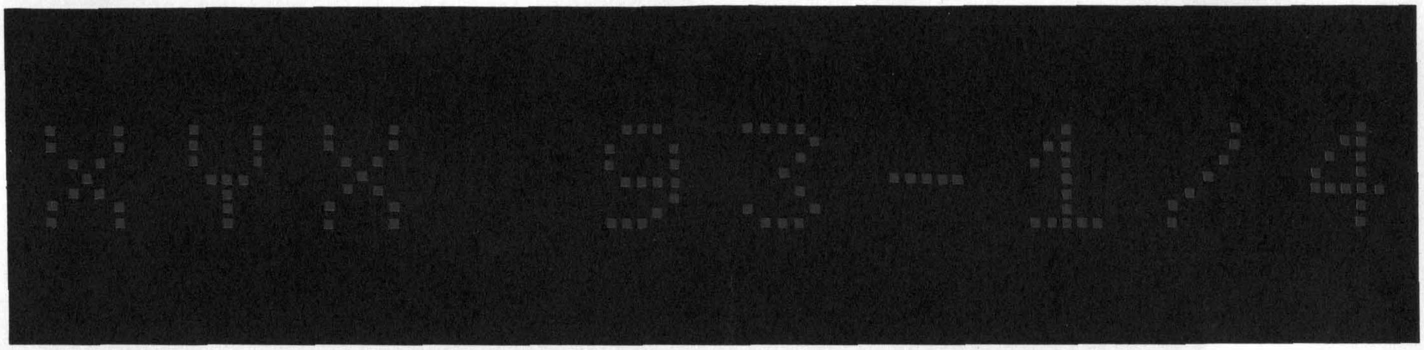
HEWLETT hp PACKARD

SOLID STATE ALPHANUMERIC INDICATOR

HP
5082–7100
thru
5082–7102

JUNE 1970



- **IC COMPATIBLE — less than 2 V dc**
- **COMPLETE ALPHANUMERIC DISPLAY**
- **5 x 7 DOT MATRIX CHARACTER — HUMAN FACTORS ENGINEERED**
- **BRIGHTNESS CONTROLLABLE — 0 to 200 fL**
- **LONG OPERATING LIFE**
- **SMALL SIZE — Standard .600 inch Dual In-Line Package**
- **RELIABLE — Designed to meet MIL Standards**

The Hewlett-Packard Solid State Alphanumeric Indicator is a rugged display module providing solid state reliability and long life to the display of alphanumeric information. Designed with several unique features, the display is ideal for conventional alphanumeric indicator requirements as well as allowing many new applications in the display of alphanumeric information.

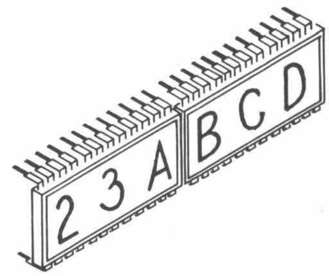
Typical areas of application for the display include airborne or shipboard equipment, fire control systems, and combat information centers; portable battery operated equipment, such as hand-held radar; calculator and computer readouts; numeric controlled machine tools; and test equipment.

The HP Solid State Alphanumeric Indicator is a small, rugged, and IC voltage compatible display module. Each character is formed by a complete 5 x 7 dot matrix of gallium arsenide phosphide, light emitting diodes, to give clear, bright, easily read alphanumeric information.

Solid state elements give the display many inherent advantages. First, it has electrical compatibility with IC's. High voltage power supplies are eliminated. Second, small size and thin design gives substantial savings in front panel space and the volume behind it. Coupled with its ability to withstand very rugged environments and adjustable brightness for varying ambient light conditions, the display is especially well suited for military/aerospace, computer and calculator applications as well as portable equipment.

The alphanumeric indicator is available in clusters of three, four and five characters. Characters are .270 inches high and spaced on approximately ⅓ inch centers for proper human factors readout. The diodes that make up each character are X-Y addressable for interconnection ease to external decoder drivers. In addition, each display is packaged in standard .600 inch high DIP modules for ease of mounting in standard hardware.

The many unique features which make it ideal for conventional display applications also allow for new types of information displays not previously possible. A listing of the features along with information as to how they might solve your display requirements is given below.



Two, 3-character clusters, end-stacked for even-spaced information display.

FIGURE 1.

IC VOLTAGE COMPATIBLE

The highest voltage required by the display is less than 2 volts. This eliminates the need for a separate high voltage power supply with corresponding savings in weight, space, and expense.

5 x 7 DOT MATRIX CHARACTER

The 5 x 7 dot matrix format gives a pleasant, easily read ¼-inch character. This qualitative characteristic (very important in human factor considerations) makes the Hewlett-Packard alphanumeric especially valuable in critical applications where ease of reading and reliability of transmitted information are the objectives. The problem of a false reading, possible with a one-segment failure of a sixteen-segment display, is eliminated.

VARIABLE BRIGHTNESS

Brightness of the display can be easily adjusted by varying the LED scan duty cycle or drive current. This allows for selection of the optimum display brightness for varying ambient light levels to give maximum display readability.

LONG LIFE

The solid state display elements coupled with a rugged design give the alphanumeric indicator long life. Since the failure mechanism of the display is a gradual decrease in light output with time, rather than a catastrophic failure, replacement, if necessary, can be accomplished without a previous loss of information. Initial tests indicate display half brightness life in excess of 100,000 hours. (Half brightness life is defined as the point in time when the display brightness is down 50% from its original value.) So for most applications, the life of the display will exceed the life of the equipment in which it is used, eliminating the necessity for replacement of display elements.

SMALL SIZE

The space required per character by the display measures only .60 in. high x .35 in. wide x .08 in. deep. This small size allows for the compact presentation of alphanumeric information. Not only is there a saving of front panel space, but the thinness of the display greatly conserves on the volume normally used behind the front panel in display installations. This savings can be used to build smaller, lighter weight equipments.

END STACKABLE

The display is packaged in industry standard 0.6 inch double DIP's. Packages are end stackable so the spacing between adjacent characters within a package and between two packages is the same. This end stackable feature allows the presentation of high density alphanumeric information with uniform spacing between characters.

HERMETICALLY SEALED, RUGGED DESIGN

The display module is hermetically sealed and of rugged design. It is suitable for environments with high shock and vibration, humidity, salt spray, and temperature fluctuation.

LOW POWER

High GaAsP efficiencies make the alphanumeric indicator suitable for many applications where display power requirements are a consideration. In portable instruments or other applications where power requirements need to be minimized, the display brightness can be reduced with corresponding power savings. For applications where the power requirements are critical, the display can be used with a "push to read" button to turn on the display only when information readout is necessary.

SINGLE PLANE/WIDE ANGLE VIEWING

The Lambertian light-emitting surface of the display LED's arrayed in a single plane provides greater than 120° of useful viewing angles (>60° from each side of normal) with constant brightness. This allows for one viewer to obtain display information from a large number of differing angles or for several viewers to watch the display at the same time.

SPECIFICATIONS
(at 25°C unless otherwise specified)

Power Dissipation (at 50 fL "Apparent" luminosity*)
- Character B (20 diodes) .... 200 mW max
- All 35 diodes lit .... 350 mW max

Peak Forward Current (per diode) .... 100 mA max

Operating and Storage Temperature .... −55°C to +95°C

Reverse Breakdown Voltage at 10 μA .... 4 V min

Luminance of Emitting Surface of Diode at 10 mA (diode average) .... 100 fL min

* "Apparent" refers to the subjective equivalent luminance value. The display output is pulsed.

TYPICAL CHARACTERISTICS

Luminance of emitting surface of diode at 10 mA (diode average) .... 150 fL

Forward Voltage at 10 mA .... 1.6 V

Peak wavelength .... 655 nm

Spectral line halfwidth .... 30 nm

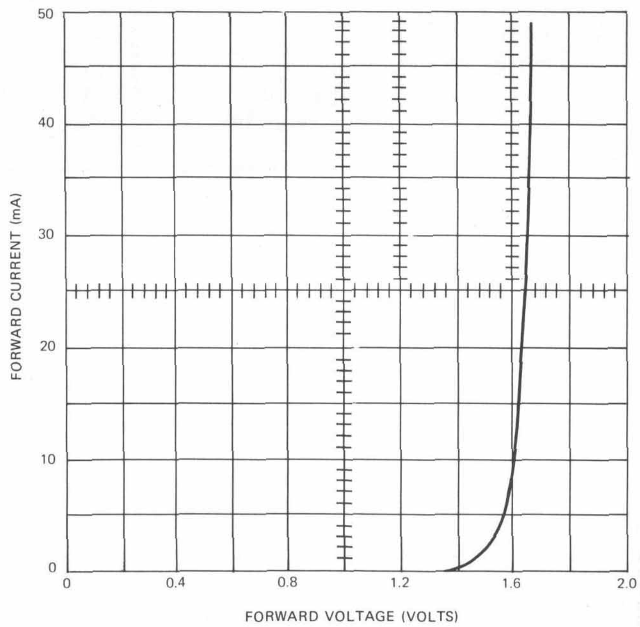


FIGURE 2. Forward current-voltage characteristic.

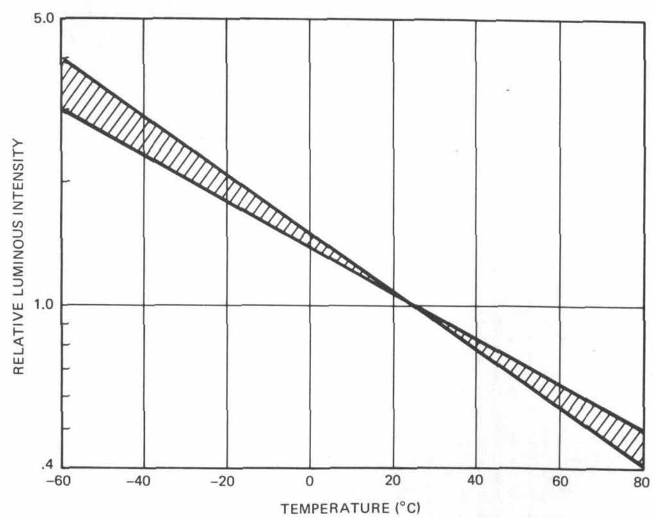


FIGURE 3. Light emitting diode brightness vs. case temperature at fixed current level.

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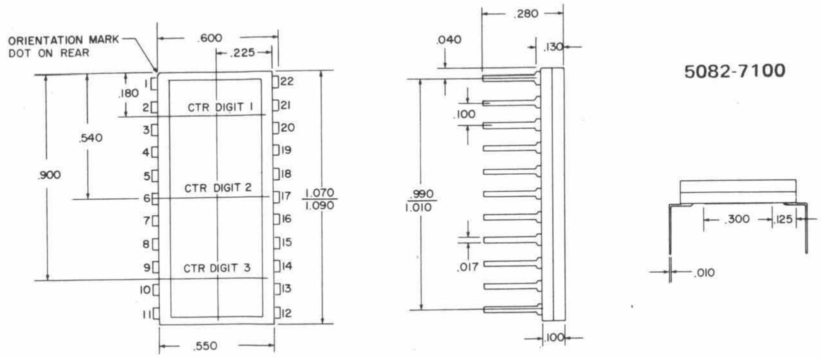

PIN NO.			PIN NO.		
1.	VII	(+)	12.	II	(+)
2.	1C		13.	3D	
3.	1D		14.	3B	
4.	VI	(+)	15.	I	(+)
5.	V	(+)	16.	2E	
6.	2B		17.	2C	
7.	2D		18.	2A	
8.	III	(+)	19.	IV	(+)
9.	3A		20.	1E	
10.	3C		21.	1B	
11.	3E		22.	1A	

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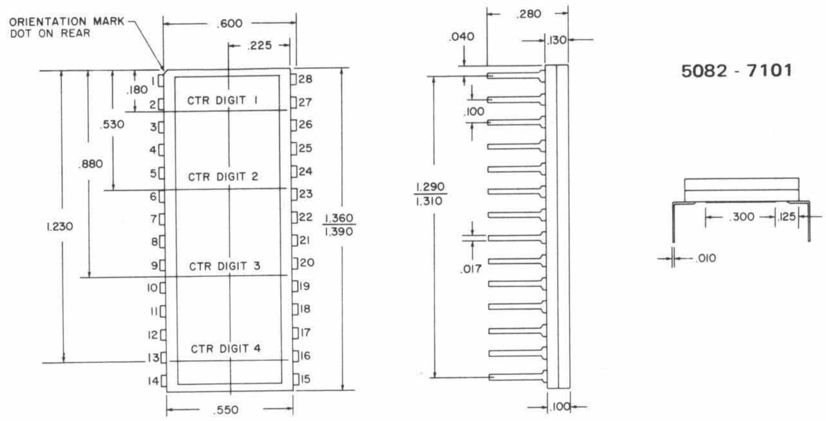

PIN NO.			PIN NO.		
1.	OPEN		15.	III	(+)
2.	1C		16.	4C	
3.	1E		17.	4A	
4.	VII	(+)	18.	II	(+)
5.	2B		19.	3E	
6.	2D		20.	3B	
7.	IV	(+)	21.	3A	
8.	V	(+)	22.	2E	
9.	3C		23.	2C	
10.	3D		24.	2A	
11.	VI	(+)	25.	I	(+)
12.	4B		26.	1D	
13.	4D		27.	1B	
14.	4E		28.	1A	

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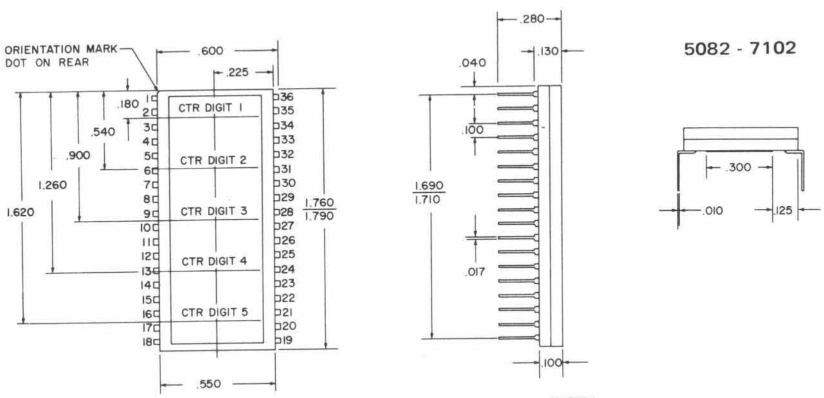
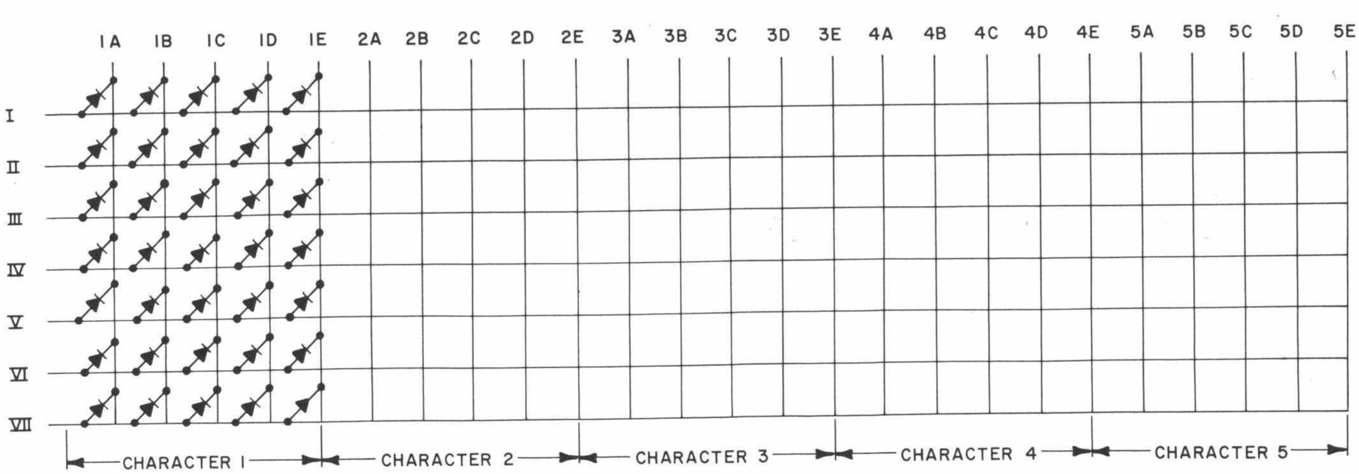


CHARACTER DIM. .273 x .190

PIN NO.			PIN NO.		
1.	OPEN		19.	5E	
2.	1C		20.	5C	
3.	1E		21.	5A	
4.	VI	(+)	22.	IV	(+)
5.	2B		23.	4E	
6.	2D		24.	4C	
7.	2E		25.	OPEN	
8.	V	(+)	26.	III	(+)
9.	3C		27.	3D	
10.	3E		28.	3B	
11.	VII	(+)	29.	3A	
12.	4A		30.	II	(+)
13.	4B		31.	2C	
14.	4D		32.	2A	
15.	OPEN		33.	I	(+)
16.	5B		34.	1D	
17.	5D		35.	1B	
18.	OPEN		36.	1A	

NOTES:
1. CHARACTER COLUMNS ARE DESIGNATED A THROUGH E
2. CHARACTER ROWS ARE DESIGNATED I — VII



5082-7100 / 7101 / 7102 SCHEMATIC WIRING DIAGRAM

Operating Considerations

ELECTRICAL

The 5 x 7 matrix of LED's, which make up each character, are X-Y addressable. This allows for a simple addressing, decoding and driving scheme between the display module and customer furnished logic.

There are three main advantages to the use of this type of X-Y addressable array:

(1) It is an elementary addressing scheme and provides the least number of interconnection pins for the number of diodes addressed. Thus, it offers maximum flexibility toward integrating the display into particular applications.

(2) This method of addressing offers the advantage of sharing the Read-Only-Memory character generator among several display elements. As will be discussed, one character generating ROM can be shared over 25 or more 5 x 7 dot matrix characters with substantial cost savings.

(3) In many cases equipments will already have a portion of the required decoder/driver (timing and clock circuitry plus buffer storage) logic circuitry available for the display.

To form alphanumeric characters a method called "scanning" or "strobing" is used. Information is addressed to the display by selecting one row of diodes at a time, energizing the appropriate diodes in that row and then proceeding to the next row. After all rows have been excited one at a time, the process is repeated. By scanning through all rows at least 100 times a second, a flicker free character can be produced composed of discrete illuminated LED's (light emitting diodes). When information moves sequentially from row to row of the display (top to bottom) this is *vertical* scanning. Information can also be moved from column to column (left to right across the display) in a *horizontal* scanning mode. For most applications (5 or more characters to share the same ROM) it is more economical to use vertical scanning.

Figure 5 indicates how with vertical scanning the letters AB would be formed by sequentially selecting the rows and energizing the correct diodes in each column. When row I is selected only columns 1B, 1C, 1D and 2A, 2B, 2C, 2D are energized. When selecting row II, columns 1A, 1E and 2A, 2E are energized and the process is continued as indicated by the solid squares in Figure 5, until all the appropriate LED's have been lighted. The cycle is repeated at a high rate so the eye sees a continuous flicker free character.

A typical vertical scanning circuit for addressing the display is shown in block diagram form in Figure 6. This particular scheme contains five display characters, however, operation for other numbers of characters is similar. Operation is as follows:

A. Coded 6 bit alphanumeric information is sequentially entered and stored in 5, 6 bit input storage buffers. The input information code in this example is a 6 line (bit) ASCII, but could be some other code if desired.

B. Next, with the input information stored in the input buffers, timing circuitry enables the ROM and input storage buffer #1 so its stored 6 bit code is read by the ROM. (All other input buffer storage are disabled.)

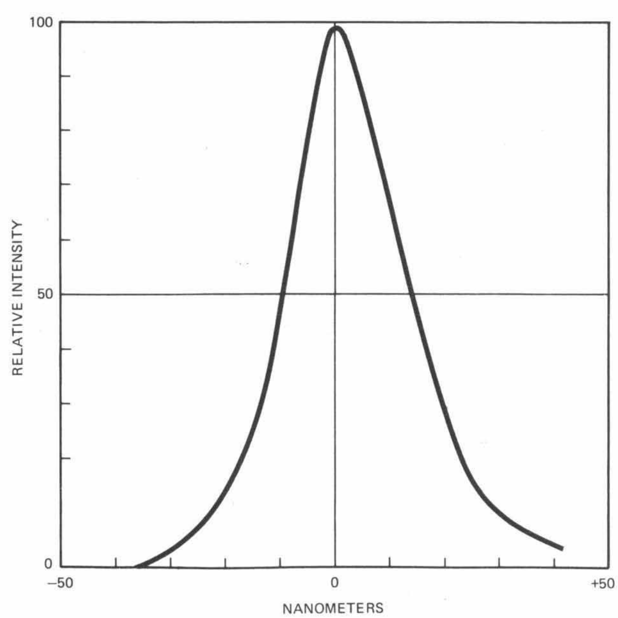


FIGURE 4. Spectral bandwidth of electroluminescent emission.

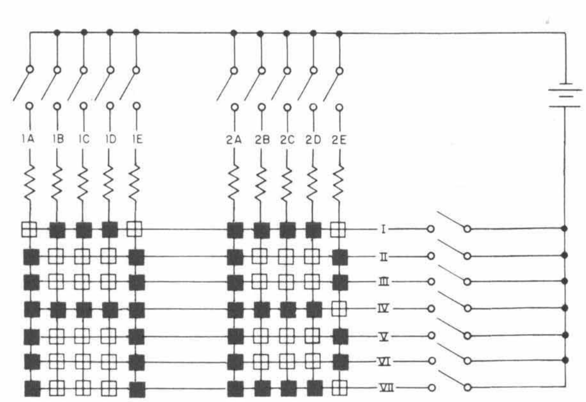


FIGURE 5. Selective matrix addressing for character generation.

C. The 6 bit input is decoded by the ROM and the first row of character information is stored in the 5 bit output storage #1. In other words, if we are writing the character "A," diodes 1B, 1C and 1D of the top row I are to be lighted (see Figure 5), and this information is stored in the first output storage buffer.

D. Having completed the first loading operation, the timing circuitry now activates input storage buffer #2 (all other input storage buffers are disabled) so the coded character is read into the ROM, decoded and the row information fed into output storage buffer #2. This operation is repeated until all 5 characters stored in the input storage buffers in 6 bit ASCII are sensed by the ROM character generator and the first line of character information stored in the output storage buffers.

E. Next, the timing circuitry connects the top row driver so current flows through and lights up all of the appropriate LED's in the top rows of the five display characters.

F. The complete cycle is next repeated to decode and display row II of the LED matrix characters, then row III on through the seventh row. Since the time to decode and load the output storage buffers is short in comparison to the time the display is lit, repeating the character scanning at a rate above 100 times per second gives a flicker free alphanumeric character.

A much more detailed description of general scanning techniques along with specific circuit recommendations is contained in HP Application Note 931.

MECHANICAL/THERMAL MOUNTING

The solid state display unit normally operates with approximately $\frac{1}{5}$ watt dissipation per character. This $\frac{1}{5}$ watt of power dissipated as heat, can result in substantial temperature rise (as much as 40°C) above ambient with resulting hazard to the device unless thermal sinking is provided. The usual mounting technique combines mechanical support and thermal heat sinking in a common structure.

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. Leads can be soldered to a printed circuit board or mounted in industry standard DIP connectors. This configuration results in less than 10°C rise.

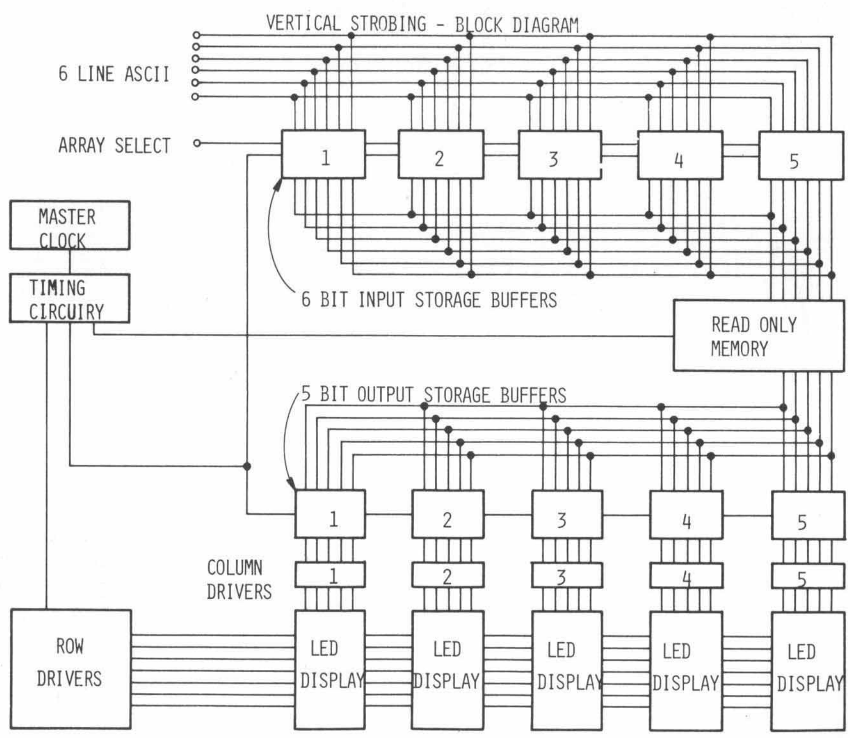


FIGURE 6. Vertical scanning block diagram.

GENERAL NOTES

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 alphanumeric indicator. Figure 7 is descriptive of the relative efficiencies of colors, the eye responsive 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 $GaAs_{1-x}P_x$.

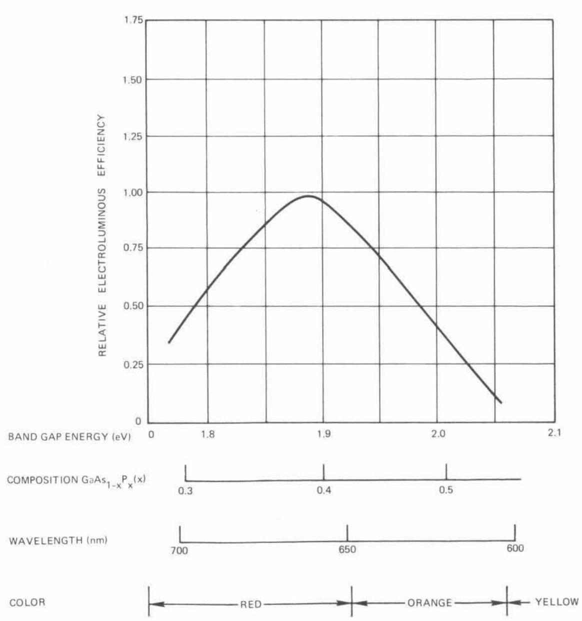


FIGURE 7. Electroluminous efficiency of gallium arsenide phosphide.

Viewing Angle

There are two typical 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 angle viewability for ambient light reflection minimization.

For the first of these, the Hewlett-Packard display module may be viewed from an angle in excess of 60° 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. There always exists the possibility of obtaining increased apparent character size and/or light emittance by magnification techniques at the cost of viewing angle.

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 Hewlett-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 bandpass ability of the filter, with the resulting double attenuation of light not within the pass band.

Size

The character size of the display modules is .270 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 .270 inch size has been selected after study of larger and smaller sizes in various display applications.

Character Font

The character font or style used in the Hewlett-Packard solid state display is selected on the basis of the particular read only memory used for character generation.

The 35 dot 5 x 7 array is of course flexible and will reproduce characters according to the particular font of the user's read only memory digital integrated circuit.

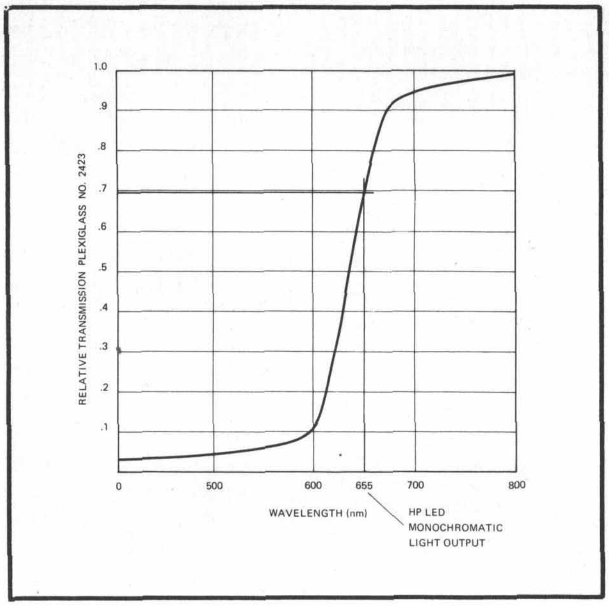


FIGURE 8. Relative transmission of Plexiglass 2423.