VIP2K rev.A Assembly Notes

(No assembly manual yet; that will take longer to write)

By Lee Hart
814 8th Ave N
Sartell MN 56377
leeahart@earthlink.net
http://www.sunrise-ev.com/projects.htm#vip2k

Last update: Jan 13, 2019

Before the Apple, Atari, and Commodore home computers, Joe Weisbecker created the RCA VIP. First sold in 1977, it was a simple, elegant, and low cost design so that everyone could have fun and learn about personal computers. It had an RCA 1802 microprocessor, 4k of RAM, a monitor program in ROM, a 16-key hex keypad, a 64x128 pixel graphics video display, and a serial port to load/save its programs on cassette tapes. That's the VIP on top of the monitor in the photo below.

For the 40th anniversary of the VIP, I decided to celebrate by making a new version you can build yourself. That's it at the bottom of the photo, below the monitor, with its tiny keyboard on top! The black box at the right is just the battery box, with four AA cells to power it.

The VIP2K has the same 1802 microprocessor, but with significant upgrades in speed, memory, and features:

- 1802 microprocessor running at 4 MHz
- 32K of RAM
- 32K of ROM, with monitor, BASIC, and CHIP8
- NTSC B/W video output with 24 lines of 24 character text, and 192x192 pixel graphics
- 43-key full ASCII keyboard
- TTL serial I/O port up to 9600 baud
- built entirely with vintage parts and through-hole technology
- ...and it all fits in a 3.5" x 2" x 0.75" Altoids tin!

This project is **under development**, so things are still changing. This manual is a "snapshot" of where we are today. Check the website (at the link on the top of the page) for details on operation, and the latest developments and software.

Parts List

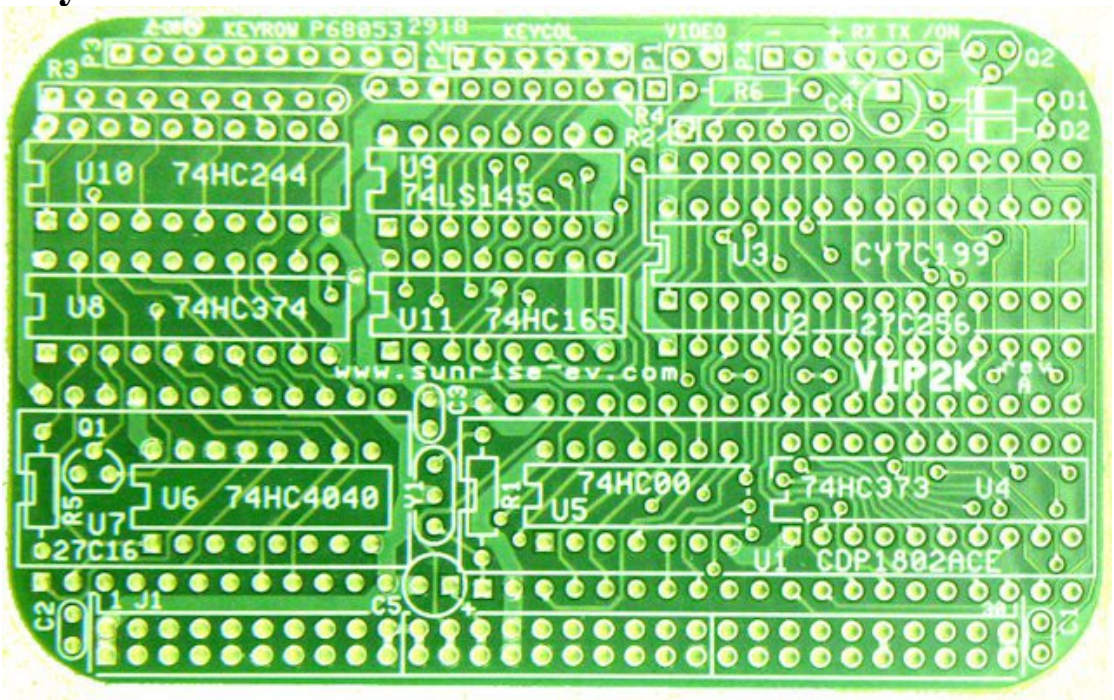
If you bought the bare boards or are building a VIP2K from scratch, here is a list of the parts you'll need:

Qty	Reference	Part	Source
3	C1, C2, C3	capacitor 0.1uF 50v X7R 0.1"LS	Jameco 1570161
2	C4, C5	capacitor 4.7uF 16vdc tantalum	Jameco 94035
1	C6	capacitor 3300pF ceramic	Mouser 594-K332K15X7RF5TL2
2	D1, D2	diode 1N4148	Jameco 36038
1	P1a,b,P1-P4	36-pin male pin header: Cut it to make	Jameco 68339
	2	P1a, P1b = 2-pin header (CPU J1 pins 1-2 and 29-30),	
	1	P1 = 2-pin header VIDEO (CPU card),	
	1	P2 = 6-pin header KEYROW (CPU card),	
	1	P3 = 10-pin header KEYCOL (CPU card),	
	1	P4 = 6-pin header POWER+SER (CPU card).	
2	J1a,b, J2	6-pin male/female stacking header	Jameco 2144614
2	J3, J4	10-pin male/female stacking header	Jameco 2177627
1	Q1	FJN4303 PNP transistor w. base resistors	Mouser 512-FJN4303RTA
1	Q2	FJN3303 NPN transistor w. base resistors	Mouser 512-FJN3303RTA
1	R1	10Meg 5% 1/4w resistor	Jameco 691817
1	R2	10K x 5 6-pin SIP bussed	Mouser 652-4606X-1LF-10K
1	R3	10K x 9 10-pin SIP bussed	Mouser 652-4610X-1LF-10K
1	R4	1K x 9 10-pin SIP bussed	Mouser 652-4610X-1LF-1K
1	R5	100K 5% 1/4w resistor	Jameco 691340
1	R6	270 ohm 5% (or 267 ohm) 1/4w resistor	Jameco 690726
43	S1-S43	tactile switch, Alps SKHHAJA010 or eq.	Mouser 688-SKHHAJ
1	U1	CDP1802ACE microprocessor (**NOTE 1**)	ebay etc.
1	U1a	40-pin IC socket, machined pins	Jameco 41136
1	U2	27C256 32K EPROM with vip2k14.hex	Jameco 39714
1	U2a	28-pin IC socket, machined pins	Jameco 40328
1	U3	CY7C199 (or equivalent) 32k RAM	Jameco 242376
1	U4	74HC373 octal transparent latch	Jameco 45831
1	U5	74HC00 quad 2-input NAND gate	Jameco 45161
1	U6	74HC4040 12-bit binary counter	Jameco 45920
1	U7	2716 2K EPROM with vip-2716.hex	Jameco 40011
1	U7a	24-pin socket, machined pins	Jameco 39351
1	U8	74HC374 octal latch	Jameco 45858
1	U9	74LS145 (or 74HC145) BCD decoder	Jameco 46666
1	U10	74HC244 octal buffer	Jameco 45655
1	U11	74HC165 8-bit shift register	Jameco 45495
1	Y1	resonator 4MHz with capacitors	Mouser 81-CSTS0400MG03
1	VIP2K	PC card & keyboard, rev.A	www.sunrise-ev.com/projects.htm#vip2k

NOTE 1: The VIP2K 1802 runs at 4 MHz. The original non-A version CDP1802 was only specified to 2.5 MHz, or 3.2 MHz for the later CDP1802A. This means you have to **select** a fast enough 1802. I have found that most non-A 1802's are too slow. But later 1802A's easily run at 4 MHz; that's what you want.

To select a fast enough part, look at the waveform on 1802 pin 39 (/XTAL out) with an oscilloscope and 10x probe. The 4MHz waveform should be a 4 volt AC peak-to-peak sine wave, with a low-state voltage less than 0.5v, and a high-state voltage within 0.5v of VCC (1802 pin 16). Most 1802's I have tested meet this criteria, and work in my VIP2K. A “slow” 1802 may still oscillate at 4 MHz; but a peak-to-peak voltage less than 3 volts won't be able to clock video shift register U11.

Assembly Notes



Assembly is a work in progress; so I'll just tell you how I built mine. Let me know if you find a better way! Most parts are easy to install (just like any other kit), but I added notes for the "tricky" parts:

( ) Install resistors R1, R5, and R6.

( ) Install 0.1uF capacitors C1, C2, and C3.

( ) Install diodes D1 and D2. The end with the band must match the board.

( ) Install U3, U4, U5, U6, U8, U9, and U10. Sockets are not supplied, but you can add them if you like. Note that U4, U5, and U6 are **under** ICs! If you want to socket them, I recommend **socket pins** (Digikey.com ED5037-ND). They drop right into the holes to make a "zero height" socket.

( ) U11: There is one cut-and-patch on the VIP2K rev.A card. **CUT** the trace between U11 pin 15-16. Then **ADD A WIRE** from U11 pin 15 to pin 8. It's easier to do this before you install U11.

( ) Install transistor Q1 (marked "R4303"). Q1 must fit under U7. Put its wires in the holes, with the flat side as shown. Then bend it over so the flat side is tight against the board. **Now** solder it in.

( ) Install IC sockets U1, U2, and U7. Use open-frame screw-machined sockets. Cut the thin plastic bars that hold the left and right sides together (to make room for the parts underneath).

( ) Install SIP resistors R2, R3, and R4. Put pin 1 on the **left** end for R2 and R3; **right** for R4. Don't mix up R3 and R4 – they look the same but are **different** values!

( ) Install transistor Q2. It is marked "R3303".

( ) Install ceramic resonator Y1.

( ) Install capacitors C4 and C5. They are polarized, so be sure to get the + and – right.

( ) Install C6. There is no place for it on the rev.A board. Put it between U8 and U11. Solder one end in the hole between U8 and U11 (GND). Solder the other end to U11 pin 1.

Headers: I bought a 36-pin header, and cut it up to make P1a, P1b, and P1-P4:

( ) P1a and P1b: Install a 2-pin header at each end of the 30-pin connector J1 on the VIP2K card. One in pins 1-2, and one in pins 29-30. They go on top of the board, in the holes **closest to the outer edge** of the board. These 2-pin headers just serve as "feet" to support the Keyboard.

( ) Install P1, a 2-pin header on the VIP2K card at the VIDEO location.

( ) Install P2, a 6-pin header on the VIP2K card at the KEYCOL location.

( ) Install P3, a 10-pin header on VIP2K card at the KEYROW location.

( ) Install P4, a 6-pin header on VIP2K card at the + / RX / TX / ON location.

( ) Program a 2716 or 27C16 EPROM with http://sunrise-ev.com/photos/1802/vip-2716.hex, and install it at U7.

( ) Program a 27256 or 27C256 EPROM with the desired program from http://sunrise-ev.com/projects.htm#vip2k and install it at U2. There are currently programs for a serial monitor; and a TV Typewriter, monitor, BASIC, and CHIP8 using the VIP2K keyboard and display.

( ) Install CDP1802ACE microprocessor U1. (It needs to be a 4 MHz part; see Note 1 on page 2.)

Keyboard

Male/female stacking connectors (used on Arduinos etc.): They go on the **bottom** of the Keyboard. To be sure the connectors line up, plug the female part onto the pins on the VIP2K board. Put the Keyboard on top. Then solder the pins on top of the keyboard. Cut off the excess pin length.

( ) Install J2, a 6-pin stacking connector. Plug the female part onto KEYCOL on the VIP2K card.

( ) Install J3, a 10-pin stacking connector. Plug the female part onto KEYROW on the VIP2K card.

( ) Install J1a and J1b. I bought 6-pin connectors, and cut one down to make 2-pin connectors for J1a and J1b. To cut it, pull out a pin with pliers, then cut the plastic body in the center of the removed pin location with a sharp knife or diagonal cutters. Plug these onto P1a and P1b.

( ) Install J1+J4. I used a single 10-pin part, and removed pins 7 and 10. Plug it onto P1 (VIDEO) and P4 (POWER/SERIAL) on the VIP2K card. The male pins are long, and not soldered to the Keyboard. Use them to connect to your video monitor, power, and serial I/O.

( ) Install tactile switches S1-S43. I have lots of SM (surface-mount) switches; so I used them. SM switch pins stick out horizontally. I pinch them with pliers to bend the pins down to fit into the holes on the Keyboard. Solder them from the TOP and keep them tight against the board.

Testing

Apply 5v power. Supply current is ~20ma with 27Cxx CMOS EPROMs, or ~75ma with 27xx NMOS EPROMs. Check for a nice 4vpp 4MHz signal on 1802 pin 39 (see Note 1 on page 2).

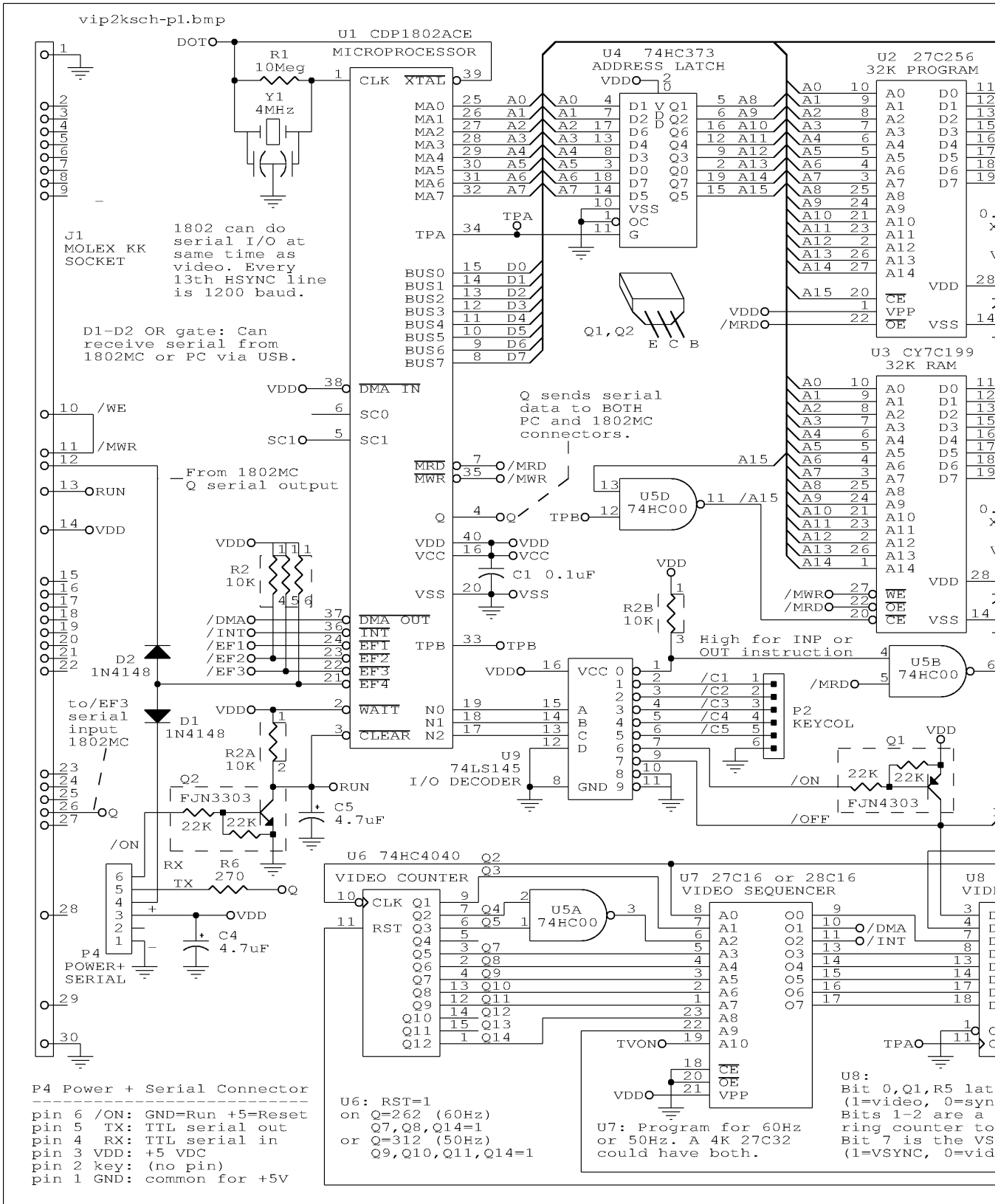
The 1802 is cleared on power-up, then runs the program in U2. Look for pulses on TPA, TPB and SC0 (1802 pins 34, 33, and 6). The program needs to have a video Interrupt handler (or, it needs to turn interrupts off as its first instruction).

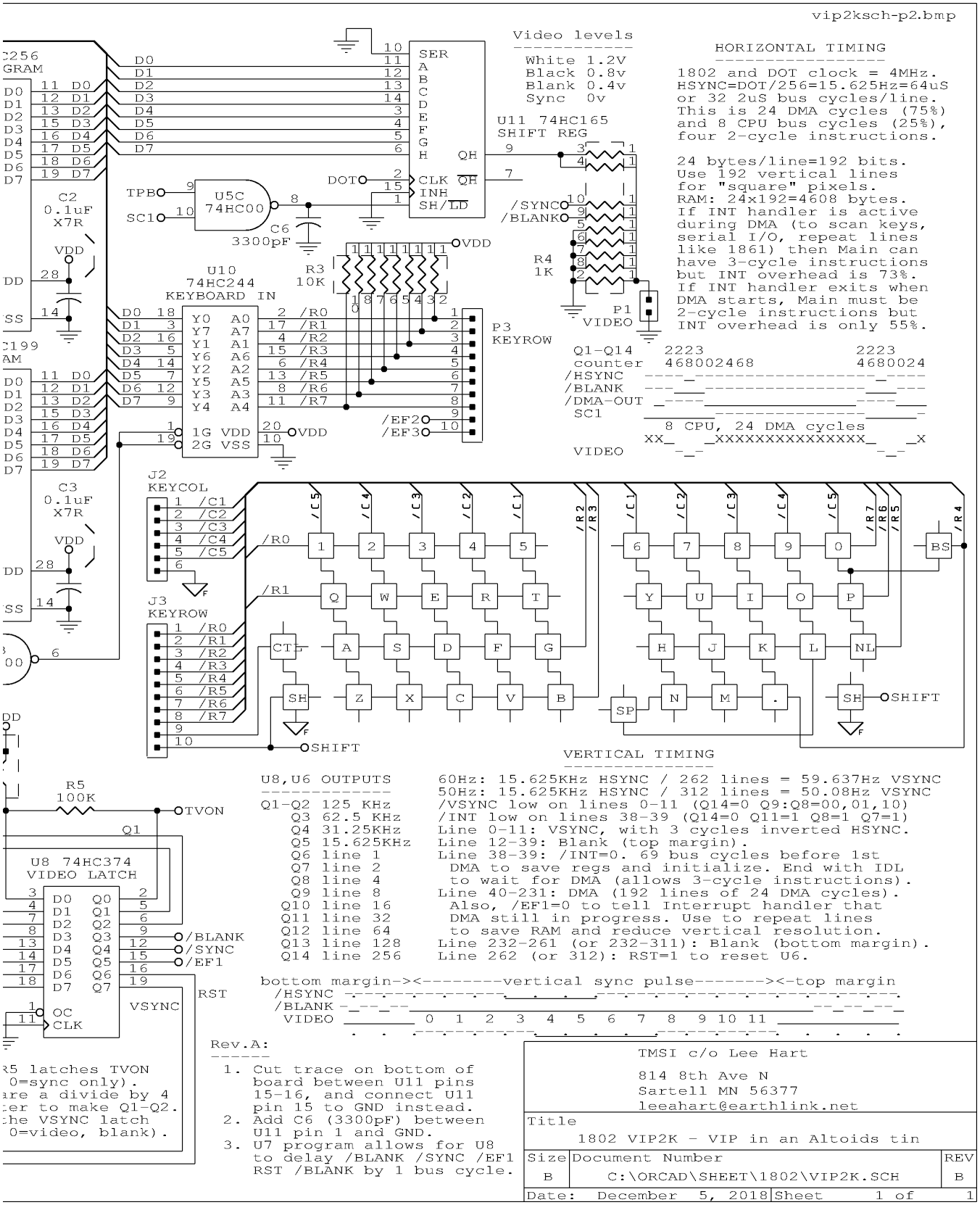
Video sequencer U6-U7-U8 generates video independently from the 1802. It is clocked by TPA. The U6 outputs will count up, U7 converts the count into commands, and there will be Hsync and Vsync pulses on U8 pins 9 and 12.

DMA is controlled by the TVON latch (Q1-R5-U8 bit 0). An IN6 instruction turns it ON, and IN7 turns it off. The program needs to turn it OFF until R0 and the interrupt handler are initialized. If you are having problems debugging, ground U9 pin 9 to keep TVON=0 so you don't get unwanted DMA or interrupts.

If all is well, connect an NTSC monitor to P1, and you should have video. With the monitor or TV Typewriter program ROM, what you type will appear on the screen. Now the fun begins! :-)

"OK, I think I found your problem. You didn't use the right swear words to assemble it."


vip2ksch-p1.bmp
U1 CDP1802ACE
MICROPROCESSOR
DOT
R1
10Meg
Y1
4MHz
CLK
XTAL
MA0
MA1
MA2
MA3
MA4
MA5
MA6
MA7
TPA
BUS0
BUS1
BUS2
BUS3
BUS4
BUS5
BUS6
BUS7
DMA IN
SC0
SC1
MRD
MWR
Q
VDD
VCC
VSS
DMA OUT
INT
EF1
EF2
EF3
EF4
WAIT
CLEAR
N0
N1
N2
U4 74HC373
ADDRESS LATCH
U2 27C256
32K PROGRAM
U3 CY7C199
32K RAM
J1
MOLEX KK
SOCKET
1802 can do serial I/O at same time as video. Every 13th HSYNC line is 1200 baud.
D1-D2 OR gate: Can receive serial from 1802MC or PC via USB.
Q sends serial data to BOTH PC and 1802MC connectors.
From 1802MC Q serial output
/WE
/MWR
RUN
VDD
R2
10K
C1 0.1uF
D2
1N4148
D1
1N4148
to/EF3 serial input 1802MC
R2A
10K
Q2
FJN3303
22K
C5
4.7uF
/ON
RX
R6
270
TX
C4
4.7uF
P4
POWER+
SERIAL
U5D
74HC00
U5A
74HC00
U5B
74HC00
R2B
10K
High for INP or OUT instruction
U9
74LS145
I/O DECODER
P2
KEYCOL
/C1
/C2
/C3
/C4
/C5
Q1
FJN4303
/OFF
U6 74HC4040
VIDEO COUNTER
U7 27C16 or 28C16
VIDEO SEQUENCER
U8
VID
TVON
TPA
/DMA
/INT
P4 Power + Serial Connector
pin 6 /ON: GND=Run +5=Reset
pin 5 TX: TTL serial out
pin 4 RX: TTL serial in
pin 3 VDD: +5 VDC
pin 2 key: (no pin)
pin 1 GND: common for +5V
U6: RST=1
on Q=262 (60Hz)
Q7,Q8,Q14=1
or Q=312 (50Hz)
Q9,Q10,Q11,Q14=1
U7: Program for 60Hz or 50Hz. A 4K 27C32 could have both.
U8:
Bit 0,Q1,R5 lat
(1=video, 0=syn
Bits 1-2 are a
ring counter to
Bit 7 is the VS
(1=VSYNC, 0=vid


vip2ksch-p2.bmp
Video levels
White 1.2V
Black 0.8v
Blank 0.4v
Sync 0v
HORIZONTAL TIMING
1802 and DOT clock = 4MHz.
HSYNC=DOT/256=15.625Hz=64uS
or 32 2uS bus cycles/line.
This is 24 DMA cycles (75%)
and 8 CPU bus cycles (25%),
four 2-cycle instructions.
24 bytes/line=192 bits.
Use 192 vertical lines
for "square" pixels.
RAM: 24x192=4608 bytes.
If INT handler is active
during DMA (to scan keys,
serial I/O, repeat lines
like 1861) then Main can
have 3-cycle instructions
but INT overhead is 73%.
If INT handler exits when
DMA starts, Main must be
2-cycle instructions but
INT overhead is only 55%.
U11 74HC165
SHIFT REG
U5C
74HC00
U10
74HC244
KEYBOARD IN
P3
KEYROW
P1
VIDEO
R3
10K
R4
1K
C2
0.1uF
X7R
C3
0.1uF
X7R
C6
3300pF
J2
KEYCOL
J3
KEYROW
SHIFT
Q1-Q14 2223 2223
counter 468002468 4680024
/HSYNC
/BLANK
/DMA-OUT
SC1
8 CPU, 24 DMA cycles
VIDEO
VERTICAL TIMING
U8,U6 OUTPUTS
Q1-Q2 125 KHz
Q3 62.5 KHz
Q4 31.25KHz
Q5 15.625KHz
Q6 line 1
Q7 line 2
Q8 line 4
Q9 line 8
Q10 line 16
Q11 line 32
Q12 line 64
Q13 line 128
Q14 line 256
60Hz: 15.625KHz HSYNC / 262 lines = 59.637Hz VSYNC
50Hz: 15.625KHz HSYNC / 312 lines = 50.08Hz VSYNC
/VSYNC low on lines 0-11 (Q14=0 Q9:Q8=00,01,10)
/INT low on lines 38-39 (Q14=0 Q11=1 Q8=1 Q7=1)
Line 0-11: VSYNC, with 3 cycles inverted HSYNC.
Line 12-39: Blank (top margin).
Line 38-39: /INT=0. 69 bus cycles before 1st
DMA to save regs and initialize. End with IDL
to wait for DMA (allows 3-cycle instructions).
Line 40-231: DMA (192 lines of 24 DMA cycles).
Also, /EF1=0 to tell Interrupt handler that
DMA still in progress. Use to repeat lines
to save RAM and reduce vertical resolution.
Line 232-261 (or 232-311): Blank (bottom margin).
Line 262 (or 312): RST=1 to reset U6.
bottom margin->
<-vertical sync pulse
<-top margin
/HSYNC
/BLANK
VIDEO
R5
100K
TVON
Q1
U8 74HC374
VIDEO LATCH
/BLANK
/SYNC
/EF1
RST
VSYNC
R5 latches TVON
0=sync only).
are a divide by 4
ter to make Q1-Q2.
the VSYNC latch
0=video, blank).
Rev.A:
1. Cut trace on bottom of board between U11 pins 15-16, and connect U11 pin 15 to GND instead.
2. Add C6 (3300pF) between U11 pin 1 and GND.
3. U7 program allows for U8 to delay /BLANK /SYNC /EF1 RST /BLANK by 1 bus cycle.
TMSI c/o Lee Hart
814 8th Ave N
Sartell MN 56377
leeahart@earthlink.net
Title
1802 VIP2K - VIP in an Altoids tin
Size B
Document Number C:\ORCAD\SHEET\1802\VIP2K.SCH
REV B
Date: December 5, 2018
Sheet 1 of 1