GUIDE

TO SELECTING

ANTI-GLARE

CONTRAST

FILTERS

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PERFORMANCE
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BASIC FILTER FACTS

The display filter (also serving as readout filter panel) is a vital point of interface between the information display system and the viewer. Since most information systems exist for the purpose of delivering visual information to viewers, thus permitting decisions to be made or actions to be taken, it is essential that communication between the imaging system and the operator is free of interference which could distort the message, delay its recognition, or create confusion.

Various display technologies can be differentiated by whether the display produces light internally -emissive- for example, CRT, EL, LED or it functions by modulating externally produced light -transmissive- for example LCD. In a practical sense, displays are neatly divided into CRTs and flat panel displays.

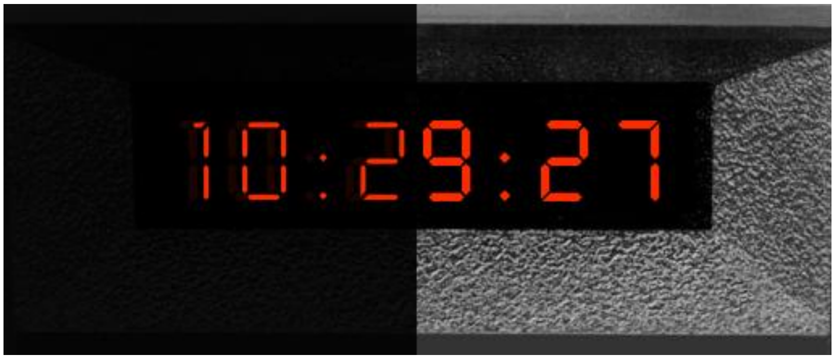
No matter what form of character generation the instrument panel employs – CRT, Liquid Crystal, EL, Plasma, Vacuum Fluorescent, LED, etc. – the primary consideration in design must be the facility of quick assimilation of the information presented. Character design, character size, stroke width, light output, and other parameters are, of course, very important. A major consideration beyond this, however, is the critical element which can greatly improve the readability of the display, or if improperly designed, can detract from its performance even to the extent of rendering it useless. This element is the optical filter which is located between the display and the operator.

A filter is any device that when placed in the path of a beam of radiation alters its frequency distribution. The filter performs several functions. One is to protect the display from dirt and damage. The second function is the primary function. The filter must be designed to meet the requirements of readability by viewers. Since the human eye is the most important factor in determining the required performance characteristics of the imaging system, including the display, to achieve maximum readability, a filter must:

1. **Reduce the effects of glare and reflections**
2. **Maintain resolution (i.e., sharpness of character) or addressability**
3. **Improve contrast of the illuminated readout display**
4. **Control input intensity or spectral response**

Other characteristics are also essential. The filter must have an abrasion and chemical resistant surface which insures that the optical qualities will not be degraded through age and use. Finally, a filter must be competitively manufactured so that its cost is relatively low. One filter family that meets all of these requirements is the Chromafilter® produced by Performance Coatings International. These remarkable filters are protected by the Vueguard 901® coatings that virtually eliminate all the shortcomings of plastics filters due to their lack of resistance to scratching.

Neutral density plastic filters provide excellent contrast enhancement for displays at relatively low cost. Color plastic filters work best with LEDs and monochrome CRT phosphors, due to their relative narrow bandpass of transmission matched to the emission spectrum of the display. Color contrast improvement can also be achieved by using broader passband filters that give a different color than the display and improve viewability. For example, a display having a luminance contrast ratio of 1:1 is not viewable if the background has the same color as the display, but is entirely acceptable if they are of different colors.



Hewlett-Packard LED display is shown with 4 digits on the right covered with Chromafilter

Chromafilter over portion of Burroughs' PANAPLEXII panel enhances readability.

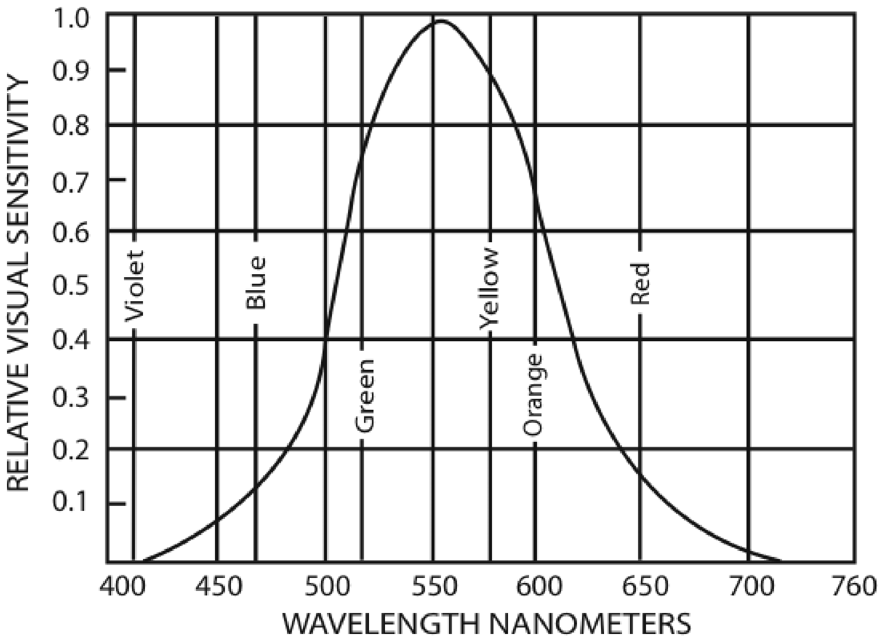


FIG. 3 Spectral Response of the human eye.

DISPLAY CHARACTERISTICS

GAS DISCHARGE TUBES

Probably the most familiar display is the cold cathode tube, usually filled with a neon gas mixture, using a common anode and several individual metallic cathodes. This is the Nixie tube and its imitators. When a specific digit is energized, the gas ionization creates a glow around the cathode emitting an orange light. An optical filter is necessary for readability because (1) the non-activated filaments are visible in the tube and get in the way of each other visually, (2) the gas discharge creates not only the corona around the individual filament, but also a soft bluish glow in the entire tube which reduces contrast, (3) the glow area around each activated filament is not sharply defined (see discussion of resolution), and (4) the glass tube is highly reflective, and these reflections interfere with the visibility of the activated element.

Gas discharge devices can also be in the form of planar displays which emit the familiar neon orange color. While there are different techniques of manufacturing the planar displays, all planar displays benefit from the improved resolution that an optical filter provides. Those planar displays which use wire cathodes further benefit from the filter through suppression of the dormant cathodes as is achieved with gas discharge tubes.

LIGHT EMITTING DIODES (LED)

The light emitting diode semiconductor display has made tremendous impact in the display market. Being a solid state device, the LED offers several advantages including long life, low current requirements, high luminance and size. Brightness is current variable. Color choices range from red to green, yellow and orange, but blue are becoming commercially viable. In direct sunlight most LED displays become “washed out.” Optical filters provide character enhancement and permit their use in environments with high ambient illumination.

CATHODE RAY TUBES (CRT)

When the cathode ray tube (CRT) is energized, the entire face of the tube is illuminated, reducing the contrast between the characters and the background. The optical filter effectively overcomes this problem by suppressing the background altogether. The proper filter also eliminates reflections, improves readability in direct sunlight and helps protect the face of the tube from damage or breakage.

INCANDESCENT

The filament which is observed in the directly viewed incandescent readout is very bright. The Numitron® for example emits 7,000 lamberts as compared to 50 to 500 foot lamberts for the gas discharge planar display or Nixie®. The optical filter improves contrast and character definition to make the figure more readable. In addition, since the incandescent readout suffers from the same type of tube to tube reflections as does the gas discharge tube because of its glass envelope, the filter minimizes these internal reflections. Finally, the broad spectrum of the light output of the incandescent display permits the use of optical filters to color the readout any desired hue. Planar type incandescent displays at commercially attractive prices have been introduced. Optical filters again are used to upgrade the display.

FLUORESCENT

The blue-green light emitted by the fluorescent display is in the sensitive color response area of the human eye and, thus, is more easily seen. However, because the eye is more sensitive to this color, relatively small differences in intensity are more readily apparent. (This is also true of the green LED). Proper filter design can minimize this problem through contrast control.

LIQUID CRYSTAL DISPLAYS

These displays do not generate light. Rather, they scatter ambient light. Depending on the application, this could be advantageous or disadvantageous. In low ambient light applications, for example, such as an automobile instrument panel at night, visibility of the characters may be too low for practical use unless back or edge lighting are employed. Contrast of the character can be improved, however, with properly designed filter which will suppress the high specular reflection of the first surface. There is also the possibility of using narrow band selective color filters for the back-light applications.

ELECTROLUMINESCENT DISPLAYS (EL)

In order to increase the light output in EL displays, the rear surface of the display can be made reflective. This in turn, further reduces the display contrast as it also reflects incoming ambient light. EL displays suffer from their need for high drive voltage, low luminance and contrast. Color filters, usually red and green are used to improve luminance and contrast with the efficient ZnS:Mn EL phosphors. Full color EL displays have been used with white phosphor and a pattern of red, green and blue filters.

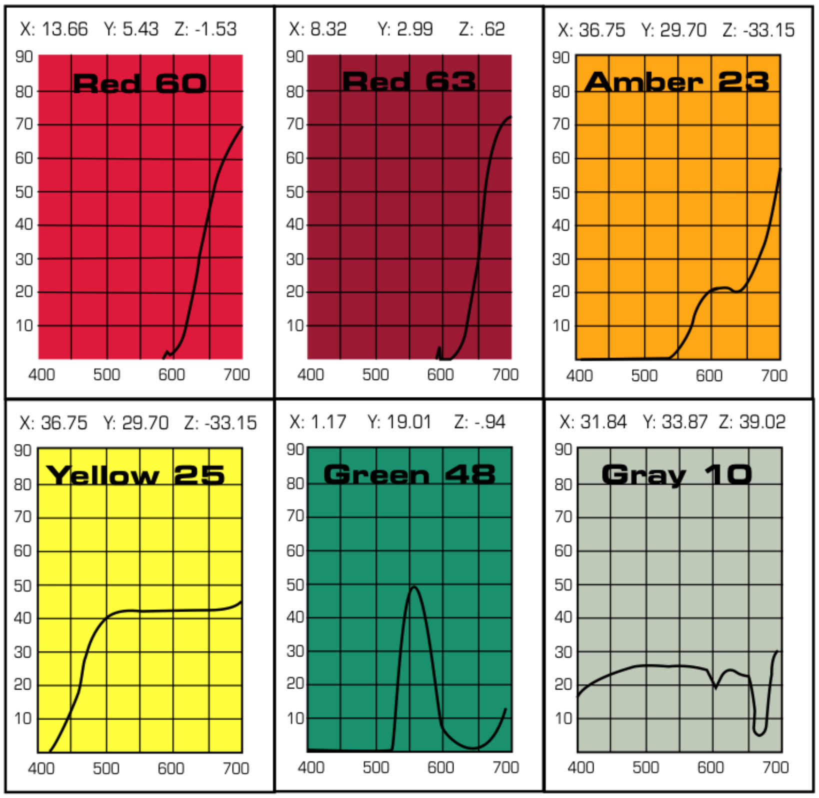
SELECTION OF COLOR

The human eye is responsive to the color spectrum between approximately 380 and 770 nanometers. At a practical level, human vision has approximate sensitivities at 420 nm short wavelength blue receptors, 535nm medium green receptors and 565 nm long wavelength red receptors. This covers the range from violet to deep red. The bell-shaped response curve peaks at about 550 nanometers as shown in Figure 3. It tails off into ultraviolet at one end and into infrared at the other. It is interesting to note that the sensitivity of the human eye to red is less than one-tenth what it is to green.

A knowledge of color and its effect on the human eye leads to two important uses of color in optical filters for readouts. The first of these is the matching of the color of the filter to the color of the readout through spectra-photometric analysis. Readability is thereby greatly enhanced, because ambient light which passes through such a filter has all wavelengths except the narrow band that the filter absorbs. A double absorption is achieved because when light does pass through the filter is again subject to the restricting influence of the filter when it is reflected back from the readout. The second use of the color filters is to greatly enhance the contrast ratio by suppressing the internal display reflections.

CHROMAFILTERS are available in a great number of colors, some of which are shown below.

Various substrates used for optical filters include: acrylic (PMMA), rigid vinyl and polycarbonate. The interchangeability of substrates permits ease in meeting special requirements such as high temperatures, or UL requirements for impact resistance and self-extinguishing properties. CHROMAFILTERS are available in various substrates in .030, .060 and .125 inch or various mm thicknesses.



GLOSSARY

Contrast

Contrast is defined as the ratio of the luminance of the viewed object (bright, full white pixel) divided by the luminance of the background (full dark pixel):

$C = L_o/L_b$

The human eye can differentiate the difference between the illuminated character and the background luminance much more accurately than it can determine absolute luminance levels. Luminance is a measure of the light energy reaching a surface. Thus, contrast is more important to the readability of a display than is total luminance of the display.

Readability as a function of contrast

It is the function of the filter to reduce the background luminance to the point where passive elements, can not be seen while having a minimal effect on the illuminated character.

Resolution

Many factors go into the determination of resolution (ability to discriminate detail in an image) including granularity, jitter, smear, scintillation, image edge gradients (commonly known as "blur"), and anything that impinges on the sharpness of the image. Of these, the most frequent cause for reading error is blur. Blur is inherent in all light emitting readouts to some degree because no type of display has been able to produce image boundaries with a step function light profile. Consequently, the uses of the anti-glare filter to eliminate blur. This attribute of the filter is usually expressed as resolving power or resolution. For example, resolution as far as 1 inch from the display should remain distinctly intact readily passing FAA Specification E-2481, yielding a minimum of 28 line pairs/mm.

The anti-glare optical filter, properly designed and properly applied, can achieve a marked improvement in resolution, but a word of caution is in order. An improperly designed and/or applied filter can seriously degrade resolution.

Filter Specifications

Filters may be specified in percent transmission, transmittance, reflectance and absorbance. Some include the specular reflection of the light from the air-to-filter interface; others represent just the internal properties of the filter. Most filters are usually specified in one or more of these properties for a range of wavelengths.

Percent Transmission is the percentage of light passing through a filter as compared to the total light entering it. Transmittance is the ratio of light passing through a filter divided by the light incident on it. Reflectance is the ratio of the light reflected by a filter divided by the light incident on it. Absorptance is the ratio of the light absorbed by a filter divided by the light incident on it. For absorbing filters, its the reciprocal of the internal transmittance.

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