacitor and 2200Ω resistor across the terminals with surface mount parts or between pins 5 and 8 of the 6502 at location A7 or pins 12 and 14 of the DIP at location B1. The FRAM board can be plugged onto the PC board connector of the Apple 1 or can be plugged into an expansion slot of a known good Expansion Board configured as shown in Figure 10. An Apple 1 ACI Board should be installed in the PC Socket on the Apple 1. The Apple 1 memory is assumed to be mapped into the $0XXX and $EXXX space, if the board has been modified for 16K chips then the modification must be made using the CS(N) pins for enabling the memory and not the Address lines directly, otherwise the VMA will not disable the on-board expanded memory.

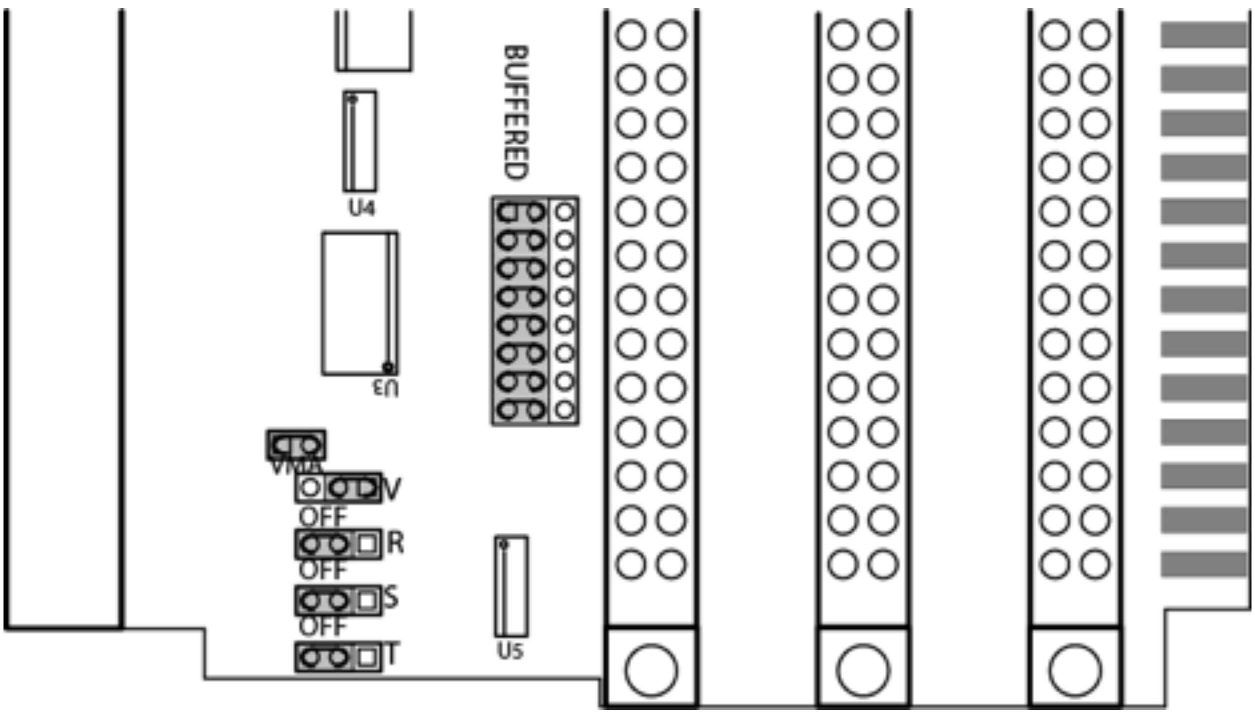


Figure 10

FRAM Board Test

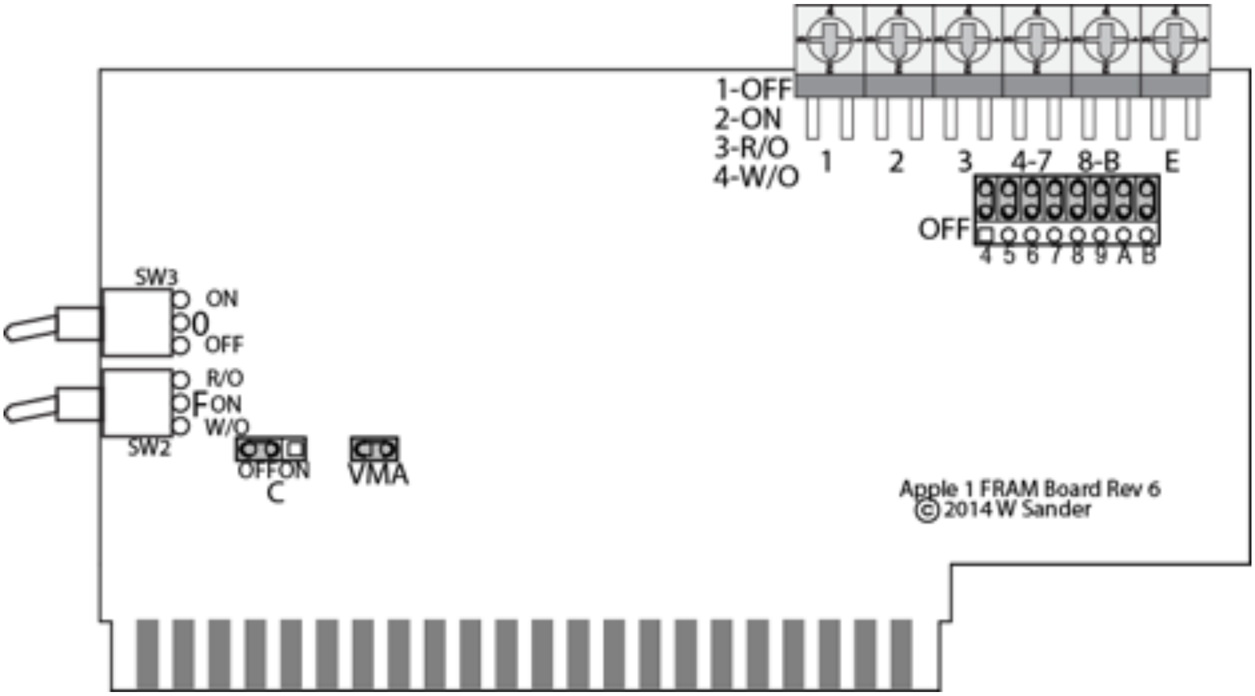


Figure 11

Configure the switches on the FRAM Board as shown in Figure 11, this will enable the FRAM board for R/W at addresses $1000 - $BFFF and $EXXX.

Power on the board and see that it Reset’s correctly.

Reset	`\`	Reset

To test for basic operation:

Type:	`1000:AA`	Write $AA to $1000
	`1000: ??`	Read undefined at $1000
Type:	`1000`	Read $1000
	`1000: AA`	$1000 = $AA
Type:	`1000:55`	Write $55 to $1000
	`1000: AA`	$1000 Was $AA
Type:	`1000`	Read $1000
	`1000: 55`	$1000 = $55

This verifies that the FRAM can read and write all data bits.

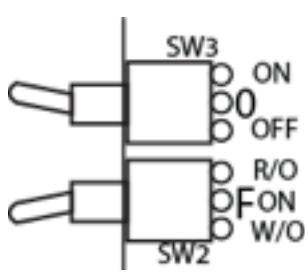
The next test covers the range from $1000 to $BFFF using a RAM test program from Mike Willegal. This program is documented on his web site “www.willegal.net” as “6502 Memory Test”. Load the file “Memory Test” from an iPod or equivalent using the ACI Board. The program will load into the Apple 1 on-board memory at $280 to $3A1.

Type:	C100R	Run the ACI at $C100
	C100: A9*	
Type:	280.3A1R	Load Range
	\	Load Complete
Type:	0:00 10 00 C0	Sets the test range from $1000 to $BFFF
	0000: ??	Read undefined at $0000
Type:	280R	Run at $280
	0280: A9PASS 01	Test Completed 1st Pass
	PASS 02	Test Completed 2nd Pass
	PASS 03	Test Completed 3rd Pass
	PASS 04	Test Completed 4th Pass
Reset	\	

Now test the space from $E000 to $EFFF

Type:	0:00 E0 00 F0	Sets the test range from $E000 to $EFFF
	0000: ??	Read undefined at $0000
Type:	280R	Run at $280
	0280: A9PASS 01	Test Completed 1st Pass
	PASS 02	Test Completed 2nd Pass
	PASS 03	Test Completed 3rd Pass
	PASS 04	Test Completed 4th Pass
Reset	\	

In order to test the $0XXX memory bank the $0 bank is turned ON and the Memory Test program loaded into the FRAM bank $0 The memory from $0800 to $0FFF can be tested. Switch the 0 toggle switch ON.



FRAM Board Test

Press Reset and Load the “Memory Test” program from the ACI.

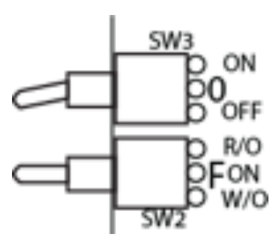
	\	Reset
Type:	C100R	Run the ACI at $C100
	C100: A9*	
Type:	280.3A1R	Load Range
	\	Load Complete
Type:	0:00 08 00 10	Sets the test range from $0800 to $0FFF
	0000: ??	Read undefined at $0000
Type:	280R	Run at $280
	0280: A9PASS 01	Test Completed 1st Pass
	PASS 02	Test Completed 2nd Pass
	PASS 03	Test Completed 3rd Pass
	PASS 04	Test Completed 4th Pass

Reset \

In order to test the $FXXX address space the Woz Monitor ROM code must be loaded into the $FF00 to $FFFF space in the FRAM in order for the Apple 1 board to continue to operate properly. The F toggle switch has three positions, when the switch is in the W/O position all reads from the $FXXX space are from the on-board PROM and all writes are to the FRAM. When the Switch is in the R/O position then all reads are from the FRAM and write operations are not performed. In the ON position all reads and writes are to the FRAM space so that is the position needed for testing the space. With the 0 switch remaining in the W/O position load the “Woz Apple 1 Monitor” code using the ACI.

Type:	C100R	Run the ACI at $C100
	C100: A9*	
Type:	FF00.FFFFR	Load Range
	\	Load Complete

The test will be run from the on-board RAM since that is the most demanding test mode. The 0 switch should move to the OFF position and the F switch to the ON position.



Reset the Apple 1, set the test range and run the test.

Reset \

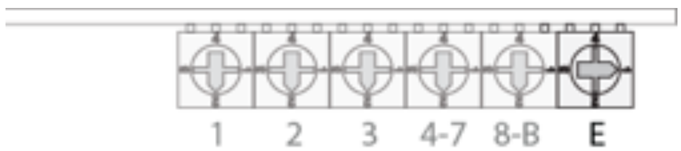
	0:00 F0 00 FE	Sets the test range from $F000 to $FEFF
	0000: ??	Read undefined at $0000
Type:	280R	Run at $280

0280: A9PASS 01	Test Completed 1st Pass
PASS 02	Test Completed 2nd Pass
PASS 03	Test Completed 3rd Pass
PASS 04	Test Completed 4th Pass

Reset ␛

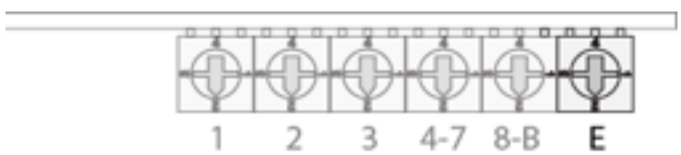
The next sequence tests the operation of the 4 position block switches. This test is performed on Block E since it is the only one that is certain to have memory both on-board and on the FRAM.

Set the E switch on the FRAM Board to position 1, FRAM OFF



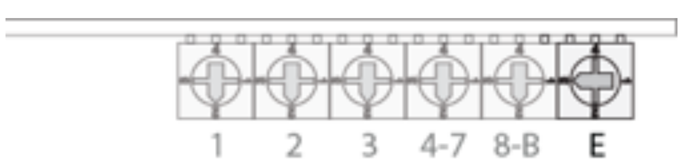
Type: E000:AA	Write $AA to $E000 on the on-board RAM
E000: ??	Read undefined at $E000
Type: E000	Read $E000
E000: AA	Read $AA from $E000 on the Apple 1 RAM

Set the E switch to position 2, FRAM ON



Type: E000:55	Write $55 to $E000 on the FRAM Board
E000: ??	Read undefined at $E000
Type: E000	Read $E000
E000: 55	Read $55 from $E000 on the FRAM Board

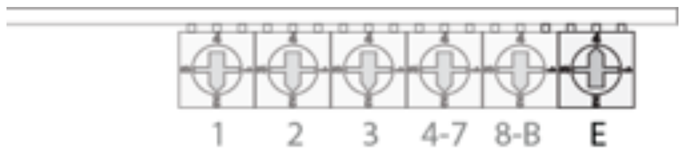
Set the E switch to position 3, FRAM R/O. In R/O (Read Only) Mode Read operations come from the FRAM and Write operations go to the on-board RAM.



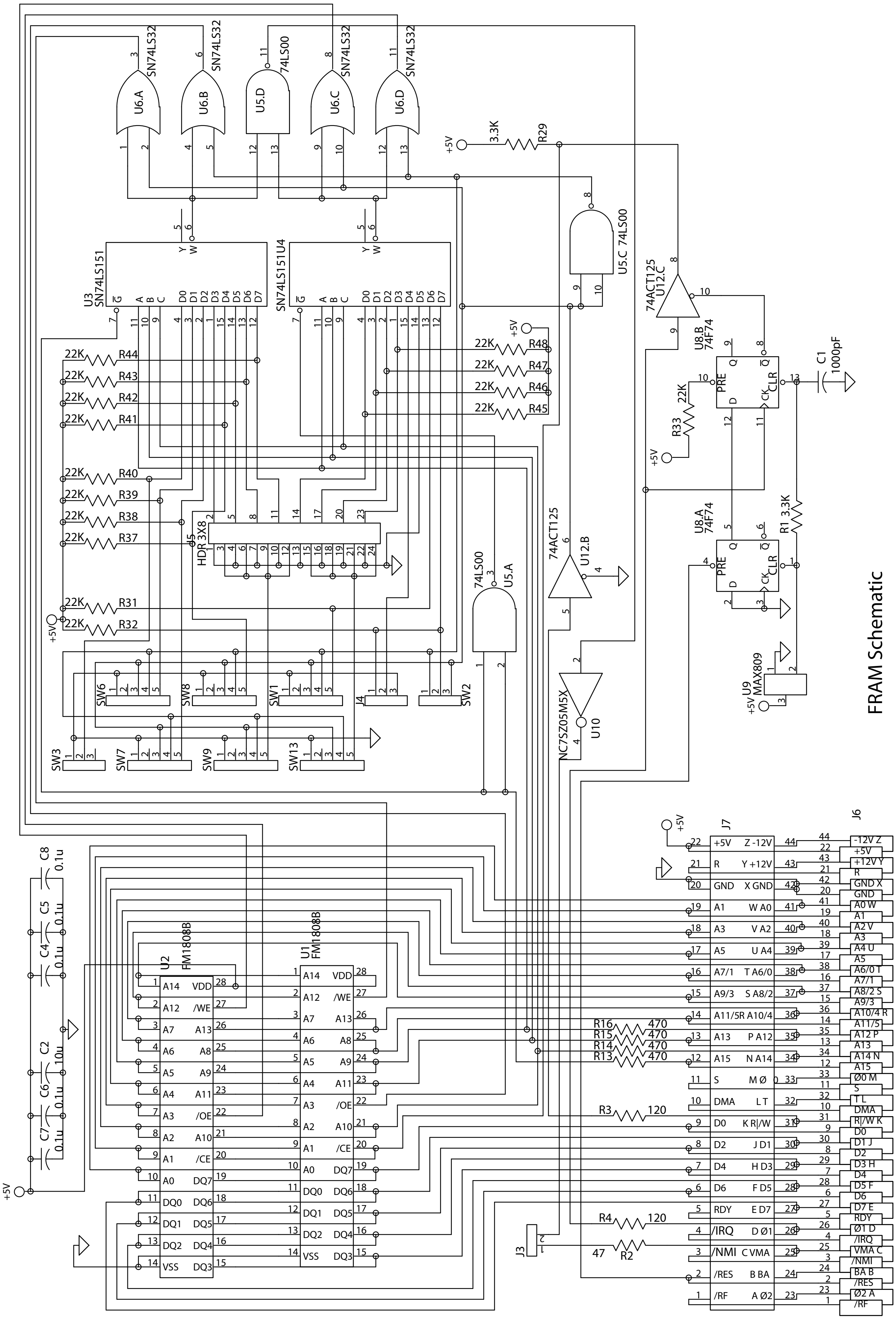
Type: E000:FF	Write $FF to $E000 on the on-board RAM

	E000: 55	Read $55 from $E000 on the FRAM Board
Type:	E000	Read $E000
	E000: 55	

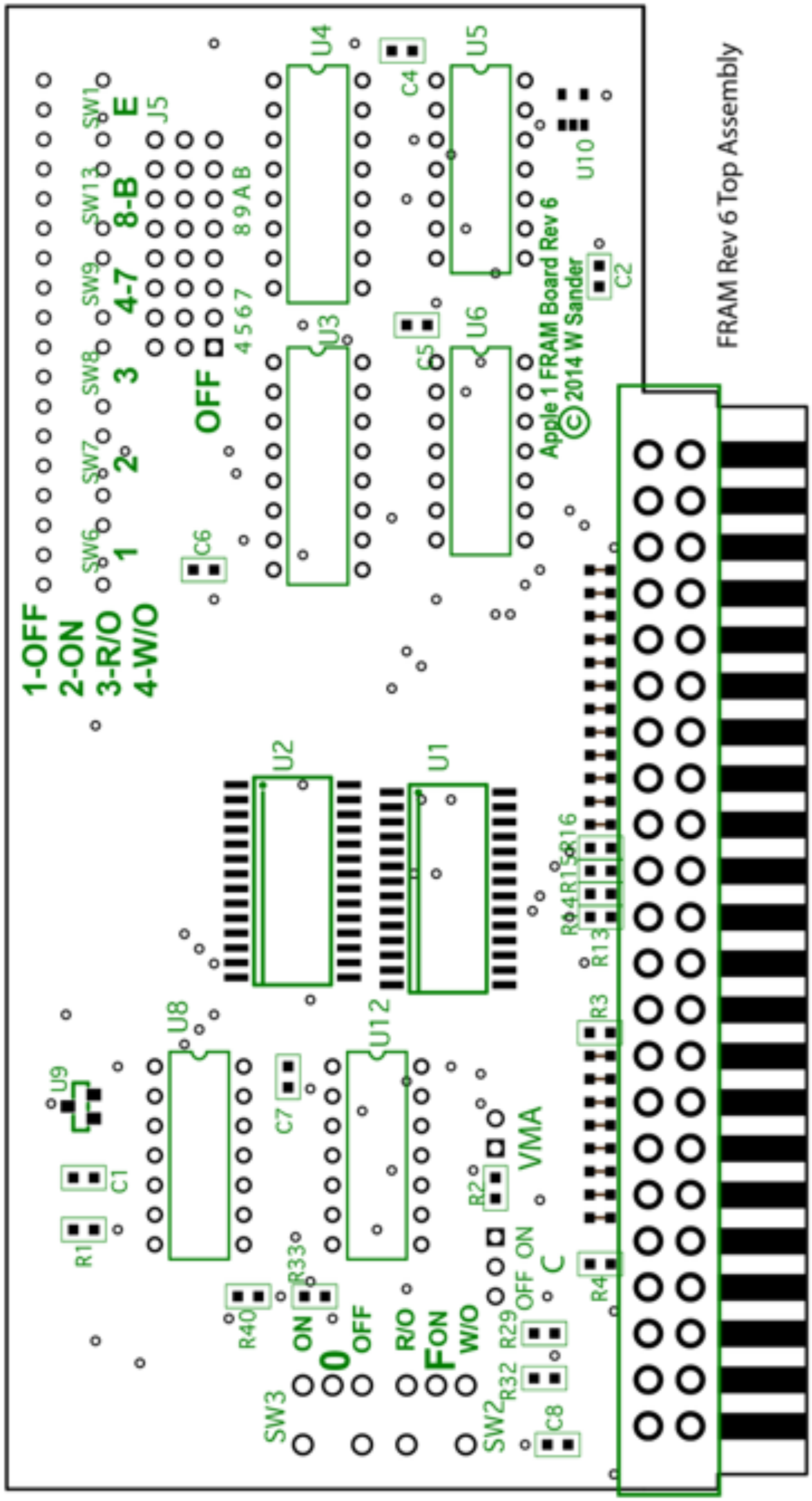
Set the E switch to position 4, W/O Mode. In W/O (Write Only) Mode Write operation go to the FRAM and Read Operations come from on-board RAM.



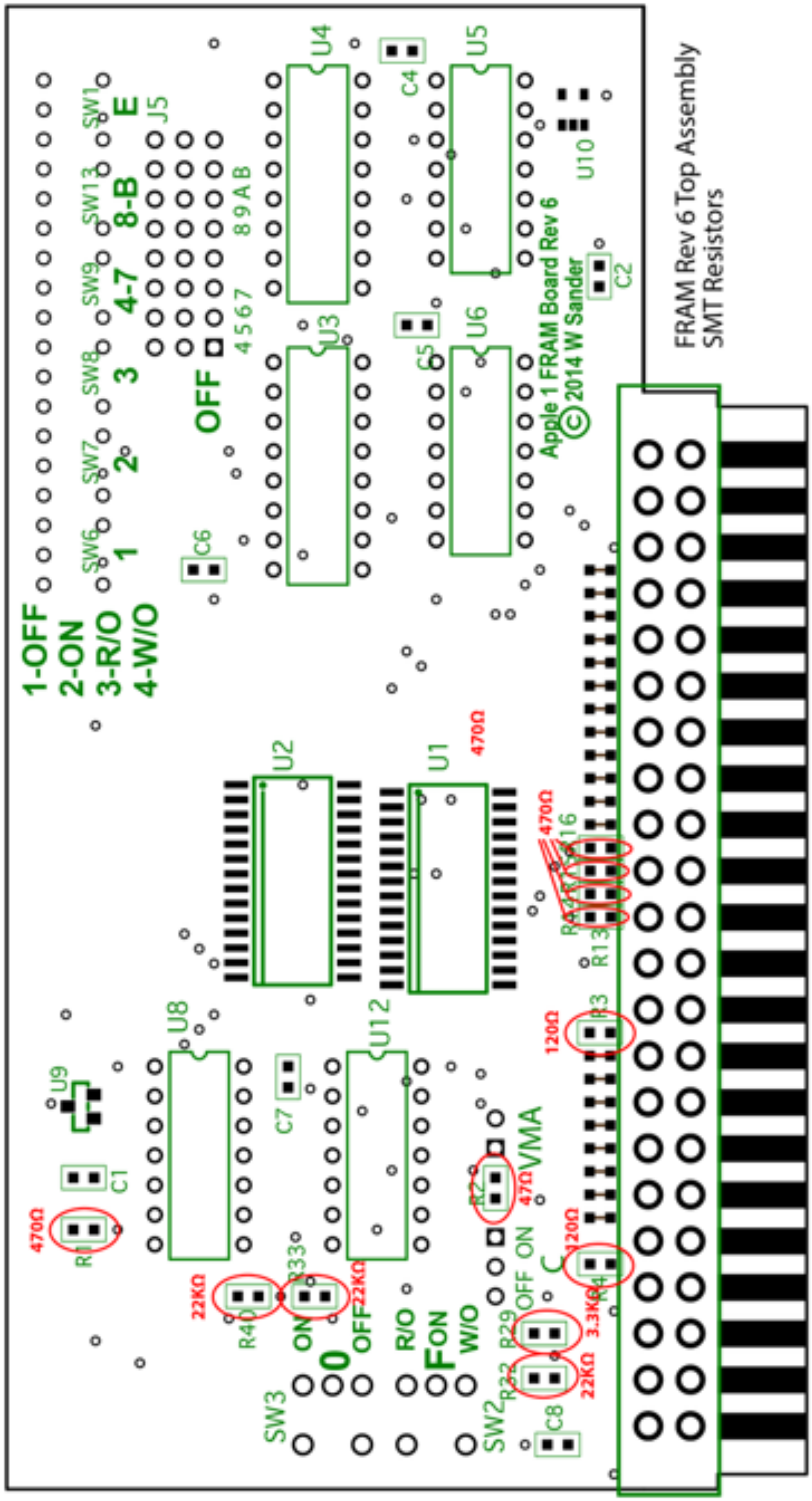
Type:	E000:00	Write $00 to $E000 on the FRAM Board
	E000: FF	Read $FF from $E000 on the Apple 1 RAM
Type:	E000	Read $E000
	E000: FF	Read $FF from $E000 on the Apple 1 RAM



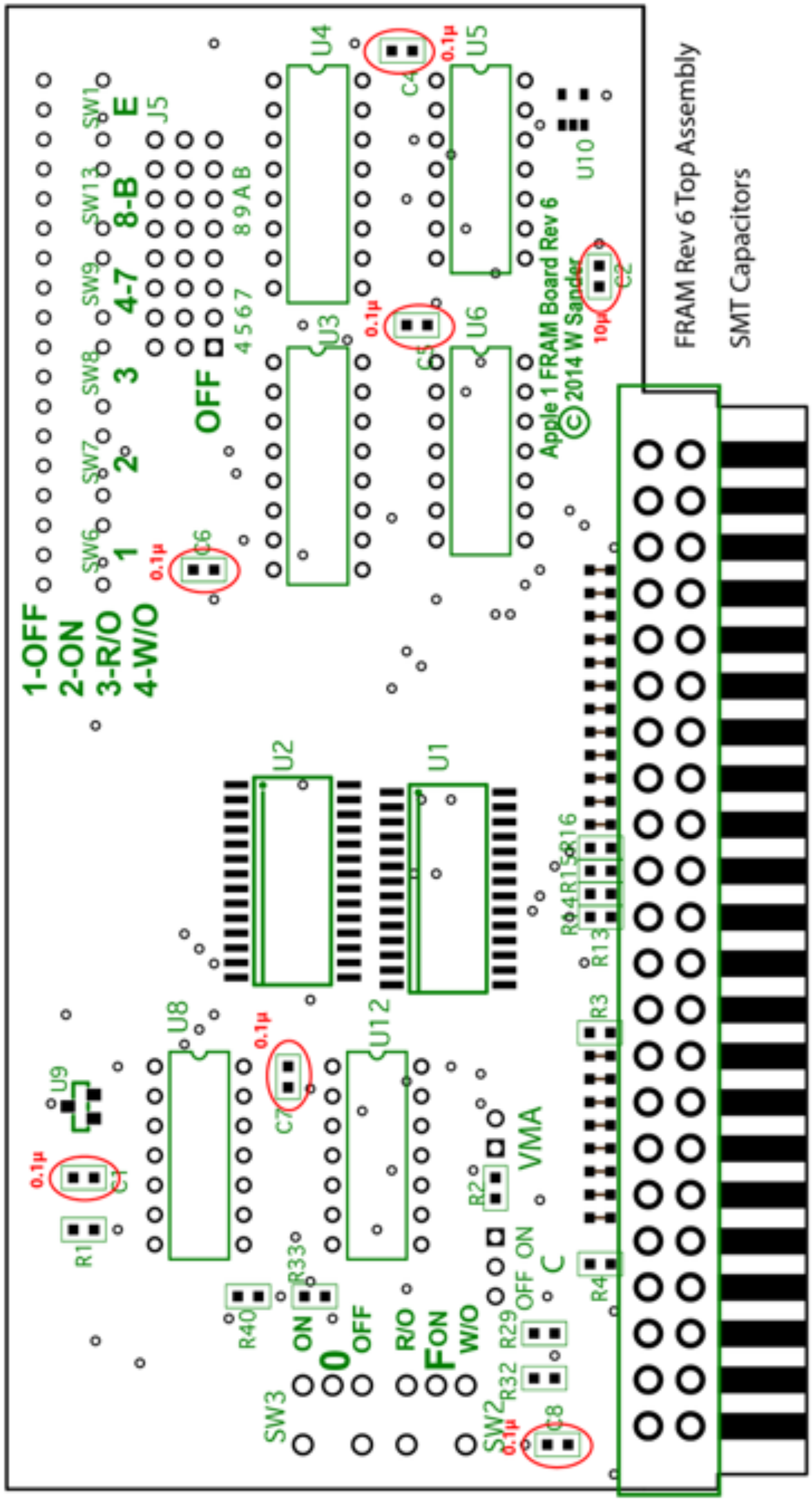
FRAM Schematic



FRAM Rev 6 Top Assembly

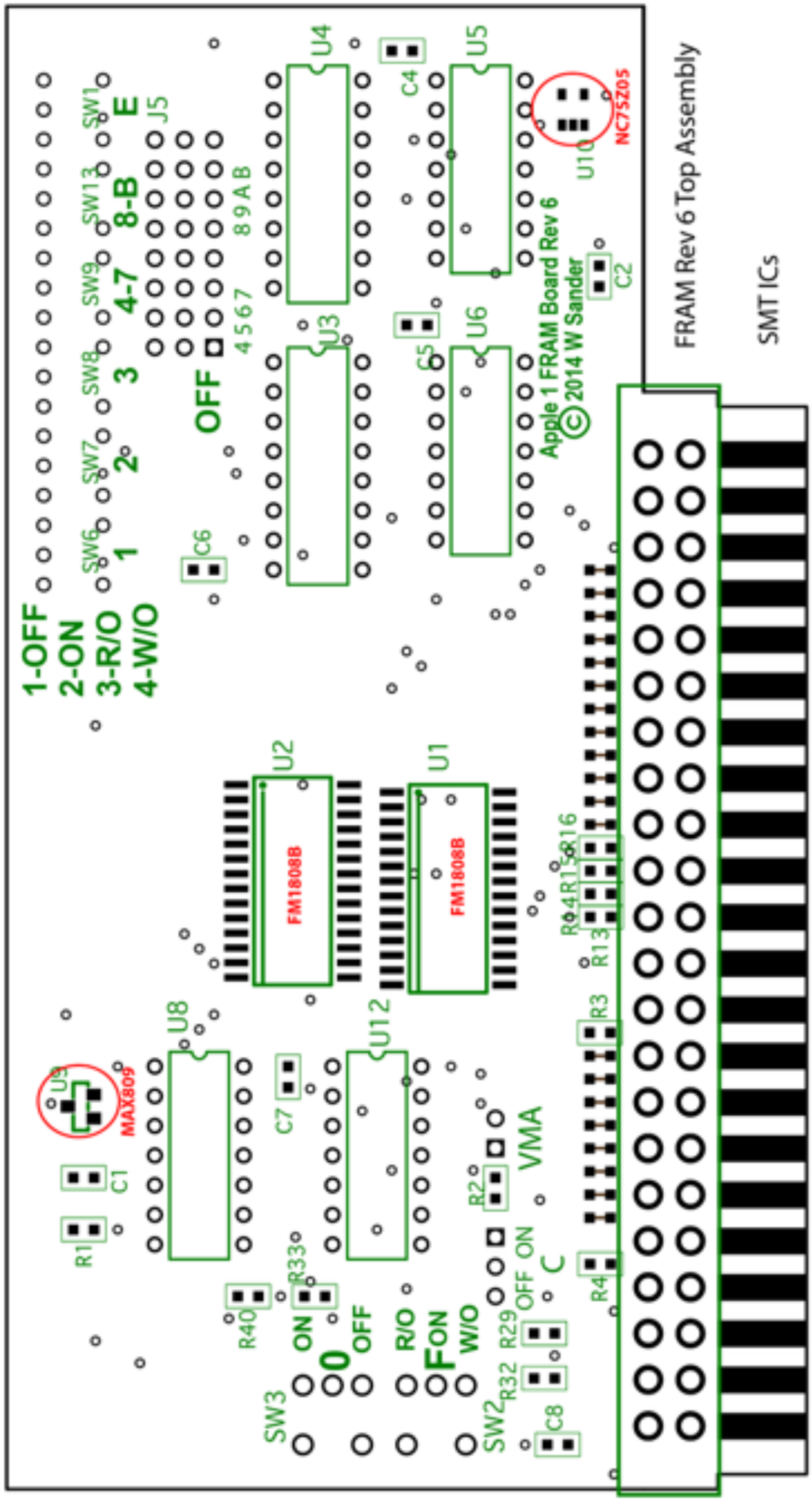


FRAM Rev 6 Top Assembly
SMT Resistors



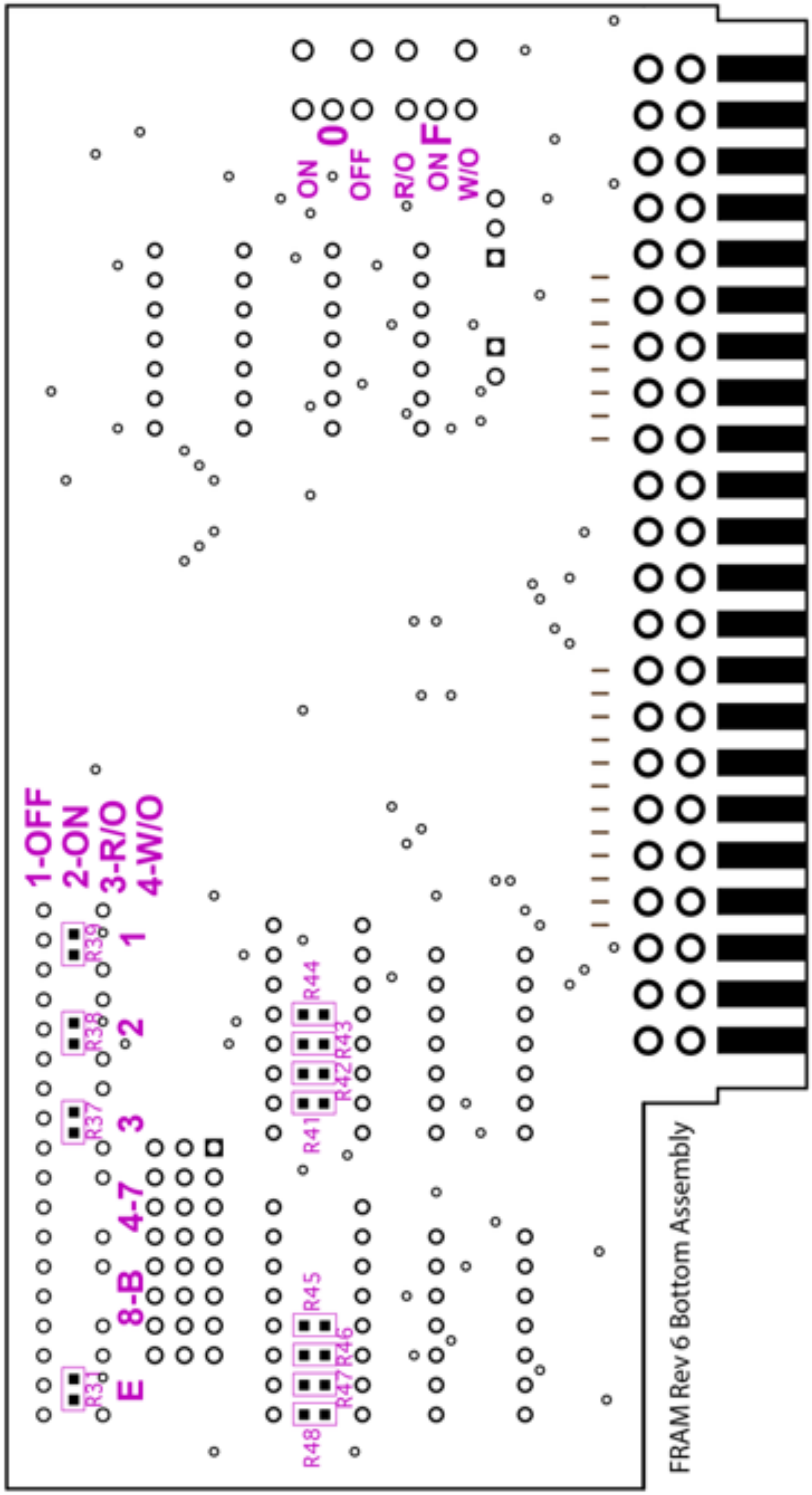
FRAM Rev 6 Top Assembly

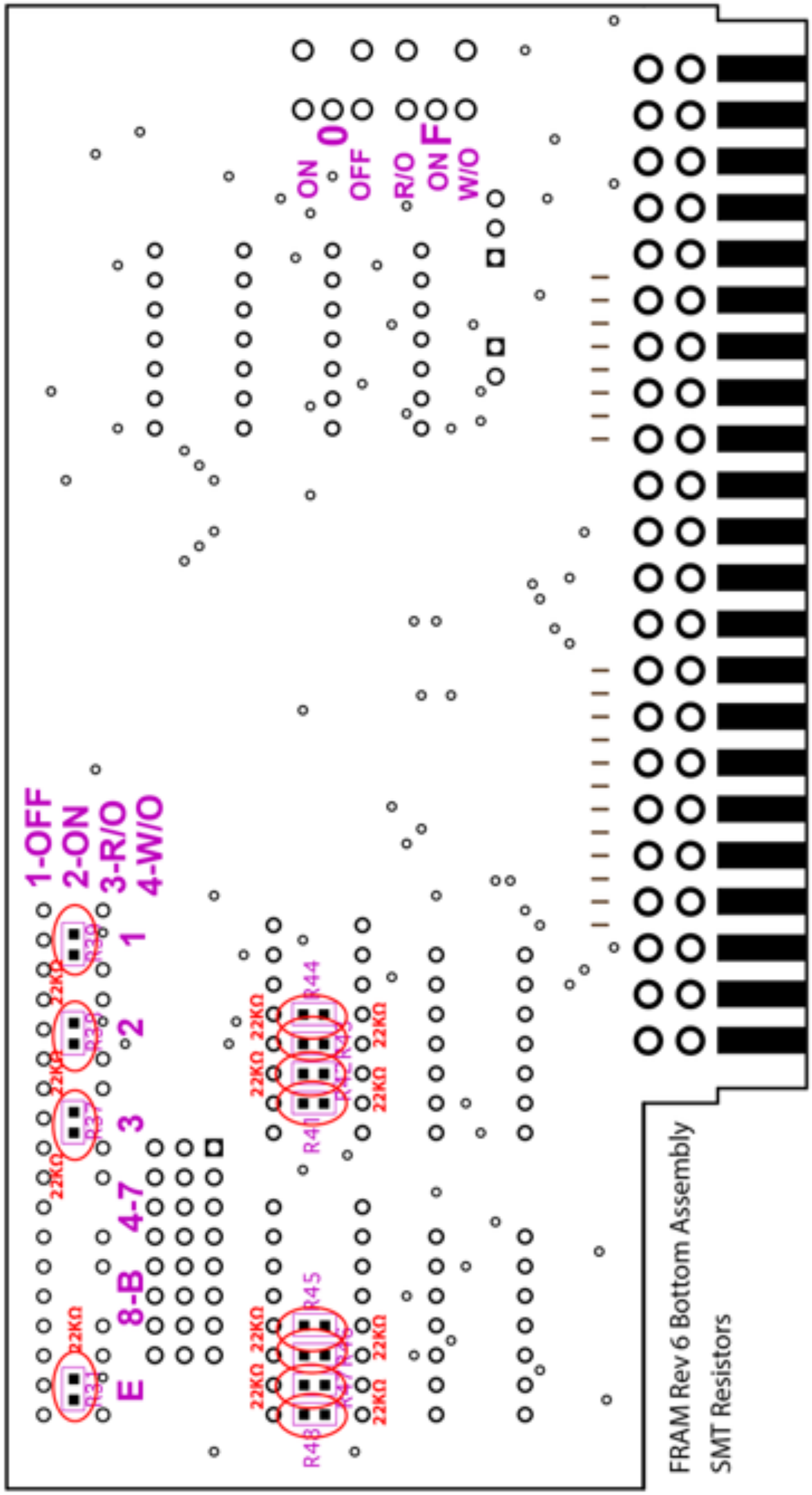
SMT Capacitors



FRAM Rev 6 Top Assembly

SMT ICs


FRAM Rev 6 Bottom Assembly
1-OFF
2-ON
3-R/O
4-W/O
ON
OFF
0
R/O
ON
F
W/O
1
2
3
4-7
8-B
E
R31
R37
R38
R39
R41
R42
R43
R44
R45
R46
R47
R48



FRAM Rev 6 Bottom Assembly
SMT Resistors

FRAM Rev 6 Parts List

Designator	Side	Part	Value	Manufacturer	Mfg Part No.	Description
C1		CAPACITOR	0.1u			0603 CAPACITOR
C2		CAPACITOR	10u			0603 CAPACITOR
C4		CAPACITOR	0.1u			0603 CAPACITOR
C5		CAPACITOR	0.1u			0603 CAPACITOR
C6		CAPACITOR	0.1u			0603 CAPACITOR
C7		CAPACITOR	0.1u			0603 CAPACITOR
C8		CAPACITOR	0.1u			0603 CAPACITOR
J1		Card Connector	44 PIN 0.156	EDAC	305-044-520-202	44-Pin .156 Connector
J3		HEADER	1X2	SAMTEC	TSW-102-07-L-S	1X2 0.1 In Header
J4		HEADER	1X3	SAMTEC	TSW-103-07-L-S	1X3 0.1 In Header
J5		HEADER	3X8	SAMTEC	TSW-108-07-L-T	3X8 0.1 In Header
R1		RESISTOR	470Ω			0603 RESISTOR
R2		RESISTOR	47Ω			0603 RESISTOR
R3		RESISTOR	120Ω			0603 RESISTOR
R4		RESISTOR	120Ω			0603 RESISTOR
R13		RESISTOR	470Ω			0603 RESISTOR
R14		RESISTOR	470Ω			0603 RESISTOR
R15		RESISTOR	470Ω			0603 RESISTOR
R16		RESISTOR	470Ω			0603 RESISTOR
R29		RESISTOR	3.3KΩ			0603 RESISTOR
R31	B	RESISTOR	22KΩ			0603 RESISTOR
R32		RESISTOR	22KΩ			0603 RESISTOR
R33		RESISTOR	22KΩ			0603 RESISTOR
R37	B	RESISTOR	22KΩ			0603 RESISTOR
R38	B	RESISTOR	22KΩ			0603 RESISTOR
R39	B	RESISTOR	22KΩ			0603 RESISTOR
R40		RESISTOR	22KΩ			0603 RESISTOR
R41	B	RESISTOR	22KΩ			0603 RESISTOR
R42	B	RESISTOR	22KΩ			0603 RESISTOR
R43	B	RESISTOR	22KΩ			0603 RESISTOR
R44	B	RESISTOR	22KΩ			0603 RESISTOR
R45	B	RESISTOR	22KΩ			0603 RESISTOR
R46	B	RESISTOR	22KΩ			0603 RESISTOR
R47	B	RESISTOR	22KΩ			0603 RESISTOR
R48	B	RESISTOR	22KΩ			0603 RESISTOR
SW1		SP4T Switch		C&K	RTE0400V04	4 POLE SWITCH
SW2		SPDT Toggle		C&K	T103MH9ABE	SBDT TOGGLE 3 POS
SW3		SPDT Toggle		C&K	T101MH9ABE	SBDT TOGGLE 2 POS
SW6		SP4T Switch		C&K	RTE0400V04	4 POLE SWITCH
SW7		SP4T Switch		C&K	RTE0400V04	4 POLE SWITCH
SW8		SP4T Switch		C&K	RTE0400V04	4 POLE SWITCH
SW9		SP4T Switch		C&K	RTE0400V04	4 POLE SWITCH
SW13		SP4T Switch		C&K	RTE0400V04	4 POLE SWITCH
U1		FM1808B	32K X 8 FRAM	CYPRESS	FM1808B	SOIC 28-PIN
U2		FM1808B	32K X 8 FRAM	CYPRESS	FM1808B	SOIC 28-PIN
U3		74LS151			74LS151	16 PIN DIP
U4		74LS151			74LS151	16 PIN DIP
U5		74LS00			74LS00	14 PIN DIP
U6		74LS32			74LS32	14 PIN DIP
U8		74F74			74F74	14 PIN DIP
U9		MAX809	4.38V	ON SEMI	MAX809MTRG	SOT23
U10		NC7SZ05M5X			NC7SZ05M5X	SOT23-5
U12		74ACT125			74ACT125	14 PIN DIP

Serial Board
May 31, 2015

The Apple 1 Serial board uses a 6551 ACIA. The addressing for this board has been designed to mimic the Apple 1 6820 PIA at the $D01X locations and still provide full access to the 6551 in the $D00X space. The 6820 is disabled during Serial Board accesses using the VMA mod where the VMA line short to +5 is replaced by a resistor and capacitor so the VMA line can become active. Using this modification the 6820 can be disabled on a cycle by cycle basis by pulling down the VMA line and the Serial board function can be enabled in its place. The board has no on board firmware and no additional software is needed for the boards operation.The board is compatible with all Apple 1 software. Figure 1 is a photo of the finished board.

Figure 1
Table 1 shows the valid addresses on the Serial board and the suggested addresses to be used. . Table 2 shows where the addresses map into the 6551 space. Table 3 shows the corresponding Apple 1 locations so that with the remapping the Serial board has exactly the same register mapping as the Apple 1 6820. Note that on the reads from $D011 and $D012 the appropriate bit is remapped to provide the proper ready bits to match the Apple 1 Keyboard and Display locations. Therefore when the VMA is pulled disabling the 6820, the Serial board provides an exact substitution. This means that the serial board operates exactly like the 6820 and there are no software changes of any kind to use the serial board. On the other hand the full set of Serial Board 6551 registers are still available at locations $D002 to $D005.

Apple 1 Serial Board Description

Full Binary Address x = “don’t care”	Suggested Address to Use
1101 xxxx xxx0 x0x0	$D002
1101 xxxx xxx0 x0x1	$D003
1101 xxxx xxx0 x1x0	$D004
1101 xxxx xxx0 x1x1	$D005
1101 xxxx xxx1 x0x0	$D010
1101 xxxx xxx1 x0x1	$D011
1101 xxxx xxx1 x1x0	$D012
1101 xxxx xxx1 x1x1	$D013

Table 1

The VMA line action from the serial board can be disabled by removing the jumper labeled VMA on the board. The address locations at $D002 to $D005 could still be used since the 6820 is disabled at these addresses but the 6820 would not be disabled at locations $D010 to $D013. This makes the Serial board useable even if there is no VMA mod made, however, substitution could not be used.

Attached is a schematic of the Serial Board. One circuit of note is Q1 and Q2 that form a circuit that will detect a Break sent from a remote device and will reset the Apple 1 when a Break is received. This permits remotely managing the Apple 1 so that the Apple 1 could be made into a dial up computer and if the Apple 1 requires a reset it can be sent. This function can be disabled by removing the jumper labeled RESET from the board.
When using the Serial Board with a Mac using the CoolTerm program and a Keyspan 19HS we observed that the use of the high bit of the characters being a 1 caused some issues. The CoolTerm expects the high bit to be a zero and sends the characters with the high bit a zero. This caused the CoolTerm to recognize the incoming characters as special characters when in 8 bit transmission mode and the characters with the high bit cleared caused the Apple 1 to not respond properly to the incoming keystrokes. J9 and J10 labeled Tx and Rx were added to optionally force the high bit to be a one as needed for general use. This change only affects the $D01x addresses so that custom programs using the $D00x space are not affected. The exact behavior is described in Table 2.

Apple 1 Serial Board Description

Switch Status	Address	Write				Read			
		Register	VMA	Bit 7 Tx Jumper		Register	VMA	Bit 7 Rx Jumper	
				On	Fixed			On	Fixed
Don’t Care	D002	6551 Write Transmit Data Register	Low	6551 Bit 7	6551 Bit 7	6551 Read Receive Data Register	Low	6551 Bit 7	6551 Bit 7
Don’t Care	D003	6551 Programmed Reset (Data “don’t care”)	Low	6551 Bit 7	6551 Bit 7	6551 Read Status Register	Low	6551 Bit 7	6551 Bit 7
Don’t Care	D004	6551 Write Command Register	Low	6551 Bit 7	6551 Bit 7	6551 Read Command Register	Low	6551 Bit 7	6551 Bit 7
Don’t Care	D005	6551 Write Control Register	Low	6551 Bit 7	6551 Bit 7	6551 Read Control Register	Low	6551 Bit 7	6551 Bit 7
KBD ON	D010	6551 Disabled	Open	N/A	N/A	6551 Read Receive Data Register	Low	6551 Bit 7	1
KBD ON	D011	6551 Disabled	Open	N/A	N/A	6551 Read Status Register	Low	6551 Bit 3	6551 Bit 3
KBD OFF	D010	6551 Disabled	Open	N/A	N/A	6551 Disabled	Open	N/A	N/A
KBD OFF	D011	6551 Disabled	Open	N/A	N/A	6551 Disabled	Open	N/A	N/A
DSP ON	D012	6551 Write Transmit Data Register	Low	6551 Bit 7	6551 (Not Bit 7)	6551 Read Status Register	Low	6551 (Not Bit 4)	6551 (Not Bit 4)
DSP OFF	D012	6551 Disabled	Open	N/A	N/A	6551 Disabled	Open	N/A	N/A
Don’t Care	D013	6551 Disabled	Open	N/A	N/A	6551 Disabled	Open	N/A	N/A

Table 2

Apple 1 Serial Board Description

Address	Write	Read
D00X	6820 Inactive	
D010		KBD Data Register
D011		KBD Control Register Bit 7=1 Ready
D012	DSP Data Register	DSP Status Register Bit 7= 0 Ready
D013	DSP Control Register	

Table 3

Table 4 shows the serial pinout on the board and the mapping for various RJ45 to DB configurations.

Signal	Serial Bd RJ45	DB9 Adapter	DB9 Xover	DB25 Adapter	DB25 Xover
Clear To Send (CTS)	8	8	7	5	4
Data Set Read (DSR) + Carrier Detect (DCD)	7	6	4	6	20
Receive Data (RXD)	6	2	3	3	2
Gnd	5	5	5	7	7
Gnd	4	5	5	7	7
Transmit Data (TXD)	3	3	2	2	3
Data Terminal Ready (DTR)	2	4	6	20	6
Request To Send (RTS)	1	7	8	4	5

Table 4 Adapter Pinouts

Apple 1 VMA Signal Activation

The VMA signal is a signal needed for the 6800 microcomputer but is not used on the 6502, the pin is a no-connect on the 6502 and a shorting connection area is provided on the Apple 1 board to short it to +5V. The signal is of interest because it is available on the I/O connector. The signal goes to the NAND gate at B1 where it is combined with refresh and the result goes to the 74514 decoder disable pins 18 and 191 disabling all the decoded addresses whenever there is either a refresh or the VMA is low. The signal also goes to a chip select pin on the 6820 PIA which is redundant because the 6820 is disabled whenever the decoder is disabled. The VMA signal can be restored to availability again by replacing the short at approximately A8 labelled 6502 with a pull up resistor. A 2200 ohm resistor in parallel with a 100 pf capacitor should be used, the capacitor controls some crosstalk that has been observed on the signal. When small surface mount parts such as the 0402 parts shown in Figure 1 are used the alteration is nearly invisible.

An alternate implementation is to remove the short at the location and put the added parts under the board between pins 5 and 8 of the 6502 at location A7 or pins 12 and 14 of the DIP at location B1. The capacitor must be connected to the +5V rail instead of GND.

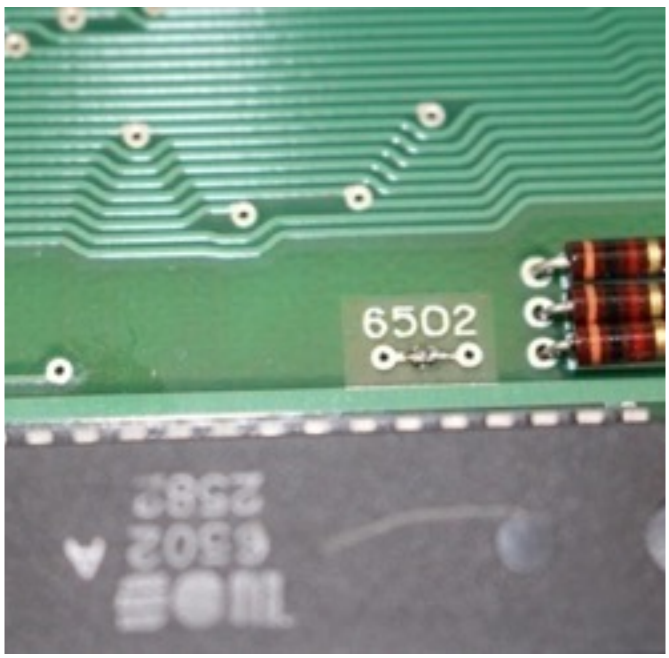


Figure 1

This modification makes available a signal on the peripheral connector that can be used to disable anything accessed using the decoder on a cycle by cycle basis. This includes the 6820 PIA, all on board RAM, the boot ROM and any peripheral using the R, S, or T signals. This permits a peripheral to perform hardware substitution for any of those functions.

For testing the Serial Board the Apple 1 or Clone must have the VMA mod performed meaning that the short on the Apple 1 labeled “6502” near the 3 3K resistors and near pin 1 of the 40 pin socket at A7 should be removed and replaced by a 100pf Capacitor and 2200Ω resistor across the terminals with surface mount parts or between pins 5 and 8 of the 6502 at location A7 or pins 12 and 14 of the DIP at location B1. The Serial board should be configured as shown in Figure 3 and plugged onto the PC board connector of the Apple 1 or can be plugged into an expansion slot of a known good Expansion Board configured as shown in Figure 2.

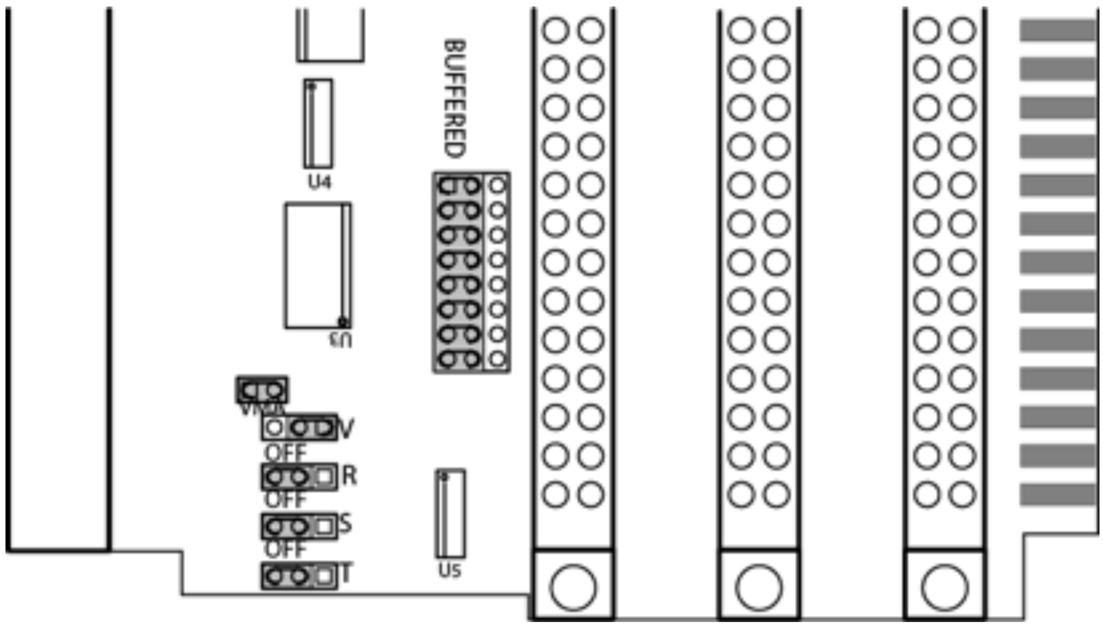


Figure 2

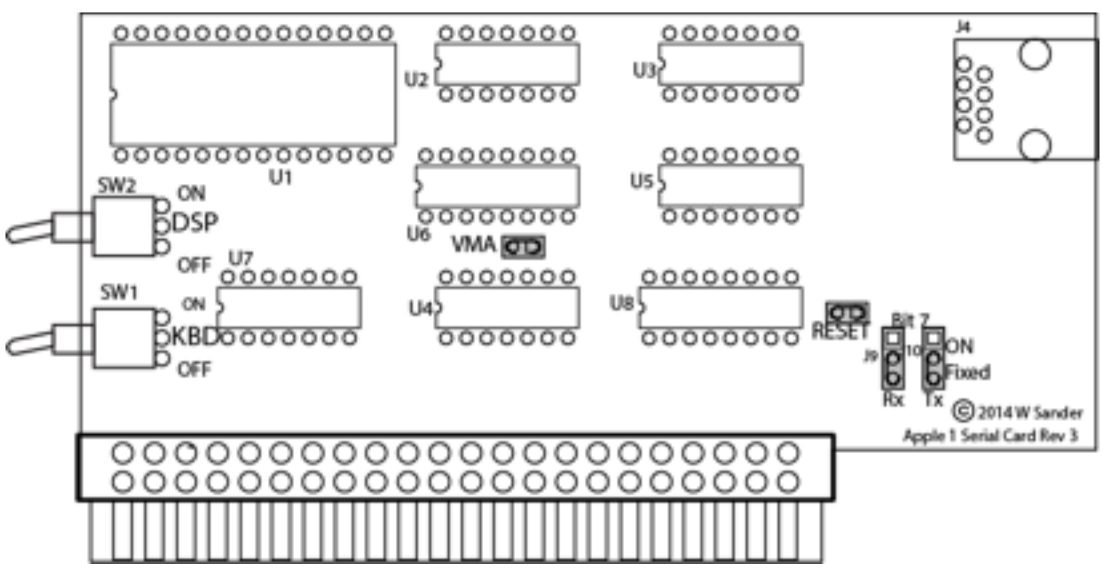


Figure 3

Power on the Apple 1 and verify that the system will reset and that the Keyboard and Display work normally.

Type `D004:8B 96`

Verify that the write was successful by reading locations D004 and D005. This will set the Serial Card to be 300 baud, 8 bit, 2 stop bits, parity disabled. Connect the serial board to an RS232 source that is configured as a dumb terminal. The Keyboard and Display should still work normally. Turn ON the KBD switch as shown in Figure 4.

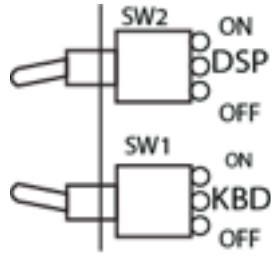


Figure 4

Now typing on the terminal device should be active and the Apple 1 display should remain active while the Apple 1 keyboard should not be active. Turn OFF the KBD switch and turn ON the DSP switch as shown in Figure 5.

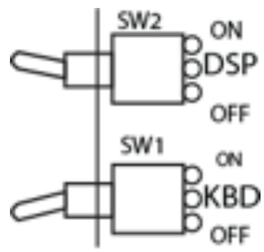


Figure 5

Now the display on the terminal device should be active and the Apple 1 Keyboard should be active while the Apple 1 display should not be active. Now turn ON the KBD switch so that both switches are ON as shown in Figure 6.

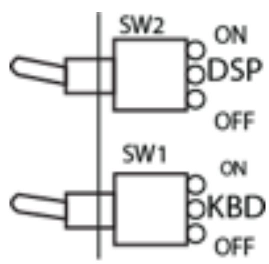


Figure 6

Now both the display and keyboard on the terminal device should be active and the display and keyboard on the Apple 1 disabled.

Send a Break signal from the dumb terminal and see that the Apple 1 is reset. The reset will take place regardless of the KBD and DSP switch settings on the Apple 1 Serial Card.

USING AN APPLE II AND SUPER SERIAL CARD AS A DUMB TERMINAL
Install an Apple II Super Serial Card into the Apple II with the Super Serial Card configured as shown in Figure 7. This will set the data rate at 300 baud and match all the settings on the Apple 1 Serial card. Connect the Apple 1 serial card using an RJ45 to DB25 adapter such as the CUI AMK-0233 wired as a "DB25 Adapter" as shown in Table 4 of the "Apple 1 Serial Board February 2015" document.

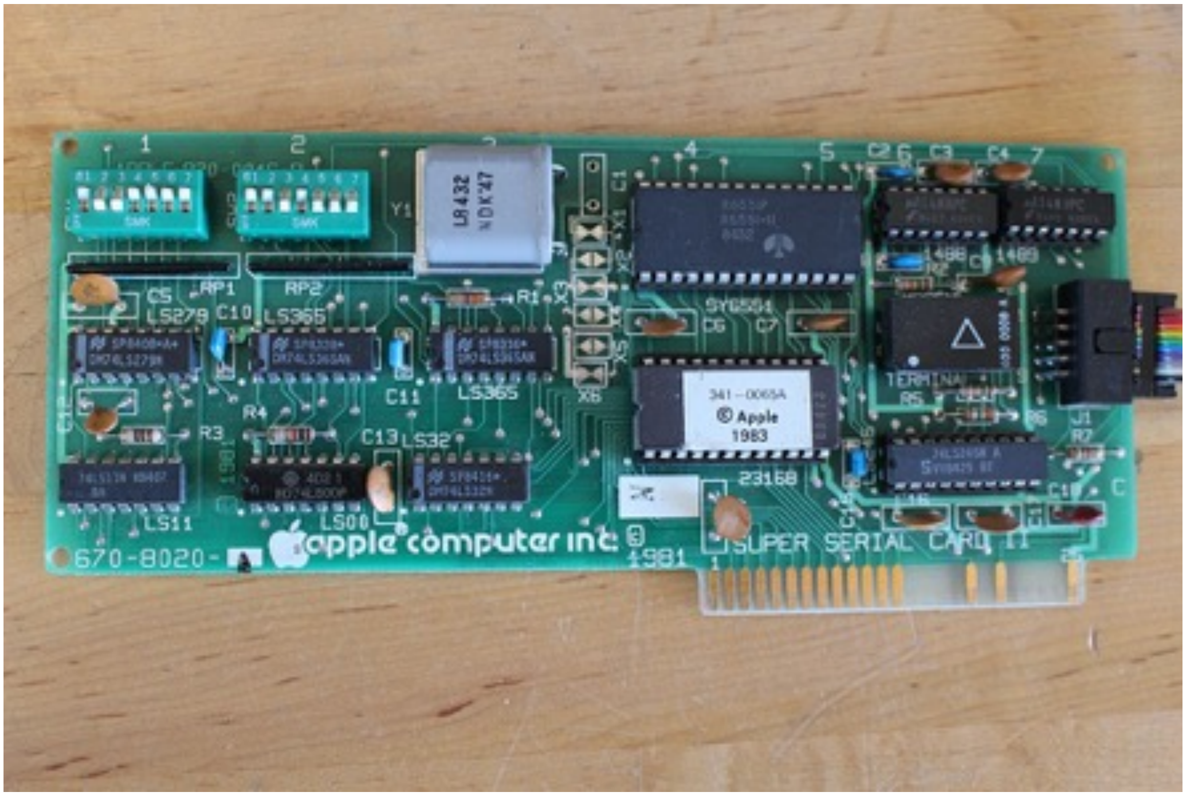


Figure 7

In this example it is assumed the Super Serial Card is in Slot 2. On the Apple II type

]IN#2 Type IN#2 to activate the Super Serial Card

] After the] prompt type ctrl(A)
APPLE SSC:T The Apple II will respond with APPLE SSC: then type T carraige return
The SSC is now in Terminal Mode.

To send a break signal again type ctrl(A)

APPLE SSC:B The Apple II will respond with APPLE SSC: then type B carraige return

The SSC will now send a Break Signal. If the Apple 1 Serial card has the DSP switch ON then the Apple II screen will show

_\

USING A MAC WITH A KEYSPAN USA-19HS AND COOLTERM AS A DUMB TERMINAL

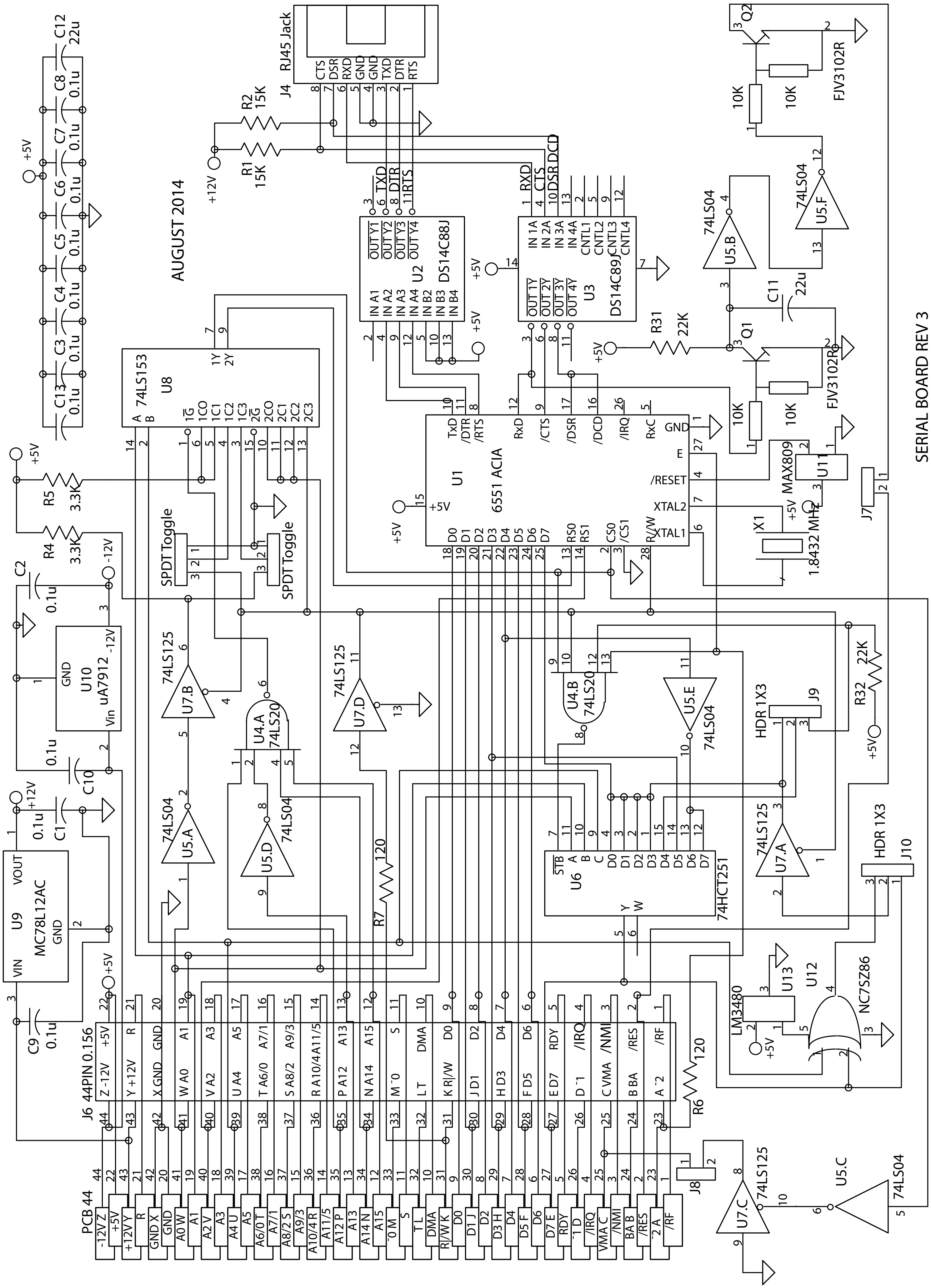
Connect the Apple 1 Serial card to the USA-19HS using an RJ45 to DB9 adapter such as the CUI AMK-0001 wired as a “DB9 Adapter” as shown in Table 4 of the “Apple 1 Serial Board February 2015” document.

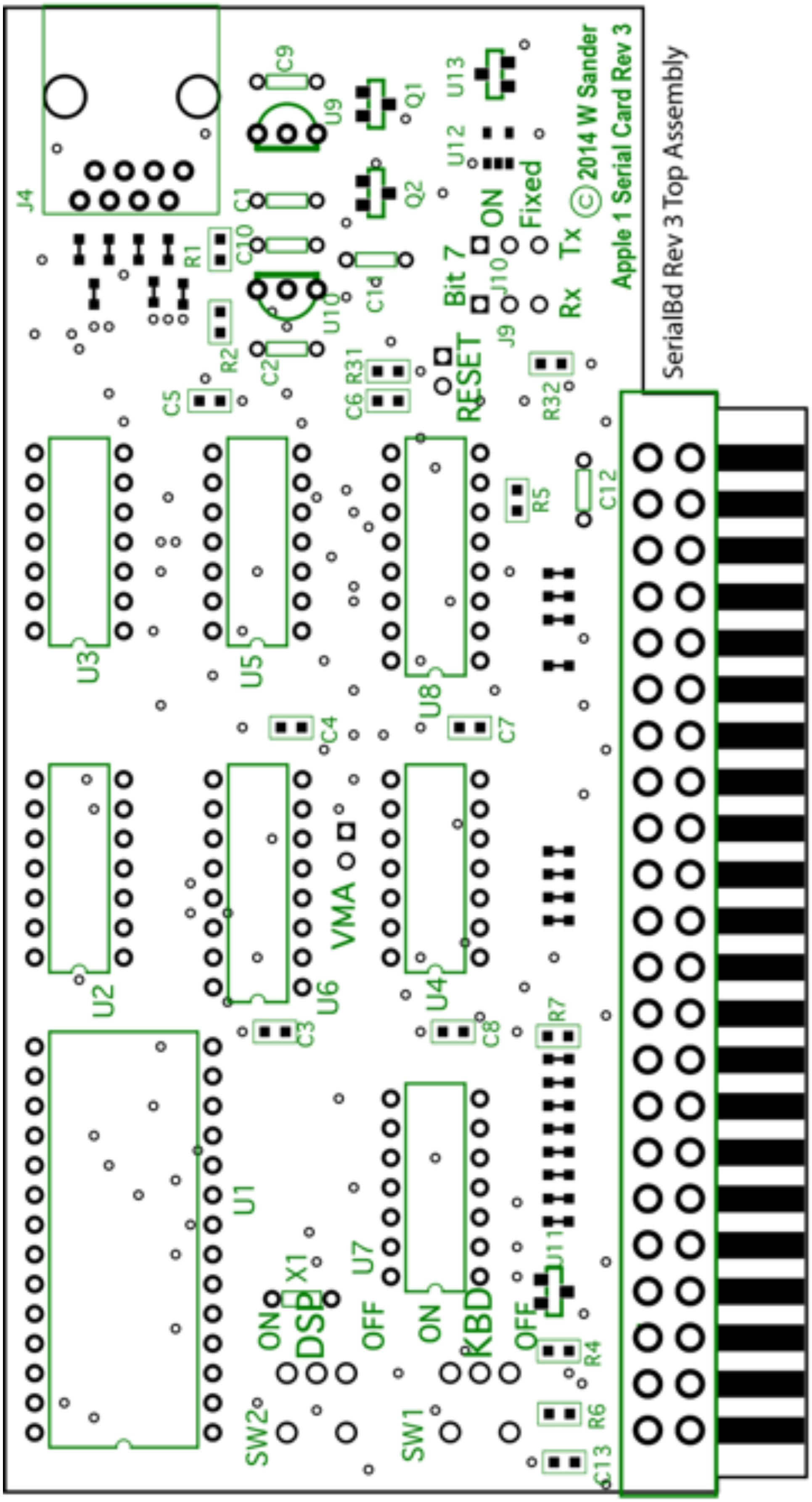
Using the configuration file labeled “CoolTerm Terminal” attached the Mac will behave as a dumb Terminal. The Send Break command is under the “Connections” tab. If a Break is sent when the Apple 1 Serial card has the DSP switch ON the response on the Mac screen will be

. . \

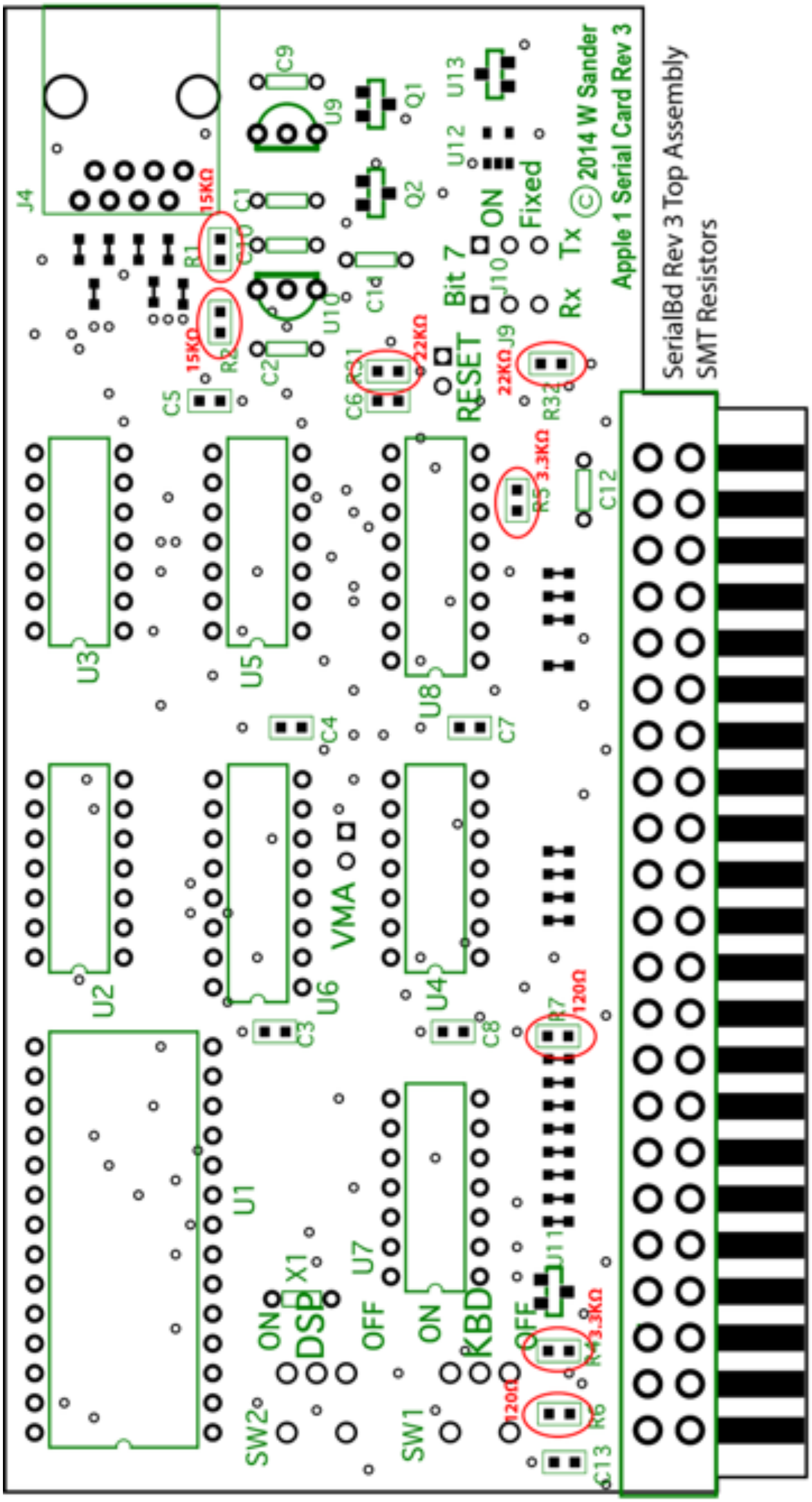
The CoolTerm Terminal file uses the font “PrintChar21” as this is a match to the Apple 1 and Apple II Fonts. This font is available from

http://www.kreativekorp.com/software/fonts/apple2.shtml

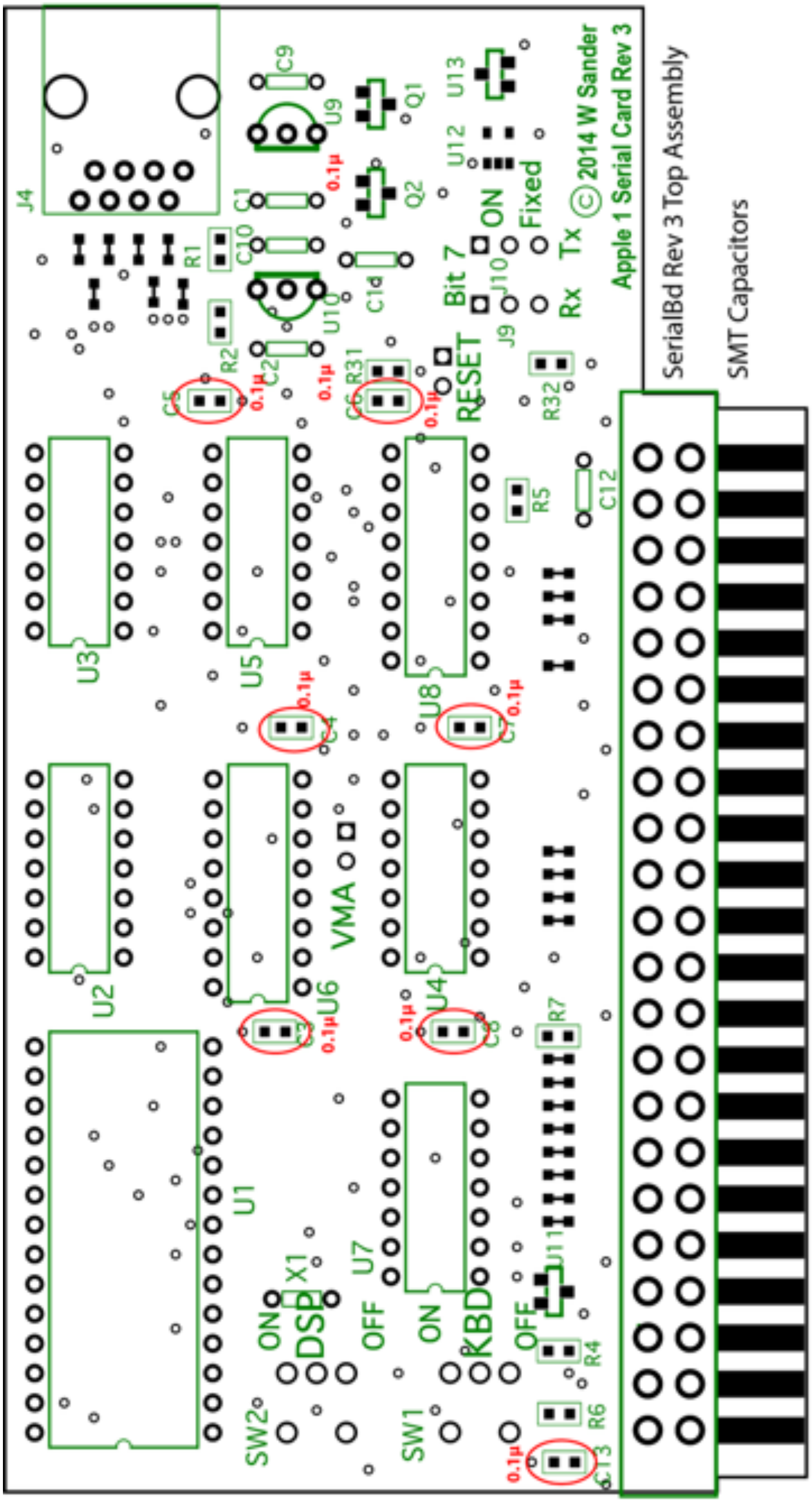

SERIAL BOARD REV 3
AUGUST 2014
RJ45 Jack
J4
U1
6551 ACIA
U2
DS14C88J
U3
DS14C89J
U8
74LS153
U6
74HCT251
U9
MC78L12AC
U10
uA7912
U11
MAX809
U12
NC7SZ86
U13
LM3480
X1
1.8432 MHz
Q1
Q2
FJV3102R
SPDT Toggle
J6 44PIN 0.156
PCB 44
HDR 1X3
J9
J10
J7
J8



SerialBd Rev 3 Top Assembly

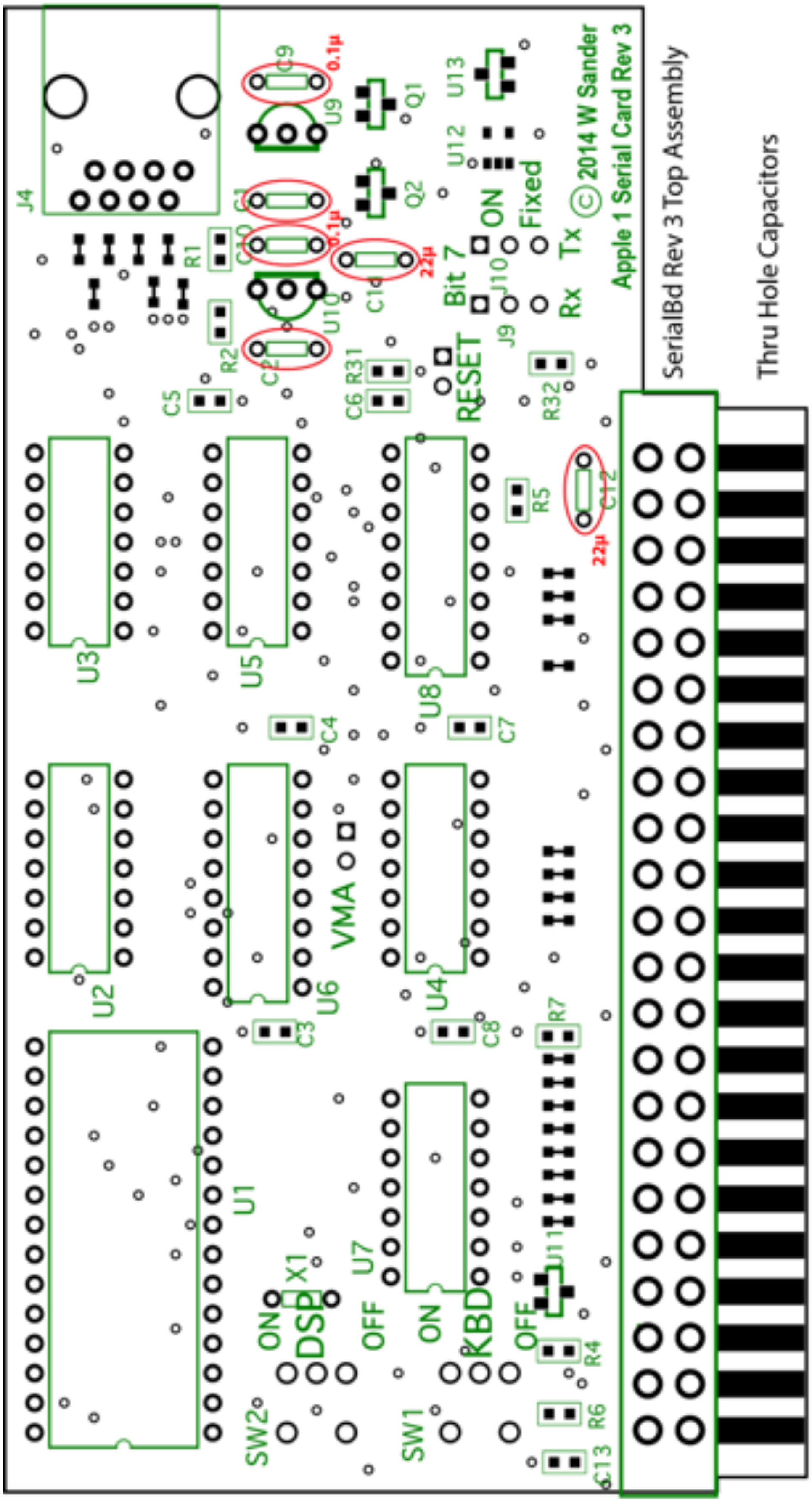


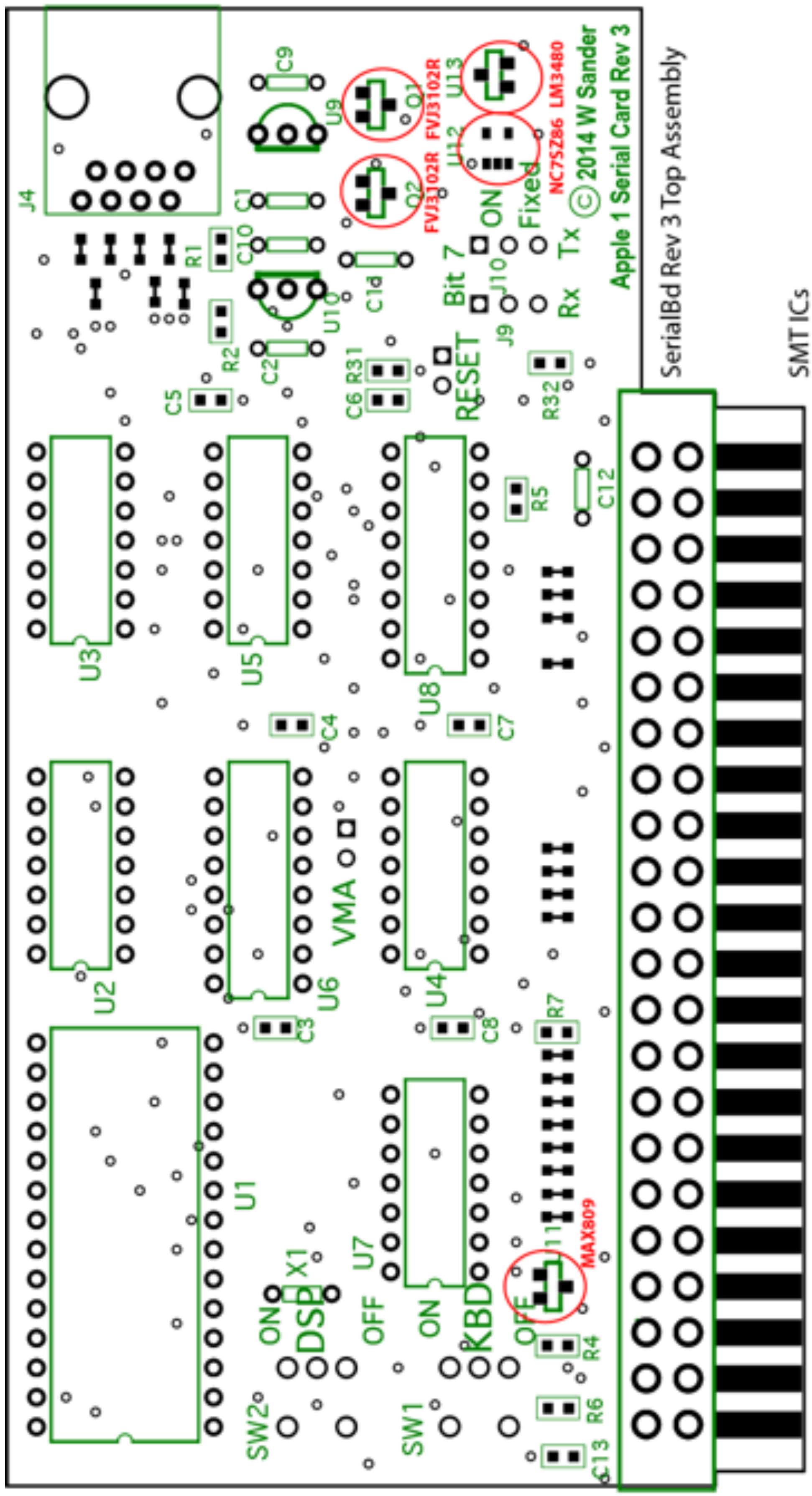
SerialBd Rev 3 Top Assembly
SMT Resistors



SerialBd Rev 3 Top Assembly

SMT Capacitors


© 2014 W Sander
Apple 1 Serial Card Rev 3
SerialBd Rev 3 Top Assembly
Thru Hole Capacitors


Apple 1 Serial Card Rev 3
© 2014 W Sander
NC7SZ86 LM3480
FVJ3102R
MAX809
SerialBd Rev 3 Top Assembly
SMT ICs

Serial Board Rev 3 Parts List

Designator	Part	Value	Manufacturer	Mfg Part No.	Description
C1	CAPACITOR	0.1u			0.2 In Radial Monlythic
C2	CAPACITOR	0.1u			0.2 In Radial Monlythic
C3	CAPACITOR	0.1u			0603 CAPACITOR
C4	CAPACITOR	0.1u			0603 CAPACITOR
C5	CAPACITOR	0.1u			0603 CAPACITOR
C6	CAPACITOR	0.1u			0603 CAPACITOR
C7	CAPACITOR	0.1u			0603 CAPACITOR
C8	CAPACITOR	0.1u			0603 CAPACITOR
C9	CAPACITOR	0.1u			0.2 In Radial Monlythic
C10	CAPACITOR	0.1u			0.2 In Radial Monlythic
C11	CAPACITOR	22u			0.2 In Radial Monlythic
C12	CAPACITOR	22u			0.2 In Radial Monlythic
C13	CAPACITOR	0.1u			0603 CAPACITOR
J4	RJ45 Jack		Molex	85503-5001	RJ45 Jack
J6	Card Connector	44 PIN 0.156	EDAC	305-044-520-202	44-Pin .156 Connector
J7	HEADER	1X2	SAMTEC	TSW-102-07-L-S	1X2 0.1 In Header
J8	HEADER	1X2	SAMTEC	TSW-102-07-L-S	1X2 0.1 In Header
J9	HEADER	1X3	SAMTEC	TSW-103-07-L-S	1X3 0.1 In Header
J10	HEADER	1X3	SAMTEC	TSW-103-07-L-S	1X3 0.1 In Header
Q1	FJV3102R		Fairchild	FJV3102R	SOT23
Q2	FJV3102R		Fairchild	FJV3102R	SOT23
R1	RESISTOR	15KΩ			0603 RESISTOR
R2	RESISTOR	15KΩ			0603 RESISTOR
R4	RESISTOR	3.3KΩ			0603 RESISTOR
R5	RESISTOR	3.3KΩ			0603 RESISTOR
R6	RESISTOR	120Ω			0603 RESISTOR
R7	RESISTOR	120Ω			0603 RESISTOR
R31	RESISTOR	22KΩ			0603 RESISTOR
R32	RESISTOR	22KΩ			0603 RESISTOR
SW1	SPDT Toggle		C&K	T101MH9ABE	SBDT TOGGLE 2 POS
SW2	SPDT Toggle		C&K	T101MH9ABE	SBDT TOGGLE 2 POS
U1	6551 ACIA				28 PIN 0.6 DIP
U2	DS14C88J		TI	DS14C88J	14 PIN DIP
U3	DS14C89J		TI	DS14C89J	14 PIN DIP
U4	74LS20			74LS20	14 PIN DIP
U5	74LS04			74LS04	14 PIN DIP
U6	74HCT251			74HCT251	16 PIN DIP
U7	74LS125			74LS125	14 PIN DIP
U8	74LS153			74LS153	16 PIN DIP
U9	LM78L12ACZ		TI	LM78L12ACZ	TO92
U10	LM79L12ACZ		TI	LM79L12ACZ	TO92
U11	MAX809	4.38V	ON SEMI	MAX809MTRG	SOT23
U12	NC7SZ86M5X	TinyLogic EOR	FAIRCHILD	NC7SZ86M5X	SOT23-5
U13	LM3480-3.3	3.3 V LDO	TI	LM3480IM3	SOT23
X1	XTAL1	1.8432 MHz	Fox Electronics	FOXLF018S	Metal Can 0.2 Center

Apple 1 USB Board
October 15, 2015

The Apple 1 USB Board uses a part called “Easy Input” that was available from Radovan Robotics based on a Cypress one chip micro that takes Serial or Parallel data input and puts the data out on a USB port that looks to the computer like a keyboard. Radovan Robotics is no longer an active company. This board uses a mod to the Apple 1 where the VMA line short to +5 is replaced by a resistor so the VMA can be become active (see Appendix A). Using this modification the 6820 can be disabled on a cycle by cycle basis by pulling down the VMA line and the USB board function can be enabled in its place. The board has no on board firmware and no additional software is needed for the boards operation.The board is compatible with all Apple 1 software. The Radovan part came in a 24 Pin DIP configuration and an SOIC. The board layout supports either part as seen in Figure 1.

I was able to get a limited supply of the “Easy Input” parts, a few in DIP and more in SOIC packages.

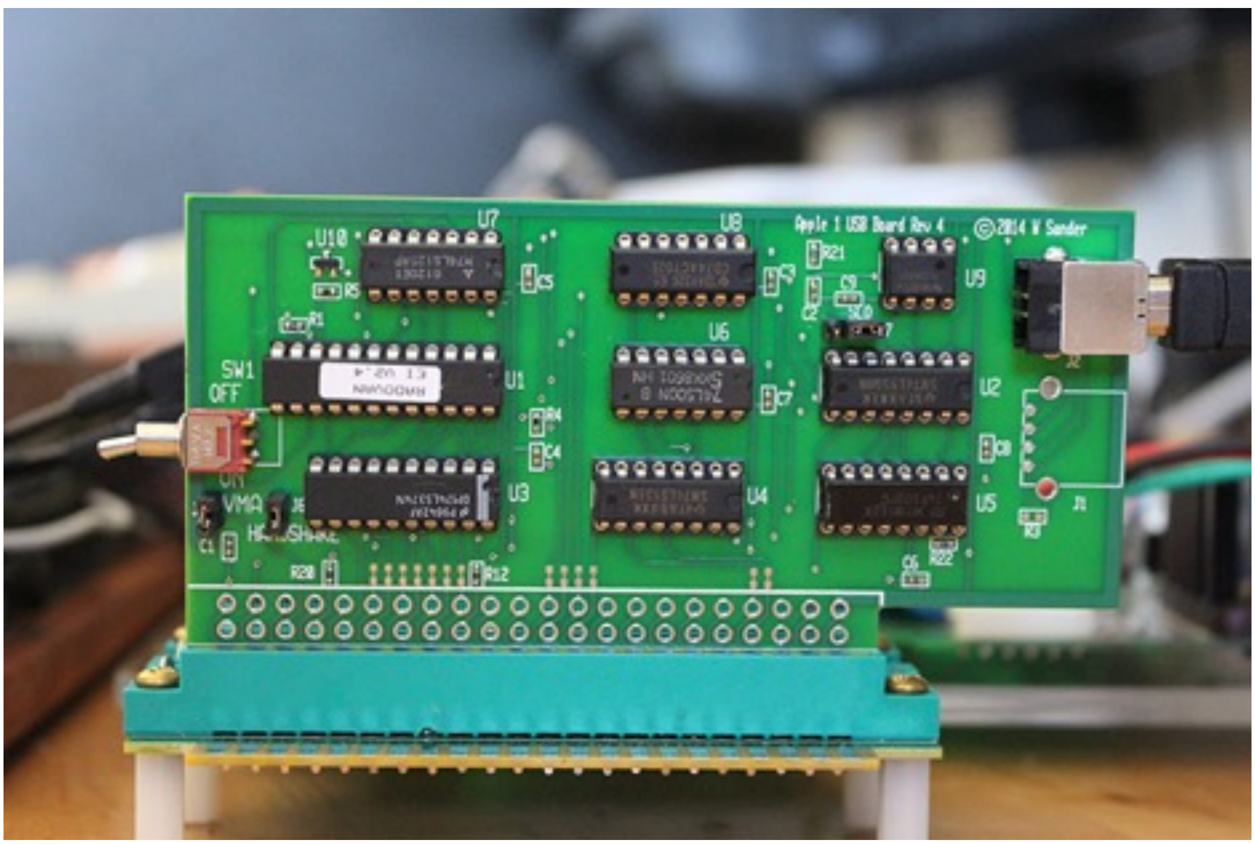


Figure 1

Table 1 shows the full address mapping for the board, Table 2 shows the mapping of the Apple 1 6820 addresses and Table 3 shows the actions of the USB board for various conditions. As can be seen if the VMA mod has been made the USB board can substitute for the Apple 1 video display routing the character stream to the USB output which looks like a USB keyboard to a Mac or PC.

USB Board Description

Full Binary Address x = “don’t care”	Suggested Address to Use
1101 xxxx xxxx xx10	$D012

Table 1 USB Board Active Address

Address	Write	Read
$D00X	6820 Inactive	
$D010		KBD Data Register
$D011		KBD Control Register Bit 7=1 Ready
$D012	DSP Data Register	DSP Status Register Bit 7= 0 Ready
$D013	DSP Control Register	

Table 2 Apple 1 I/O Address Mapping

Switch Status	USB	Address	Write		Read	
			Register	VMA	Register	VMA
Don’t Care	Don’t Care	$D010	X	Open	X	Open
Don’t Care	Don’t Care	$D011	X	Open	X	Open
TEST	Don’t Care	$D012	Date Register	Low	Bit 7 Low If Ready	Low
OFF	Don’t Care	X	X	Open	X	Open
ON	ON	$D012	Date Register	Open	Bit 7 Low If Ready	Low

Table 3 USB Board Address Mapping

The VMA pull down and USB Board register Read can be deactivated by jumpers on the board labelled VMA and HANDSHAKE. When these are removed the USB board will function “open loop” (no handshake) even if the VMA mod has not been done. Since the USB board is a little faster than the Apple 1 display the Apple 1 display and USB output will both happen. Occasionally the USB board may miss a character in this mode, usually at the beginning or end of a character stream.

The application note for the Radovan Easy Input device states that the Cypress chip should be powered from the USB power, however that can cause a problem. The chip is subject to “back powering” which means that if the chip is powered down inputs to the chip that are at 1 levels can power the chip through the protection diodes on those inputs. With CMOS parts the power supply can be pulled to over 4 volts, effectively powering the chip. To avoid this problem a power on reset chip U10 is used to detect the presence of USB power and tri-state the inputs if there is no USB power. This signal is also used to activate the USB Board when the toggle switch is ON and there is USB power.

Sometimes the output of the board can overrun the device to which it is connected. A 555 timer U9 can be used to optionally slow down the rate. This function is activated but the position of the shorting bar on J7. The rate is set to about 10 Characters per second but can be changed by changing R21 and/or C2.

If a generic keyboard is plugged in to the Mac, the user is asked to press the keys next to the shift keys for detection of the type of keyboard. If there is a problem with getting the board identified then this identification sequence can be found in the Keyboard section of the System Preferences when the board is connected to the computer. If the keyboard type is asked for it is ANSI. More information on this is in the Board Test Section.

USB Board Testing

For testing the USB Board the Apple 1 or Clone must have the VMA mod performed meaning that the short on the Apple 1 labeled “6502” near the 3 3K resistors and near pin 1 of the 40 pin socket at A7 should be removed and replaced by a 100pf Capacitor and 2200Ω resistor across the terminals with surface mount parts or between pins 5 and 8 of the 6502 at location A7 or pins 12 and 14 of the DIP at location B1. The USB board should be configured as shown in Figure 3 and plugged onto the PC board connector of the Apple 1 or can be plugged into an expansion slot of a known good Expansion Board configured as shown in Figure 2.

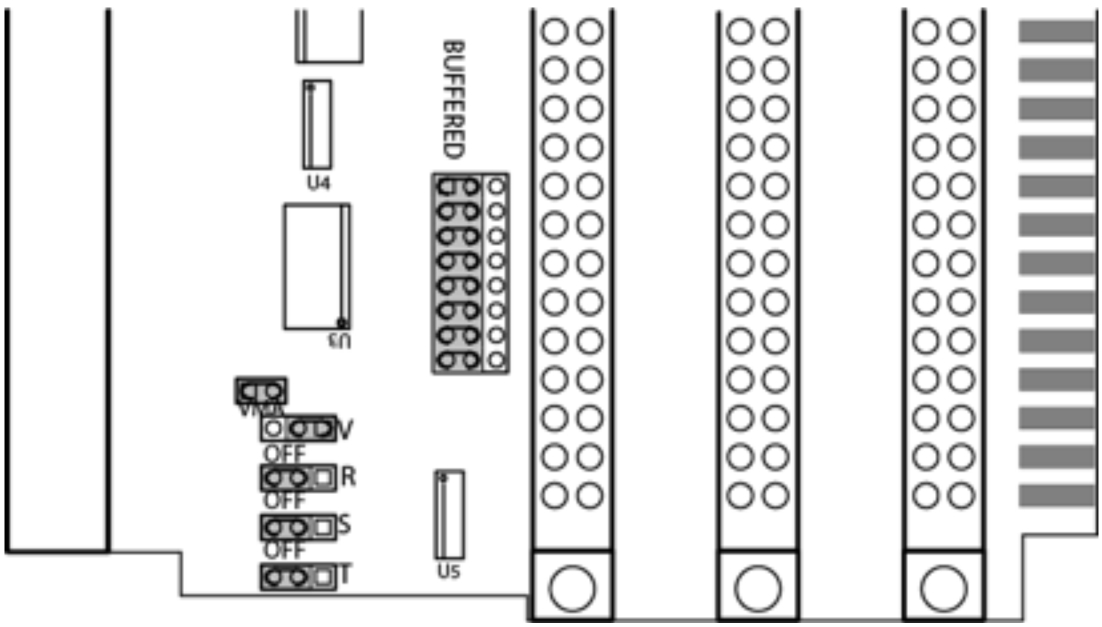


Figure 2

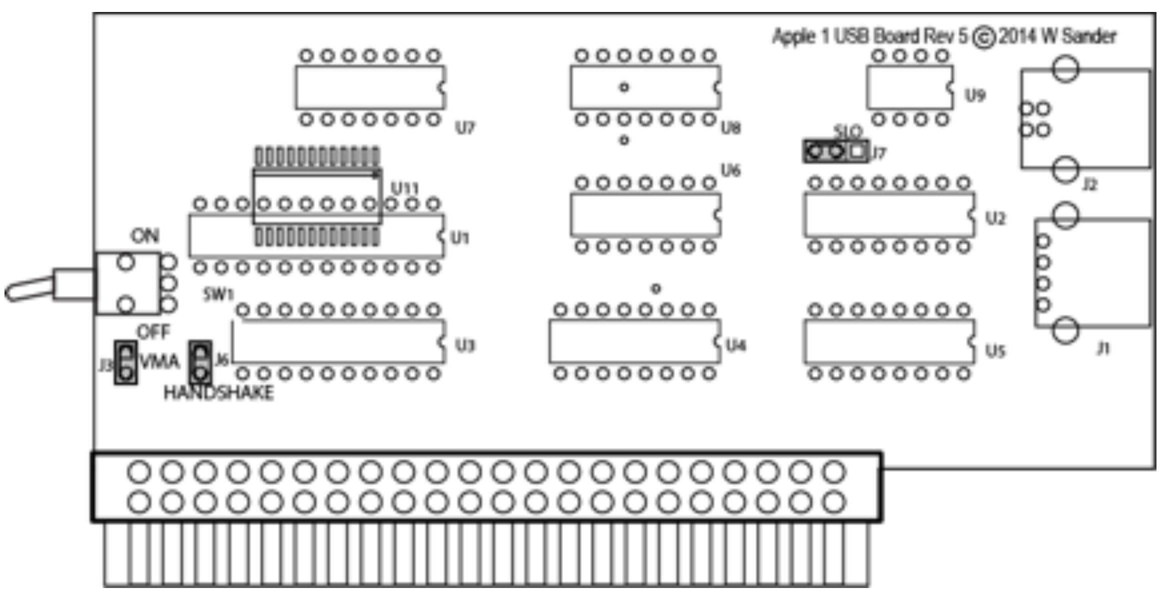


Figure 3

Power on the Apple 1 and verify that the system will reset and that the Keyboard and Display work normally. Switch the toggle switch on the USB Board to ON, the Apple 1 Display will still work normally until the USB cable is connected to the computer.

USB Board Testing

Connect the USB Board to a Mac computer with a USB Cable. The first time a working USB board is connected to a Mac the Mac will go through the Keyboard Setup sequence of Figures 4 through 8. If the sequence is successfully completed then the Mac will not request go through the sequence again. If the Mac has already had a USB board activated then to test a new USB board go to System Preferences/Keyboard and you will see either the screen of Figure 8 or Figure 9. If the screen of Figure 9 without the "Change Keyboard Type…" option then the USB connection to the USB Board is not working properly. If the "Change Keyboard Type…" option is available then choosing the option will enter the sequence of Figures 3 through 8. Note that the "Change Keyboard Type…" option will appear even if the Apple 1 is not powered because the USB chip on the USB Board is powered from the USB cable. Once the USB Board completes the sequence all keystrokes can be tested.

The TextEdit document "Apple 1 Screen" is formatted to provide an Apple 1 display and can be used with the USB Board. Move the cursor to the end of the file before use. It is best to use a copy of the file particularly if you want to keep the session. The TextEdit application autosaves. The document uses the PrintChar21 character set that can be found at

http://www.kreativekorp.com/software/fonts/apple2.shtml

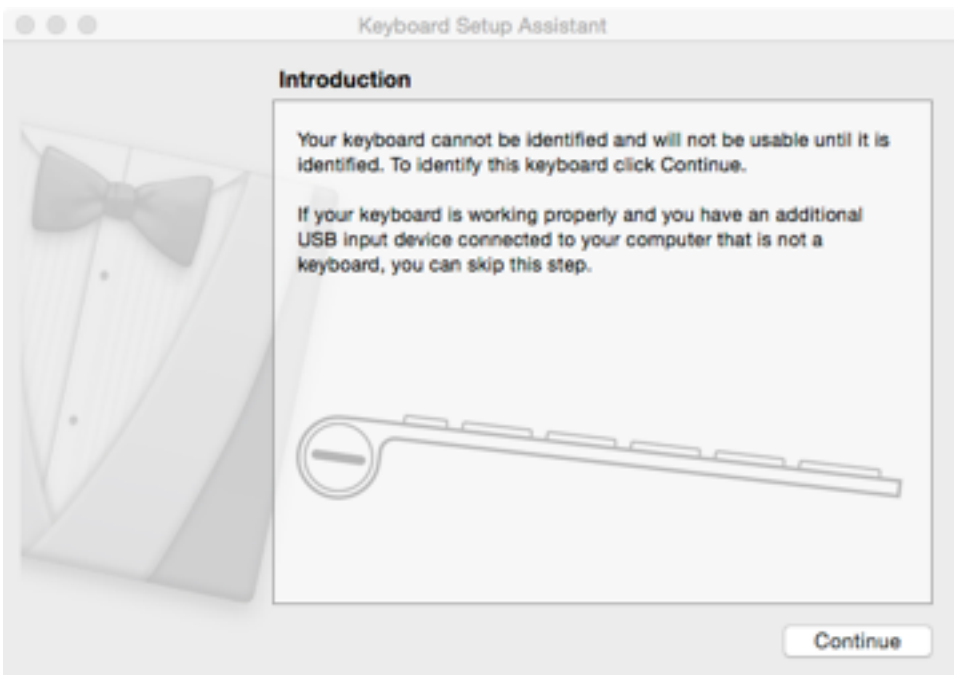


Figure 4

Figure 5

Figure 6

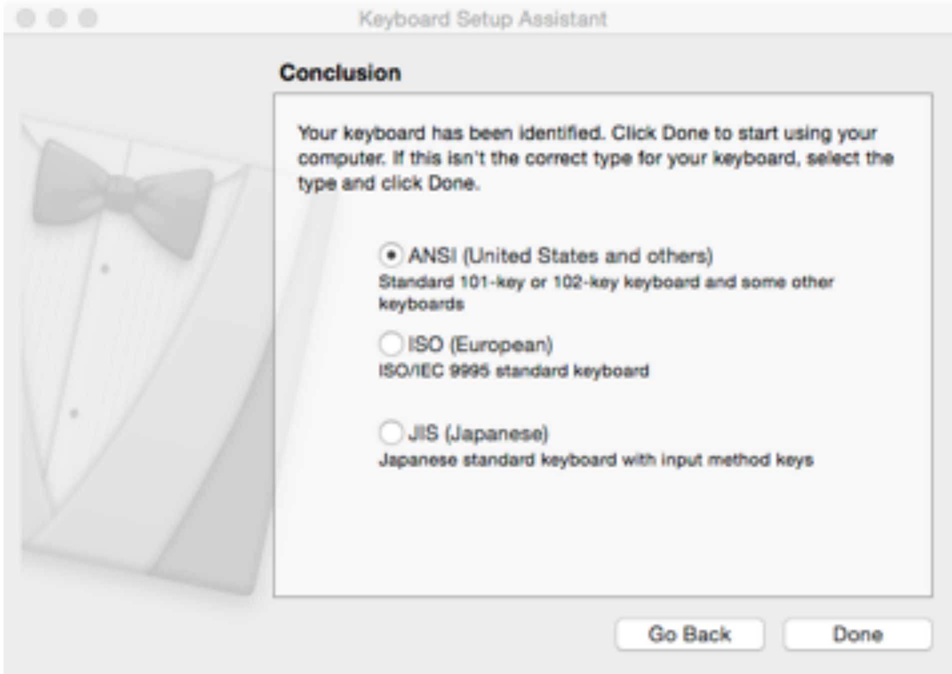


Figure 7

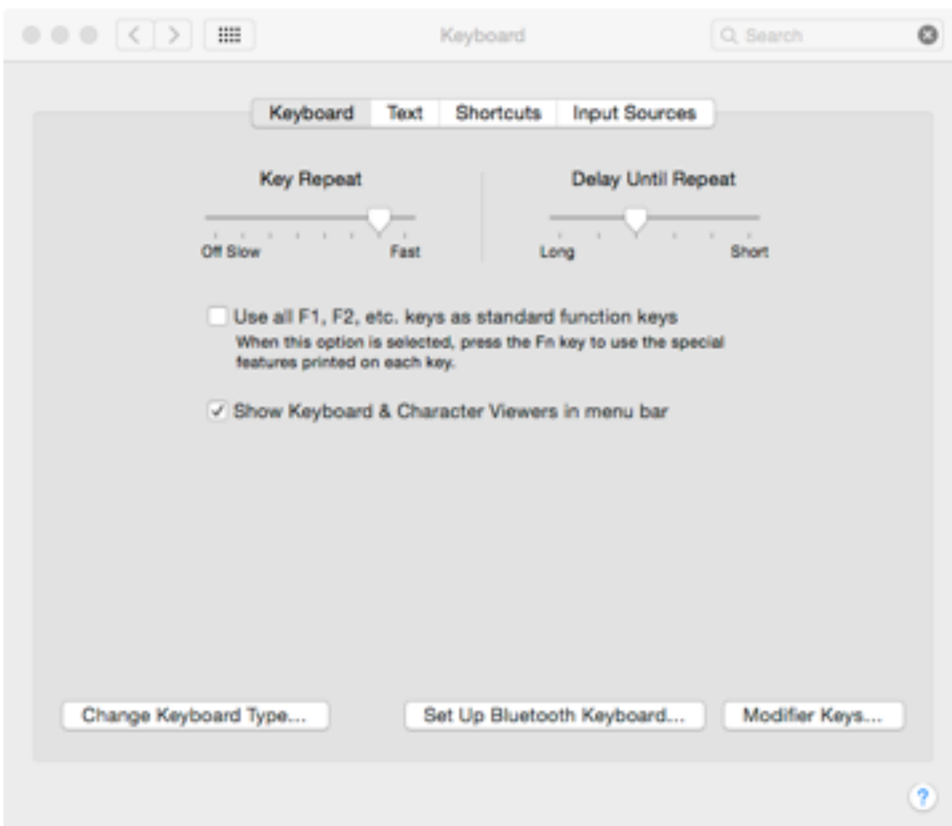
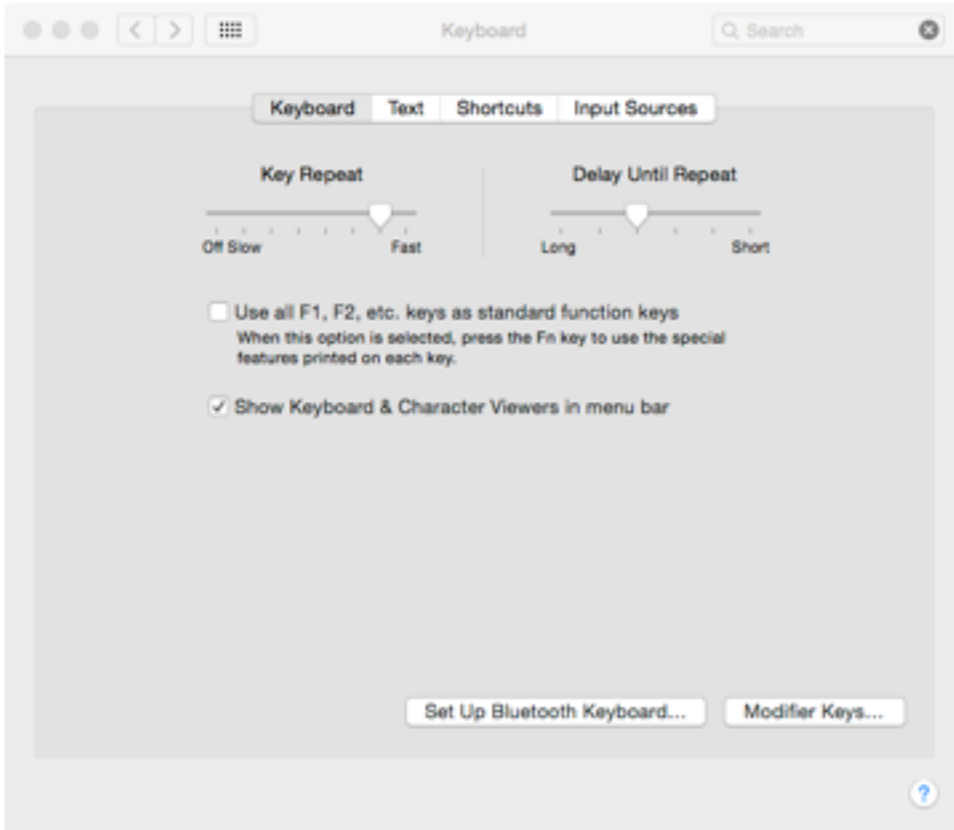
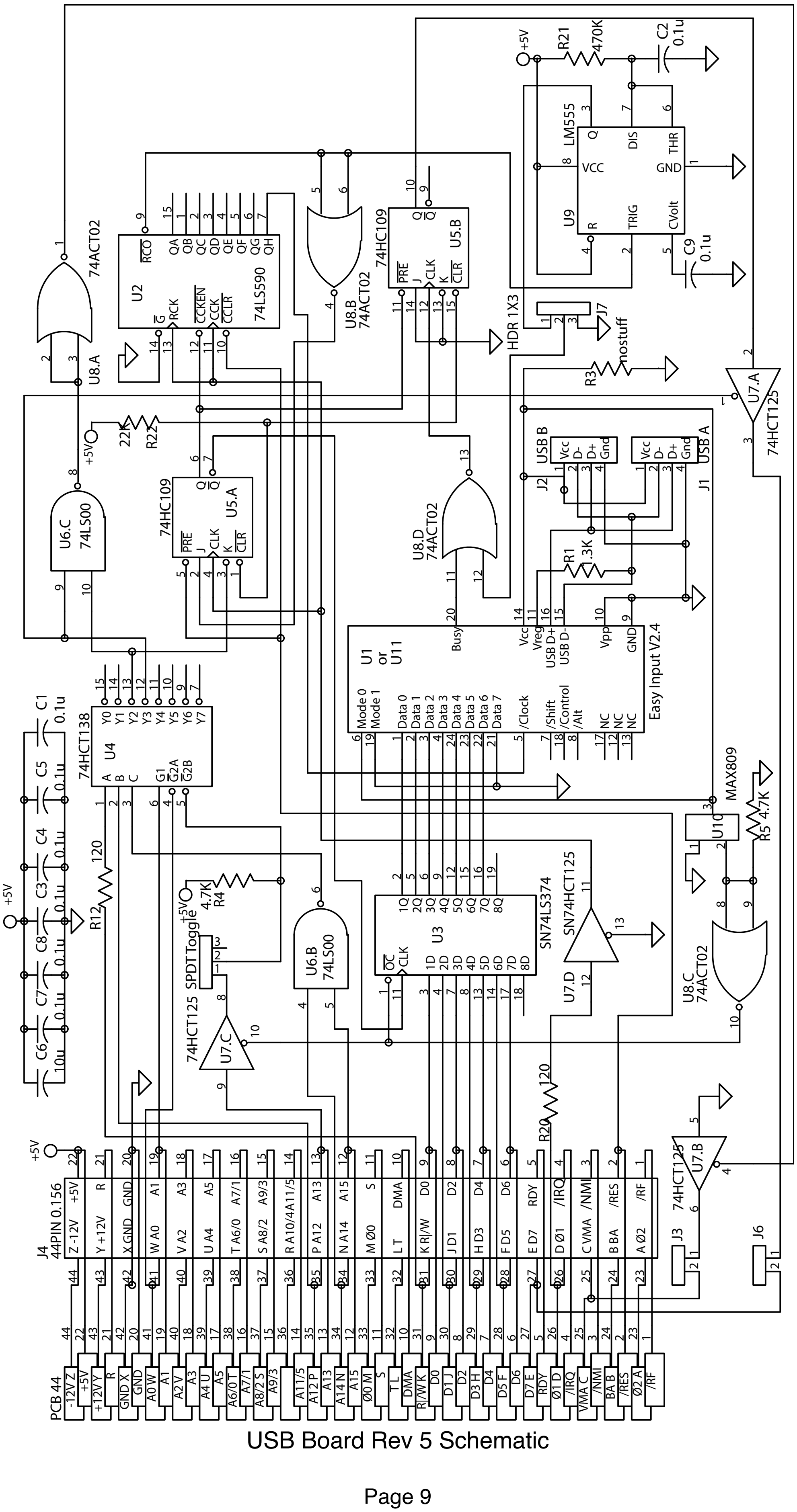


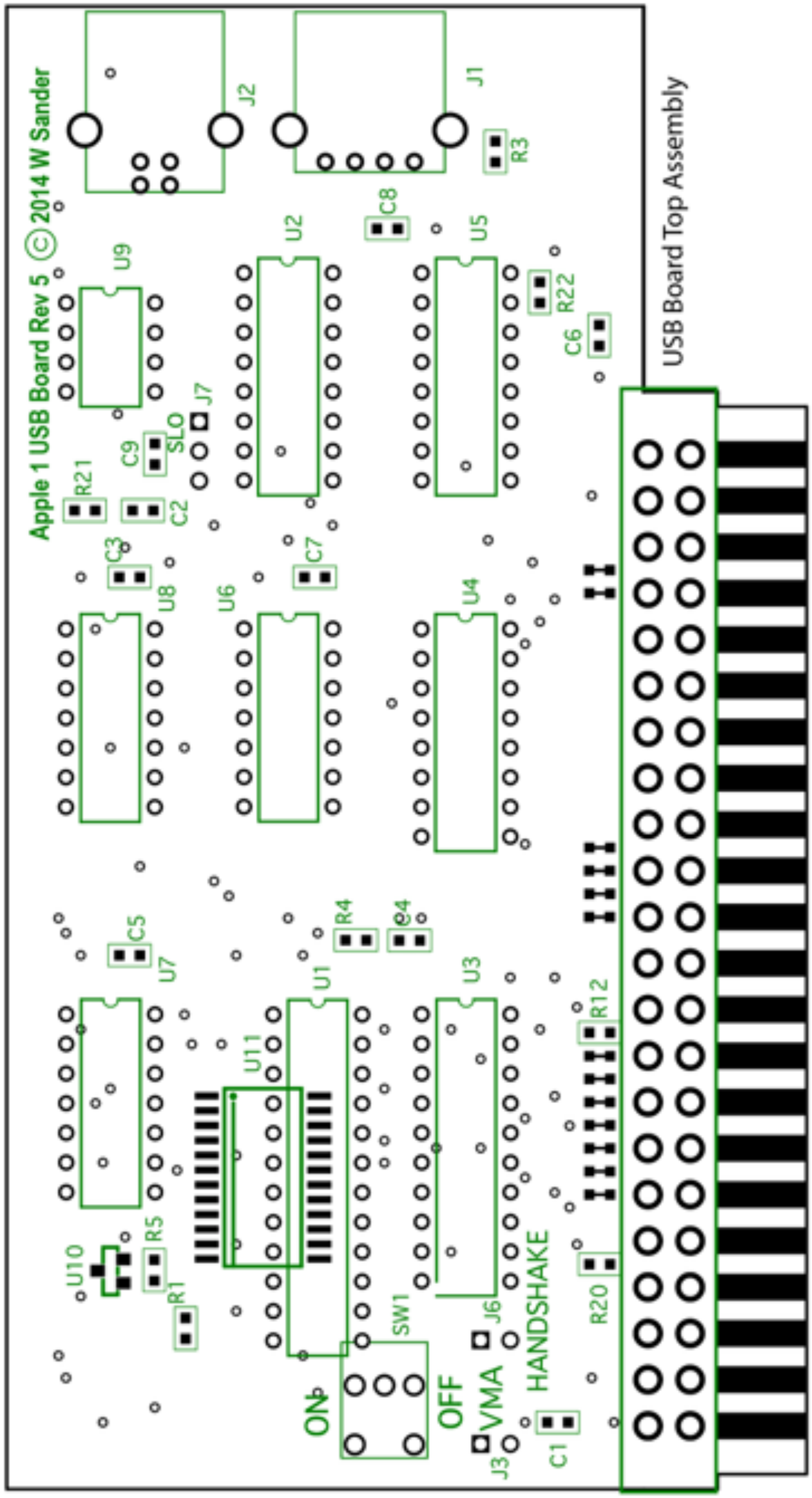
Figure 8


Keyboard
Search
Keyboard
Text
Shortcuts
Input Sources
Key Repeat
Off Slow
Fast
Delay Until Repeat
Long
Short
Use all F1, F2, etc. keys as standard function keys
When this option is selected, press the Fn key to use the special features printed on each key.
Show Keyboard & Character Viewers in menu bar
Set Up Bluetooth Keyboard...
Modifier Keys...

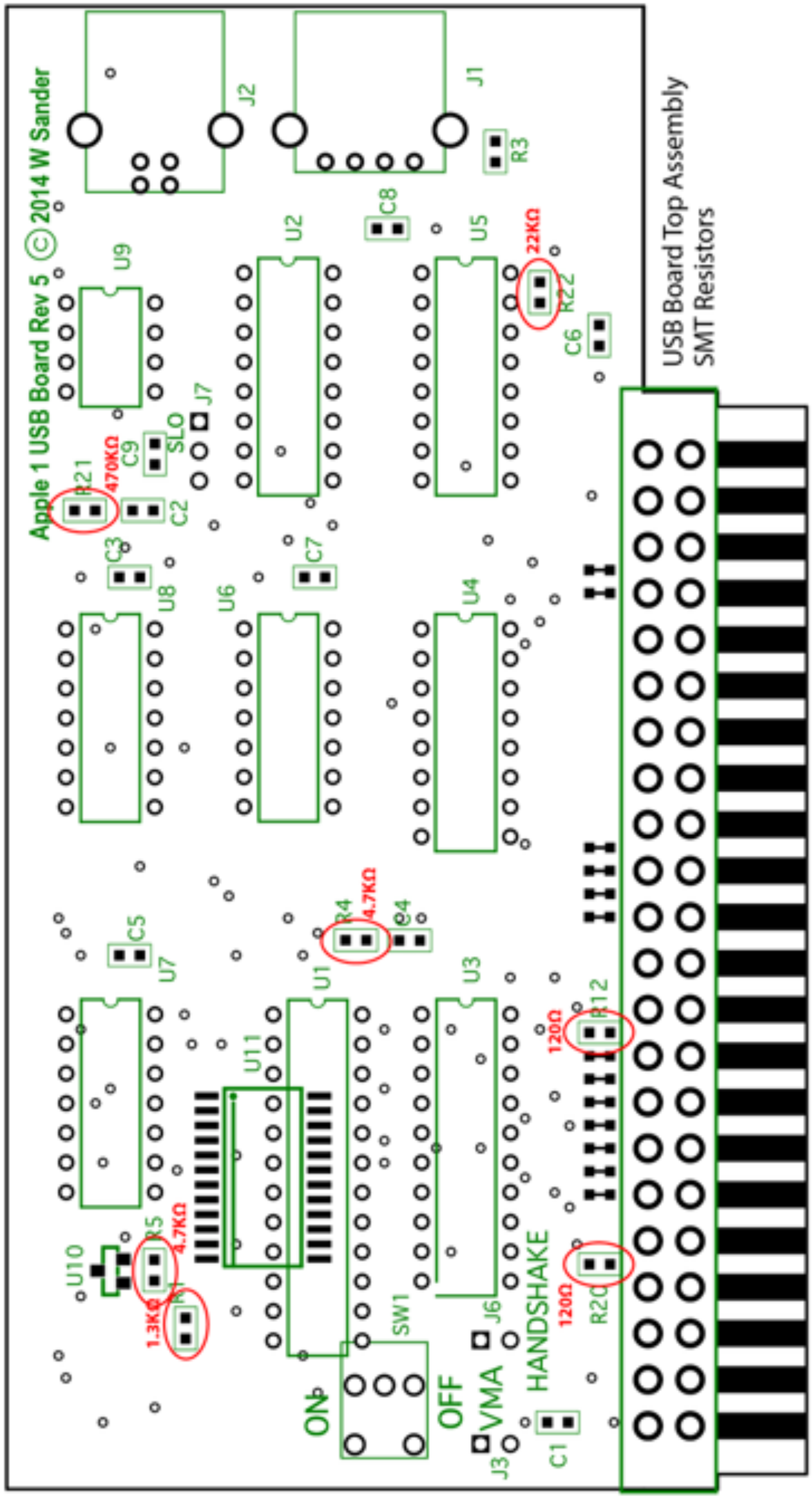
Figue 9



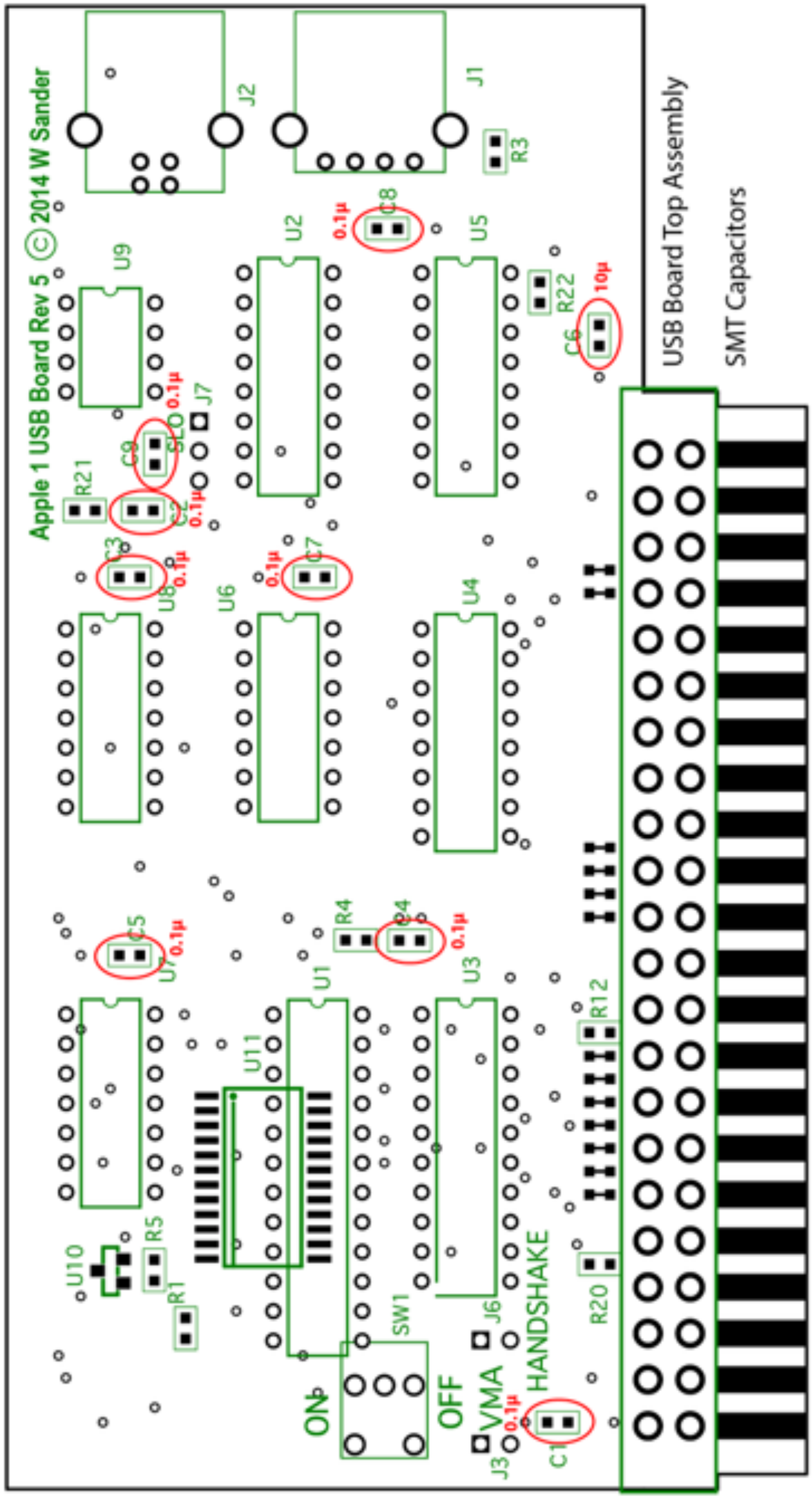
USB Board Rev 5 Schematic



USB Board Top Assembly



USB Board Top Assembly
SMT Resistors



USB Board Top Assembly

SMT Capacitors

USB Rev 5 Parts List

Designator	Part	Value	Manufacturer	Mfg Part No.	Description
C1	CAPACITOR	0.1u			0603 CAPACITOR
C2	CAPACITOR	0.1u			0603 CAPACITOR
C3	CAPACITOR	0.1u			0603 CAPACITOR
C4	CAPACITOR	0.1u			0603 CAPACITOR
C5	CAPACITOR	0.1u			0603 CAPACITOR
C6	CAPACITOR	10u			0603 CAPACITOR
C7	CAPACITOR	0.1u			0603 CAPACITOR
C8	CAPACITOR	0.1u			0603 CAPACITOR
C9	CAPACITOR	0.1u			0603 CAPACITOR
J1	USB A		TE Connectivity	292303-1	USB Type A Connector
J2	USB B		TE Connectivity	292304-1	USB Type B Connector
J3	HEADER	1X2	SAMTEC	TSW-102-07-L-S	1X2 0.1 In Header
J4	Card Connector	44 PIN 0.156	EDAC	305-044-520-202	44-Pin .156 Connector
J6	HEADER	1X2	SAMTEC	TSW-102-07-L-S	1X2 0.1 In Header
J7	HEADER	1X3	SAMTEC	TSW-103-07-L-S	1X3 0.1 In Header
R1	RESISTOR	1.3KΩ			0603 RESISTOR
R3	RESISTOR	nostuff			0603 RESISTOR
R4	RESISTOR	4.7KΩ			0603 RESISTOR
R5	RESISTOR	4.7KΩ			0603 RESISTOR
R12	RESISTOR	120Ω			0603 RESISTOR
R20	RESISTOR	120Ω			0603 RESISTOR
R21	RESISTOR	470KΩ			0603 RESISTOR
R22	RESISTOR	22KΩ			0603 RESISTOR
SW1	SPDT Toggle		C&K	T101MH9ABE	SBDT TOGGLE 2 POS
U1	Easy Input V2.4		Radovan Robotics	Easy Input V2.4	24 PIN 0.3 DIP
U2	74LS590			74LS590	16 PIN DIP
U3	74LS374			74LS374	20 PIN DIP
U4	74LS138			74LHCT138	16 PIN DIP
U5	74F109			74HC109	16 PIN DIP
U6	74LS00			74LS00	14 PIN DIP
U7	74LS125A			74HCT125	14 PIN DIP
U8	74ACT02			74LS04	14 PIN DIP
U9	555 Timer		TI	TLC555CP	8 PIN DIP
U10	MAX809	4.38V	ON SEMI	MAX809MTRG	SOT23
U11 (alt to U1)	Easy Input V2.4		Radovan Robotics	Easy Input V2.4	24 PIN SOIC