Vido Displays are usually implemented by Cathode Ray Tubes

- Electron Beam is focused into a small spot on the screen
- Energy delivered to a phosphor creates a glowing dot (pixel)

Beam can be moved rapidly in 2 dimensions
Beam current determines brightness of the spot

Composite Frames

- The 'frame' is a single picture (snapshot)
- It is made up of many lines
- Each frame has a synchronizing pulse (Horizontal Sync)
- Each line has a synchronizing pulse (Horizontal Sync)
- Brightness is represented by positive voltage
- Horizontal and Vertical intervals both have blanking

Digital Displays

- White Dots on a Black Screen
  - White is positive
  - Black is a low voltage
  - Sync is below black

- Sync pulse is in the middle of the blanking interval

Video Displays

- Television and most computer displays use raster-scan:
Composite Synchronization

Horizontal Sync coordinates lines
Vertical Sync coordinates frames
Similar but for time scales
And they are superimposed on one another
These numbers are for television like displays

Recovery of Signals

Composite Video has picture data and both syncs
Video is above sync level
Separation is easy
Sync recovered by noting when composite is below sync level
Horizontal sync is used directly
Vertical sync is slower:
Low pass filter
Square up with Schmitt Trigger

Generation of Signals

Assume 1 bit per pixel
This is a simple way of building a front end
Timing about right for TV style displays
's38 is fast open collector part

Control

Try this display format:
256 pixels X 192 rows
7.16 MHz clock ==> .13966 microseconds/pixel
Display time = 35.8 microseconds (active line)
256 X 192 = 49,152 = 48k pixels = 6k bytes

This control scheme would work:
Timing of Control Signals

Frame Counters and ROM produce sync signals
FCLK is at pixel rate
SCLK is FCLK/4
TVC controls picture memory access
LDSR controls loading shift register
DLD controls system access to picture memory

Generation of Sync Signals, etc.

These are just bits in ROMs
Note that EOL (active low) causes a line count and clears dot counter
And that (EOF AND EOL) causes a clear of line counter

What would go into those ROMs

Vertical PROM:

<table>
<thead>
<tr>
<th>Number of Locations</th>
<th>Addresses</th>
<th>Bits Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>192</td>
<td>0 - 191</td>
<td>Vactive</td>
</tr>
<tr>
<td>26</td>
<td>192 - 217</td>
<td>Vblanking</td>
</tr>
<tr>
<td>6</td>
<td>218 - 223</td>
<td>Vsync</td>
</tr>
<tr>
<td>37</td>
<td>224 - 260</td>
<td>Vblanking</td>
</tr>
<tr>
<td>1</td>
<td>261</td>
<td>EOF</td>
</tr>
</tbody>
</table>

Horizontal PROM:

<table>
<thead>
<tr>
<th>Number of Locations</th>
<th>Addresses</th>
<th>Bits Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0 - 31</td>
<td>Hactive</td>
</tr>
<tr>
<td>9</td>
<td>32 - 40</td>
<td>Hblanking</td>
</tr>
<tr>
<td>7</td>
<td>41 - 47</td>
<td>Hsync</td>
</tr>
<tr>
<td>8</td>
<td>48 - 55</td>
<td>Hblanking</td>
</tr>
<tr>
<td>1</td>
<td>56</td>
<td>EOL</td>
</tr>
</tbody>
</table>

Color Displays

Are similar to 3 black and white
Colors Add
Here is the schedule for an "8 Color Display"
More colors possible with more bits
Sync is often carried separately
Sometimes is on the Green line
Character Displays

Characters are fixed bit patterns
Have the same shape
Can appear at different places on the screen
Letters and numbers are characters
But other patterns can be useful

On a 256 column X 192 row screen:

<table>
<thead>
<tr>
<th>Char Size</th>
<th>Rows</th>
<th>Columns</th>
<th>Chars/Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 x 16</td>
<td>12</td>
<td>32</td>
<td>384</td>
</tr>
<tr>
<td>8 x 12</td>
<td>16</td>
<td>32</td>
<td>512</td>
</tr>
</tbody>
</table>

(16 X 12 = 192)

Use of Characters can save video memory: 256 X 192 = 49152 dots = 6144 bytes

Character Format (8 x 16 pixels)

Simple Formatting:
Lower 4 bits of screen address indicate which row in character
9 bits of screen address tell which character

Character Format (8 x 12 pixels)

Row formatting not quite as simple
But re-mapping is done easily in a PROM

Video Controllers

MC6847 is obsolete but easy to use
Several display modes
256 x 192 2 color (well, 1 and black)
Other color graphics with lower resolution