Hercules Graphics Card Plus: Notes

The Hercules Graphics Card Plus is an extension to the original Hercules Graphics Card, allowing redefinable fonts in text mode.

- Hardware requirements
- The hardware
- Memory Map
- Register I/O
- Memory Access
- Character attributes
- Recommended CRTC values
- The printer port

Hardware requirements

The card is an 8-bit ISA card containing the display controller and a printer port. When present in a computer, it requires the following system resources:

- 4k-64k of RAM at address 0B0000h.
- I/O addresses 03B0h-03BFh.
- The printer port uses IRQ7.

The hardware

Font ROM   LPT 112 chip

6845 CRTC   Lightpen connector
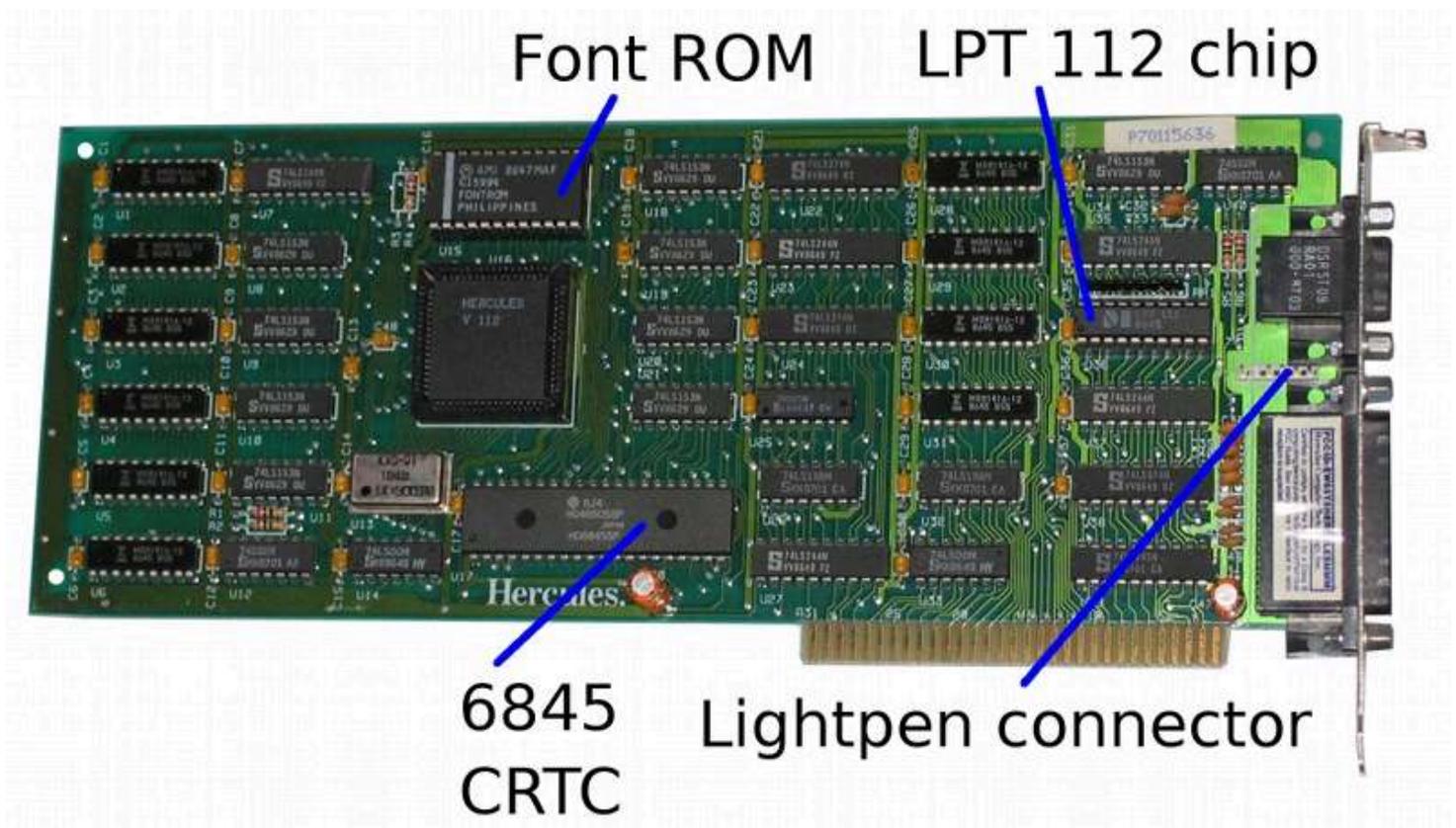
  3. Not used
  4. Not used
  5. Not used
  6. Intensity
  7. Video
  8. Horizontal sync
  9. -Vertical sync

The font rom is marked AMI C15994 FONTROM (the same ROM is used on the Hercules InColor card). As on the original IBM MDA, this is a 9264 rather than a 2764, so it can't be read in a standard EPROM programmer. The memory layout isn't the same as on the MDA, so you can't swap the chip with one from an MDA and expect it to make sense. Both ROMs are divided into four 2k blocks; on the MDA, the font is in blocks 0 and 1, but here it is in blocks 1 and 3.

The card uses the 14-pixel font in the ROM:

The ROM also contains two 8-pixel fonts (in blocks 0 and 2) which do not appear to be used.

Memory Map

On power-up, the HGC+ behaves like an MDA, producing an 80×25 text screen in white on black. Each character is 9 pixels wide and 14 high, giving a 720×350 pixel resolution. Although the characters are 9 pixels wide, the bitmaps in the ROM (or the RAM) only cover the first 8. For characters 0C0h-0DFh, the ninth pixel column is a duplicate of the eighth; for others, it's blank.

In text mode, the usual MDA-esque scheme is used, with two bytes of RAM for each character. The first byte is the character code, and the second gives the attribute.

The HGC+ outputs four possible combinations of video signal:

Video	Intensity	Resulting 'colour'
0	0	Black
0	1	Dim
1	0	Normal
1	1	Bright

On startup, the character attribute scheme behaves like an MDA:

- Bits 2-0: 1 for underline.
- Bit 3: Foreground colour is *bright*.
- Bit 7: If blinking is enabled: Blink. Else: Background colour is *dim*.

with eight exceptions:

- Attributes 00h and 08h display as *black* space.
- Attributes 80h and 88h display as *dim* space.
- Attribute 70h displays as *black* on *normal*.
- Attribute 78h displays as *dim* on *normal*.
- Attribute F0h displays as a blinking version of 70h (if blinking is enabled); as *black* on *bright* otherwise.
- Attribute F8h displays as a blinking version of 78h (if blinking is enabled); as *dim* on *bright* otherwise.

Register I/O

03B4h: CRTC address register.

Write a CRTC register number (0 to 1Ch) to this port to select the CRTC register that will appear at port 03B5h. Registers 0-11h are standard 6845 registers and are described on the 6845 datasheet.

Registers 14h-16h are used to control the HGC+'s additional features, and are described below.

On the MDA, the CRTC address and data register are partially decoded, so that any even-numbered address between 03B0h and 03B7h will get you the CRTC address register, and any odd-numbered address gets you the data register. I don't know whether this holds for the HGC+.

This is a write-only register.

03B5h: CRTC register read/write.

This gives access to the selected CRTC data register. Most CRTC registers are write only; some are read/write or read-only.

Bit 7: Graphics page to display

If bit 7 is 1, the graphics page at 0B8000h is displayed. Otherwise, the page at 0B0000h is displayed.

Bit 5: 1 to enable blinking, 0 to disable it.

If bit 5 is 1, characters with attribute bit 7 set will blink. If not, they will have high intensity background.

Bit 3: 1 to enable video output, 0 to disable it.

If bit 3 is 0, screen output will not be shown. The usual use of this is if you're reprogramming the CRTC registers; disable video output beforehand and re-enable it after.

Bit 1: 1 for graphics mode, 0 for text.

When the card is switched between text and graphics modes, the 6845 must be reprogrammed with suitable parameters for the new mode.

03B9h: Set light pen flip-flop

Any write to this port sets the flip-flop.

03BAh: Status Register

This is a read-only register.

- Bit 7: 0 if vertical sync active, 1 if inactive.
- Bits 6-4: Card ID (001b = 1 for HGC+). The manual advises programs checking for HGC+ features to test only the bottom 2 bits; that way, they'll also work on an InColor card (ID 101b = 5).
- Bit 3: Video. This is 1 if a pixel is being drawn on the screen at this moment.
- Bit 1: Light pen flip-flop.
- Bit 0: Retrace. This is 1 if the horizontal retrace is active.

03BBh: Reset light pen flip-flop

Any write to this port resets the flip-flop.

03BFh: Graphics mode enable

This is a write-only register.

- Bit 1: Set to page in the upper 32k of memory at 0B8000h, clear to page it out.
- Bit 0: Set to allow graphics mode, clear to disallow it. Also enables access to memory from B1000h to B7FFFh.

Additional CRTC registers

The additional CRTC registers are:

Bit 0: 0 to use ROM font, 1 to use RAM font.

If the RAM font is selected, character bitmaps are read from 0B4000h. Each bitmap holds 16 bytes per character; the top 14 (normally) are drawn.

Bit 1: 0 for 80-column mode, 1 for 90-column mode.

If this bit is changed, the first four CRTC registers need to be reprogrammed. For 80-column mode, they should be set to `61 50 52 0F`, and for 90-column mode they should be set to `6D 5A 5C 0F`.

In 90-column mode characters are 8 bits wide, and so there is no special treatment of characters 0C0h-0DFh.

Bit 2: 0 for 4k RAMfont, 1 for 48k RAMfont

In 48k RAMfont mode, the low 4 bits of the attribute byte become a font selector, 0-11 (Values 12-15 render as vertical stripes). This selects the font used for drawing: font 0 is at B4000h, font 1 is at B5000h and so on.

Register 15h: Underline

This is a write-only register, initialised to 0Dh on reset. It only applies in 48k RAMfont mode; it sets the position of the underline for underlined characters. Bits 3-0 give the row (0-15).

Register 16h: Strikethrough

This is a write-only register, initialised to 0Dh on reset. It behaves as underline, for characters with the 'strikethrough' attribute.

Character Attributes

There are two ways the card can interpret character attributes. In normal text mode or in the 4k RAMfont mode, they behave like an MDA (as described above). In the 48k RAMfont mode, the semantics are different. The low 4 bits become a font number, 0-11 (with 12-15 giving characters composed of random vertical stripes) and the high 4 bits give the attribute:

Blink on	Bit 7=High intensity Bit 6=Blink Bit 5=Strikethrough Bit 4=Underline
Blink off	Bit 7=Boldface Bit 6=Reverse video Bit 5=Strikethrough Bit 4=Underline

Recommended CRTC values

Hercules graphics cards do not include any form of BIOS extension, and the standard IBM BIOS treats them as an MDA. Consequently, to switch between text and graphics modes (or 80- and 90- column

In the tables below, all values are in hexadecimal.

Register	80-column text	90-column text	Graphics
00 Horizontal total	61	6D	35
01 Horizontal displayed	50	5A	2D
02 Horizontal blanking	52	5C	2E
03 Sync width	0F	0F	07
04 Vertical total	19	19	5B
05 Vertical adjust	06	06	02
06 Vertical displayed	19	19	57
07 Vertical sync position	19	19	57
08 Interlace and skew	02	02	02
09 Max raster	0D	0D	03
0A Cursor start	0B	0B	00
0B Cursor end	0C	0C	00

The manual also provides timing values for different character heights, allowing (for example) a 43-line display with 8-pixel characters. In this situation, a suitable font of the correct height should be loaded into RAM.

Register	Character height												
	4	5	6	7	8	9	10	11	12	13	14	15	16
04 Vertical total	5C	4A	3D	34	2D	28	24	20	1D	1B	19	17	16
05 Vertical adjust	02	00	04	06	02	01	00	07	0A	06	06	0A	02
06 Vertical displayed	58	46	3A	32	2B	26	23	1F	1D	1A	19	17	15
07 Vertical sync position	59	46	3B	33	2C	27	23	20	1D	1B	19	17	16

The printer port

According to the manual, the printer port can be disabled (if it conflicts with another piece of hardware) by removing the chip marked HCT LP112 adjacent to the port.

The printer port behaves like the one on an MDA:

- Write to port 03BCh: Set data lines.
- Read from port 03BCh: Reads last value sent to printer.
- Read from port 03BDh: Get printer status.
    - Bit 3: ~Error
    - Bit 4: Select
    - Bit 5: Paper out
    - Bit 6: ~Acknowledge
    - Bit 7: Busy

  Bits 2 and 0 always appear to be 1. Bit 1 varies between 0 and 1.

- Write to port 03BEh: Set control lines.

- Bit 4: Enable interrupt when the printer sets ~Acknowledge to 0.
- Read from port 03BEh: Reads bits 4-0 of last value written. The top 3 bits always appear to be 1,1,1.

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