

Apple II Developer's Conference

Breaking the 16 Color Barrier

I. Introduction

II. Basic Information

a. Definitions - Some terms to get us started.

Color - A color on the Apple IIgs is made up of 3 components, red, green, and blue. Each component is made up of 4 bits or one nibble. This can also be called a true color.

Color Table - A color table is made up of 16 colors. It can also be called a palette.

Dithered Color - a dithered color is usually made up of two colors. A dithered color alternates colors to trick the eye into seeing another color. For example a dark red could be made up of a fine pattern of alternating black and red pixels.

NIBBLE - A nibble represents 4 bits. A bit is either on or off. Thus the range of a nibble is 0 - 15. The number 16 and multiples thereof, are important on the gs, because it defines a lot of the limits.

Pixel - Short for Pixel Element. A pixel is a dot of the color (on the GS, black and white on the Classic's), it makes up a picture.

b. Limits - Every computer has its limits, some more than others.

Screen resolutions - The Apple IIgs display is limited to 640 x 200 pixels and 320 x 200 pixels. The 640 x 200 mode has a maximum of 4 true colors, or 16 dithered colors. We're only interested in 320 mode though.

Colors - The maximum number of colors per scan line in 320 mode is 16. Period. A common belief is that 256 or 3200 modes allow more than 16 colors per line, this is not true.

c. Video memory layout

Video Memory Layout Bank \$e1

\$2000 - \$7cff	Pixel Data
\$7d00 - \$7dc7	Scanline Control Bytes (SCB's)
\$7dc8 - \$7dff	Reserved (for SHR Convert :))
\$7e00 - \$7fff	Color tables

Pixel Data - A pixel on the screen corresponds to one nibble in memory (assuming 320 mode). A pixel has a range of 0 - 15, which brings us to the maximum number of colors per line on the Apple IIgs, 16 colors. Each value from 0 - 15 corresponds to a color in a color table.

Scanline Control Bytes - SCB's contain the characteristics of each scanline. There are 200 SCB's one for each line. An SCB is one byte, but we are only interested in the lower nibble. The layout of an SCB is documented in the Firmware Ref, or most other references.

Color tables - This area contains 16 color tables of 16 colors, or 256 colors total. Most pictures only use the first 16 colors. The different color tables are accessed by the SCB's. More below.

III. The graphic modes.

- a) 16 color mode. 16 color mode is a subset of 256 color mode. See below for the reasons.
- b) 256 color mode. This is the best kept secret on the Apple IIgs. 256 color pictures don't require any extra processor time to display, or any extra code. It requires a little setup for the picture, but the results are well worth it.

Basic theory - The lower nibble of the SCB has the value from 0 - 15. this value points to a palette in the color table data. By setting up the SCB's, there can be up to 16 palettes of 16 colors, or 256 colors.

The SCB of the line determines what palette will be used when drawing.

- c) 3200 color mode. This produces the highest quality pictures on the Apple IIgs. 3200's are best for static pictures, such as title pages or credits.

Basic theory - The Apple IIgs has a limit of 16 colors per scan line as previously discussed. If we were to change the palette every line, as the screen is being refreshed we could

display 200 lines, of 16 different colors, for a total of 3200 simultaneous colors on the screen at one time. This takes up a lot of processor time since it requires a program to continually change the colors in the color tables. In order for the picture to appear the displayer has to keep up with 60 frames per second, which means it has to move color data around very quickly. Since the GS can only access video ram at 1 Mhz that makes the task that much more difficult, and the only way to attain the speeds required is to shadow the stack onto the SHR colortable memory, and move the colors into the memory by pushing them onto the stack.

Pseudo Display code -

1. Move the pixel data into the video buffer.
2. Set up the SCBS in a fashion such that palette 15 is mapped to line 0, and 14 to line 1. Repeat this pattern until you reach the bottom of the screen.
3. Turn on shadow of the SHR buffer from bank \$01 to \$e1, and set up the stack so that its mapped into bank \$01 by enabling the auxramrt softswitch.
4. Synchronize with the top of the screen.
5. Push 256 colors onto the stack.
6. Sync at line 15
7. Push next 256 colors onto the stack
8. repeat steps 6 and 7, only on line 31
9. repeat step 8, adding 16 to the line
10. for the sync at line 192, only push 128 colors on the stack
11. go back to step for 4

IV. Filetypes

16 or 256 filetypes

FT	Aux	Description
\$C0	\$0000	Paintworks 16 color picture
\$C0	\$0001	PackBytes 16/256 color picture
\$C0	\$0002	16 Color Apple Preferred Format
\$C0	\$0002	256 Color Apple Preferred Format
\$C1	\$0000	Raw data for both 16/256 color pictures

Note: All of the above are officially recognized by Apple. They are all documented in the filetype technotes.

3200 filetypes

FT	Aux	Description
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\$C0 \$0002 3200 Color Apple Preferred Format
\$C1 \$0002 Raw Data 3200 color Image

The above are the only 3200 formats supported by Apple.

Now for the unsupported ones.

BIN \$---- Raw Data 3200 color Image. It is recognizable by its file length, 76 blocks or 38 k. It has the exact same format as a \$c1 \$0002. Old 3200's may still use this filetype.

BIN \$---- APP 3200 format (French format). Its header is 'APP', followed by a 0. It's format is:

\$0 - 3 - Header 'APP' followed by \$0
\$4 - \$1903 - Raw data color tables, 200 color tables in the same format as \$c1 \$0002, backwards.
\$1904 - \$xx - Packbyted pixel data (tool call) Unpacks to \$7d00 bytes. This includes just pixel data.

\$C0 \$3200 BRAIN format. Modified packbytes. Hardly used.

\$F1 \$0C80 DreamGrafix 3200 color format. LZW compressed 3200 color raw data screen. For more information contact DreamWorld.

V. For fun...

a. Top 10 reasons why multiple palettes are good.

10. Your pictures will look better.
9. It'll make people say "Wow, is this a new mac?"
8. Just do it. Everyone else is.
7. It'll make your gs look good... see below.
6. And Apple won't like it. (not true, but a good reason)
5. No additional hardware required. It's cheap!.
4. It does the body good.
3. You can use DreamGrafix!! :P
2. It's guaranteed to blow away a monochrome Macintosh.

<drum roll please> < - You'll have to imagine this.

1. The FTA uses them, and so you should too!

Source code for 3200 color picture displaying is available, talk to us after the lecture or at the expo. Please bring a disk.

For more information about 3200's, DreamGrafix, or just life in general, you can contact us through these channels...