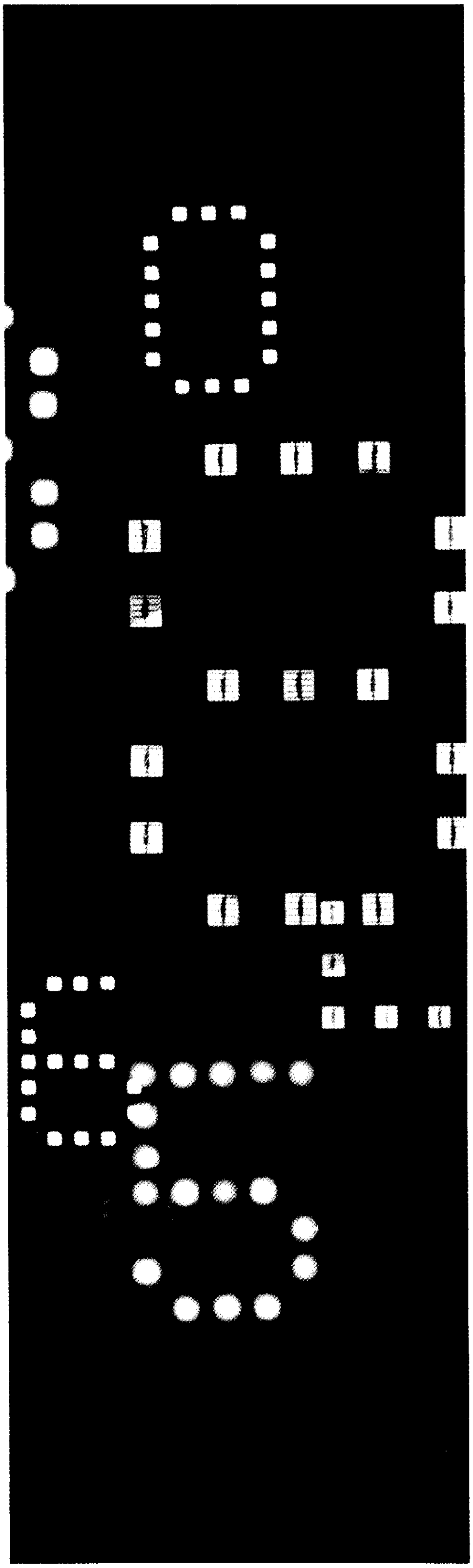
HEWLETT PACKARD

# SOLID STATE NUMERIC INDICATOR

HP 5082-7000
5082-7001



**IC COMPATIBLE—5 V dc**

**LOW POWER—500 mW**

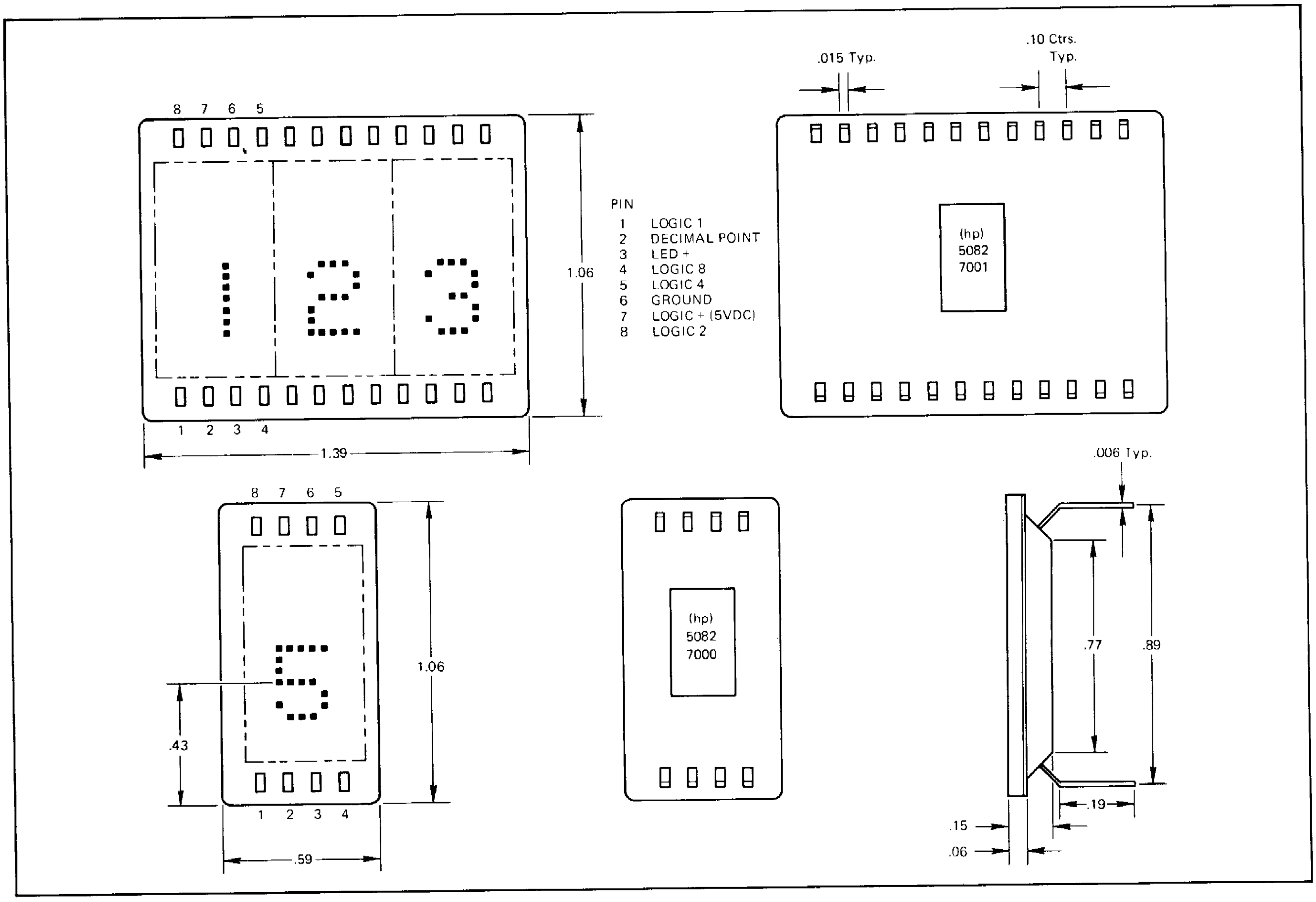
**INCLUDES DECODER/DRIVER—8421 BCD INPUT**

**BRIGHTNESS VARIABLE—LED VOLTAGE 1.6 TO 4.2 V**

**RELIABLE—DESIGNED TO MEET MIL STANDARDS**

The Hewlett-Packard Solid State Numeric Indicator is a rugged numeric display module providing solid state reliability for information presentation. Four input connections provide selection of the character set 0 through 9, using standard 8421 four-line negative logic BCD. A separate connection is provided to permit decimal point display from an external range switch. Character brightness is variable as a function of LED voltage over the range of 5 to $>50$ footlamberts.

The small size of the module, with its self-contained switching logic, permits use where space is at a premium. The 0.25-inch high character is easily read at 8 feet and the Lambertian light-emitting surface provides extremely wide viewing angles ($>60^\circ$ from the normal) with constant brightness independent of viewing angle.




## ABSOLUTE MAXIMUM RATINGS

Power Supply: All power and logic inputs referred to common (ground).

IC Logic Voltage ........ 5.25 V dc
LED (Light Emitting Diodes) Voltage ........ 4.2 V dc
Storage Temperature Range ........ −65° to +100°C
Operating Temperature Range ........ −55° to +95°C
High Logic Level ........ 5.5 V dc

## TYPICAL CHARACTERISTICS

Luminance of Emitting Surface at 4 V LED + ........ 200 fL
Power Dissipation at 200 fL ........ 500 mW
Peak Wavelength ........ 655 nm
Spectral Line Halfwidth ........ 30 nm
Character Response Time ("on" or "off") ........ <1 μs
IC Logic Current at 5 V dc (logic + to ground) ........ 25 mA
LED Current at 4 V dc (LED + to ground) ........ 200 mA

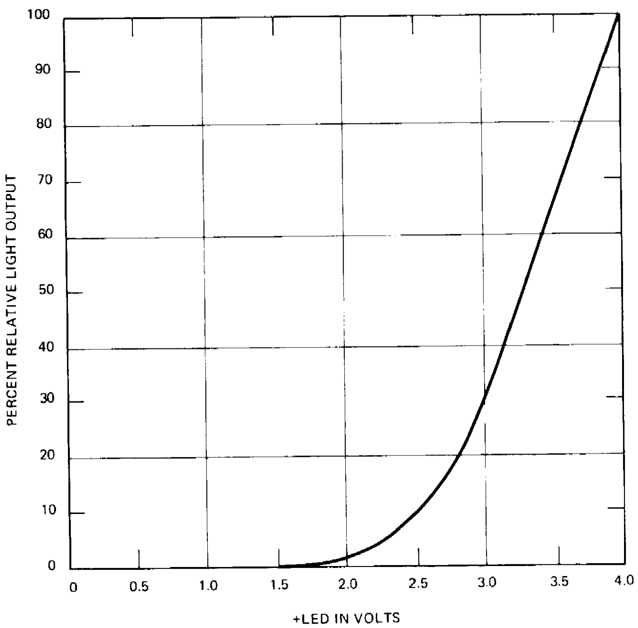



**Figure 1.** Relative light output as a function of LED voltage. Typical display held at 25°C case temperature.

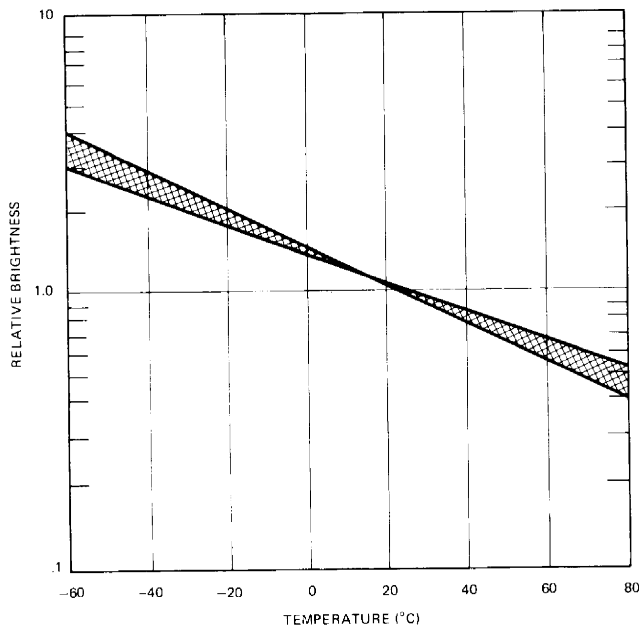



**Figure 2.** Light emitting diode brightness vs. case temperature at fixed current level.

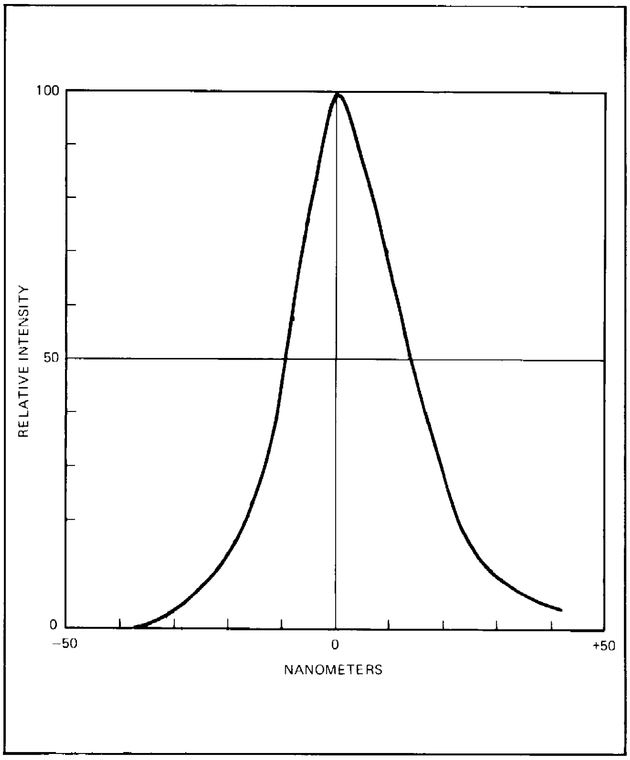



**Figure 3.** Spectral bandwidth of electroluminescent emission.

| | LOGIC | | | |
|---|---|---|---|---|
| NUMERIC | 1 | 2 | 4 | 8 |
| 0 | H | H | H | H |
| 1 | L | H | H | H |
| 2 | H | L | H | H |
| 3 | L | L | H | H |
| 4 | H | H | L | H |
| 5 | L | H | L | H |
| 6 | H | L | L | H |
| 7 | L | L | L | H |
| 8 | H | H | H | L |
| 9 | L | H | H | L |
| BLANK | H | L | H | L |
| BLANK | L | L | H | L |
| BLANK | H | H | L | L |
| BLANK | L | H | L | L |
| BLANK | H | L | L | L |
| BLANK | L | L | L | L |

H = 5.0 Volts
L = 0 Volts

**Figure 4.** Truth table for 5082-7000 and -7001 solid state numeric display.

## OPERATING CONSIDERATIONS

### ELECTRICAL

The electrical drive requirements for the solid state display module are:

(1) 5 V dc filtered power supply with adequate regulation to prevent over-voltage conditions to provide typically 25 mA per character for integrated circuit logic operation,

(2) A 3.5 V dc supply providing up to 180 mA per character,* or alternatively a voltage-variable supply from 2.5 to 4.2 V to permit display brightness variation,

(3) 4-line BCD negative logic
(2.8 V ≤ "0" ≤ 5.0 V: 0 V ≤ "1" ≤ 0.8 V), and

(4) A 10 mA **current limited** source to excite the separately driven decimal point. The decimal point is not current protected. All signals and power supplies are referred to a common ground connection. References to the package outline drawing will indicate electrical connections to the case leads.

The binary code truth table is shown in Figure 4; it is in conformity with the ASCII coding. No memory has been provided in the integrated circuit, therefore the display will conform to the input coding with a character change interval of $< 1\ \mu s$ and typically less than 200 nanoseconds. This high character change rate coupled with all light character forming elements being in a common plane, makes this device an excellent consideration for photographic film recording. No over-voltage protection is provided with this package and it is critical that the display be protected from voltage transients in excess of 5.5 V either on the BCD lines or on the integrated circuit power supply lead.

The integrated circuit in this module is compatible with 5 V TTL and DTL logic.

* The power supply used for the LED drive may alternatively be a 60-cycle or higher frequency full wave rectified unfiltered source providing low cost independent power supply for the display.

### MECHANICAL/THERMAL MOUNTING

A solid state display unit normally operates with approximately ½ watt dissipation. This ½ watt of power, dissipated as heat, can result in substantial temperature rise (typically 50°C) above ambient, with resulting hazard to the device unless thermal sinking is provided. It is expected that the usual mounting technique will combine mechanical support and thermal heat sinking in a common structure. The devices may normally be operated without forced-air cooling where thermal conduction access to the front panel of the instrument is available. The absolute temperature increase above ambient will, of course, be a function of the number of units mounted in the display, but mounting should limit the thermal differential between the hottest display module and the front panel mounting points to less than 10°C. A suggested structure with this capability is shown in Figure 5. Inquiries are invited for quotation on mounting hardware of this design. With this arrangement, leads are attached to printed circuit boards by hand soldering. Silicone grease should be applied between the back of the case and the mounting strap to provide a thermal path from the display module case. Where additional mechanical rigidity of mounting is required, a silicone pad, GE RTV815 or equivalent, may be inserted between the clear front glass window of the module and the glass or plastic optical filter forming the front window of the display. The front window is also mounted by the hardware shown in Figure 5. This is only a suggested mounting and other mounting techniques may be dictated by operating environment conditions, as severe shock, vibration, or other operational needs. It is obvious that the plain glass window of the package makes care in handling a necessary consideration for installation.

If the suggested mounting is of interest to you, Hewlett-Packard may be contacted for premounted assemblies, eliminating the need for subassembly handling in your facility.

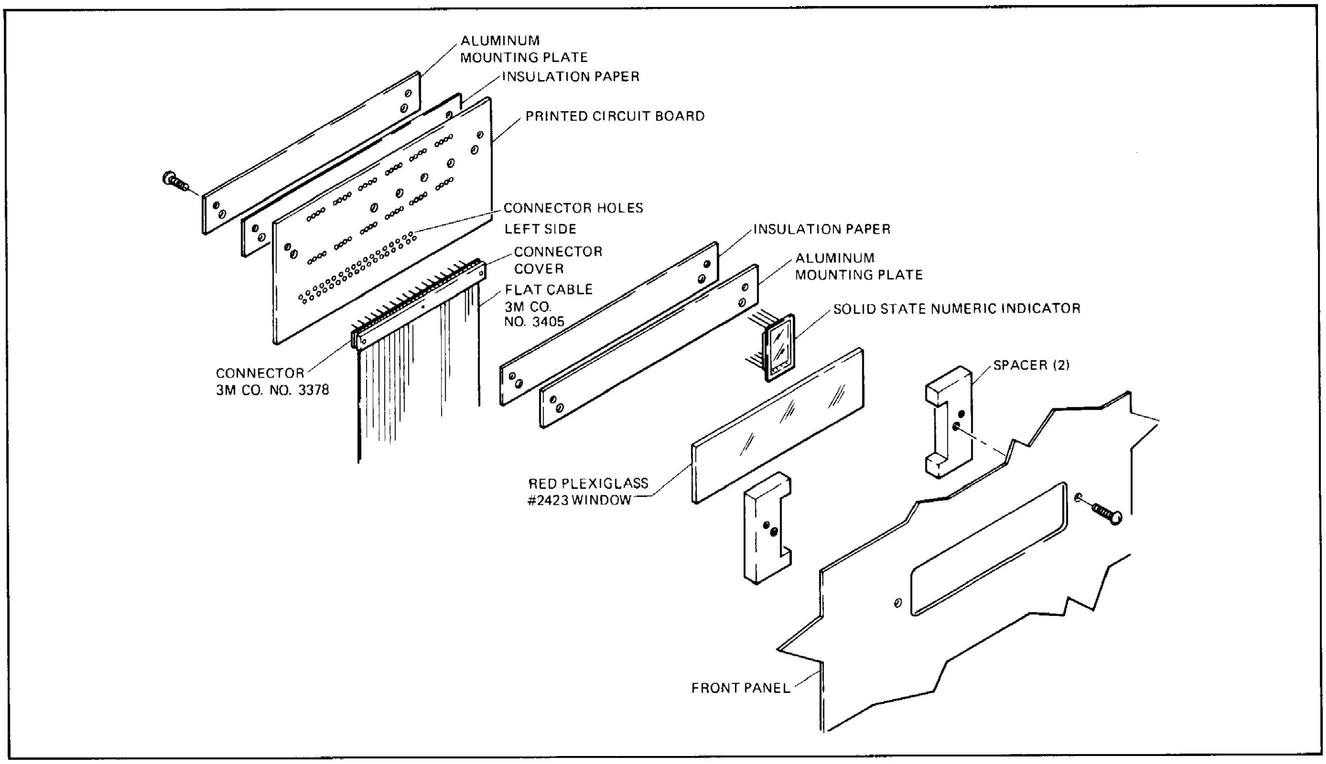



**Figure 5.** Suggested mounting for HP 5082-7000 solid state numeric display.

## OPTICAL

### Color:

The color of the Hewlett-Packard solid state display module is red (655 nanometers). The material used in diode fabrication is GaAsP. It is a characteristic of GaAsP that the luminous efficiency, i.e., light output as viewed by the eye, is a function of the wavelength of light emitted. By varying the alloy composition, the light emitted may vary from infrared at 910 nanometers, to green at 555 nanometers. The alloy ratio is, of course, determined at the time of device material synthesis. Therefore, high controllability of the desired dominant emitted light wavelength is attainable. However, in providing the alloy compositional change from the infrared to the green, there is substantial loss of efficiency at the green end of the spectrum. Conversely, the sensitivity of the eye to emitted light has a substantial degradation going from the green-yellow sensitivity peak toward the infrared. There exists a natural cross-over point where maximized luminous efficiency results, and this cross-over point has been the determinant in the selection of the red used in the numeric indicator. Figure 6 is descriptive of the relative efficiencies of colors, the eye response curve, and the cross-over point of response.

Red was chosen as the color of the light emitted by the new solid state indicators because the electroluminous efficiency of HP's gallium arsenide phosphide alloy is highest for that color. Electroluminous efficiency is a measure of visual brightness per unit diode current. It is a function of the alloy composition, that is, the value of x in the formula $GaAs_{1-x}P_x$. Typical diodes have junction areas of 0.002 $cm^2$ and electroluminous efficiencies of 30 $fL/Amp/cm^2$; this is equivalent to a brightness of 150 fL at 10 mA.

### Viewing Angle:

There are two general display operating conditions:

(1) The bench-mounted instrument situation where wide angle viewing is highly desirable to permit the observation of a number of instruments by a single operator, or groups of operators, and

(2) Aircraft pilot situations wherein the head is held in a relatively fixed position with respect to the display to be viewed and where it is usually desirable to trade off wide angle viewability for ambient light reflection minimization.

For the first of these, the Hewlett-Packard display module may be viewed from angles in excess of 60°

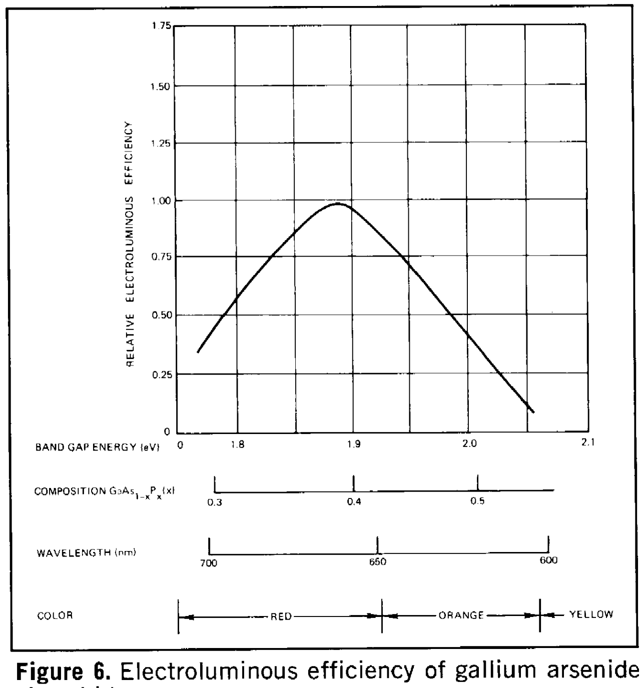



**Figure 6.** Electroluminous efficiency of gallium arsenide phosphide.

from the normal to the display, vertically or horizontally, with good readability. The only precaution must be that no mechanical obstruction is provided by the mechanical mounting or the panel opening of the instrument.

For Condition (2), it is frequently desirable to artificially constrain the radiation pattern to take advantage of the light emission optimization and to use the pilot's head as a block to panel illumination from ambient lighting conditions. Figure 7 illustrates a method by which this may be adapted. There always exists the possibility of obtaining increased apparent character size and/or light emittance by optical enhancement techniques at the cost of viewing angle.

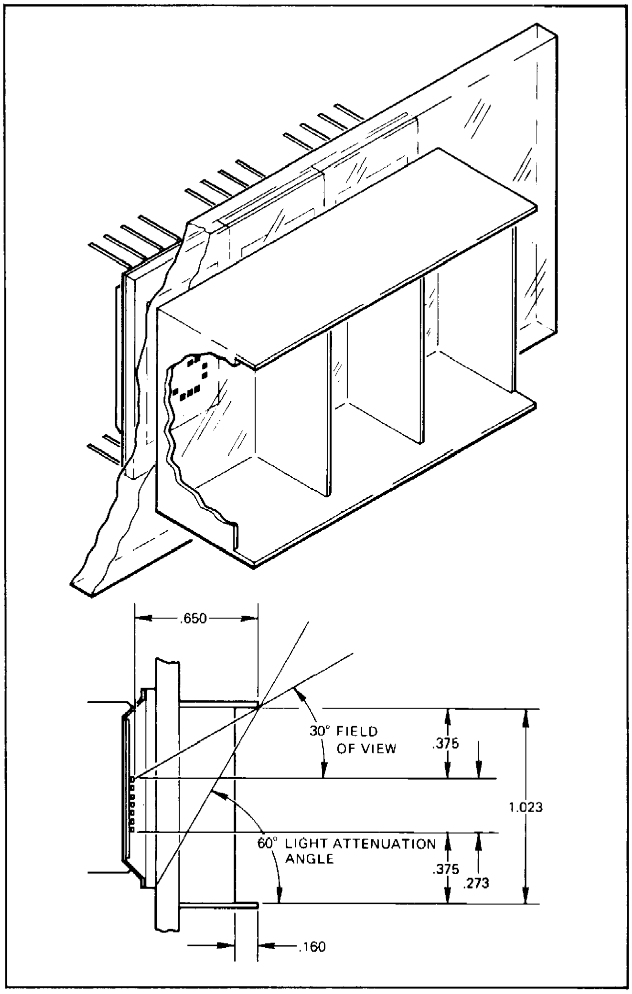



**Figure 7.**

**Brightness:**

The design specification for the display module is that 100 fL or more will be provided (diode average) when 4.0 dc is applied to the plus LED lead. It is possible by varying the LED voltage to control the brightness of the display. The typical response curve is shown in Figure 1. The power input to the display is reduced substantially when reduced voltage is applied to the plus LED lead. A twelve-digit display has been operated with 250 mW total power applied to the LED display (not including the integrated circuit logic power requirement) with adequate brightness for comfortable reading in a subdued lighting room. The use of a display in this mode for dark room operation is suggested. Also, reduced-brightness space vehicle operation, where power conservation is of prime importance, may be provided by this module feature. This product can also be provided as a premium device at nominal additional cost with the operating power requirement reduced approximately ½ without sacrifice of display brightness or dependability.

**Contrast:**

Contrast is defined to be the ratio of luminous value of a lighted die to the surround of the display, usually within the window area. This contrast ratio should usually be well in excess of 10. (Color contrasting display may also be provided.) Contrast in this display device is enhanced by the front window. Reasons behind this may be seen by looking through the clear window of the package. The ceramic substrate and the metallic interconnect striping on the ceramic provide reflection surfaces to external light. The reflection of these surfaces is controlled by selection of a filter used as a front window for this package. Therefore, the observed contrast ratio is a function of the transmittance of the window both at the color of the light emitting die and the rest of the visible spectrum. One would ideally, for maximum contrast, have full transmittance of the narrow band color produced by the light emitting die and a transmission density of 3.0 or greater for the balance of the spectrum. While filters of this type may be provided, the cost is substantially greater than a simple filter with a long wave pass band characteristic such as Plexiglass 2423. The transmittance spectrum of this Plexiglass material is shown in Figure 8. It is not within the control of Hew-

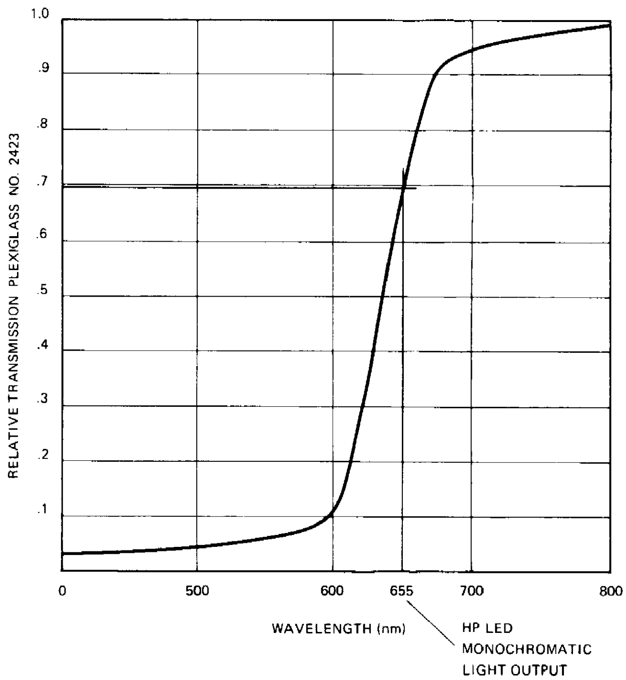



**Figure 8.** Relative transmission of Plexiglass 2423.

lett-Packard to guarantee that Plexiglass 2423 will always exhibit this characteristic, but this curve was generated by a representative sample.

Another device for contrast enhancement is the use of anti-reflective coating at reflection producing surfaces between the lighted die and the outside of the case. Such a coating should be hard to permit window cleaning and is comprised of a coating applied where the glass or plastic, with a typical reflective index of 1.5, interfaces with air, with a typical refractive index of 1.0. Reflection at each of these surfaces is reduced roughly by a factor of two, providing a display where the surround to the lighted dot is substantially "blacker" than would otherwise attain. The blackness of this surround is determined by the ambient brightness level, the directional properties of the ambient room lighting, the position of the lighting with respect to the instrument and the viewer, and the reflectivity of the elements of the package. Reflection from surfaces behind the "red" front window of the display are sharply attenuated because of the limited band pass ability of the filter, with the resulting double attenuation of light not within the pass band.

**Size:**
The character size of both the 5082-7000 and 5082-7001 display modules is $\frac{1}{4}$ inch. It is an interesting aside that most observers will estimate the size to be larger by about 50%. This is a subjective effect produced by the light emitting properties (high contrast) of this display. The $\frac{1}{4}$-inch size has been selected after study of larger and smaller sizes in various display applications. The individual display modules (-7000) would normally be mounted on a 0.600-inch center-to-center spacing. The minimum spacing is limited by the package width. To permit closer character spacing and to provide groups of three, commonly used in numeric display, the -7001 package is provided. Character center-to-center spacing within this package is 0.400 inch. Minimum vertical character center-to-center spacing would be about $1\frac{1}{4}$ inches. The front-to-back space required using the suggested mechanical mounting structure and including the colored glass filter in the front of the package is $\frac{7}{16}$ inch.

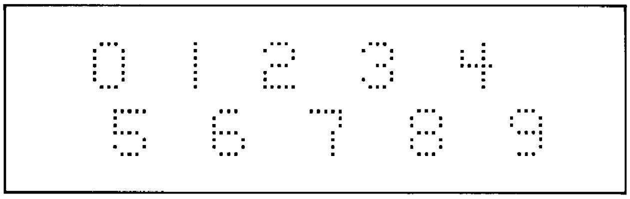



**Figure 9.** Character set.

**Character Font:**
The character font or style used in the Hewlett-Packard solid state display has been selected on the basis of readability without ambiguity, freedom from reading error in the case of a device burnout, and production economy that can be obtained by using a slightly stylized character set. The character set is presented below and in the display figures.