MAY 1982

JEDEC STANDARD No. 23

TEST METHODS AND CHARACTER DESIGNATIONS

FOR

LIQUID CRYSTAL DEVICES

JEDEC

Solid State Products Engineering Council

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JEDEC
Electronic Industries Association
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Formulated by

JEDEC JC-23.1 Committee on Liquid Crystal Devices

May, 1982

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F O R E W O R D

The material contained in this JEDEC Standard was developed by members of the JEDEC JC-23.1 Committee on Liquid Crystal Devices. It is intended to be applicable to both manufacturers and users of Liquid Crystal Devices.

1.0 PURPOSE and SCOPE

1.1 PURPOSE

The purpose of this document is to specify a collection of procedures for testing and character designation of Liquid Crystal Devices which compass the following areas:

A. Reliability and Stress Testing

B. Electro-Optical Testing

C. Segment and Character Designations

1. Alpha-Numeric Characters

2. Total Display Designations

3. Dot-Matrix Displays

These procedures are intended for use by manufacturers and users to promote standardization of the above areas throughout the Liquid Crystal Device Industry.

1.2 SCOPE

This document was developed primarily by members of the commercial Liquid Crystal Display industry and in some cases primarily for small surface area or "Watch" displays. However, it has been the intent of the committee to make the procedures proscribed herein usable to as much of the Liquid Crystal device industry as possible and therefore, unless otherwise specified, the procedures contained in this publication should be used as the basis for testing and designation of all Liquid Crystal Devices.

2.0 SUPPORTING DOCUMENTS

The following documents may be useful to the reader and will support and expand upon the information contained within this publication.

JEDEC Standard 77

SECTION 3.0

RELIABILTY

AND

STRESS TESTS

TEST METHOD 3.1

HIGH TEMPERATURE and HIGH HUMIDITY STORAGE TEST for LIQUID CRYSTAL DEVICES

High Temperature and High Humidity Storage (non-operating):

50°C ±2°C at 85 ±5% relative humidity for 200 hours for all devices including polarizers if they are part of the device.

A. Nematic to isotropic temperature to be reported as initial and final value.

B. Total display current to be reported as initial and final value.

C. Detectable visable (cosmetic) changes to be reported when examined with the unaided eye at 30 cm with 1000 Lux illumination under both operating and non-operating conditions.

D. Threshold voltage to be reported as initial and final value.

NOTE: Within the test chamber, the devices shall not be subjected to high air turbulence, but only to minimal air circulation necessary to maintain homogeneous and constant temperature and humidity.

TEST METHOD 3.2

HIGH TEMPERATURE STORAGE TEST for LIQUID CRYSTAL DEVICES

High Temperature Storage (non-operating):

70°C ±2°C at less than 40% relative humidity for 96 hour for twisted nematic devices (TND) with polarizers and for 1000 hours for other LCD's and TND's without polarizers.

A. Nematic to isotropic temperature to be reported as initial and final value.

B. Total display current to be reported as initial and final value.

C. Detectable visible (cosmetic) changes to be reported when examined with the unaided eye at 30 cm with 1000 Lux illumination under both operating and non-operating conditions.

D. Threshold voltage to be reported as initial and final value.

TEST METHOD 3.3

LOW TEMPERATURE STORAGE TEST for LIQUID CRYSTAL DEVICES

Low temperature storage (non-operating):

-40°C for 1000 hours under non-condensing conditions. In the case of twisted nematic devices (TND), the test is to be performed with polarizers.

A. Nematic to isotropic temperature to be reported as initial and final values.

B. Total display current to be reported as initial and final value.

C. Detectable visable (cosmetic) changes to be reported when examined with the unaided eye at 30 cm with 1000 Lux illumination under both operating and non-operating conditions.

D. Threshold voltage to be reported as initial and final value.

TEST METHOD 3.4

TEMPERATURE CYCLE TEST for LIQUID CRYSTAL DEVICES of SURFACE AREA 13 SQUARE CM or LESS

Temperature cycle test (non-operating):

-40°C to +70°C cycle with 10 minute minmum dwell times at the extremes and a maximum 5 minute transfer time, to be performed under non-condensing conditions. 10 cycles are required, all transfers to be air to air. In the case of twisted nematic devices (TND), test is to be performed with polarizers.

A. Nematic to isotropic temperature to be reported as initial and final value.

B. Total display current to be reported as initial and final value.

C. Detectable visable)cosmetic) changes to be reported when examined with the unaided eye at 30 cm with 1000 Lux illumination under both operating and non-operating conditions.

D. Threshold voltage to be reported as initial and final value.

TEST METHOD 3.5

THERMAL SHOCK TEST for LIQUID CRYSTAL DEVICES

Thermal Shock (non-operating):

0°C to +100°C with a 5 minute minimum dwell time at the extremes and a maximum 15 second transfer time. 10 cycles required with all transfers to be water to water. In the case of twited nematic devices (TND), test to be performed without polarizers.

A. Nematic to isotropic temperature to be reported as initial and final value.

B. Total display current to be reported as initial and final value.

C. Detectable visible (cosmetic) changes to be reported when examined with the unaided eye at 30 cm with 1000 Lux illumination under both operating and non-operating conditions.

D. Threshold voltage to be reported as initial and final value.

TEST METHOD 3.6

ELEVATED TEMPERATURE and VOLTAGE TEST for LIQUID CRYSTAL DEVICES

Elevated temperature and voltage operation test to be performed at twice the specified operating voltage at normal frequency at 50°C ± 2°C, at less than 40% relative humidity, for 1000 hours. In the case of twisted devices, test is to be performed with polarizers.

A. Nematic to isotropic temperature to be reported as initial and final value.

B. Total display current to be reported as initial and final value.

C. Detectable visible (cosmetic) changes to be reported when examined with the unaided eye at 30 cm with 1000 Lux illumination under both operatingand non-operating conditions.

D. Threshold voltage to be reported as initial and final value.

SECTION 4.0

CHARACTER DESIGNATION RECOMMENDATIONS

This document was formulated by representitives of the Liquid Crystal Display manufacturing industry to promote standardization of segment and display designation. It is intended to be used as a guideline in specifying the alpha-numeric identification of various segments and discriptors in a Liquid Crystal Display device. It consists of two parts:

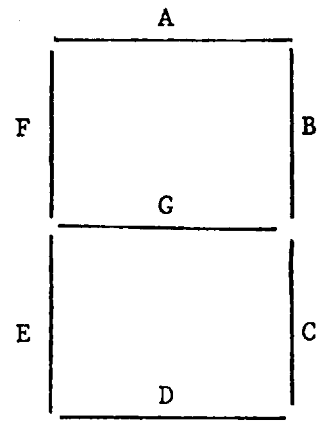
1. Segment Identification

2. Total Display Designation

each of which may be expanded to fit the needs of a particular device.

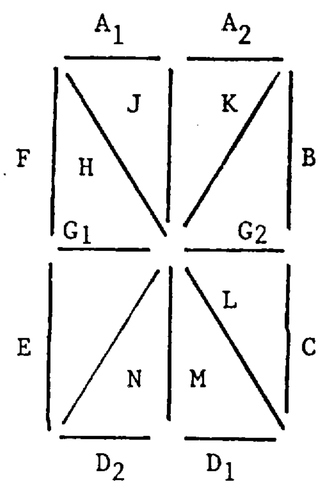
SEGMENT IDENTIFICATION

Standard 7 Segment



½ Digit

Alpha Numeric



1. Delete Letters:

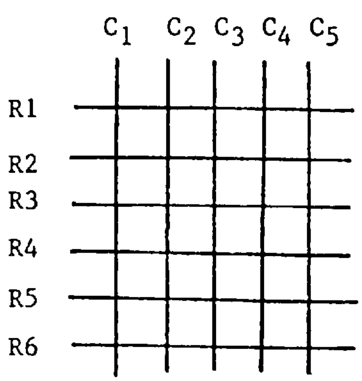
   I, O, Q

2. After designating standard segment A-G, begin in upper left-hand quadrant with "H" and proceed in a clockwis· direction

Dot Matix

(5 x 6 shown)

Columns



Use number designation to describe matrix, i.e., 5 X 7, 5 X 9, (number of columns by number of rows)

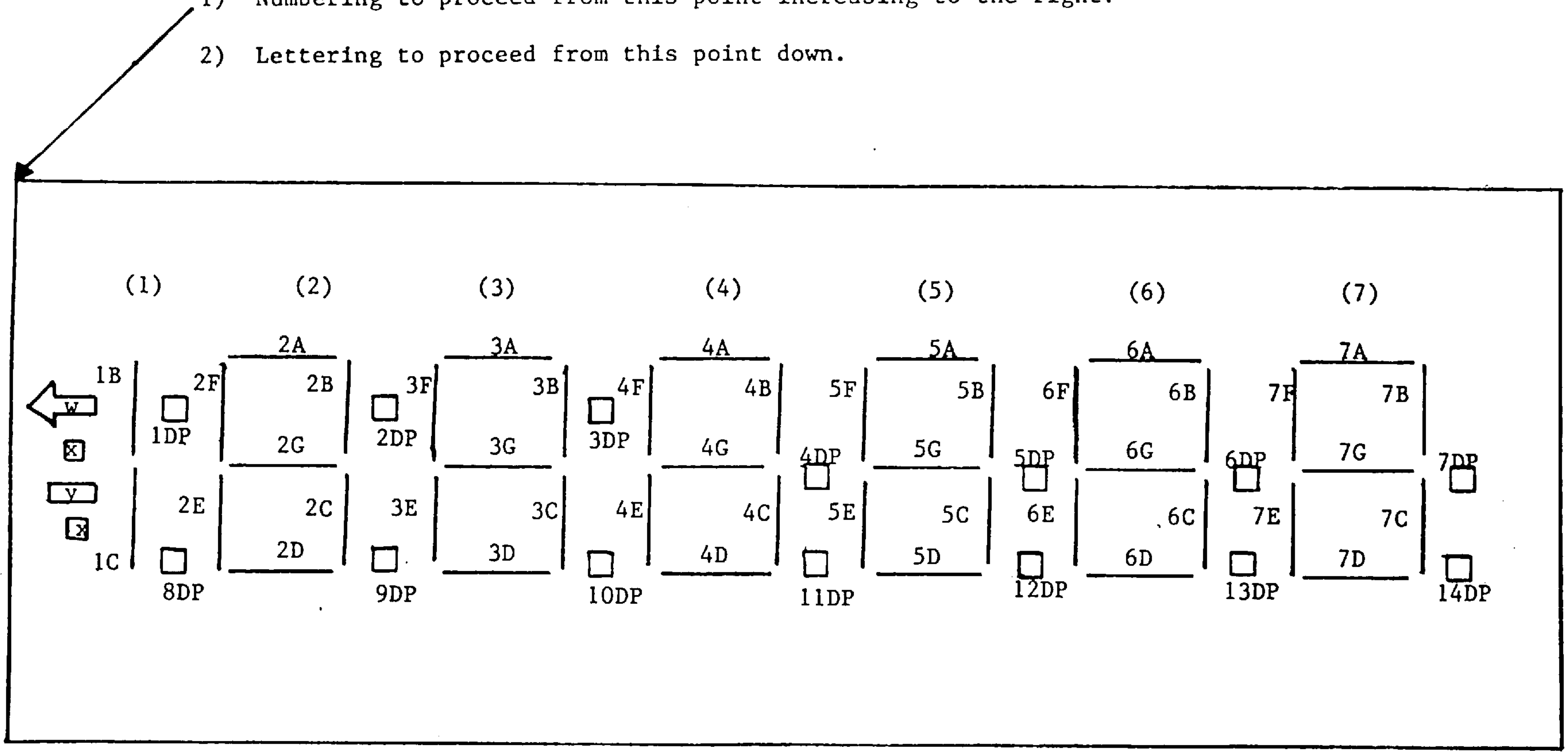
"Flags" or Descriptors

User to specify the letter designation for non-standard descriptors or "flags" so that they do not conflict with standard segment idnetification. For example, DP may be used fpr decimal point but not D1, D2, etc.

Total Display Designation

1) Numbering to proceed from this point increasing to the right.

2) Lettering to proceed from this point down.



SECTION 5.0

TERMS AND DEFINITIONS

(FROM JEDEC STANDARD 77)

LIQUID-CRYSTAL DEVICES

1.0 - General

1.1 General Terms and Definitions

	Term	Definition
1.1.1	C-N point temperature ----	See 1.1.24.
1.1.2	cholesteric liquid crystal-	A liquid crystal in which the molecules are arranged in parallel layers with the average direction of the long axis of each molecule in any given layer slightly and systematically rotated (i.e., twisted) from the average direction of the axes of the molecules in adjacent layers. (See Figure G1)
1.1.3	clearing point ------------	See 1.1.25.
1.1.4	contrast ratio ------------	The ratio of the luminance of a liquid crystal device in the light state to that in the dark state under conditions of constant illuminance.
1.1.5	crystalline solid or ------ solid-state crystal	A material that behaves mechanically as a solid, and in which the molecules display long-range order in three dimensions.
1.1.6	crystalline-to-nematic ---- temperature	See 1.1.24.
1.1.7	cutoff frequency ----------	The highest frequency at which a liquid-crystal device continues to function in a specified mode.
1.1.8	delay time ----------------	See 1.1.27.1.
1.1.9	director ------------------	A vector that indicates the average direction in which the long axes of the LC molecules are pointing.
1.1.10	fall time -----------------	See 1.1.27.2.
1.1.11	homeotropic alignment -----	Molecular orientation in which the average alignment of the long axes of the molecules tends to be perpendicular to the surface. (See Figure G5)

1.0 - General

1.1 General Terms and Definitions (Cont'd)

	Term	Definition
1.1.12	homogeneous alignment ----	Molecular orientation in which the average alignment of the long axes of the molecules tends to be parallel to the surface. (See Figure G5)
1.1.13	homogeneous alignment, uniform ----	Homogeneous alignment in which the long axes of the molecules tend to be parallel to each other as well as to the surface.
1.1.14	isotropic liquid ---------	A liquid in which the molecules exist in a random orientation and are free to move and/or rotate in any direction (e.g., any common liquid such as water).
1.1.15	liquid crystal -----------	A liquid organic compound in which, over a specific temperature range, the molecular axes tend to form an orientational array as in solid-state crystals, except that each molecule is free to rotate about its long axis and its center of mass has mobility in at least two directions. NOTE: In the liquid-crystal state, a liquid-crystal material exhibits the anisotropic optical properties of some crystalline solids (e.g., the refractive index depends upon the direction from which the material is examined, i.e. birefringence) and also the mechanical properties of a liquid in that it can be poured and assumes the shape of its container. (See cholesteric liquid crystal, nematic liquid crystal, and smectic liquid crystal).
1.1.16	liquid-crystal cell ------	A passive structure, controllable only as a single unit, in which a liquid crystal material is the controllable element. NOTE: The structure is physically equivalent to a parallel-plate capacitor in which the liquid-crystal material serves as the dielectric.
1.1.17	liquid-crystal state -----	A state of matter intermediate between a crystalline solid and an isotropic liquid, the existence of which is a result of the gross physical anisotropy of the liquid-crystal molecules.

1.0 - General

1.1 General Terms and Definitions (Cont'd)

	Term	Definition
1.1.18	N-I point temperature ----	See 1.1.25.
1.1.19	nematic liquid crystal ---	A liquid crystal in which the molecules have their long axes essentially parallel to each other and have mobility such that their centers of mass are randomly distributed. (See Figure G2) NOTE: This liquid crystal is the type normally used in liquid-crystal displays that provide digital, alphabetical, or other pattern readouts.
1.1.20	nematic-to-isotropic ----- temperature	See 1.1.25.
1.1.21	rise time ----------------	See 1.1.27.3.
1.1.22	saturation voltage -------	The voltage above which further change in a defined optical characteristic is relatively small. NOTE: The preferred implementation of this definition is the voltage at which the luminance has changed by 90% of the maximum change in luminance.
1.1.23	smectic liquid crystal ---	A liquid crystal in which the molecules are arranged in layers one molecule thick with their long axes approximately perpendicular to the plane of the layers and in which the molecules have mobility in all directions within their own layer. (See Figure G3). NOTE: Within each layer the molecules may be regularly spaced as in a crystalline solid or they may be randomly distributed.
1.1.24	temperature, C-N point; -- low transition point; crystalline-to-nematic temperature; melting point	The temperature at which a crystalline solid changes into a nematic liquid crystal as the temperature is increased.
1.1.25	temperature, N-I point; -- high transition point; nematic-to-isotropic temperature; clearing point	The temperature at which a nematic liquid crystal changes into an isotropic liquid as the temperature is increased. NOTE: The N-I point is the upper temperature limit of the liquid-crystal state.

1.0 - General

1.1 General Terms and Definitions (Cont'd)

	Term	Definition
1.1.26	threshold voltage	The voltage below which further change in a defined optical characteristic is relatively small. NOTE: The preferred implementation of this definition is the voltage at which the luminance has changed by 10% of the maximum change in luminance.
1.1.27	time	Reference Figure G4.
1.1.27.1	delay time, t_d	The time interval between the initiation of an input pulse train and the luminance reaching its 10%-on value.
1.1.27.2	fall time, t_f	The time interval during which the luminance is changing from its 90%-on value to its 10%-on value.
1.1.27.3	rise time, t_r	The time interval during which the luminance is changing from its 10%-on value to its 90%-on value.
1.1.27.4	turn-off delay time, $t_{d(off)}$	The time interval between the end of the input pulse train and the luminance reaching its 90%-on value. NOTE: This interval is usually negligible compared with fall time.
1.1.27.5	turn-off time, t_{off}	The sum of $t_{d(off)}$ and t_f.
1.1.27.6	turn-on time, t_{on}	The sum of t_d and t_r.
1.1.28	transition point	See 1.1.24 and 1.1.25.
1.1.29	turn-off delay time	See 1.1.27.4.
1.1.30	turn-off time	See 1.1.27.5.
1.1.31	turn-on time	See 1.1.27.6.

1.0 - General

1.1 General Terms and Definitions (Referenced Figures)

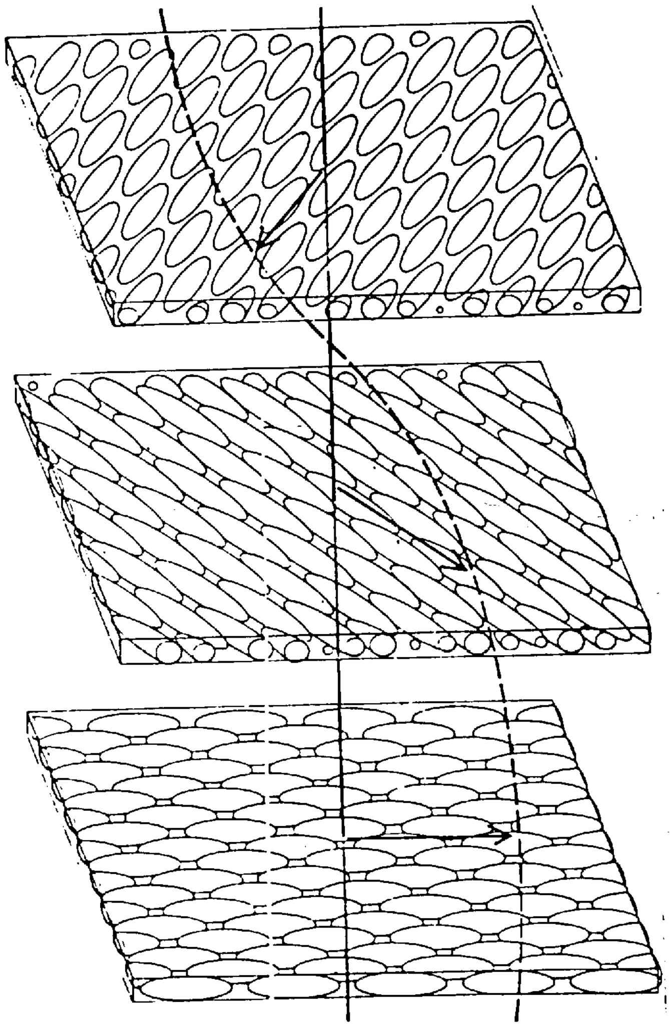


Figure G1 - Arrangement of molecules in a cholesteric liquid crystal. Within each layer, the average molecular directions are parallel. However, the orientation of molecules in one layer is displaced from that of the molecules in adjacent layers so that a helical pattern (vertical line and broken helical line) is formed from layer to layer. (For clarity, diagram has been simplified to show layers only one molecule thick.)

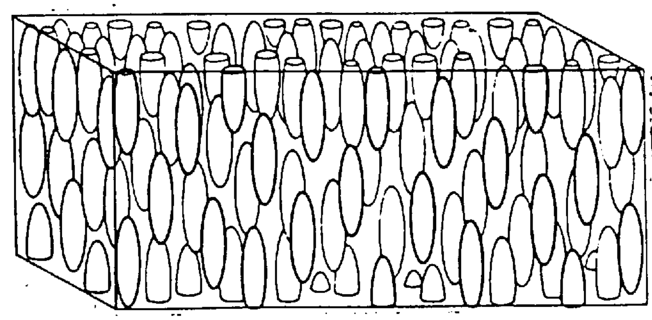


Figure G2 - Arrangement of molecules in a nematic liquid crystal.

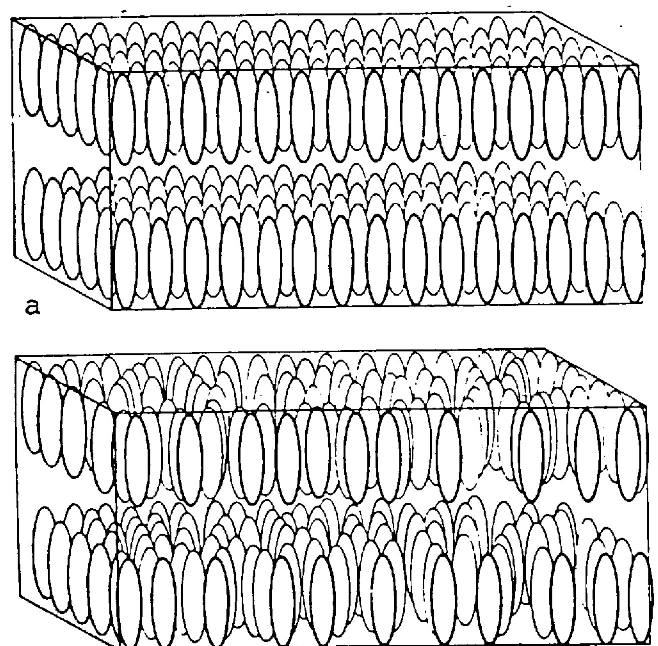


Figure G3 - Arrangements of molecules in adjacent smectic liquid crystals. The layers can slide over one another because the molecules in each layer can move from side to side or forward and backward, but not up and down. Within each layer, molecules may be ordered in ranks (a) or may be randomly distributed (b).

1.0 - General

1.1 General Terms and Definitions (Referenced Figures)(Cont'd)

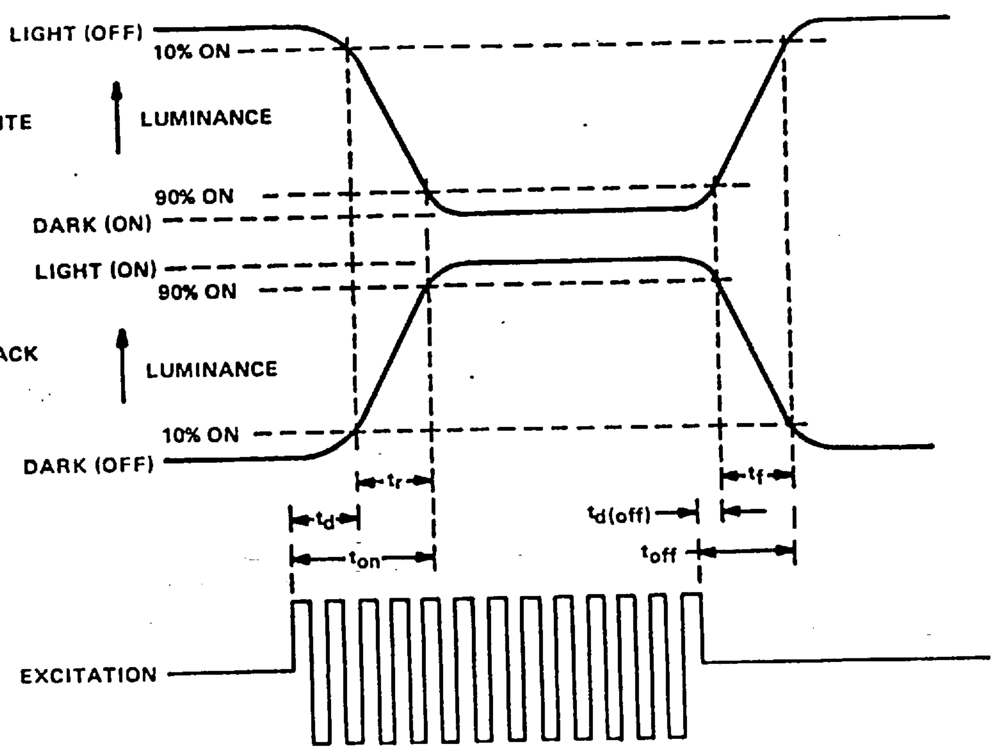


Fig. G4 - Response times.

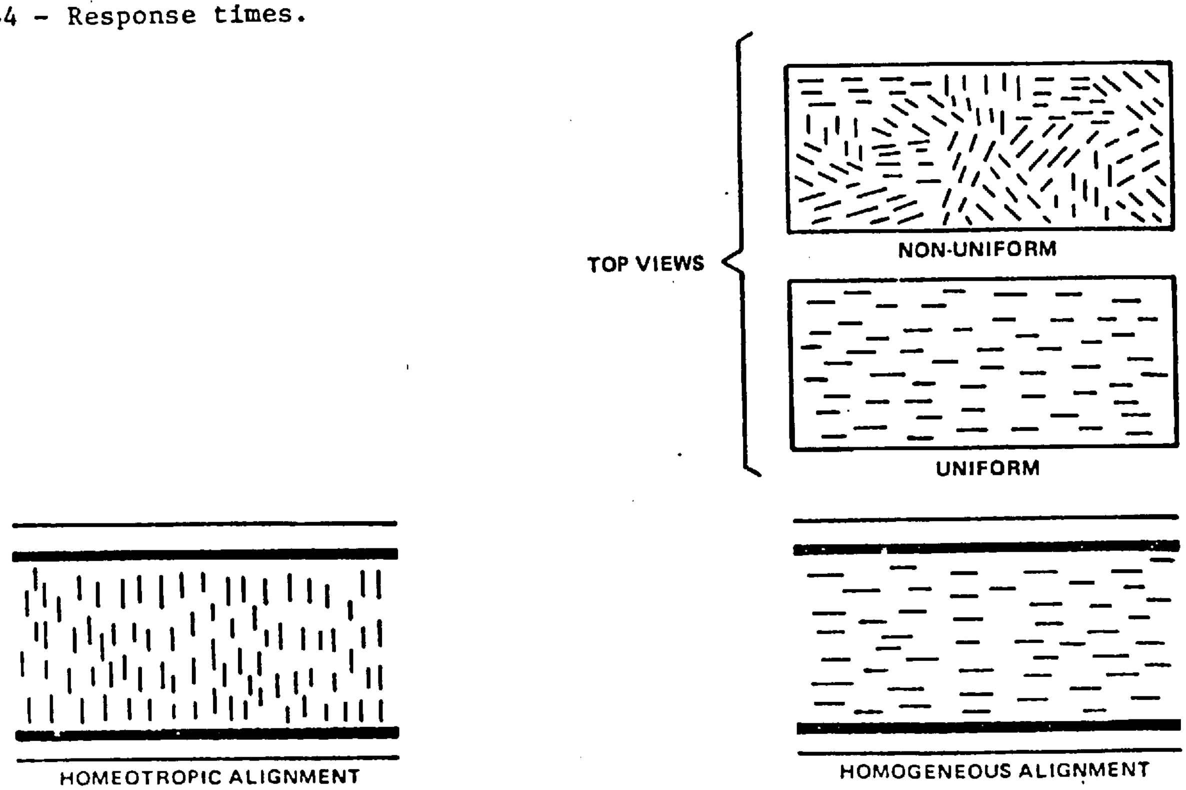


Fig. G5 - Types of liquid-crystal alignments.

2.0 - Types of Display Devices

2.1 General Terms and Definitions

	Term	Definition
2.1.1	liquid-crystal display (LCD)	A planar device in which visible information is displayed by control of a liquid-crystal material. NOTE 1: Control may be by thermal, electrical, or magnetic means. NOTE 2: Typical construction of an electrically controlled LCD consists of two plates (at least one of which is transparent) with a liquid-crystal material sandwiched between them. The transparent plates are usually glass, with a thin transparent conductive coating on each of the inner surfaces. A pattern in one of the conductive coatings defines the electrically controllable portion of the display. The liquid-crystal material exhibits controllable optical changes in response to voltages applied to the conductive coatings. Homeotropic or homogeneous alignment of the liquid-crystal material can be achieved by one or more of a variety of surface treatments applied to the inner surfaces of the display. The treatments used determine the directors of the molecular alignment. The liquid-crystal material is confined within the cell structure by a perimeter seal. (See Figure G6)
2.1.2	LCD, dynamic scattering	A liquid-crystal display in which the display pattern is produced by a light-scattering effect that results from an electrohydrodynamic instability in the molecular orientation of a liquid-crystal when a voltage is applied to appropriate segments. NOTE: In this type of liquid-crystal display, the liquid-crystal segments are transparent in the quiescent state, but become opaque (frosted) when a voltage is applied to the segments.

2.0 - Types of Display Devices

2.1 General Terms and Definitions (Cont'd)

	Term	Definition
2.1.3	LCD, reflective -----------	A liquid-crystal display that uses a reflective surface as part of the display structure to reflect light back through the liquid-crystal material. (See Figure G7)
2.1.4	LCD, storage mode ---------	A liquid-crystal display that has the ability to retain displayed information for long periods of time (e.g., days, weeks, or months) after the applied voltage has been removed.
2.1.5	LCD, transflective --------	A liquid-crystal display that incorporates, as part of the display structure, a partially reflecting surface that permits the display to be viewed by either reflected light or by light transmitted from behind the display.
2.1.6	LCD, transmissive ---------	A liquid-crystal display that is designed to be viewed by light transmitted through the display in only one direction. (See Figure G8)
2.1.7	LCD, twisted "nematic" ---- field-effect (TNFE)	A liquid-crystal display in which the liquid-crystal material is aligned in a uniform homogeneous manner on each cell wall, but the director on one surface is oriented at 90° to that on the other surface. NOTE: The director angle turns smoothly through 90° as one moves through the liquid-crystal film, from one surface to the other. Linearly polarized light that enters the cell with its polarization vector parallel to or perpendicular to the director at the cell wall is rotated through 90° as it passes through the liquid-crystal film. Application of a specific voltage above the threshold voltage aligns the directors of the liquid-crystal material such that an alignment approximately perpendicular to the surface is obtained. The 90° rotation of polarized light is lost and the voltage-activated areas appear dark against a clear background or clear against a dark background when the polarizers are crossed and parallel respectively.

2.0 - Display Devices

2.1 General Terms and Definitions (Referenced Figures)

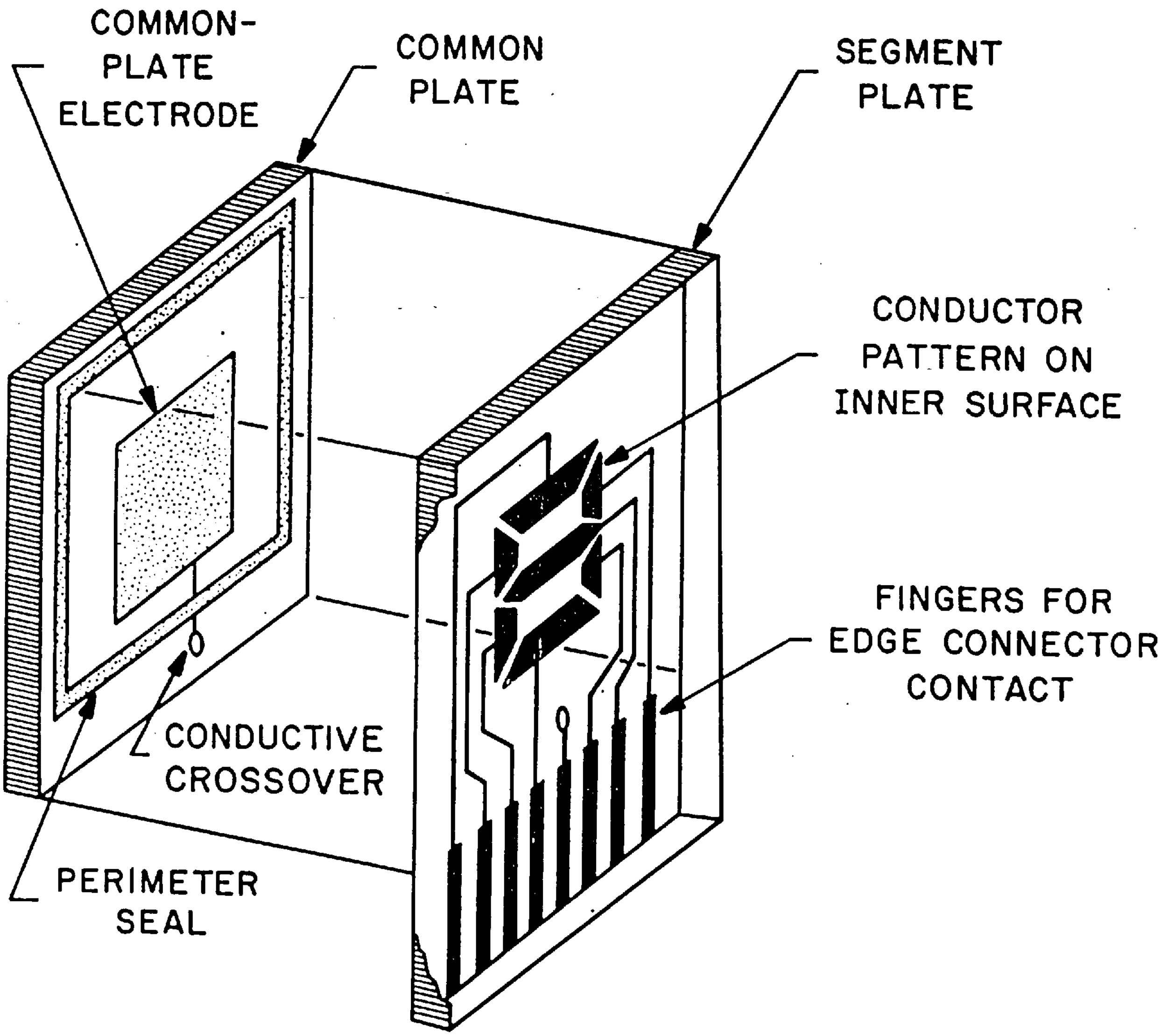


Fig. G6 - Expanded view of a typical liquid-crystal display.

2.0 - Display Devices

2.1 General Terms and Definitions (Referenced Figures)(Cont'd)

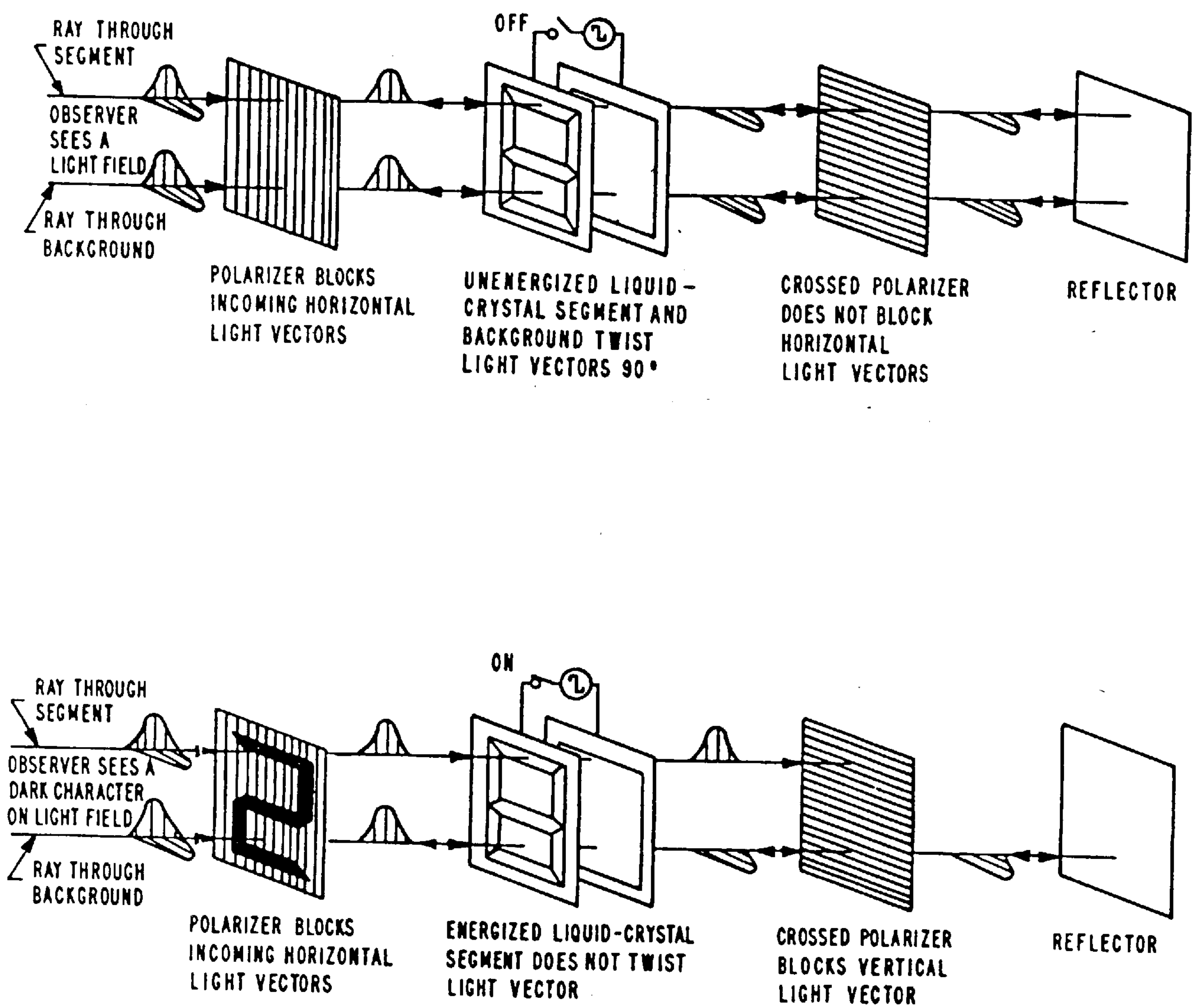


Fig. G7 - Operation of the polarizers in the reflective field-effect display. (Note: Rotating one polarizer 90 degrees will produce a light character on a dark field.)

2.0 - Display Devices

2.1 General Terms and Definitions (Referenced Figures)(Cont'd)

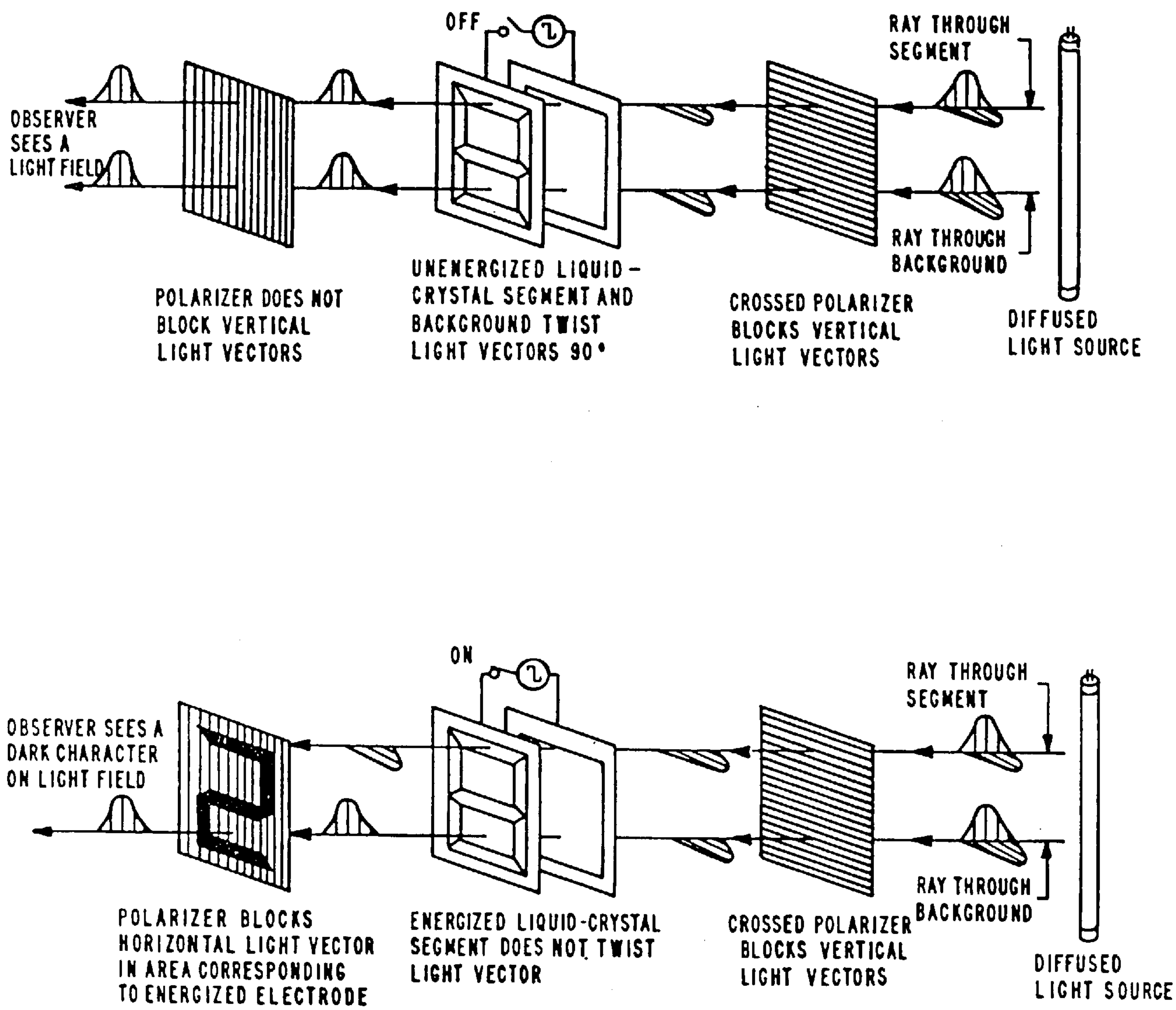


Fig. G8 - Operation of the polarizers in the transmissive field-effect display. (Note: Rotating one polarizer 90 degrees will produce a light character on a dark field.)