HRX Graphics System -- HRG Utility Software Manual

Written by: Chris Marvell

Document:

User Manual and Software Description for the HRG Graphics Utility Software Package.

Software Version:

HRG Version 2.5/2.6, March/April 1984

This document notes any differences between versions 2.5 and 2.6 in the text.

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Hardware Requirements for this Software Package:

SM1 SBC Computer with 4, 6 or 8 MHz clock and 64kbytes RAM
At least one floppy or hard disc drive
Colour or Monochrome HRX Graphics boards

Operating environment:

CPM V1.4 or V2.2 operating system

Purpose of software:

To provide immediate user control of the HRX Graphics hardware by means of a set of primitive picture manipulation commands. This version of HRG allows only immediate interaction by the user typing commands directly on the console, but the software is written in a modular way as a "toolbox" of commands structured as a set of subroutines directly accessible from a user program. Later versions of HRG will provide for direct use of the graphics commands from high level or machine code programs. The present version requires the use of the direct execution command interpreter provided or the manual linking of required subroutines by the user with the user's application program.

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1. The HRX Graphics System.

The hardware for the HRX graphics system consists of a double-width controller and memory card and further optional double memory cards (required for colour use). In addition, if frame grabbing is required, a single (monochrome) or three channel (colour) flash A/D converter is required. A typical colour system consists of the controller/memory board, which acts as the GREEN frame store, an additional double memory board for RED and BLUE frames and the three channel flash A/D board. The controller part of the system provides the interface to the SM1 bus 60 way edge connector which allows it to accept control and data direct from the SM1 bus. Each memory section (frame store) is equipped with an 8 bit high speed look-up-table RAM which allows the user to set up a colour map for each channel (R,G and B) and finally a high speed ECL 8 bit D/A converter provides as output to a video monitor a standard 1 volt peak-peak 75 ohm video signal.

Input of video signals is accomplished by way of the flash A/d converters which provide a 6 bit (the least significant 2 bits are not used with these A/D converters) parallel digital signal as input to the HRX memory sections. When grabbing frames in colour, the system stores data at a rate of 7.2Mbytes/second and also reads out this data directly (via the look-up-table or palate RAM and D/A converter) onto a video monitor. Frame grabbing in no way affects video readout and computer (Z80) access to the RAM can take place randomly at any time in the video raster readout without having any effect on the read out picture. This is possible because the system generates two sets of memory access cycles which are interleaved so that a video readout cycle always follows a video input cycle. Video input cycles preclude computer access to the frame store but do not inhibit computer access to the other functions of the graphics controller.

The graphics controller section of the system, which is implemented from Schottky TTL has the function of controlling the input and output memory cycle timing, arbitrating between the video and computer access to the frame stores, setting and reading the look-up-table RAMs, positioning the video readout area on the monotor screen and determining which area of RAM is operated on by the Z80 and which area is read out to the video screen. The controller operates on a standard 625 line 50Hz raster (or 525 line 60Hz) and allows the following screen formats:

256 * 256 pixel square format non-interlaced
378 * 256 pixel rectangular format non-interlaced
256 * 512 pixel square format interlaced
378 * 512 pixel rectangular format interlaced
512 * 256 pixel square format non-interlaced, double res.
756 * 256 pixel rectangular format non-interlaced, double resolution.
512 * 512 pixel square format interlaced, double res.
756 * 512 pixel rectangular format interlaced, double res.

Notes on video formats:

1) Double resolution requires a double memory board be used for each frame store (3 double memory boards are hence required for colour operation).
2) The present version (2.5) of HRG does not support double resolution working.
3) If the system is used with the NTSC standard 525 line 60Hz raster, frame blanking requirements cause the maximum number of displayable lines to be approximately 480 in interlaced mode (out of 512 possible) or 240 in non-interlaced mode (out of 256 possible).

The graphic controller organises the frame store so that the computer interface in accomplished as follows:

The available frame memory (for a given colour, single resolution) is organised for video readout as 4 pages which may be selected separately for display as 4 256 by 256 screens or by interlacing two screens together 256 by 512 (2 screens) or by placing 2 screens side by side 378 by 256 (2 screens, the horizontal pixel count being limited by the aspect ratio of the screen) or, finally using all 4 pages to provide one screen full of picture by choosing 2 screens set side by side and interlacing the other 2 screens with this (1 screen, 378 by 512). Any of the screens or any combination of them can be displayed as required. The video input is always directed into the currently visible screen and the mode of frame grabbing will correspond to the video readout mode selected: e.g. if page 0 is interlaced with page 1 to give a video readout of an interlaced 256 (horizontal) by 512 (vertical) picture, then the frame grab will grab an equivalent 256 by 512 interlaced square format picture.

The Z80 on the SM1 SBC board gains access to the frame store by having a selected video line mapped into its memory map. Before accessing the HRX graphics controller, the Z80 must execute a program to open a "window" in the (normally continuous) 64k address space of the SM1. This window is a 1k segment of memory and can be positioned at any 1k boundary in the 64k addressing range of the Z80. The 1k area represents one video line of each of the 4 video pages (4 lots of 256 bytes). To address a specific video line (of the 256 available) the Z80 must write the line number required to be accessed (0 to 255) to an output port associated with the graphics controller. Once a line has been addressed in this way the Z80 can without restriction acces the value of pixels in that line in each of the four available video pages. Access can be either read or write, data representing the intensity of a pixel is stored in the frame store as an 8 bit byte for each colour, a further output port is used to select which frame store (R, G or B) is to be read from and which of the frame stores any data is to be written to when a write command is issued by the Z80.

The I/O ports associated with the HRX Graphics controller allow the user to select which plane to read and write from/to (separately) and which look-up-table RAM (palate RAM) to access (read data, write data and write address). An output port allows

the user to select one of four sync sources to enable an internal, external, computer generated or user-supplied sync source to be used: this allows the raster of the HRX display to be synchronised with an external TV signal, a camera or the computer display terminal's own sync to allow the graphics display to appear on the same monitor as the console terminal. An input port allows the user to determine the status of the display controller (line and frame blanking times and ready when reading or writing from/to the palate RAMs). Further input ports allow a light pen to be used in conjunction with the display to allow the user to read back the address of the pixel on the screen coinciding with the light pen position. More output ports are provided to allow the user to switch the display on and off, select wide screen or narrow screen mode, double resolution and to select the page or pages (see above) which are visible on the monitor screen.

The I/O ports described above are organised into a 16 byte block for input and output. This block can be set by switches on the controller board to be at any 16 byte boundary in the 256 byte I/O map of the Z80.

For use with the HRG software, the memory window must be set at 0DC00H and the I/O block set at 0D0H.

Input to the system flash converters is 1 volt peak-peak 75 ohm video R G B and sync with level from 1 volt peak-peak to 5 volts peak-peak. On a monochrome signal, only the Green channel of the flash converter is used and a composite video input is expected, there being a sync separator on the flash A/D board. Output from the system is standard 1 volt peak-peak 75 ohm video and TTL level sync.

2. HRG Software Overview

The basic software package to allow operation of the HRX hardware is called "HRG". The package is basically a subroutine set to allow the user to call graphics functions from his application program, whether it is BASIC, PASCAL, ASSEMBLY or any other language. The addition of a console handler and command string interpreter (CSI) module allows a demonstration system to be constructed by linking the entire subroutine set with this CSI module to give the user instant (immediate mode) access to all the available graphics commands by typing the command (and its arguments if applicable) on the keyboard.

This command string interpreter is called, as a module, "HRG", and when linked with the .REL subroutine set (The HRGLIB library) forms a .COM file again called "HRG". The command interpreter can be invoked as with any other standard CP/M program merely by the user typing its name. It then initialises the graphics system and waits for the user to type further commands on the keyboard.

The total size of the HRG.COM program (CSI + Subroutines + Buffer memory space) is 40kbytes. It requires at least a 48k version of CP/M to run successfully and hence determines that the system it is executed on must have 64k of RAM.

The software is written entirely in 8080 and Z80 assembler code, assembled using the Microsoft M80 macro assembler. The maximum size of a single module (.REL format) is 8k bytes.

The processing provided by the HRG software package falls into eight categories, these are:

1) Pixel movement commands
2) Image processing commands
3) Colour conversion commands
4) Real Time video input commands
5) Picture selection and placement commands
6) Plotting commands for drawing lines or points
7) Disc load/store commands
8) Utility commands

To give a brief overview of these command types, lists of commands in each category now follow. Section 3 of this document describes the function and usage of each command separately in an alphabetical list.

1) Pixel movement commands

These cause pixels on the screen to be moved to different positions on the screen, commands in this category are:

EXCHANGE	Swap pages of frame store
LOAD	Load page 1 into page 0
MOVE	Move any page to any other page
PAN	Move the picture up/down/left/right on all pages.
QUARTER	Shrink all 4 pages into page 0
ROTATE	Rotate page 0 by 90 degrees
SAVE	Save page 0 in page 1
SHIFT	Move the picture in pages 0 and 1 left/right
SHRINK	Move page 1 to occupy a specified quarter of page 0
TURN	Rotate page 0 by 180 degrees (mirror image)
ZOOM	Expand a specified quarter screen area to occupy the full screen.

2) Image Processing commands

These cause repetitive operations to be performed on all the pixels in page 0 to isolate one feature of the displayed picture or to remove noise from the displayed picture. The commands are:

AVERAGE	Average corresponding pixels on 2 specified pages
COMBINE	Combine R G and B into a single averaged picture in the Green frame store
DIFFERENCE	Take difference of corresponding pixels on 2 specified pages
EDGE	Detect Edges on page 0
ENHANCE	Simple non-recursive 3 by 3 pixel highpass filter to enhance detail on page 0
FILTER	Simple non-recursive 3 by 3 pixel lowpass filter to reduce noise on page 0
FORCE	Operate on stored pixels using the palate memory contents.
FOURAVERAGE	Produce an average picture of all 4 pages in page 0.
LOGICAL	Perform pixel by pixel logical operations on corresponding pixels in page 0 and 1
NEGATIVE	1's complement all pixels in page 0
NORMALISE	Adjust pixel values so that the average value of all pixels in page 0 is 50% brightness

3. Colour conversion commands.

These commands operate on the palate (look-up-table) RAM without affecting the contents of the frame store. The commands are used to alter brightness or hue of a picture and can be used for special colour effects. These commands can be used while the system is grabbing frames (since they do not affect the frame stores) and hence provide real-time colour conversion or many other special effects. The commands are:

ANIMATE	Sequentially switch between palate settings to give simple animation of stored pictures
BIT	Show only 1 bit of the 8 stored bits of each pixel in the frame store(s)
BRIGHT	Allow the picture brightness to be altered
COLD	Adjust picture hue to emphasise blue at the expense of red
CONTOUR	Cause the palate to be set to produce video output only at certain values of stored information so that a banded effect occurs.
CONTRAST	Operate on the palate to enhance the intermediate tones for each colour to enhance the picture contrast.
COOL	Operate on the palate to reduce red intensity and increase blue intensity at intermediate brightness levels.
HOT	Adjust picture hue to emphasise red at the expense of blue (inverse of COLD)
INVERSE	Invert the palate: thus bright becomes dark etc.
REFLECT	Reflect the palate: the last 128 bytes of palate RAM are forced to contain the mirror image of the first 128 bytes.
SETUP	Set a palate to contain a linear transfer function: thus the displayed picture is an exact representation of the contents of the frame store.
UNCONTRAST	Reduce picture contrast by operating on the palate (inverse of CONTRAST)
VIEW	Display on the screen only a selected number of quantisation levels
WARM	Operate on the palate to reduce blue intensity and increase red intensity at intermediate brightness levels (inverse of COOL)
ZERO	Set a palate to contain all zeroes: thus no visible picture is produced from the frame store concerned.

4. Real Time Video Input Commands

These commands allow the user to "grab" frames or to use the HRX system as a real time colour conversion system with continuous video input and continuous display. The commands are:

FASTGRAB	Grab single frames into each frame store page sequentially with a time delay set by DELAY between each grab.
GRAB	Grab frames continuously into page 0
SEQGRAB	Grab frames into page 0 and store each frame at a resolution level set by ANIMRES for later animation by the ANIMATE command
STARTGRAB	Begin frame grabbing continuously into page 0 then relinquish control so that other commands may be executed.
STOPGRAB	Stop a grabbing sequence begun by STARTGRAB

5. Picture Selection and Placement Commands

These commands allow the user to select which of the stored pictures in the frame stores to view, switch frame stores on and off to select operation by the computer on a given colour (or all colours) and to set the video display format and the frame position on the video monitor screen. The commands are:

ADDINTPAGE	Set the frame store page which would appear as the extra right hand extension in wide screen interlace mode.
ADDPAGE	Set the frame store page which would appear as the extra right hand extension in wide screen mode as the basic page.
BASEPAGE	Set the frame store page which would appear in the normal display position.
BLACK	Allow computer access to no frame stores
BLUE	Allow computer access only to the blue frame store if MONOCHROME mode is active.
COLOUR	Set COLOUR mode (opposite of MONOCHROME) in this mode all frame stores are acted upon by palate or frame store manipulating commands.
CYAN	Allow computer writes to be made simultaneously to the blue and green frame stores when MONOCHROME mode is active.
FULL	Set up the screen so that wide screen mode is activated (WIDE) with pages 0 and 1 interlaced with pages 2 and 3
GREEN	Allow computer access only to the green frame store if MONOCHROME mode is active.
HALF	Set up narrow screen mode (NARROW) with page 0 interlaced with page 2
INTPAGE	Set the frame store page which is interlaced with the basepage (BASEPAGE).
MAGENTA	Allow computer writes to be made simultaneously to the red and blue frame stores when MONOCHROME mode is active.
MONOCHROME	Activate MONOCHROME mode (opposite of COLOUR) in this mode, only the selected frame store(s) is/are acted upon as set by the user.
NARROW	Set narrow (square) screen format
RED	Allow computer access only to the red frame store if MONOCHROME mode is active.
SINGLE	Set a single page to be the basepage, interlace page, additional page and additional interlace page.
WHITE	Allow computer writes to be made simultaneously to the red, green and blue frame stores when MONOCHROME mode is active.
WIDE	Set wide (rectangular) screen format
YELLOW	Allow computer writes to be made simultaneously to the red and green frame stores when MONOCHROME mode is active.

6. Plotting commands for drawing lines or points

These commands allow the user to plot dots (single pixels) or lines (vectors) or rectangles on the screen by positioning cursors and instructing the graphics controller accordingly. Lines and dots which are drawn are stored in a "drawing list" which can then be used to save and redraw the line drawing as required. The commands are:

BACKGROUND	Set the background intensity to erase to when using style ERASE.
BANDOFF	Switch off the "rubber band" vector which can be placed on the screen as a drawing aid.
BANDON	Switch on the "rubber band" vector.
BORDER	Cause a border to be drawn round the perimeter of the displayed picture in page 0
CURSOR	Position a graphics cursor on the screen which can be moved up/down/left/right to set a point position on the screen.
DOT	Draw a single point at the cursor position.
GRID	Cause a grid of selectable spacing to be drawn onto page 0
INTENSITY	Set the intensity at which subsequent line drawing operations will draw.
RECTANGLE	Draw a rectangle from one cursor position to a second cursor position, the two cursor positions defining opposite corners of the rectangle.
STYLE	Set the style in which subsequent lines are drawn.
VECCLEAR	Clear the drawing list held in memory
VECDRAW	Draw on the screen the lines specified in the drawing list held in memory.
VECTOR	Draw a vector from one cursor position to a second cursor position, the two cursor positions defining the ends of the line.

7. Disc load/store commands

These commands enable the user to save and retrieve to/from disc either complete pictures (colour or monochrome), converted representations of pictures or files containing drawing lists. The commands are:

CHARLOAD	Load a picture in character format into page 0 of a frame store (Monochrome only, uses the green frame store)
CHARSAVE	Saves a picture in character format from page 0 of the green frame store.
LOAD	Load a pixel for pixel image from disc into page 0
MTXLOAD	Load a picture in MTX (Memotech) format into page 0 (COLOUR, all frame stores are loaded)
MTXSAVE	Save a picture from page 0 in MTX (Memotech) format.
SAVE	Save a pixel for pixel image on disc from page 0.
VECLOAD	Load a drawing list into memory from disc.
VECSAVE	Save a drawing list held in memory on disc.

8. Utility commands

These commands allow the user to perform useful functions not covered by the preceding sections, in particular they are used for clearing and initialising the HRX system. The commands are:

ANIMRES	set the number of bits to save when creating a series of pictures in SEQGRAB for subsequent animation.
CLEAR	Clear page 0 to a set intensity
DELAY	Set the delay used for animation
EXIT	Finish with HRG: all parameters are lost, the frame stores and palates are left unchanged and control is passed to CP/M.
FUNCTION	A graph of the current values stored in a palate is drawn on the screen: this is the look-up-table transfer function.
HELP	A list of available commands is displayed on the console screen.
HGRAPH	The intensity of pixels held in frame store in a line addressed by the cursor in page 1 is graphed in the appropriate colour on page 0.
HSTART	The horizontal start position of the frame on the monitor screen is set.
OFF	The graphics display output is disabled
ON	The graphics display output is enabled
RESET	All parameters are set to initial values
SYNC	Allows the user to select the active sync source.
TEST	Constructs a test pattern on the screen (page 0).
VGRAPH	The intensity of pixels held in frame store in a vertical line addressed by the cursor in page 1 is graphed in the appropriate colour on page 0.
VSTART	The vertical start position (from the top of the screen) of the frame is set.
X	Same as EXIT.