Using ODS and the Macro Facility to Construct Color Charts and Scales for SAS® Software Applications

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Abstract

Highly accessible HTML files have increased the importance and use of color as means for enhancing reports and summarizing data. The reference manual for SAS/GRAPH® software contains an entire chapter devoted exclusively to color. In fact, the chapter lists 292 predefined SAS colors by their names, RGB (red/green/blue) and HLS (hue/light/saturation) codes. Nevertheless, the list is hampered by the absence of the colors themselves. VPAPB for "very pale purplish blue" continues to remain in the eye of the beholder.

With ODS it is now possible to construct a fully annotated color chart from the list of predefined SAS colors found in SAS OnlineDoc. Actual colors are displayed in an HTML format along with their names, RGB, and HLS codes.

A color scale new to SAS software and developed from the color chart is also described in the paper. The color scale uses a decimal conversion macro in a looping structure to display one hue in varying degrees of luminescence. The paper provides illustrations, instructions for construction, and applications of both the color chart and the color scale. These visual aids should promote the effective use of color for communicating information in SAS Software applications.

Constructing a SAS Color Chart

To obtain a listing of the predefined SAS colors appearing on pages 146-154 in Version 8 of the SAS/GRAPH manual, download the table from SAS OnlineDoc in HTML format into a text file by completing the following steps:

1) Access the table of contents and drill down to:
   SAS/GRAPH
   SAS/GRAPH COLORS
   Color-naming schemes
2) Select All and then Copy and Paste to insert the material into a Microsoft Word file.
3) Delete extraneous text and annotations keeping only the table.
4) Select the table, and press Convert Table to Text specifying comma delimited output.
5) Save the output to a TXT file that is used as input to a SAS program.

The SAS program that processes the downloaded text file uses a macro together with traffic lighting to add color blocks to output from PROC Report. The macro that is invoked from a compute block in PROC Report assigns the correct background color to Column #2 with a SELECT statement:

```sas
%macro selectRGB;
  select (_C2_);
  %do i = 1 %to &NColors;
    when (&&i.) CALL DEFINE(_COL_,"STYLE", "STYLE=\{ BACKGROUND=&&RgbN&&i. \} ");
  %end;
  otherwise;
end;
%mend selectRGB;
```

1) The variable CNUM is column #2, the argument of the SELECT statement in the SELECTRGB macro.
2) CNUM is set to missing with the MISSF format so that only the background color is displayed. The MISSF format is defined with a single range:

   ```sas
   value missf low-high=' ';   
   ```

3) The SELECTRGB macro is invoked from the COMPUTE block.

Selected Displays of the Color Chart

A partial listing of uniquely defined SAS colors not belonging to a larger color group is displayed in Figure 1. The color description is omitted from the display, since it is identical to the SAS color name. Otherwise the SAS code used for generating this table is identical to that described in the previous section.

Different SAS Color NAMEs can map to the same color defined by the RGB code. Figure 2 lists all duplicates by name, RGB and HLS codes. The displayed shades confirm the presence of synonyms in the predefined color list.

There is also one error in the predefined color list that has remained undetected up to now. Technically, the HLS and RGB codes for the same color should display identical shades. In Figure 3, however, the two color blocks are distinctly different for **vivid purple**.
The Color Scale

The idea for a SAS color scale comes from the outstanding user-interface supplied by Microsoft PowerPoint for adjusting colors. The caption in Figure 4 shows how to get to the Custom window in PowerPoint to define a color for any object on a slide. The color scale in the window is the narrow vertical band to the right of the main color display. The triangle next to it makes it work like a slider bar. By sliding the triangle up or down the color scale, the New upper half of the square in the lower right corner becomes lighter or darker reflecting the adjacent shade on the bar.

Figure 1. A subset of unique predefined SAS colors along with their actual shades.

Figure 2. A list of predefined SAS Colors with different NAMES that map to the same RGB codes and shades. Note that a single RGB code can appear with different HLS codes. Even so, the HLS shades are identical to their RGB counterparts in every instance.

Figure 3. HLS and RGB colors should be identical for each SAS color name in the predefined list. RGB and HLS codes produce different color blocks for vivid purple.

The Color Scale

The idea for a SAS color scale comes from the outstanding user-interface supplied by Microsoft PowerPoint for adjusting colors. The caption in Figure 4 shows how to get to the Custom window in PowerPoint to define a color for any object on a slide. The color scale in the window is the narrow vertical band to the right of the main color display. The triangle next to it makes it work like a slider bar. By sliding the triangle up or down the color scale, the New upper half of the square in the lower right corner becomes lighter or darker reflecting the adjacent shade on the bar.

When the slider bar is operated in the Custom window, all three RGB numbers change. In contrast, only the lum(inescence) or light number changes in the HLS scale, and the change reflects the position of triangle alongside the bar. The value 76 for lum in Figure 4, for example, is nearly one third of the distance between 0 and 255. Because only one component is needed from the HLS code to adjust the shade of a given color, it rather than the RGB code should be used for deriving a color scale in SAS.

Unfortunately, though, the HLS scale is configured differently in SAS. Some of the differences can be easily remedied. A decimal conversion macro changes a decimal number to hexadecimal, and code components can simply be rearranged to change a Microsoft HSL into a SAS HLS.

The story is not so simple for the hue component, however. In Microsoft, values for hue range from 0 to 255 whereas the maximum value for hue in SAS is 360 reflecting the Tektronix Color Standard. Even when a correction is made with interpolation, the same HLS code produces different colors in the two software packages. In contrast RGB codes are the same, but they cannot be used in this instance, because their components change unpredictably when a color scale is scanned.
The Color Scale is derived from the Color Chart

A SAS macro PLCOLSC is used to create a color scale from the list of predefined SAS colors stored locally in a permanent SAS data set. The color scale in Figure 5 was made possible by matching the macro parameter GOLD to its SAS defined HLS code in the data set. Using a fully annotated color chart as a guide is the only way to get an exact color scale in SAS.

```sas
run;
%mend scale;
%scale;
```

Using a fully annotated color chart as a guide is the only way to get an exact color scale in SAS. The color gray is automatically produced if the three components in the RGB code have the same value. Consequently, the conversion macro GRAYHEX is a simplified version of RGBHEX:

```sas
%macro PltColSc(SASCol);
proc sql noprint;
    select hls, cDesc into :hls, :cDesc
    from rgb.SASColors
    where cName eq "%upcase(&SASCol)";
quit;
%let hlsdec=%hlsdec(&hls);
%let DHue=%substr(&hlsdec,2,3);
%let DLum=%substr(&hlsdec,5,3);
%let DSat=%substr(&hlsdec,8,3);
%mend PltColSc;
%mend PltColSc;

The Color Scale for SAS Color GOLD

Hue: 160   Saturation: 255

Figure 5. A color scale for GOLD. The vertical line identifies the LIGHT component of HLS code for the predefined SAS color.

All hexadecimal numbers in SAS are converted to decimal not only for display but because program looping is impossible otherwise. Thus for GOLD, H0A080FF in Figure 1 becomes D160128255 in Figure 5. The structure for the HLS code is identified below:

<table>
<thead>
<tr>
<th>HLS (Hue, Light Saturation) Code</th>
<th>Hexadecimal</th>
<th>Decimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>H0A080FF</td>
<td>D160128255</td>
</tr>
<tr>
<td>Identifying Prefix</td>
<td>H</td>
<td>D</td>
</tr>
<tr>
<td>Hue (hhh) (ddd)</td>
<td>0A0</td>
<td>160</td>
</tr>
<tr>
<td>Light (LL) (LLL)</td>
<td>80</td>
<td>128</td>
</tr>
<tr>
<td>Saturation (SS) (SSS)</td>
<td>FF</td>
<td>255</td>
</tr>
</tbody>
</table>

Numeric conversion macros play an important role in working with SAS colors. The programmer works and thinks in decimal, but the programs must convert to both hexadecimal and decimal when needed. This conversion and re-conversion process is apparent in the following code fragment from the PLOTCOLSC macro:

```sas
%macro PltColSc(SASCol);
    proc sql noprint;
        select hls, cDesc into :hls, :cDesc
        from rgb.SASColors
        where cName eq "%upcase(&SASCol)";
    quit;
    %let hlsdec=%hlsdec(&hls);
    %let DHue=%substr(&hlsdec,2,3);
    %let DLum=%substr(&hlsdec,5,3);
    %let DSat=%substr(&hlsdec,8,3);
%mend PltColSc;
```

The RGBHEX macro converts Microsoft decimal numbers to hexadecimal notation that SAS software understands. The macro contains only one statement:

```sas
%macro RGBHex(rrr,ggg,bbb);
    %sysfunc(putn(&rrr,hex2.))
    %sysfunc(putn(&ggg,hex2.))
    %sysfunc(putn(&bbb,hex2.))
%mend RGBHex;
```

The SAS function COMPRESS is used rather than the macro function %COMPRESS to remove all internal blanks from the returned hexadecimal color code. For example, %RGBHEX(0,204,153) returns CX00CC99. If %COMPRESS were used instead, the returned string would be unusable as CX00 CC 99. Note that the macro statement is missing a semicolon. If one were present, it would be returned as a portion of the string constant causing an error.

Gray is unique

The color gray is automatically produced if the three components in the RGB code have the same value. Consequently, the conversion macro GRAYHEX is a simplified version of RGBHEX:
Because of this property, the RGB scale can be used to construct a color scale for gray. Here is an adjusted version of the SCALE macro that works with RGB rather than HLS to define the gray scale displayed in Figure 6:

```sas
%macro scale;
  data anno;
  %sysfunc(system(2,2,2));
  %do i=0 %to 255 %by 5;
    ylow=10; yhigh=20; xleft=&i; xright=xleft+5;
    %bar(xleft,ylow,xright,yhigh,%GrayHex(&i),0,solid);
    output;
  %end;
  %bar(0,10,260,20,black,0,empty); /*outline*/
  stop;
%mend scale;
```

Figure 6. A gray scale based on the more intuitive decimal notation enables a developer to define a precise shade for an application.

A Table of Conversion Macros

Since the conversion macros are typically brief, they are being grouped together in Table 1 below. If the source code has already been listed in the paper, a reference is made to it.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Parm(s)</th>
<th>Source Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAYHEX</td>
<td>Convert an RGB decimal code into Hexadecimal format.</td>
<td>GRAY, a 3-digit zero-filled decimal number.</td>
<td>See section Gray is Unique</td>
</tr>
<tr>
<td>HLSDEC</td>
<td>Convert a SAS HEX HLS color to its decimal equivalent.</td>
<td>HHHHLLSS a hexadecimal number with a leading character H.</td>
<td>See section Working with the RGB Code</td>
</tr>
</tbody>
</table>

Applications

- Matching SAS/GRAPH and PowerPoint backgrounds

The presence of too many colors can lead to "garish, difficult to interpret and confusing interfaces" according to Preece (89). The potential for clashing colors is very great when the output from SAS/GRAPH is pasted into a PowerPoint Presentation. By matching the PowerPoint background color in SAS, it is easy to produce the color-coordinated tree graph in Figure 7.

Figure 7. Binary tree plots with white selection handles match background colors in PowerPoint. The decimal RGB code is copied from PowerPoint and then matched in SAS by adding CBACK="%rgbhex(0,150,136)" to the GOPTIONS statement.
Producing a bar chart where the shades of gray can be distinguished from each other

By referencing the gray scale in Figure 6, the bar charts in Figure 8 that depict relative speeds of format resolution times in graduated shades of gray can be produced with the following source code:

```sas
%macro c19;
  %let j=1;
  %do i=80 %to 190 %by 10;
    *land;
    pattern&j value=msolid
    color=%hlshex(152,&i,045);
    %let j=%eval(&j+1);
  %end;
%mend c19;
```

With decimal notation, it is easy to remember that low numbers are dark and high numbers are light.

Two visual aids, the color chart and color scale, have been presented in this paper. The color chart is used to enhance the SAS list of predefined colors by associating an actual color with its NAME, HLS and RGB code. The color scale developed from the color chart displays one hue in varying degrees of luminescence. The color scale is particularly helpful for designing graphs that depict magnitude through a meaningful arrangement of related colors.

Finally, here is the actual color associated with VPAPB-hardcopy in a shade of gray.

```
color=%hlshex(001,61,145)
```  

Summary and Conclusions

Two visual aids, the color chart and color scale, have been presented in this paper. The color chart is used to enhance the SAS list of predefined colors by associating an actual color with its NAME, HLS and RGB code. The color scale developed from the color chart displays one hue in varying degrees of luminescence. The color scale is particularly helpful for designing graphs that depict magnitude through a meaningful arrangement of related colors. Finally, here is the actual color associated with VPAPB-hardcopy in a shade of gray.

```
VPAPB very pale purplish blue CXC0A3E5
```

References


SAS Sample Library. Name: GR2401. Title: *Simple Contour Plot*. Product: GRAPH. System: ALL.


Contact Information

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Figure 9. First rendition of Mill Pond is garish in full color. There is no rationale behind coloring the deepest part of the pond red, and the shallowest part yellow. Some study is also required to realize that dashed lines are used for depicting dry land.

Figure 10. In the revised contour plot, water depth is depicted in varying shades of blue and land height takes on darker shades of brown at higher elevations. There is no need for a legend, since all communication is conveyed in the title.