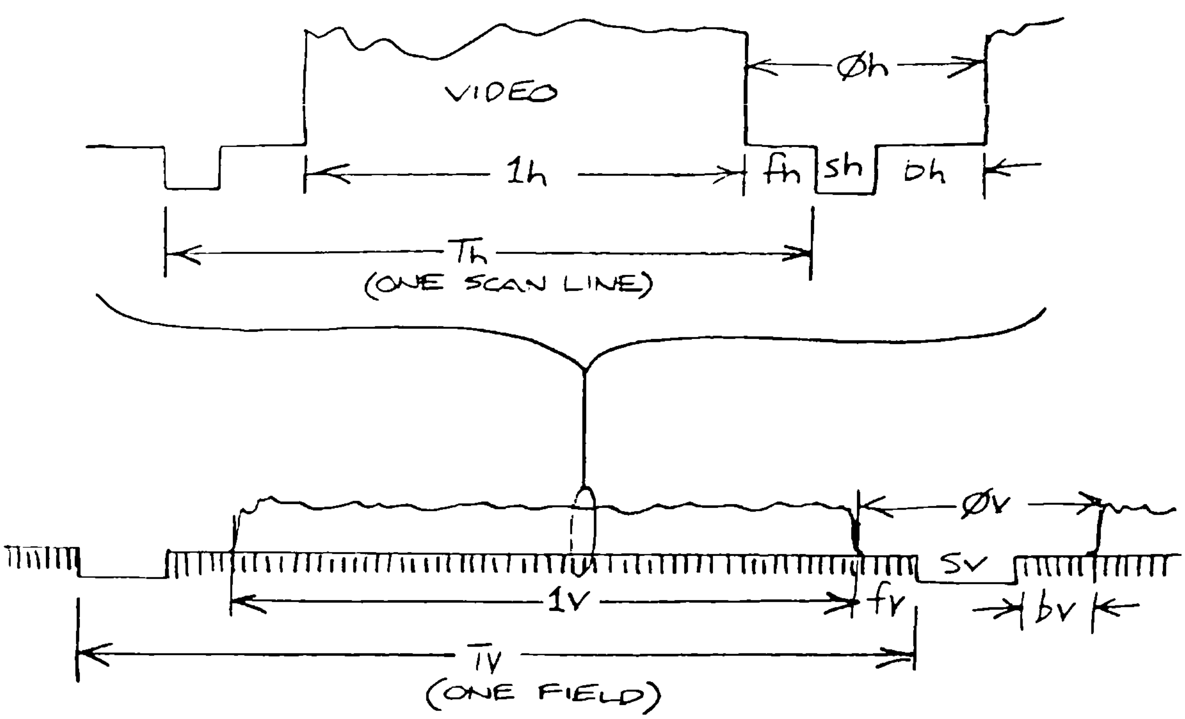
Reprogramming the Omega Video Timing

Definition of symbols:

Fh	horizontal scan frequency, KHz.
Th	horizontal scan period, microseconds
Fv	vertical scan frequency, Hz.
Tv	vertical scan period, milliseconds
0h	horizontal blanking time, microseconds
1h	horizontal display time, microseconds
0v	vertical blanking time, microseconds
1v	vertical display time, microseconds
sh	horizontal sync pulse duration, microseconds
fh	horizontal front porch, microseconds
bh	horizontal back porch, microseconds
sv	vertical sync pulse duration, microseconds
fv	vertical front porch, microseconds
bv	vertical back porch, microseconds
X	x resolution, pixels
Y	y resolution, pixels
Zx	x zoom factor
Zy	y zoom factor
ct	character time, microseconds (.4414 for Omega 400,.3636 for 1Kx1K)

The following timing diagrams illustrate how these symbols are used:



These are relations between symbols derived from their definitions:

Fh=1000/Th
Fv=1000/Tv
0h=fh+sh+bh
0v=fv+sv+bv
1h=Th-0h
1v=Tv-0v

The Omega allows access to ten video timing control registers. These are loaded via the op code CRTWR (hex 46), followed by register number (range 0 to 9) and the value to be written. In the following table, (r0) means the contents of r0 and thus is the value following the hex sequence 46 00; similarly to write hex 57 into register 4, one would transmit 46 04 57.

- (r0)=int[Th/ct]-1 ;r0 controls horizontal rate.
- (r1)=int[1h/ct]+2 ;r1 controls horizontal display time. Also ;r1 determines X resolution by:

  X*Zx=16*[(r1)-2]

- (r2)=(r1)-int[hf/ct] ;r2 controls horizontal front porch.
- (r3)=16*int[sv/Th]-int[sh/ct] ;r3 controls horizontal AND vertical sync.
- (r4),r(5) and (r9) work together to define the vertical period. One may choose any values that produce the correct period, within the constraints:

  (r4) ranges from 0 to 127 decimal (r5) ranges from 0 to 31 decimal (r9) ranges from 0 to 31 decimal

  There are three formulas to use:

  interlace, (r4)*(r9) even: 2*int[Tv/Th]=[(r4)+1]*[(r9)+2]+2*(r5)-1

  interlace, (r4)*(r9) odd: 2*int[Tv/Th]=[(r4)+1]*[(r9)+2]+2*(r5)

  non-interlaced: int[Tv/Th]=[(r4)+1]*[(r9)+1]+(r5)

- (r6): (r9) also works with (r6) to define y resolution, and may affect the selection of (r9) in the previous calculations:

  interlaced: Zy*Y=(r6)*[(r9)+2]

  non-interlaced: Zy*Y=(r6)*[(r9)+1]

  (note. no zoom means Zy=1; a times 2 zoom means Zy=2, etc).

Selection of a value for r7 requires first that vertical front porch be rounded to the nearest multiple of 4*Th for interlace and 8*Th for non-interlace- these are the finest increments that the vertical sync pulse can be positioned. Assuming this has been done:

- (r7)=(r6)-int[vf/ct]
- (r8)=0 for non-interlaced
  =3 for interlaced

APPLICATIONS

Normally, one reprograms the Omega to optimize system performance. This could mean maximize X and Y resolution, and push monitor bandwidth to the limits of its performance. The Omega constraints are defined by: X and Y cannot exceed 1023 without wrap-around

and ct is fixed by the crystal frequency

The monitor typically is constrained in terms of most of the video timing parameters previously used. One usually will try to achieve the maximum refresh rate to minimize flicker.

Where some items are not included in the monitor spec, standards such as EIA RS-343 or RS-170 may be consulted.

Both groups of constraints come into play in the first example, the standard 1024 by 768 resolution, 33 Hz. interlace display of the standard Omega 400.

Example 1: 1024 by 768, 34 Hz. interlaced.

Assume we begin with X resolution:

X=1024=16*[(r1)-2] so (r1)=66.

Monitor blanking time is spec'ed at 6 microseconds, nominal. RS-343 specifies 7.25 useconds, max. It is desirable to maximize blanking, as it allows the processor to operate at a higher duty cycle; so we choose the largest multiple of ct within 7.25 i.e. 16.

1h=ct*[(r1)-2]= 28.25 us.

Th=28.25+7.06=34.31 usec. Fh=28.32 KHz. (Within monitor specs)

(r0)=(r1)-int[Oh/ct]-3 ; since we chose Oh to be 16*ct, (r0)=79.

Horizontal sync data are not in the 3619 spec, so we use RS-343.

Let sh=ct*int[2.75/ct] =2.65 usec. Let fh=ct*int[.75/ct] = .88 usec.

fh determines (r2): (r2)=(r1)+int[fh/ct]=(66)+2=68.

The resulting backporch is generous; bp=0h-fh-sh=3.53 usec.

To continue, we use Y=768 (derived from aspect ratio considerations) and the RS-343 vertical retrace time of 1.25 msec. Actually, we use 1.257 msec, as it is the closest multiple of Th/2.

Tv=(768/2)*Th+1.257=14.48 msec. Fv=1000/Th=69.1 Hz field rate. The frame rate is half this, or 34.5 Hz.

Now we can select total lines per frame:

Lines=int[2*Tv/Th]=841.

Since this number is odd, we use:

841=[(r4)+1]*[(r9)+2]-2*(r5) and 768=(r6)*[(r9)-2]. Choose (r9)=6 for convenience. Then

(r6)=96 (r4)=103 (r5)=4

Since we are interlaced, (r8)=3. All that remains is to select a value for r7. The monitor spec says nothing about vertical sync position; RS-343 says 0 to 250 usec. We will minimize it to give the monitor the maximum time to stabilize before beginning the next scan.

(r7)=(r6); vf=0. Actually, due to hardware, a 2 usec vf exists.

Example 2: 640 X 480 30 Hz. Interlaced (RS-170).
RS-170 dictates almost all video parameters:

Fh=15.73426 KHz
Th=63.555 usec

Fv=59.94 Hz
Tv=16.683 msec

Other parameters are derived from these-

0h=.16*Th=10.168 usec
1h=Th-0h=53.387 usec
fh=.02*Th=1.27 usec
sh=.08*Th=5.084 usec
bh=.06*Th=3.813 usec

0v=.075*Tv=1.251 msec
1v=Tv-0v=15.432 msec
fv=0
sv=.04*Tv=.667 msec
bv=0v-sv=.584 msec

The crystal frequency required is 72.5035 MHz; this is the standard

Omega 400 crystal value. It yields a character time of:

ct = 32/crystal freq. = .4414 usec

Th dictates the value programmed into r0:

(r0)=int[Th/ct]-1=int[63.555/.4414]-1=143

(r1)=int[th/ct]+2=123; however this would yield an Zx*X of

16*121=1936. Assuming a Zx of 3, 645.3 pixels in x results So we must compromise the RS-170 standard, and let r1 be set by resolution of 640 X:

(r1)=int[Zx*X/16]+2=int[3*640/16]+2=122

(r2)=(r1)+int(fh/ct)=122+3=125

(r3)=16*int(sv/Th)+int(sh/ct)=16*3+11=59

(r4),(r5) and (r9) are chosen for 525 scans per frame. Use the formula for interlaced, with (r4)*(r9) odd:

525=[(r4)+1]*[(r9)+2]+2*(r5)+1

The problem is one of factoring 524 within the range constraints on the registers. One combination that works is:

(r4)=86
(r5)=1
(r9)=4

For (r6), use the target y resolution of 480:

480=(r6)*[(r9)+2] ; since (r9)=4, (r6)=80

(r7) is set by vf; assume this is zero, as the controller is restricted to multiples of 4*Th:

(r7)=(r6)+int(vf/ct)=(r6)+80

and for this application, (r8)=3.

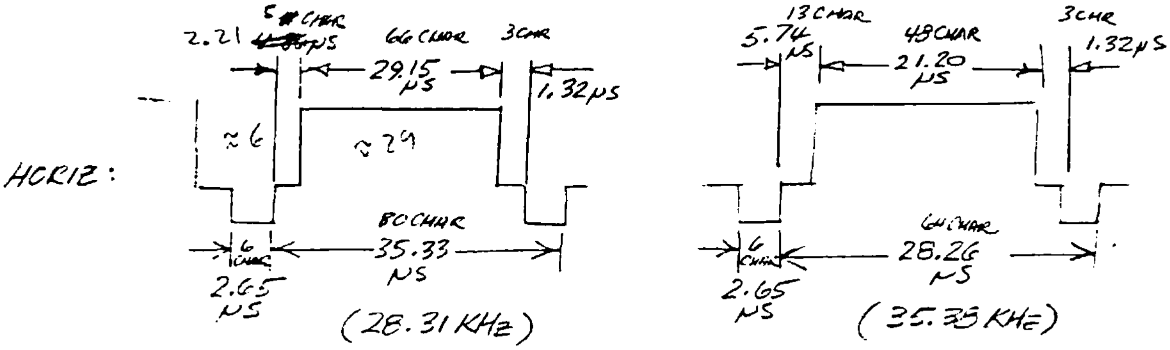
CRT CONTROLLER SETUP : CHAR TIME = 441.6 nSEC

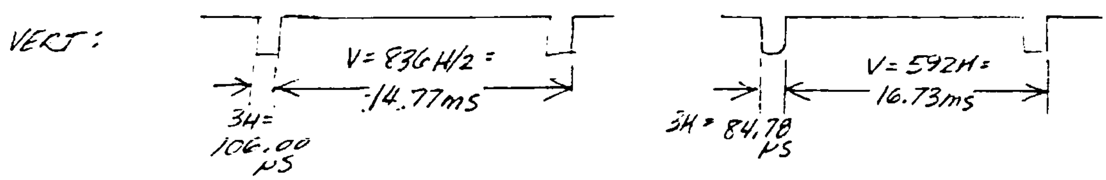
(1) 1024 x 768 INTERLACE, 33 Hz FRAME RATE

	VALUE	MEANING
R0	79	80 CHAR/LINE
R1	66	66 CHAR DISPLAY
R2	68	HSYNC AT 69TH CHAR
R3	54	HSYNC 6 CHAR, VSYNC = 3H sync
R4	103	104 ROWS/FRAME (836 LINES)
R5	4	ADJUST: 4 SCAN LINES (836 LINES)
R6	96	96 ROWS DISPLAYED
R7	96	V SYNC AFTER 96 ROWS
R8	3	INTERLACE
R9	6	8 RASTERS/ROW

(2) 736 x 552 NON-INTERLACE, 60 Hz FRAME RATE

	VALUE	MEANING
R0	63	64 CHAR/LINE
R1	48	48 CHAR DISPLAY
R2	50	H SYNC AT 51ST CHAR
R3	54	HSYNC 6 CHAR, Vsync = 3H sync
R4	73	74 ROWS/FRAME (592 LINES)
R5	∅	NO ADJUST (592 LINES)
R6	69	69 ROWS DISPLAYED
R7	69	V SYNC AFTER 69 ROWS
R8	∅	NO INTERLACE
R9	7	8 RASTERS/ROW





ALL TIMING ACCURATE WITHIN 1%

Horiz [illegible] total 168/2 × [illegible] usec 2.3 msec

Vtotal 101 × 8 = 836 rasters/frame

Vblank [illegible] – 2.4 msec [illegible] 10.4 K [illegible] vblank.

[illegible] / vertical [illegible]

[illegible] blank

21.3 K [illegible]