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.

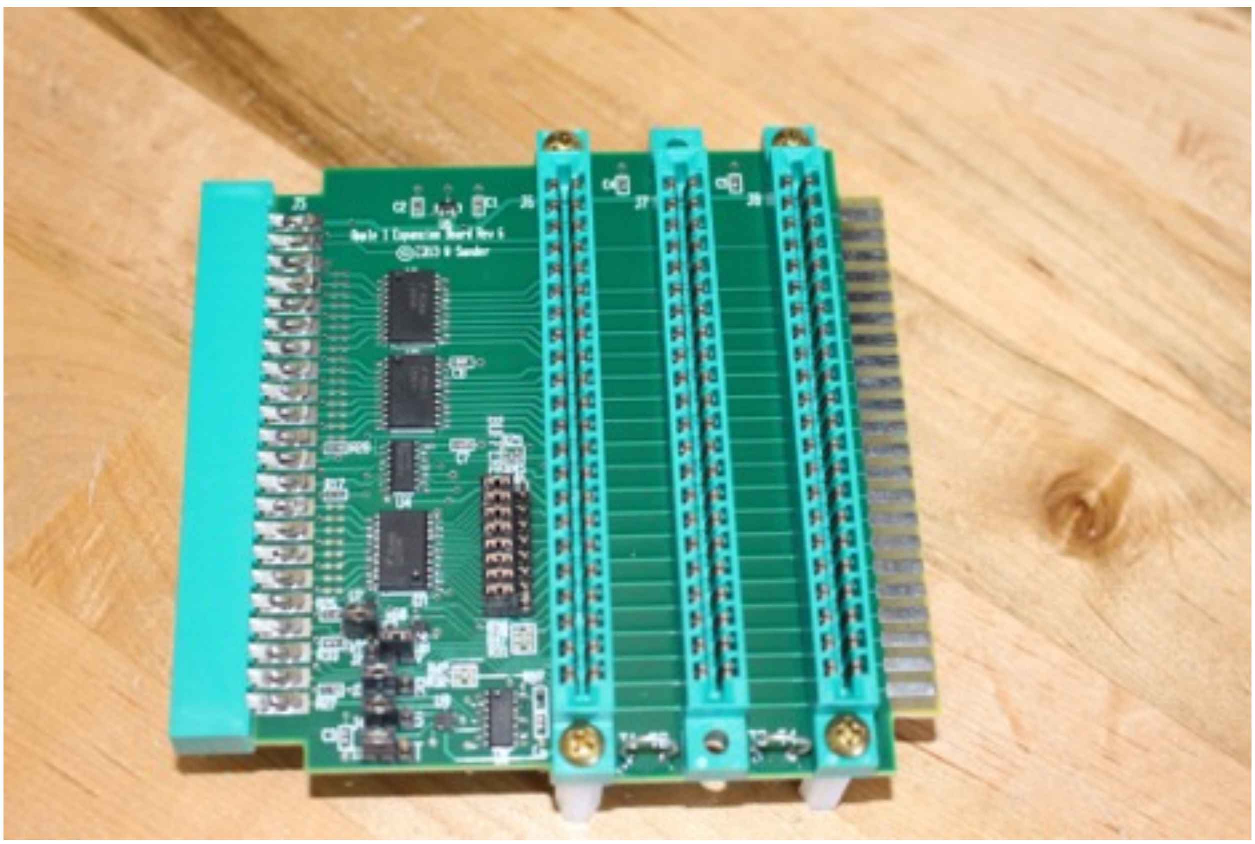


Figure 1

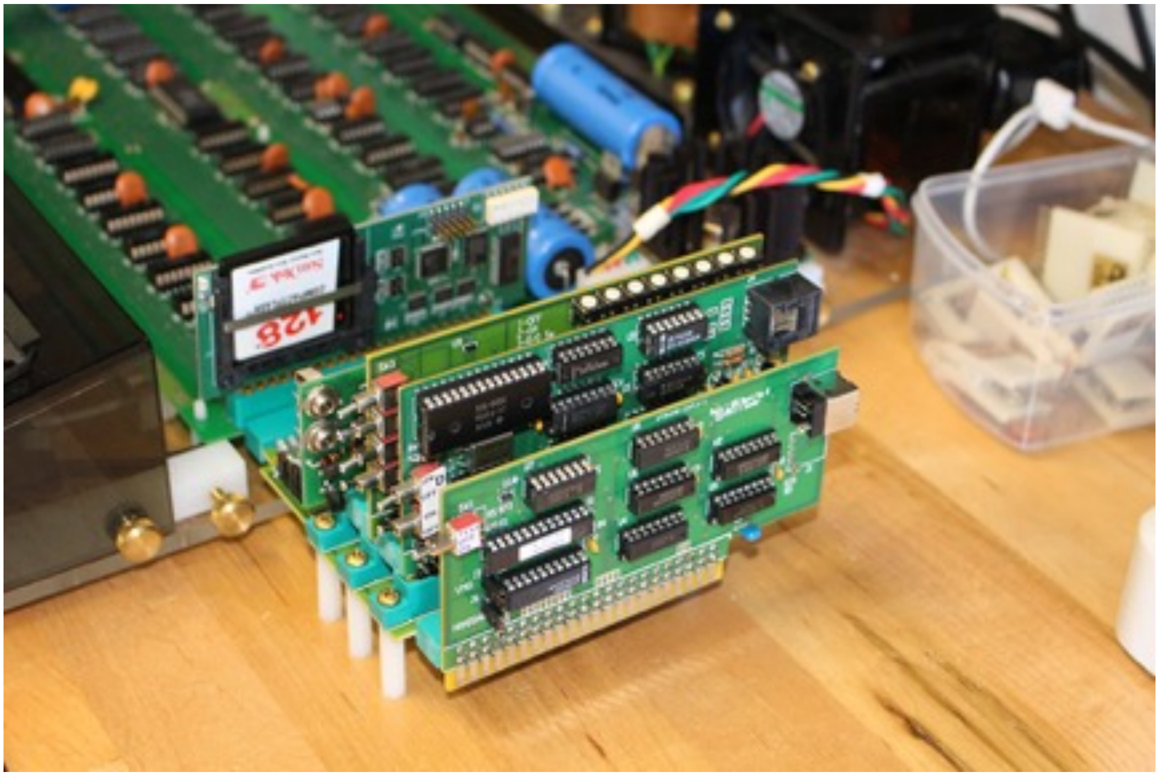


Figure 2

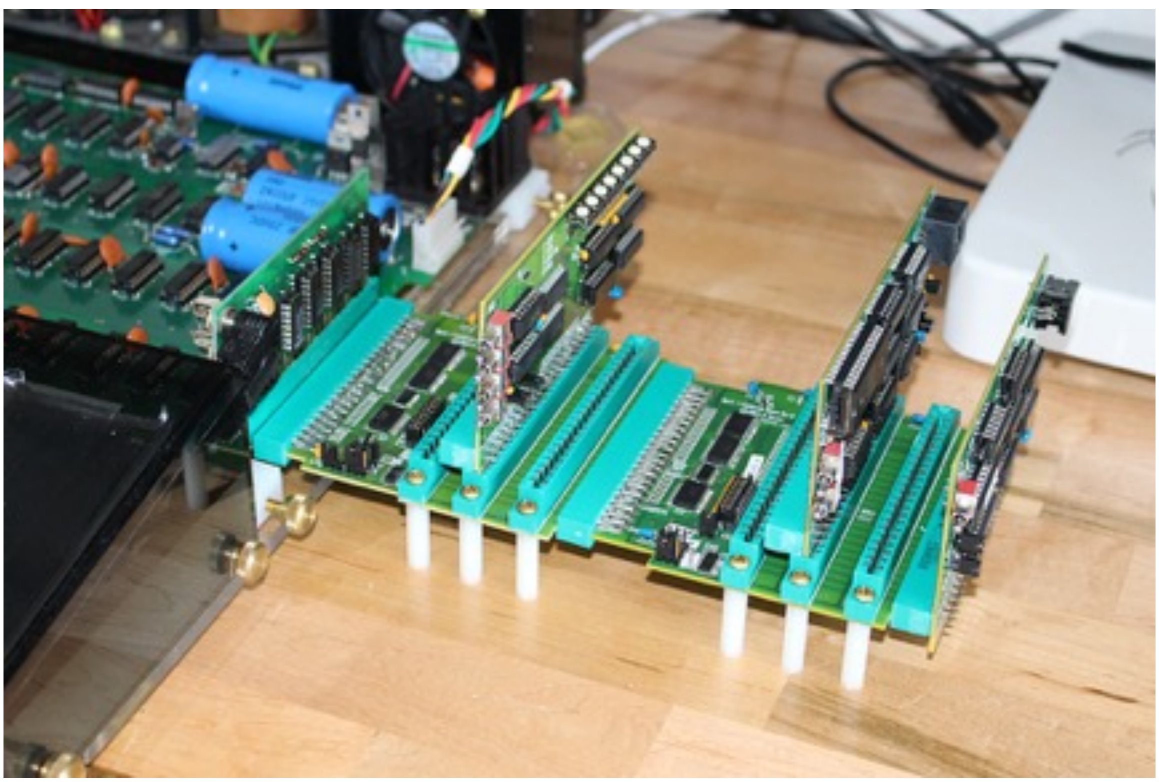


Figure 3

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.

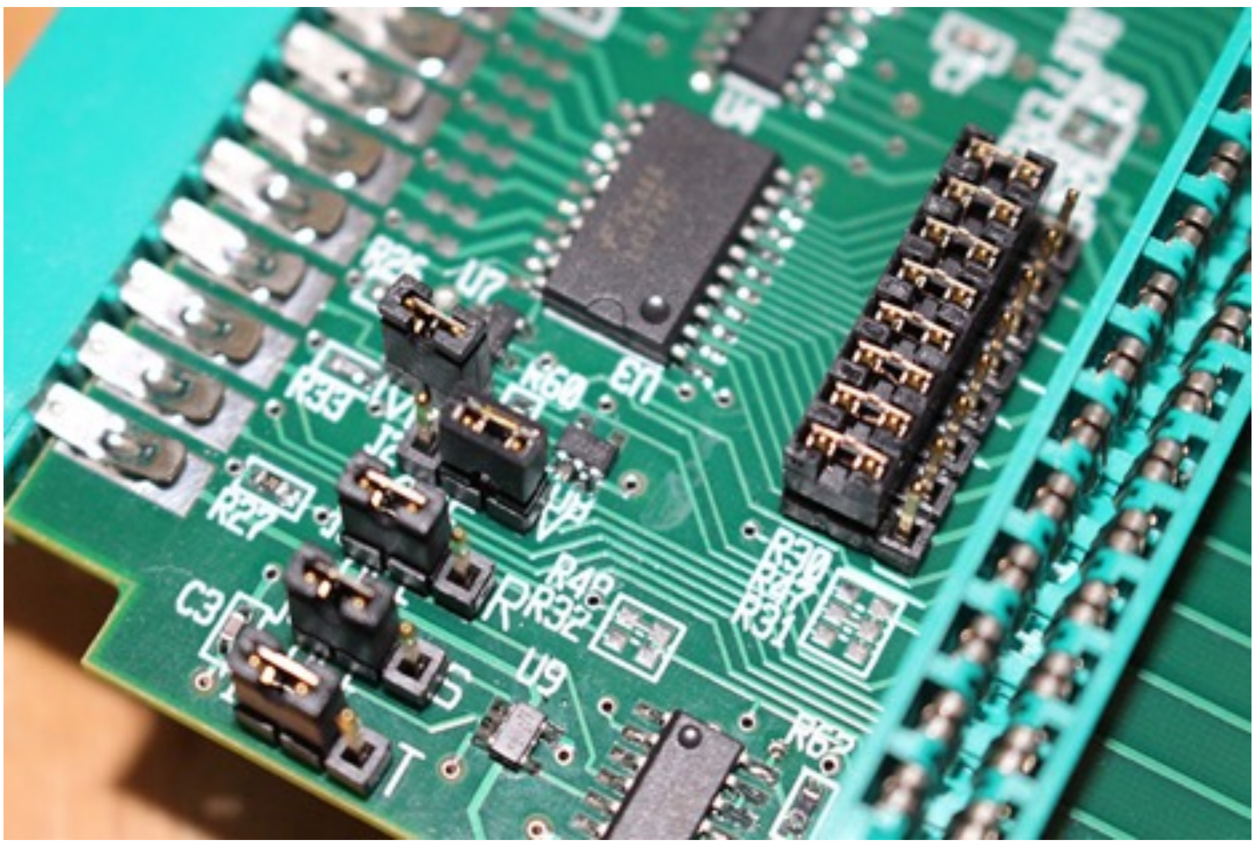


Figure 4

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.

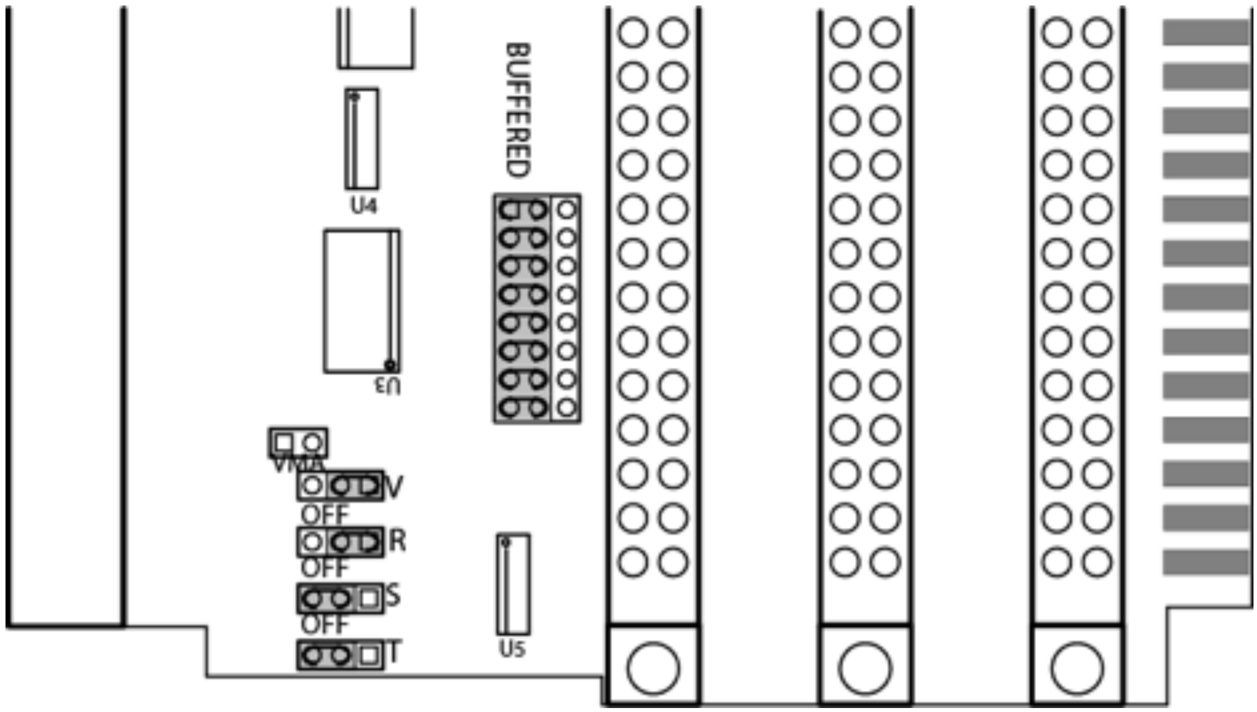


Figure 6

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.

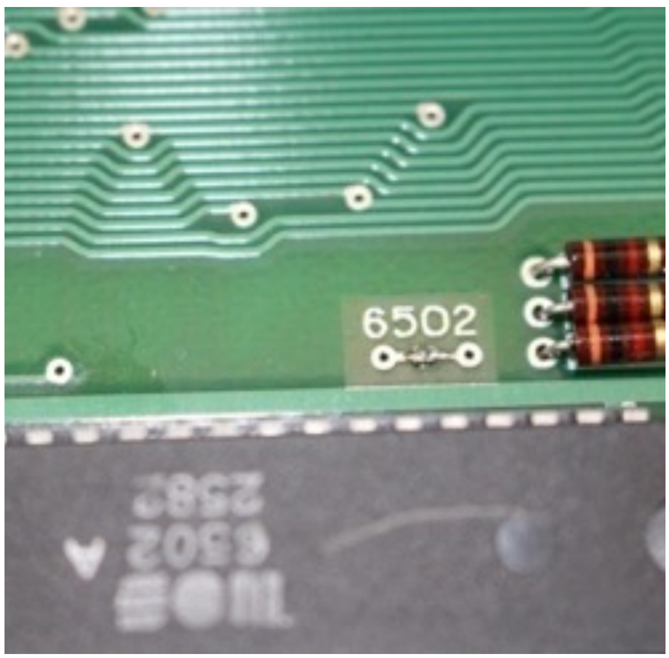


Figure 1

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 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.

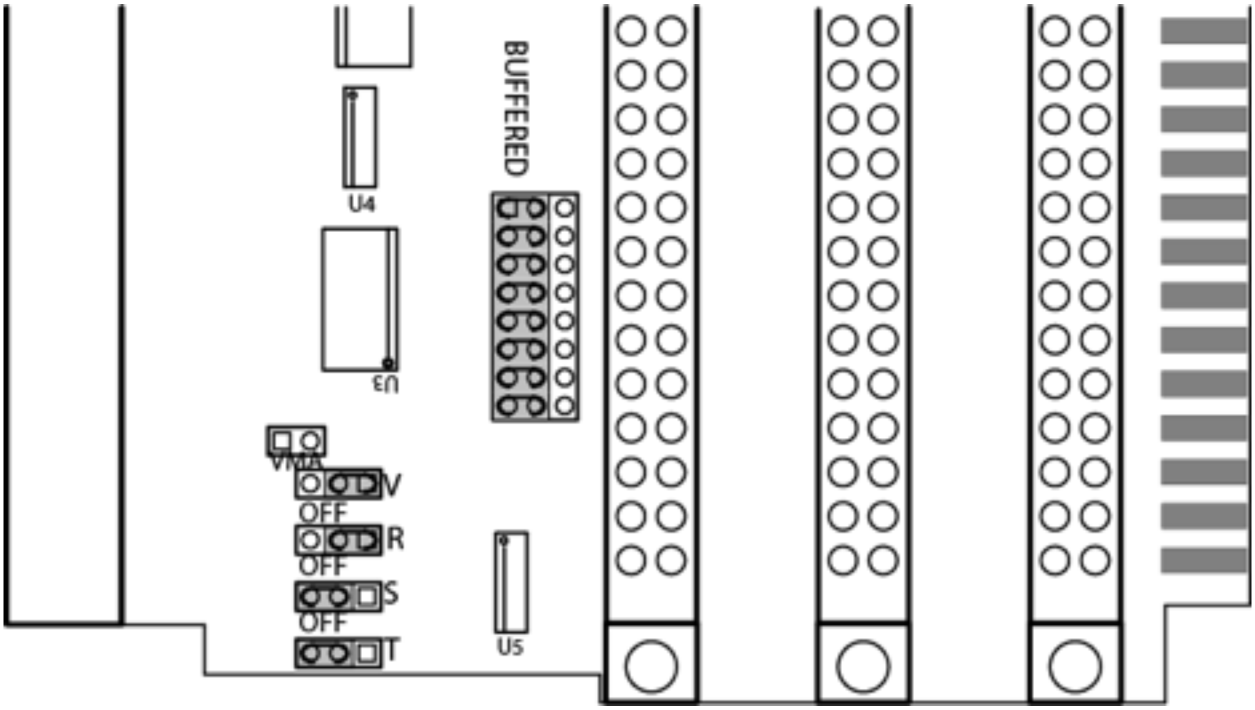


Figure 7

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

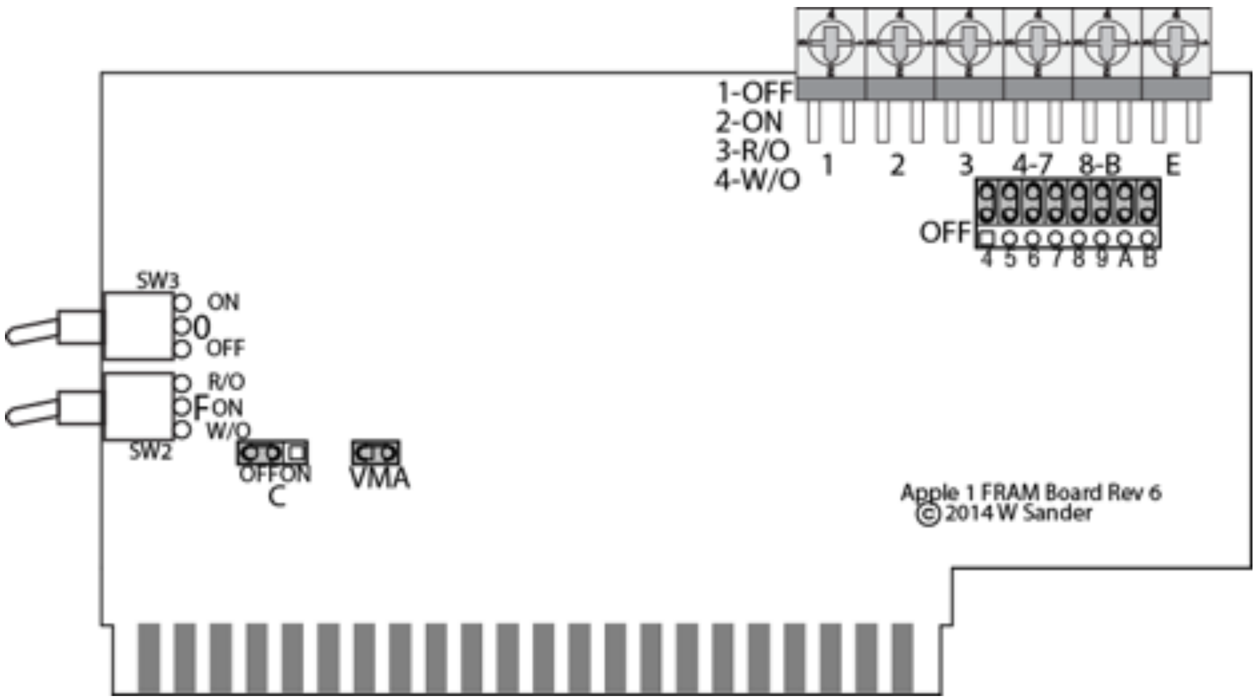


Figure 8

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.

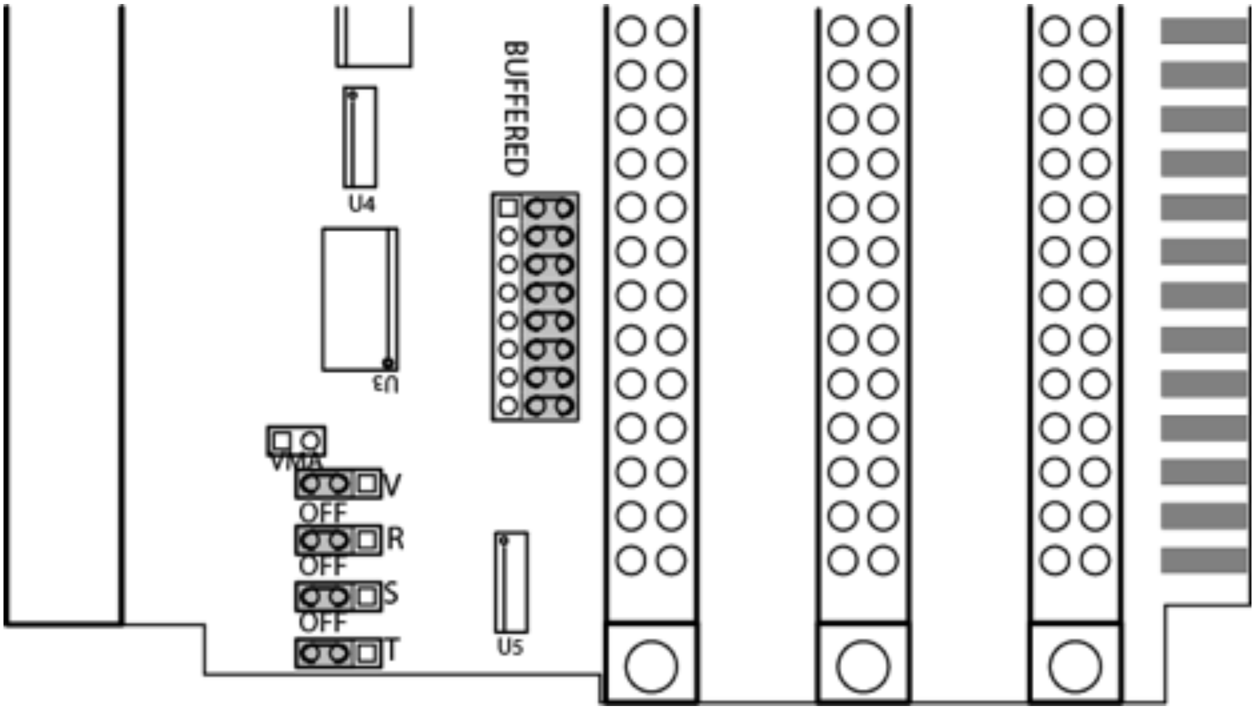
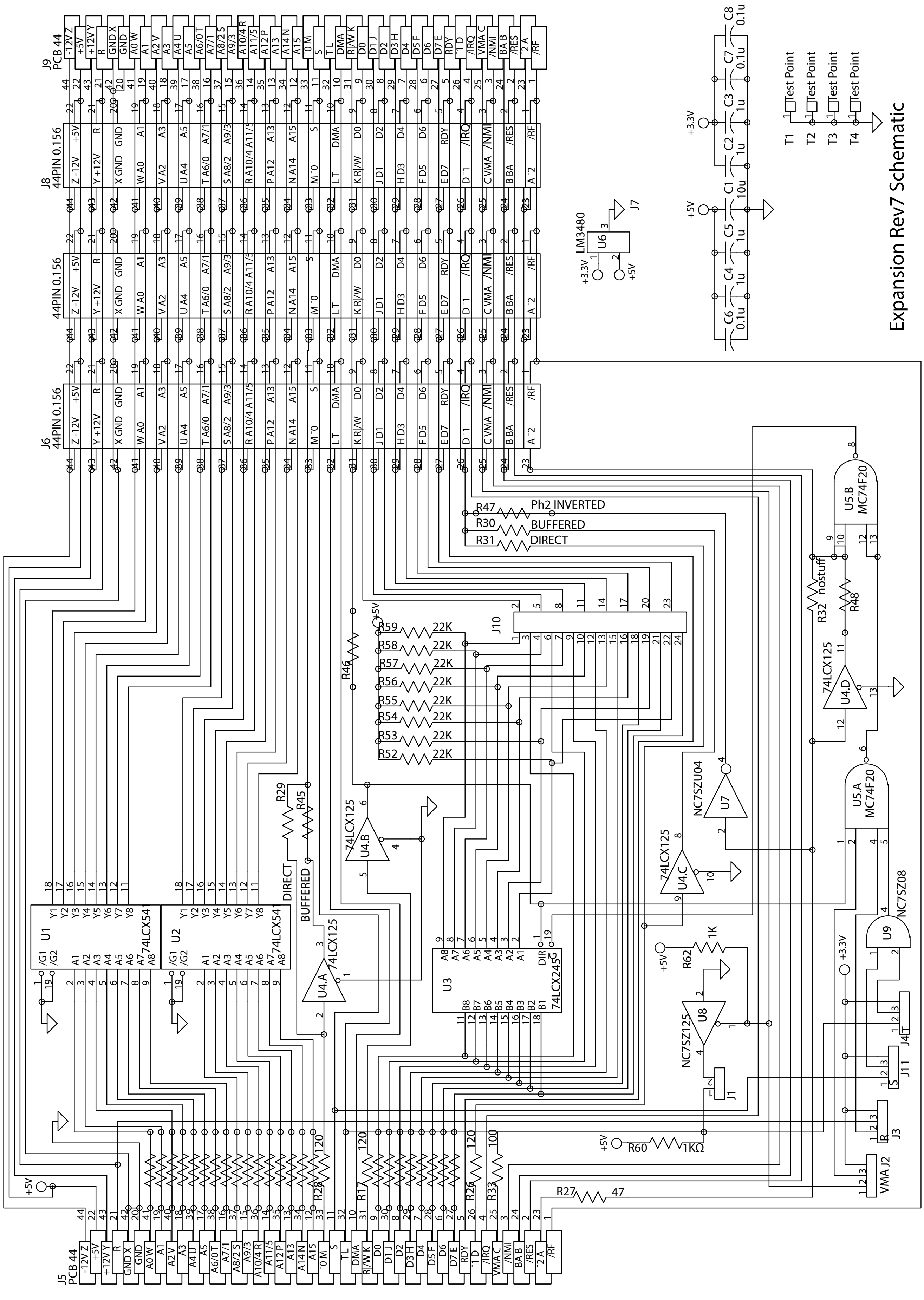
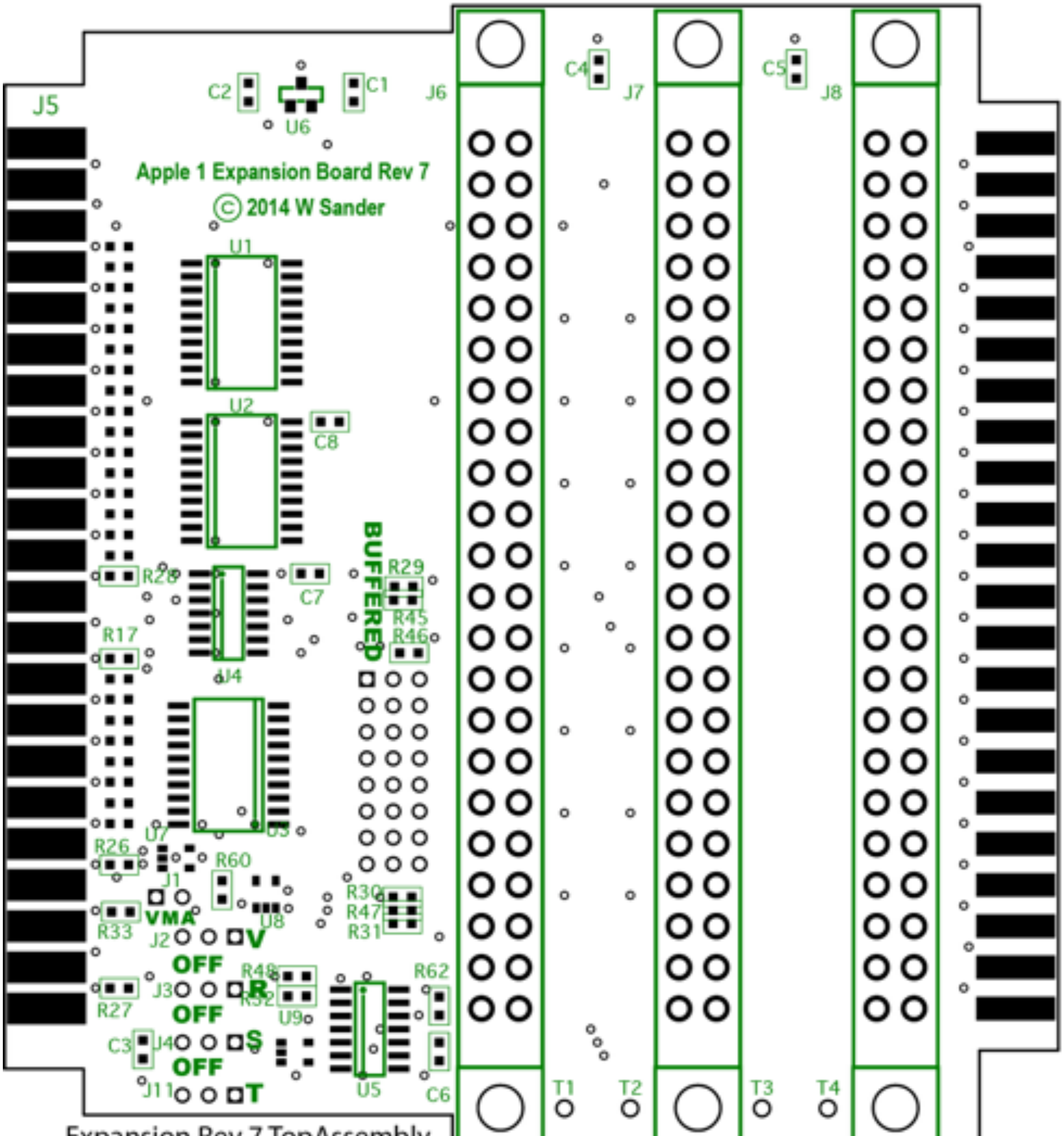


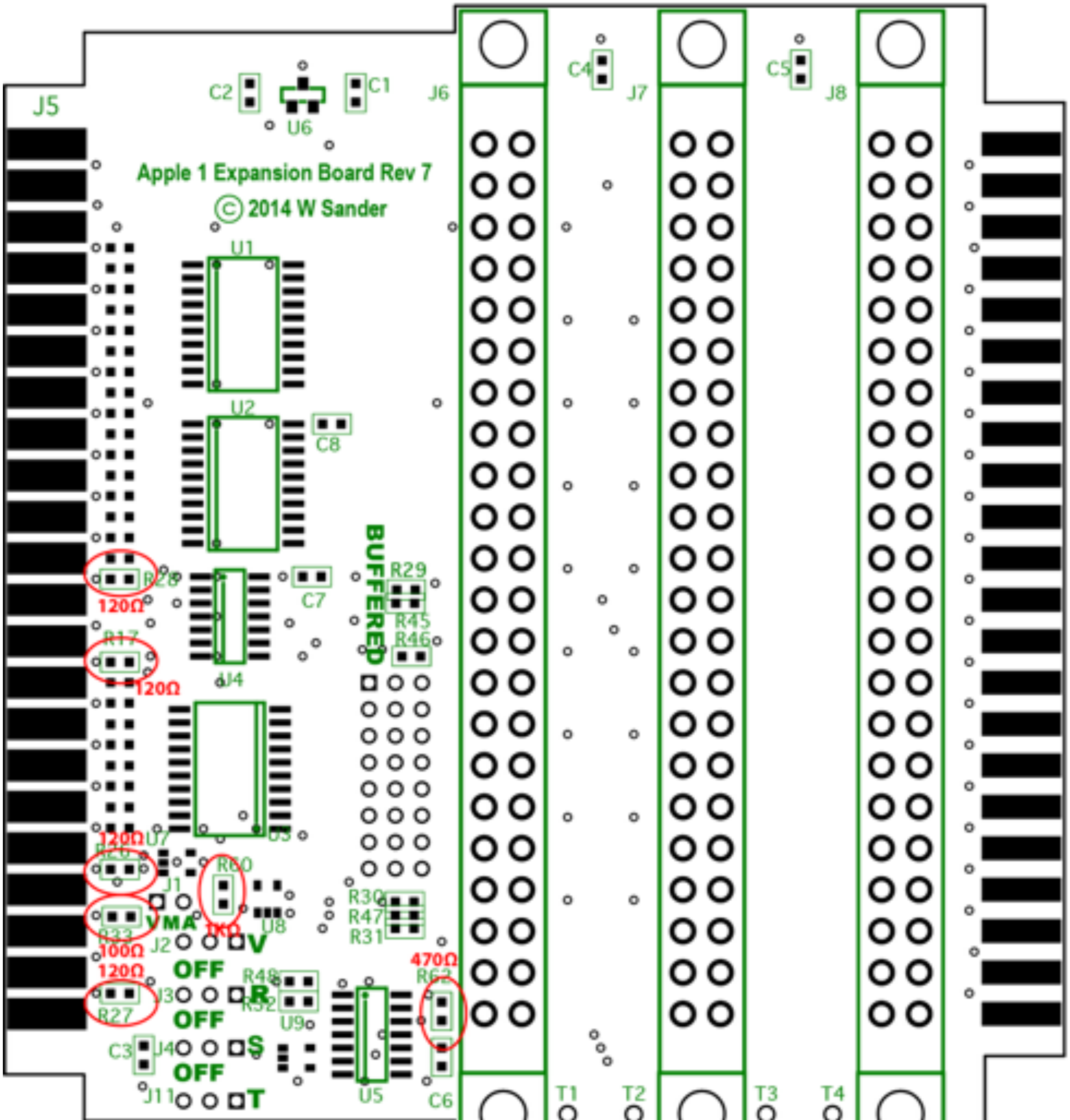
Figure 9

Power ON, Reset and repeat the Memory Test section.


Expansion Rev7 Schematic

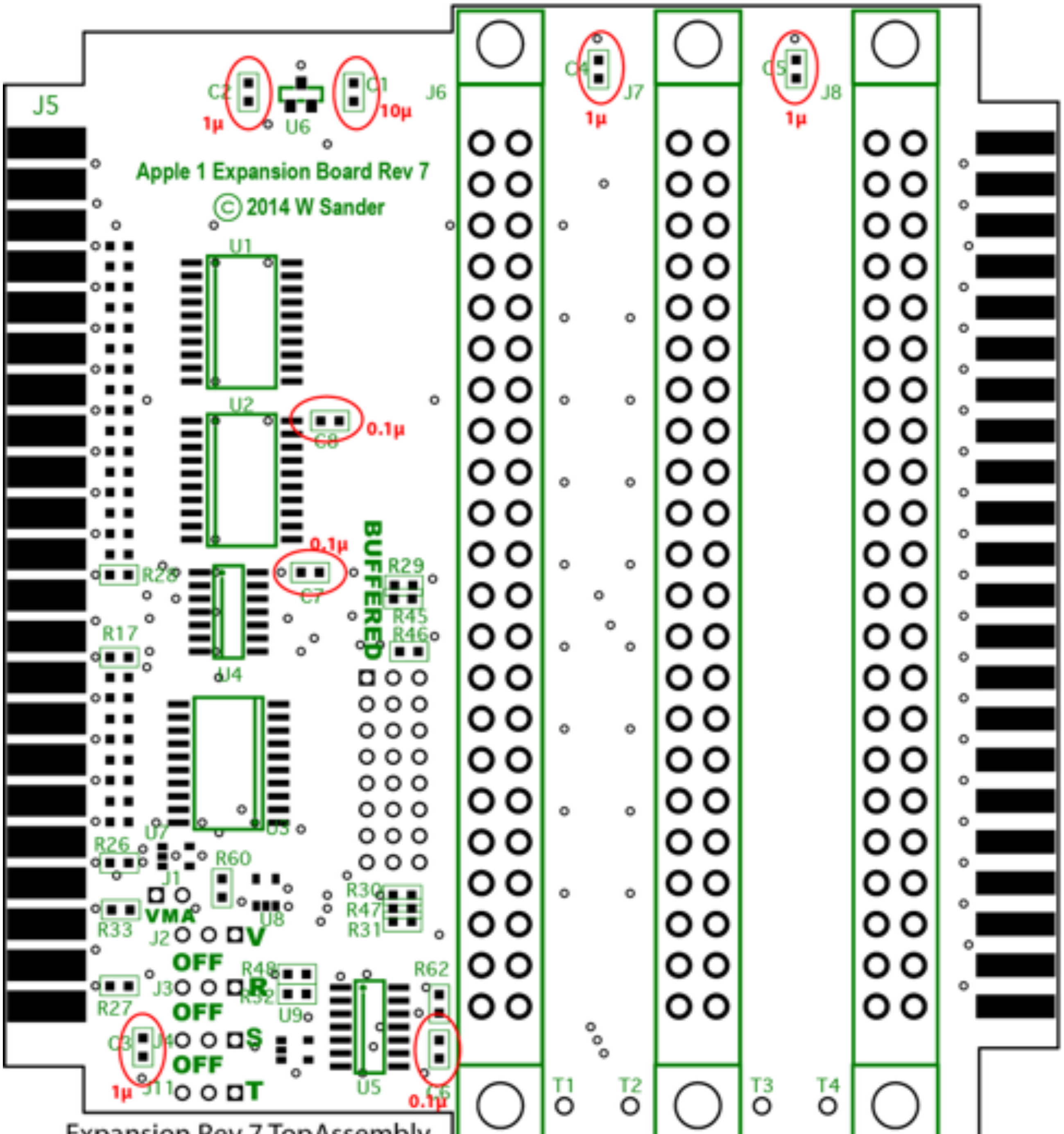


Expansion Rev 7 TopAssembly



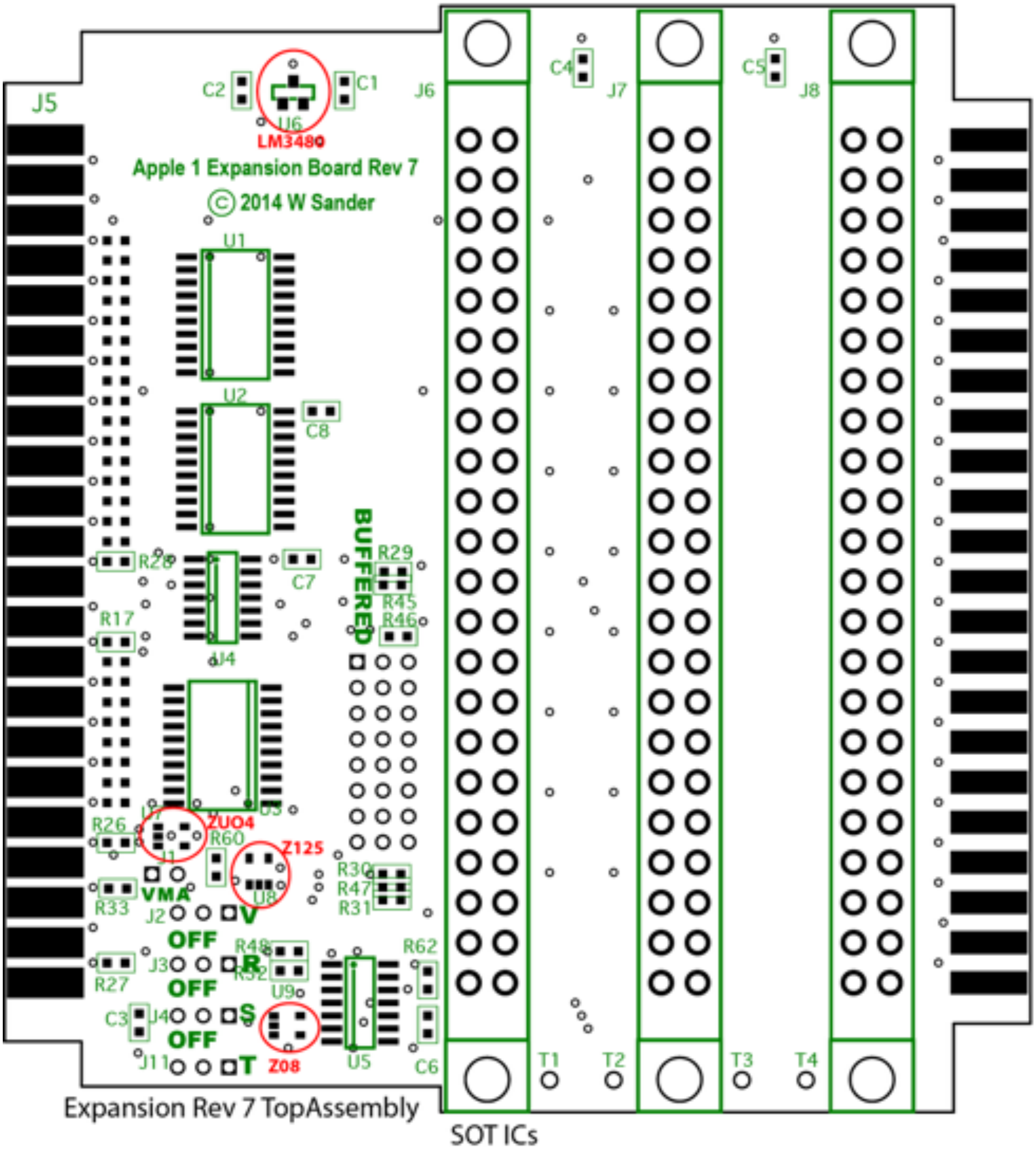
Expansion Rev 7 TopAssembly

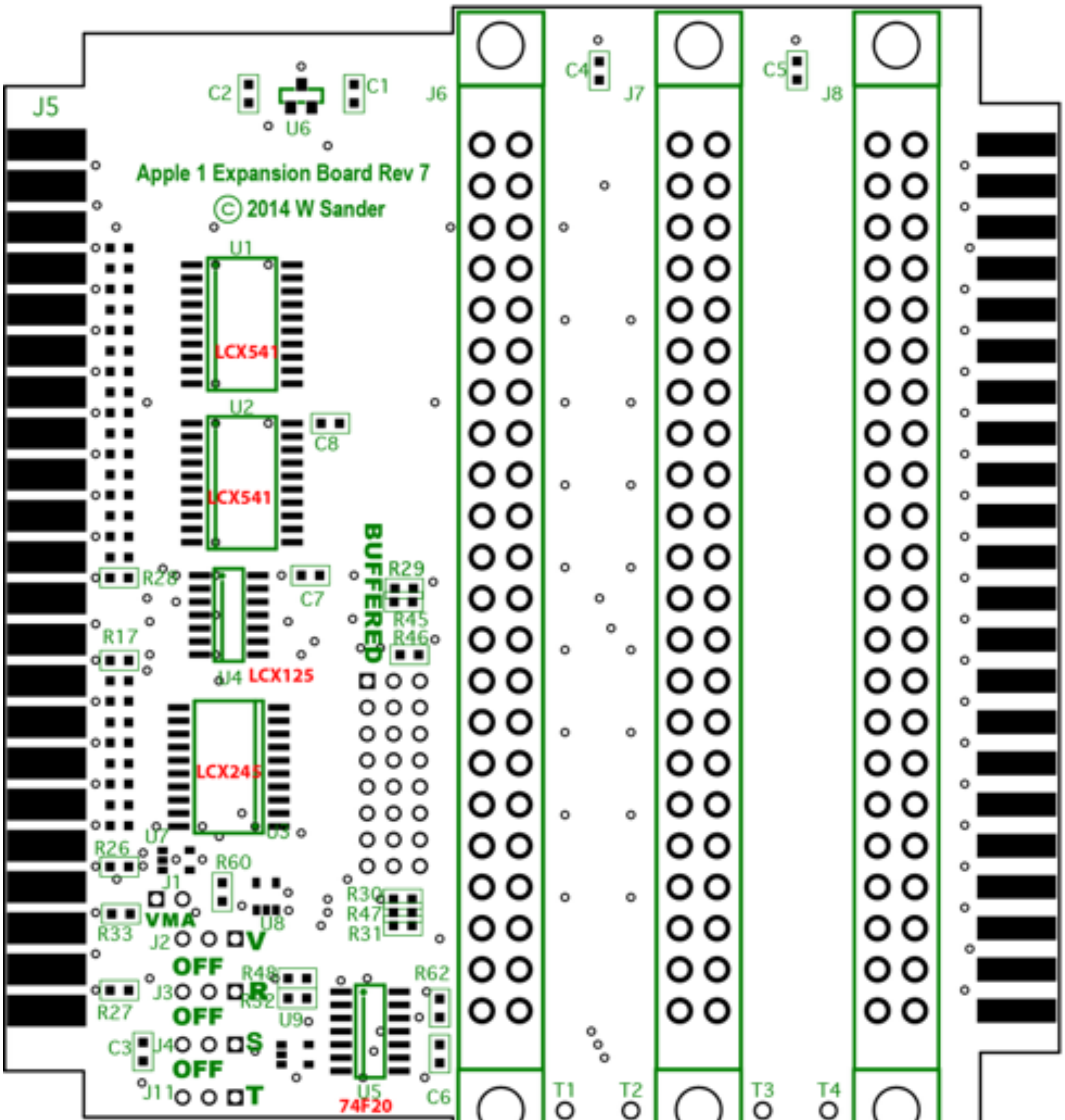
SMT Resistors



Expansion Rev 7 TopAssembly

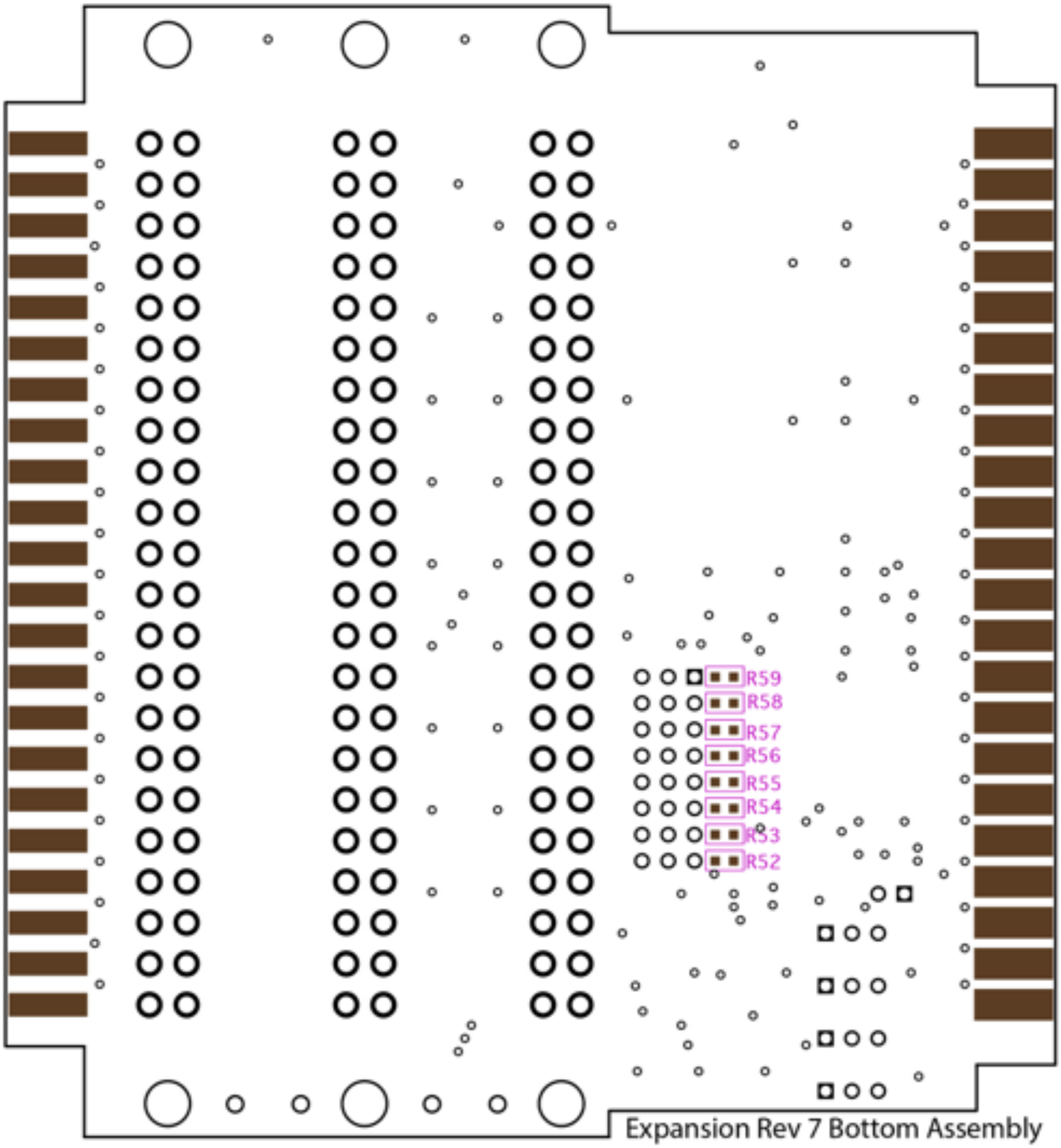
SMT Capacitors

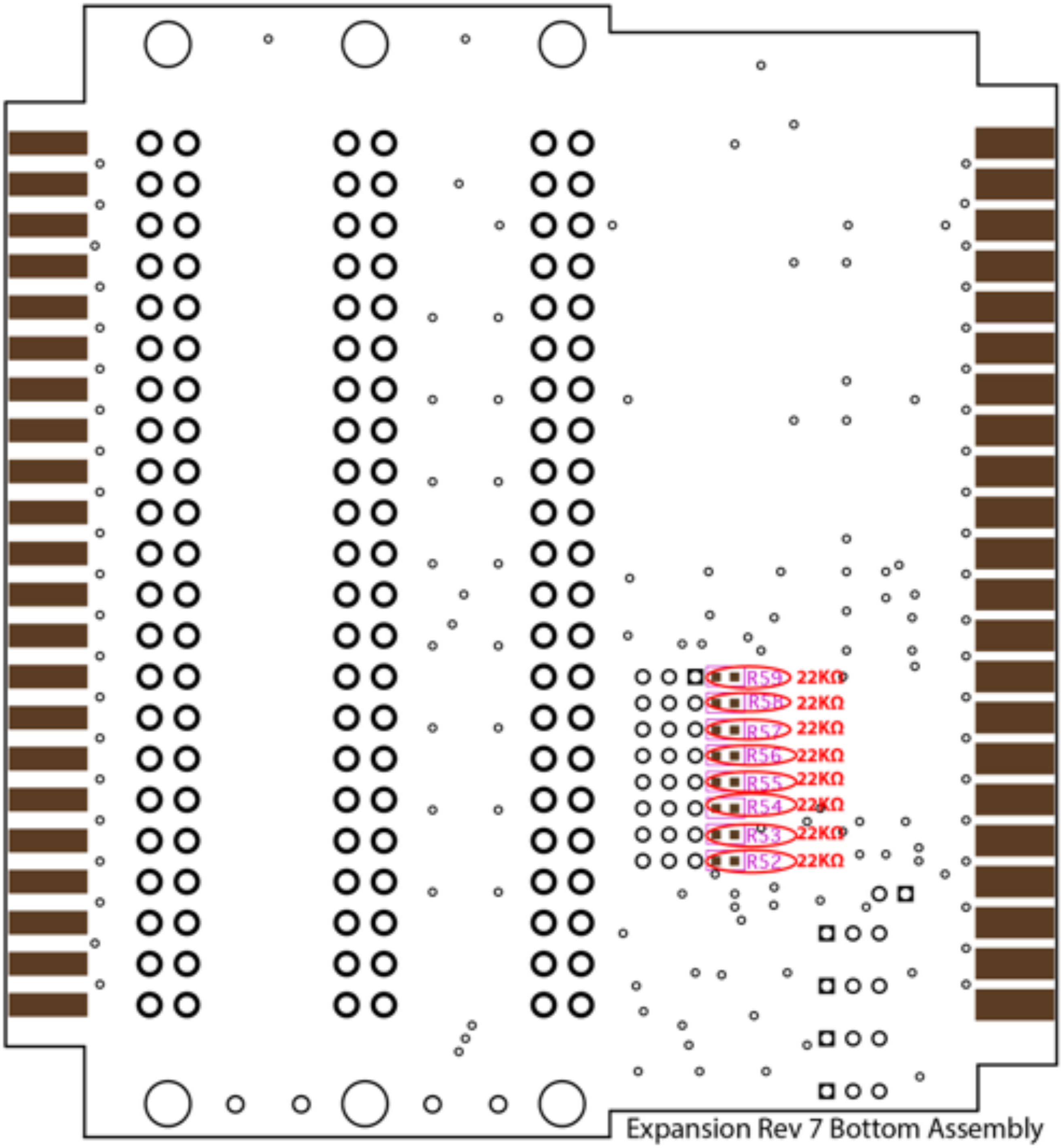

J5
C2
C1
U6
LM3480
J6
C4
J7
C5
J8
Apple 1 Expansion Board Rev 7
© 2014 W Sander
U1
U2
C8
BUFFERED
R28
R29
C7
R45
R46
R17
U4
U3
R26
ZUO4
R60
Z125
J1
VMA
R33
U8
R30
R47
R31
J2
V
OFF
R48
R52
R62
J3
R
R27
U9
C3
J4
S
OFF
J11
T
Z08
U5
C6
T1
T2
T3
T4
Expansion Rev 7 TopAssembly
SOT ICs



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