Ultim809 Rev 0 Board Bringup Procedure

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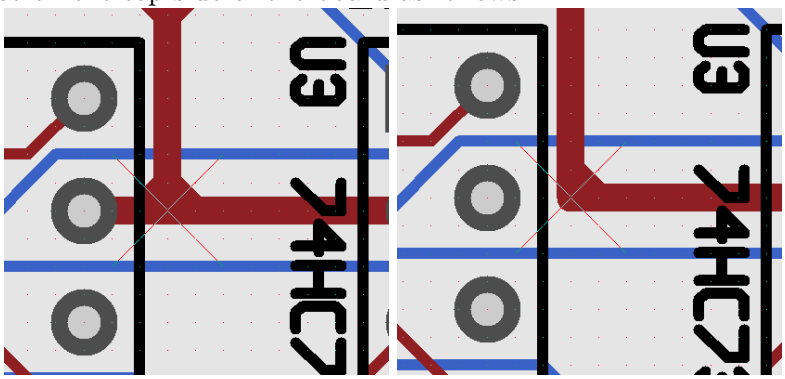
1 Board Errors

1.1 U4 TSC

Pin 39 of **U4** (TSC) is incorrectly connected to Vcc. It should be connected to GND. Cut the trace on the top side of the board as follows:



On the bottom of the board, solder a piece of enameled magnet wire or wire-wrap wire from **pin 39** to **pin 1**.

1.2 U16 TX and RX swapped

U16 pin 10 (RX) is mistakenly connected to **J2 pin 5** (RXD), and **U16 pin 11** (TX) is mistakenly connected to **J2 pin 4** (TXD). These two need to be swapped. Since it is difficult to fix this on the board, you will have to fashion an adapter on a piece of perfboard.

1.3 $\overline{\text{CSW}}$ and $\overline{\text{CSR}}$ swapped

U21 pin 14 ($\overline{\text{CSW}}$) is mistakenly connected to **U17 pin 11** and **U21 pin 15** ($\overline{\text{CSR}}$) is mistakenly connected to **U17 pin 10**. The two should be swapped. Cut traces on the back of the board at **U17 pin 10-11**. Add a wire from **U17 pin 11** to **U21 pin 15** and a wire from **U17 pin 10** to **U21 pin 14**.

1.4 VRAM bus incorrect

Cut the traces on the back of the board at **U23 pin 12** and **U26 pin 26**. Add a wire from **U23 pin 19** to **U26 pin 4** and a wire from **U24 pin 19** to **U26 pin 26**.

2 Assembly and testing

2.1 Sockets

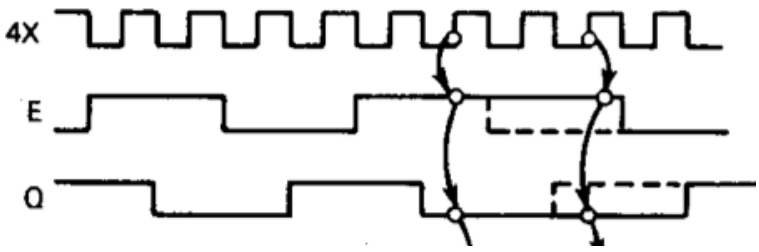
- Install all IC sockets.

2.2 Power

- Install **D2** (power LED), **R3** (1 kΩ), **D1** (1N4001), **C2** and **C4** (0.1 µF), **C1** and **C3** (10 µF electrolytic, rated for 50 V), **U1** (7805), **J1**, and **S1**.
- Ensure **S1** is in the down (disconnected) position.
- Connect 9 V DC power to **J1**. The center pin is positive and the outer ring is ground.
- Turn on **S1**. **D2** should light.
- Measure Vcc (for example, at **U14 pin 16**) and ensure it is roughly 5 V.

2.3 Clock signals

- Install **X1** (8 MHz), **U3** (74HC73), and decoupling capacitor **C16**.
- Turn on power.
- Using a frequency counter, measure the clock signals. **U3 pin 1** should read 8 MHz. **U4 pin 34** (E) and **U4 pin 35** (Q) should read 2 MHz.
- Using a two-channel oscilloscope or logic analyzer, observe the E (**U4 pin 34**) and Q (**U4 pin 35**) waveforms.



2.4 Processor integrity

- Install **RN1** (10 kΩ), **C6** (10 µF), **D3** and **D4**, **R4** and **R5** (1 kΩ), **S5**, **S2**, and **S3**.
- Flip **S5** up to HALT.
- Turn on power.
- Ensure **U4 pin 40** ($\overline{\text{HALT}}$) is 0 V.
- Ensure **pin U4** ($\overline{37}$)RESET, **pin 2** ($\overline{\text{NMI}}$), **pin 3** ($\overline{\text{IRQ}}$), and **pin 4** ($\overline{\text{FIRQ}}$) are 5 V.

- Flip **S5** down to RUN and ensure **pin 40** is 5 V.
- Ensure **pin 37** is 0 V when **S2** is depressed and **pin 2** is 0 V when **S3** is depressed.
- Turn off power, install **U4** (68B09E) and decoupling capacitor **C17**.
- Flip **S5** up to HALT and turn on power.
- Ensure **D3** and **D4** are both lit. This indicates the processor is in good condition.

2.5 ROM, program execution, and address decoding

- Burn `romtest1.s19` to an 8K×8 EEPROM, using the Arduino ROMBurner and the `ser09` utility.
- Install the EEPROM in **U9**, and install **U5** (74HC00), **U7** (74HC139), **RN3** (10 kΩ), **S4**, and associated decoupling capacitors.
- Flip **S4** to the left (EEPROM WRITE PROTECT ON) and ensure **U9 pin 27** ($\overline{\mathsf{WE}}$) is connected to **RN3 pin 6**. (Resistance between **pin 27** and Vcc is 10 kΩ.)
- Flip **S4** to the right (EEPROM WRITE PROTECT OFF) and ensure **pin 27** is connected to **U8 pin 29** ($\overline{\mathsf{WR}}$).
- Flip **S4** to the left and flip **S5** to HALT.
- Turn on power. **D3** and **D4** should light.
- Flip **S5** to RUN. **D3** and **D4** should turn off. The program should now be running. After about one second, **D3** should light (SYNC acknowledge), indicating the test program is finished. Pressing **S2** or **S3** will restart the program: the light will go out, and should come on about a second later.
- Turn off power.
- With a logic analyzer, attach probes to **U4 pins 8-23** (A0-A15), **U4 pin 34** (E), **U4 pin 32** (R/$\overline{\mathsf{W}}$), **U5 pin 6** ($\overline{\mathsf{RAMSEL}}$), **U7 pin 4** ($\overline{\mathsf{IOSEL}}$), **U7 pin 5** ($\overline{\mathsf{ROMSEL}}$), **U7 pin 9** ($\overline{\mathsf{RD}}$), and **U7 pin 10** ($\overline{\mathsf{WR}}$). The positive edge of E should be used as the clock signal.
- Set **S5** to HALT, run the logic analyzer, and set **S5** to RUN. Repeat multiple times to verify the following truth table:

E	R/$\overline{W}$	$\overline{RD}$	$\overline{WR}$
0	x	1	1
1	1	0	1
1	0	1	0

A0-A15	$\overline{RAMSEL}$	$\overline{IOSEL}$	$\overline{ROMSEL}$
$0xxx	0	1	1
$1xxx	0	1	1
$2xxx	0	1	1
$3xxx	0	1	1
$4xxx	0	1	1
$5xxx	0	1	1
$6xxx	0	1	1
$7xxx	0	1	1
$8xxx	0	1	1
$9xxx	0	1	1
$Axxx	0	1	1
$Bxxx	0	1	1
$Cxxx	1	0	1
$Dxxx	1	0	1
$Exxx	1	1	0
$Fxxx	1	1	0

The test program attempts to read and write to successive addresses, so the address decoding may be observed.

2.6 I/O decoding

- Install **U6** (74HC14), **U10** (74HC138), and associated decoupling capacitors.
- Attach logic analyzer probes to **U4 pins 8-23** (A0-A15), **U10 pin 15** ($\overline{VIASEL}$), **U10 pin 14** ($\overline{UARTSEL}$), **U10 pin 13** ($\overline{SRSEL}$), **U10 pin 12** ($\overline{AVSEL}$), **U10 pin 11** ($\overline{EXT1SEL}$), **U10 pin 10** ($\overline{EXT2SEL}$), **U10 pin 9** ($\overline{EXT3SEL}$), **U10 pin 7** ($\overline{EXT4SEL}$), and **U5 pin 8** ($\overline{EXTIOSEL}$). The positive edge of E should be used as the clock signal.
- Run `romtest1.s19` again and verify the following truth table:

A0-A15	$\overline{VIA}$	$\overline{UART}$	$\overline{SR}$	$\overline{AV}$	$\overline{EXT1}$	$\overline{EXT2}$	$\overline{EXT3}$	$\overline{EXT4}$	$\overline{EXTIO}$
$Bxxx	1	1	1	1	1	1	1	1	1
$C000-$C3FF	0	1	1	1	1	1	1	1	1
$C400-$C7FF	1	0	1	1	1	1	1	1	1
$C800-$CBFF	1	1	0	1	1	1	1	1	1
$CC00-$CFFF	1	1	1	0	1	1	1	1	1
$D000-$D3FF	1	1	1	1	0	1	1	1	0
$D400-$D7FF	1	1	1	1	1	0	1	1	0
$D800-$DBFF	1	1	1	1	1	1	0	1	0
$DC00-$DFFF	1	1	1	1	1	1	1	0	0
$Exxx	1	1	1	1	1	1	1	1	1

2.7 UART

- Install **U16** (16C550), decoupling capacitor **C29**, **R10** (1 MΩ), **R11** (1.5 kΩ), **C8** (27 pF), **C9** (47 pF), **X2** (1.8432 MHz), **J2**, **R1** (330 Ω), **R2** (1.5 kΩ), and **D5**. Orient **D5** so the shortest lead (the green anode) is on the left and is inserted into the square hole.
- Burn `romtest2.s19` onto the EEPROM.
- Connect a 5 V FTDI USB-to-serial cable to **J2**, with the black wire on the right. Connect the other end to a PC. Start a terminal program listening at 38400 baud, 8 data bits, no parity, 1 stop bit.
- Turn on the system and run the program.
- The status LED **D5** should turn off and the system should print the following:

  ```
  Hello World!
  Type r, y, g, or o to change LED color
  ```

  Typing one of the four letters from the terminal changes the LED color (red, yellow, green, off) and prints a message. ("`Red.`" or "`Yellow.`" or "`Green.`" or "`Off.`")
- Additionally, use a frequency counter to check the UART's clock rate at **U16 pin 9**. It should be 16× the baud rate: in this case, approximately 614 400 Hz.

2.8 RAM and bank switching

- Install diode **D7** (1N4148).
- Test **D7** using a multimeter in diode mode. Place the positive lead on **U4 pin 4** ($\overline{\mathsf{FIRQ}}$) and place the negative lead on **U11 pin 21** ($\overline{\mathsf{IRQ}}$). (**U11** should not be installed yet.) The meter should read a small positive voltage. Reverse the leads and the meter should indicate an open circuit.
- Install **U8** (512K SRAM), **U11** (W65C22S), **U12** (74HC157), **U13** (74HC08), and associated decoupling capacitors.
- Burn `romtest3.s19` onto the EEPROM.
- Connect the serial cable and start the terminal as in the previous step.
- Run the program. It tries to determine the size of the RAM by cycling through the 16K pages and counting them until it detects wraparound. It should print

  ```
  0512KB RAM available.
  ```

  on the console.

2.9 Audio/video I/O decoding

- Install **U17** (74HC139), **U18** (74HC02), **U19** (74HC74), and associated decoupling capacitors.
- Burn `romtest4.s19` onto the EEPROM.
- Attach logic analyzer probes to **U17 pin 1** ($\overline{\text{AVSEL}}$), **U17 pin 2-3** (A1-A2), **U17 pin 4** ($\overline{\text{VDPSEL}}$), **U17 pin 5** ($\overline{\text{PSGSEL}}$), **U17 pin 6** ($\overline{\text{FF1SEL}}$), **U17 pin 7** ($\overline{\text{FF2SEL}}$), **U17 pin 13** ($\overline{\text{RD}}$), **U17 pin 14** ($\overline{\text{WR}}$), **U17 pin 10** ($\overline{\text{CSR}}$), **U17 pin 11** ($\overline{\text{CSW}}$), **U18 pin 3** (A0), **U18 pin 1** (BC1), **U18 pin 4** (BDIR), **U18 pin 13** (FF1CP), **U18 pin 10** (FF2CP), **U19 pin 3** (A3), **U19 pin 5** (VBANK), and **U19 pin 9** (PADSELECT). The positive edge of E should be used as the clock signal.
- Run the program and verify the following truth tables:

$\overline{\text{AVSEL}}$	A0-A2	$\overline{\text{RD}}$	$\overline{\text{WR}}$	$\overline{\text{VDPSEL}}$	$\overline{\text{PSGSEL}}$	$\overline{\text{FF1SEL}}$	$\overline{\text{FF2SEL}}$	$\overline{\text{CSR}}$	$\overline{\text{CSW}}$
1	%xxx	x	x	1	1	1	1	1	1
0	%00x	1	0	0	1	1	1	1	0
0	%00x	0	1	0	1	1	1	0	1
0	%01x	x	x	1	0	1	1	1	1
0	%10x	x	x	1	1	0	1	1	1
0	%11x	x	x	1	1	1	0	1	1

$\overline{\text{AVSEL}}$	$\overline{\text{PSGSEL}}$	A0-A2	$\overline{\text{RD}}$	$\overline{\text{WR}}$	BC1	BDIR
1	1	%xxx	x	x	0	0
0	0	%010	x	0	1	1
0	0	%010	x	1	1	0
0	0	%011	x	0	0	1
0	0	%011	x	1	0	0

$\overline{\text{AVSEL}}$	$\overline{\text{FF1SEL}}$	$\overline{\text{FF2SEL}}$	$\overline{\text{RD}}$	A3	FF1CP	FF2CP	VBANK	PADSELECT
1	1	1	x	x	0	0	no change	no change
0	0	1	1	x	0	0	no change	no change
0	0	1	0	0	1	0	0	no change
0	0	1	0	1	1	0	1	no change
0	1	0	0	0	0	1	no change	0
0	1	0	0	1	0	1	no change	1

2.10 Audio/gamepads

- Install **U20** (YM2149), **R6**, **R7**, and **R8** (1 kΩ), **R9** (4.7 kΩ), **C7** (1 µF), **J9**, and **J10**. Also install decoupling capacitors.

2.11 Video

- Install **U21** (TMS9918A), **U22** (74HC04), **U23**, **U24**, and **U25** (74HC574), **U26** (62256), **D6** (1N4148), **C10** and **C11** (33 pF), **X3** (10.738 635 MHz), **R19** (470 Ω), **R20** and **R21** (75 Ω), **C12** (22 µF), **C13** (0.1 µF), **C15** (220 µF), **L1** (ferrite bead), **Q1** (2N3904), and **J6**. Also install decoupling capacitors.