

The horizontal counter is made up of seven stages: H0, H1, H2, H3, H4, H5, and HPE'. The input to the horizontal counter is the 1 MHz signal that controls the reading of data being displayed. The complete cycle of the horizontal counter consists of 65 states. The six bits H0 through H5 count normally from 0 to 63, then start over at 0. Whenever this happens, HPE' forces another count with H0 through H5 held at 0, thus extending the total count to 65.

The IOU uses the 40 horizontal count values from 25 through 64 in generating the low-order part of the display data address, as described later in this chapter in the section "Display Address Mapping." The IOU uses the count values from 0 to 24 to generate the horizontal blanking, the horizontal sync pulse, and the color-burst gate.

When the horizontal count gets to 65, it signals the end of a line by triggering the vertical counter. The vertical counter has nine stages: VA, VB, VC, V0, V1, V2, V3, V4, and V5. When the vertical count reaches 262, the IOU resets it and starts counting again from zero. Only the first 192 scanning lines are actually displayed; the IOU uses the vertical counts from 192 to 261 to generate the vertical blanking and sync pulse. Nothing is displayed during the vertical blanking interval. (The vertical line count is 262 rather than the standard 262.5 because, unlike normal television, the Apple IIe's video display is not interlaced.)

- ❖ *Smooth animation:* Animation displays sometimes have an erratic flicker caused by changing the display data at the same time it is being displayed. You can avoid this on the Apple IIe by reading the vertical-blanking signal (VBL) at location \$C019 and changing display data while VBL is low only (data value less than 128).

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## Display memory addressing

As described in Chapter 2 in the section "Addressing Display Pages Directly," data bytes are not stored in memory in the same sequence in which they appear on the display. You can get an idea of the way the display data is stored by using the Monitor to set the display to graphics mode, then storing data starting at the beginning of the display page at hexadecimal \$400 and watching the effect on the display. If you do this, you should use the graphics display instead of text to avoid confusion: the text display is also used for Monitor input and output.