LQ9RA03
TFT-LCD Module

FEATURES

- Display Diagonal: 8.6"
- Display Format: 960 × 456
- Overall Dimensions:
  225 (W) × 194 (H) × 33.5 (D) mm
- Active Area: 173.8 (W) × 130.4 (H) mm
- Dot Pitch: 0.181 (W) × 0.286 (H) mm
- Viewing Angle: 6 O'Clock
- Dual Mode Type: NTSC (M) and PAL (B, G) Standards
- MBK-PAL or MaBiKi-PAL Which Enables the 456-Scanning Lines Panel to Display a Picture with Virtually 548-Scanning Lines
- Built-in Video Interface Circuit and Control Circuit Responsive to Two Sets of Standard RGB Analog Video Signals Which can be Superimposed
- High-Quality, Full-Color Rendition with Backlight Source Incorporated

DESCRIPTION

The SHARP LQ9RA03 Color TFT-LCD module is an active matrix LCD (Liquid Crystal Display) produced by making the most of SHARP's expertise in liquid-crystal and semiconductor technologies. The active device is amorphous silicon TFT (Thin Film Transistor). The module accepts full-color video signals (composite video and analog RGB) conforming to the NTSC (M) system standards.

When additionally provided with the backlight-driving DC/AC inverter, it is applicable to pocket TVs and various display monitors.

The module consists of a TFT-LCD panel, driver ICs, control PWB mounted with electronic circuits, fluorescent tube, reflector, frame, front and rear shielding cases.

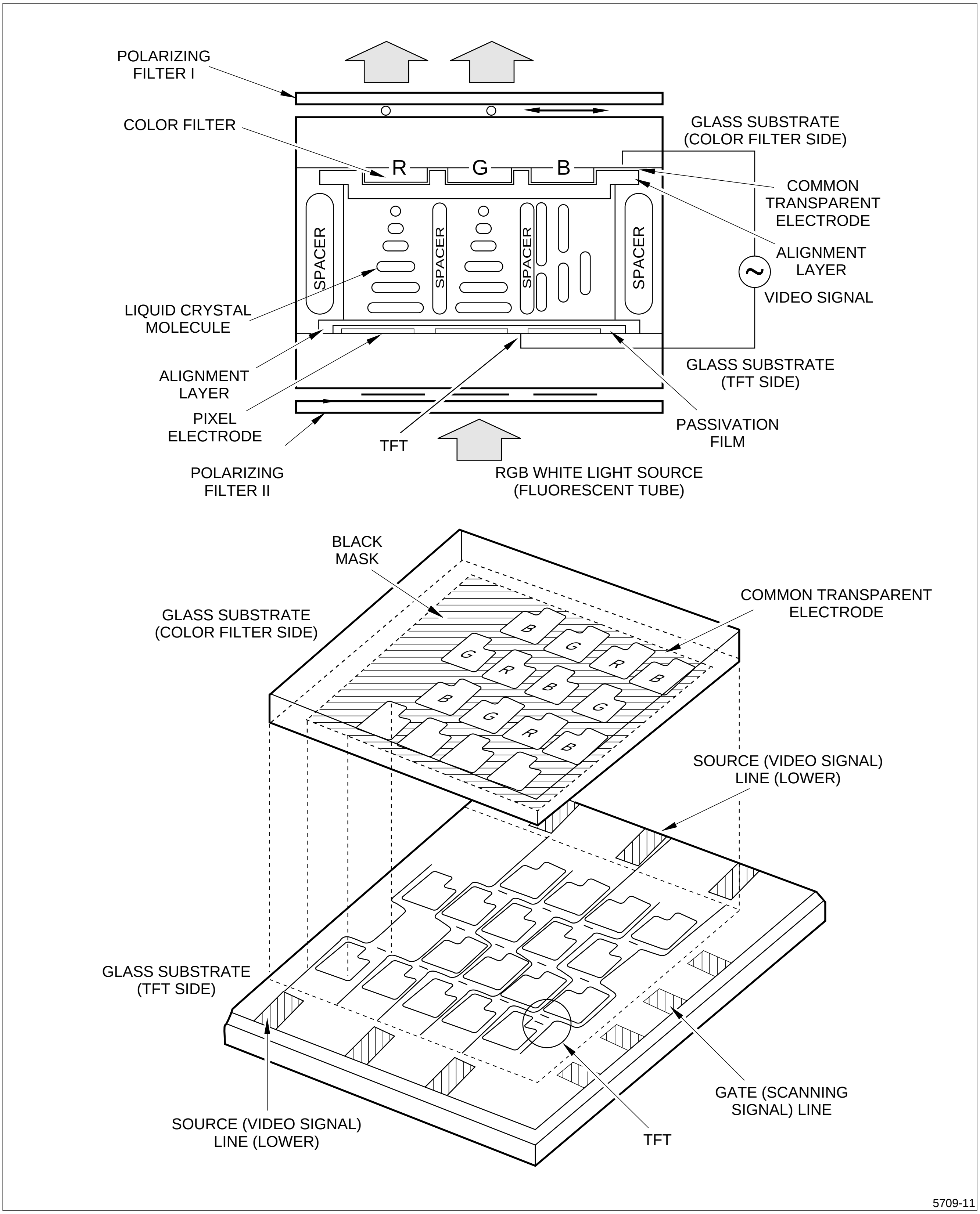


Figure 1. LQ9RA03 TFT-LCD Panel

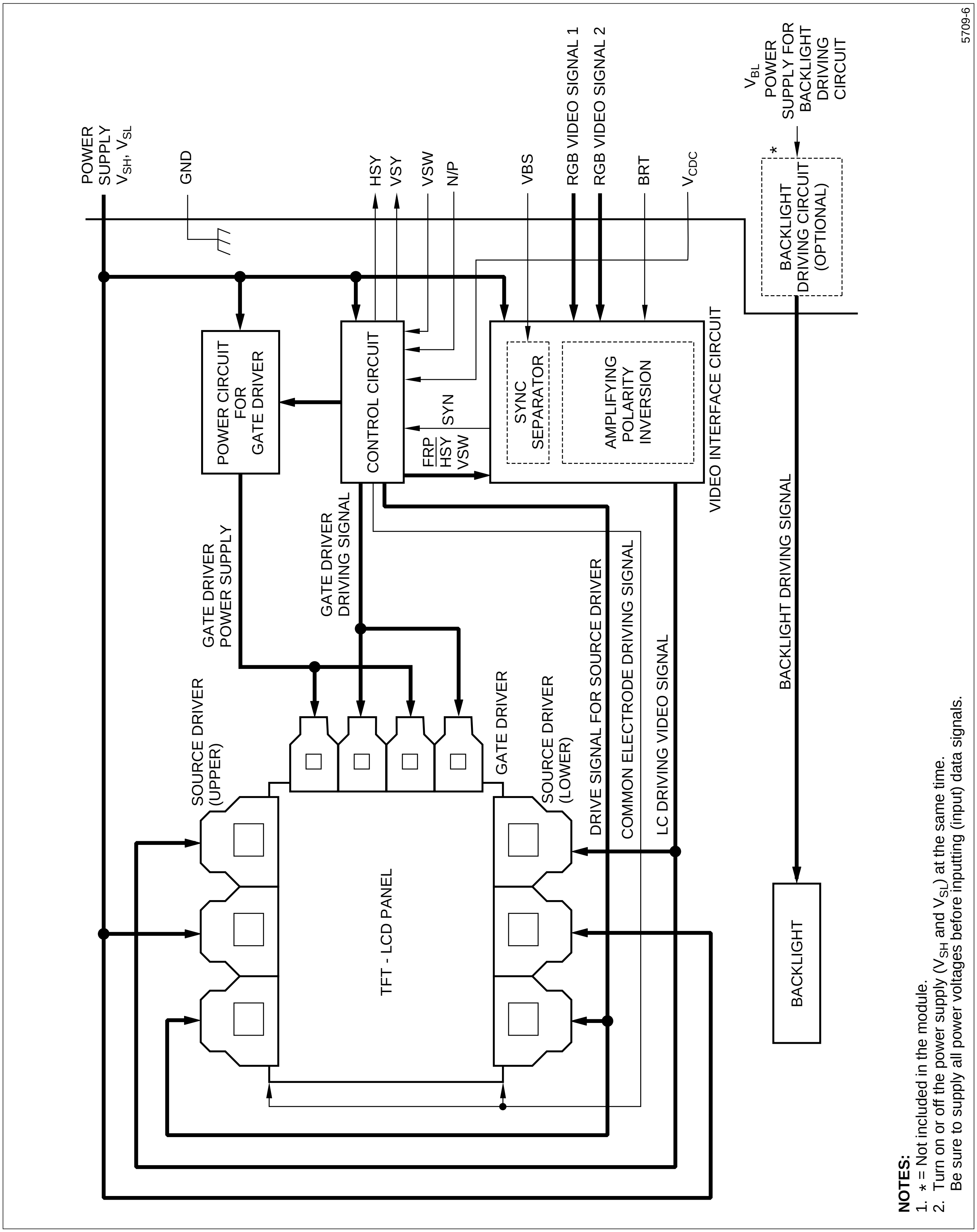


Figure 2. LQ9RA03 Block Diagram

MECHANICAL SPECIFICATIONS

PARAMETER	SPECIFICATIONS	UNIT	NOTE
Display Format	145.920	pixels	–
	960 (W) × 456 (H)	dots	–
Active Area	173.8 (W) × 130.4 (H)	mm	–
Screen Size	8.6 (Diagonal)	inches	–
Dot Pitch	0.181 (W) × 0.286 (H)	mm	–
Dot Configuration	RGB Delta Configuration	–	–
Outline Dimensions	225 (W) × 194 (H) × 33.5 (D)	mm	1
Weight	860	g	–

NOTE:
1. Excludes protrusions.

ABSOLUTE MAXIMUM RATINGS (GND = 0 V, t_A = 25°C)

SYMBOL	PARAMETER	MIN.	MAX.	UNIT	NOTE
V_{SH}	Positive Power Supply Voltage	–0.3	+6.0	V	–
V_{SL}	Negative Power Supply Voltage	–9.5	+0.3	V	–
V_{IA}	Analog Input Signal	–	2.5	V_{P-P}	1
V_{ID}	Digital Input Signals	–0.3	V_{SH} +0.3	V	2
V_{CDC}	DC Bias Voltage of Common Electrode Driving Signal	VSL	V_{SH}	V	–
V_{BRT}	Brightness Adjusting Terminal Voltage	0	V_{SH}	V	–
t_{STG}	Storage Temperature	–25	60	°C	3
t_{OPP}	Operating Temperature – Panel Temperature	0	60	°C	
t_{OPA}	Operating Temperature – Ambient Temperature	0	40	°C	

NOTES:
1. $\overline{VBS}$, VR1, VG1, VB1, VR2, VG2, VB2 terminals (Video signal).
2. VSW, N/$\overline{P}$ terminals.
3. Maximum wet-bulb temperature ≤38°C. No dew condensation.

INPUT/OUTPUT TERMINALS – TFT-LCD PANEL DRIVING SECTION (CN1)

PIN NUMBER	SYMBOL	I/O	DESCRIPTION	NOTE
1	$\overline{\text{HSY}}$	O	Internal Horizontal Sync Signal (In Phase with $\overline{\text{VBS}}$)	–
2	$\overline{\text{VSY}}$	O	Internal Vertical Sync Signal (In Phase with $\overline{\text{VBS}}$)	–
3	TST	–	This Shall be Electrically Opened During Operation	–
4	N/$\overline{\text{P}}$	I	Terminal for display mode selection, NTSC or PAL	1
5	TST	–	This Shall be Electrically Opened During Operation	–
6	TST	–		–
7	VSW	I	Selection Signal of Two Sets of Video Signals	2
8	GND	I	Ground (Digital)	–
9	V_{CDC}	I	DC Bias Voltage Adjusting Terminal of Common Electrode Driving Signal	3
10	V_{SH}	I	Positive Power Supply Voltage	–
11	$\overline{\text{VBS}}$	I	Composite Video Signal for Sync separator	4
12	BRT	I	Brightness Adjusting Terminal	5
13	VR1	I	Color Video Signal (Red) 1	–
14	VG1	I	Color Video Signal (Green) 1	–
15	VB1	I	Color Video Signal (Blue) 1	–
16	V_{SL}	I	Negative Power Supply Voltage	–
17	VR2	I	Color Video Signal – Red 2	–
18	VG2	I	Color Video Signal – Green 2	–
19	VB2	I	Color Video Signal – Blue 2	–
20	GND	I	Ground (Analog)	–

NOTES:

In the following descriptions, ‘High’ means ‘V_{SH}’ and ‘Low’ means ‘GND.’

1. Selects display mode:
   a. When N/$\overline{\text{P}}$ is ‘High’ or open, the module operates in NTSC (M) mode.
   b. When N/$\overline{\text{P}}$ is ‘Low,’ the module operates in PAL (BG) mode.
2. Selects a set of RGB video signals:
   a. When VSW is ‘High’ or open, composite video signal (Pin Numbers 13 through 15) is selected.
   b. When VSW is ‘Low,’ RGB signal set (Pin Numbers 17 through 19) is selected.
3. The DC component of V_{COM} (V_{CDC}) is adjusted to the optimum value with V_{SH} and V_{SL} being the typical value on shipping. In case of change of the optimum value (for example, lowering of the power source), it should be readjusted by the built-in variable resistor (V_{CDC}) or external circuit. Refer to ‘Adjusting Method of Optimum Common Electrode DC Bias Voltage’ for readjusting.
4. Responsive to standard composite sync signal with negative polarity of the same amplitude level as that of the composite video signal.
5. Brightness (black level of video signal) is adjusted by the DC voltage supplied to the pin. Brightness is adjusted to the optimum value on shipping but can be readjusted by the built-in variable resistor (BRT, CNT, COL, TIN) or external circuit (Figure 3).

INPUT/OUTPUT TERMINALS – BACKLIGHT DRIVING SECTION (CN2 – 5)

PIN NUMBER	SYMBOL	I/O	CONNECTOR	DESCRIPTION
1	VH1	I	CN2	Power Supply for Fluorescent Tube Filament (1)
2	VH2	I		Power Supply for Fluorescent Tube Filament (2)
1	NC	–	CN3	No Connection
2	GND	I		Ground 1, 2
1	VH3	I	CN4	Power Supply for Fluorescent Tube Filament (3)
2	VH4	I		Power Supply for Fluorescent Tube Filament (4)
1	NC	–	CN5	No Connection
2	GND	I		Ground 3, 4

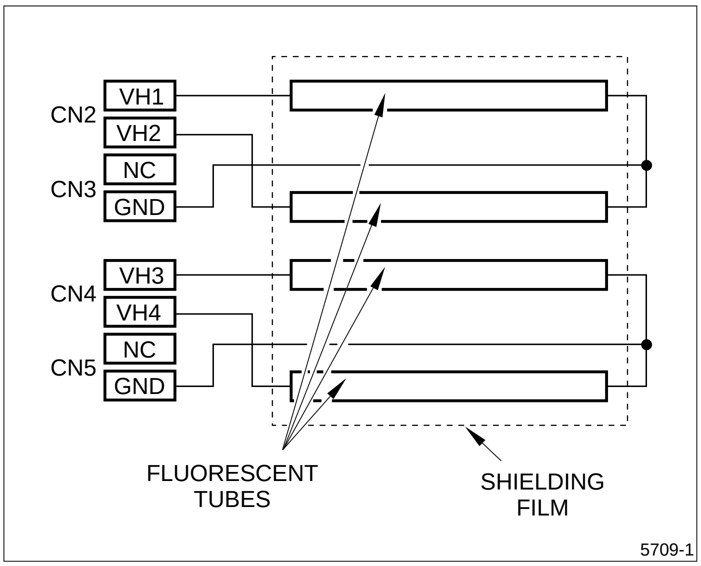


Figure 3. Wiring Diagram of Backlight Unit

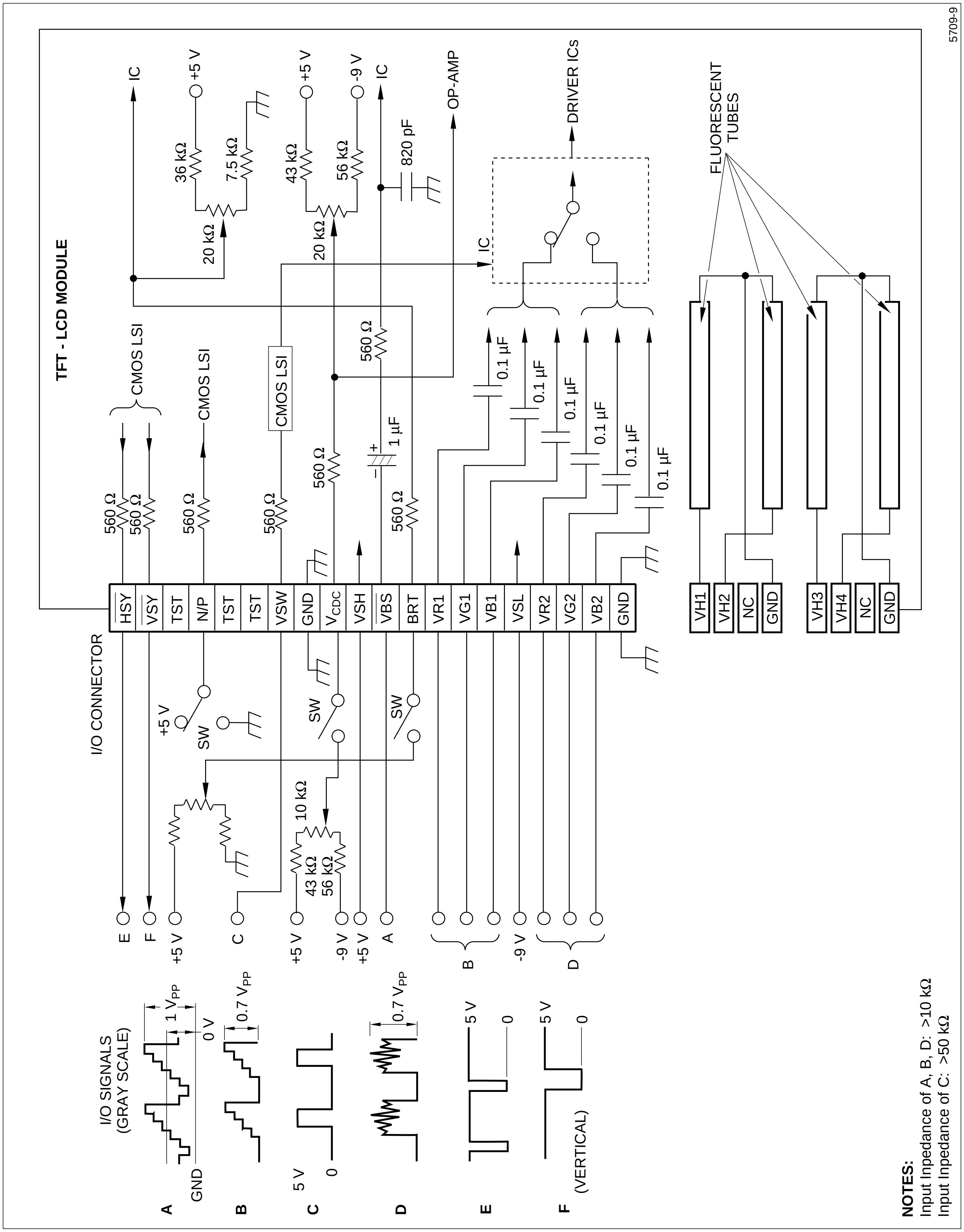


Figure 4. Recommended Circuit for TFT-LCD Module

RECOMMENDED OPERATING CONDITIONS – TFT-LCD PANEL SECTION ($GND = 0$ V, $t_A = 25°C$)

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT	NOTE
V_{SH}	Positive Power Supply Voltage	+4.8	+5.0	+5.2	V	–
V_{SL}	Negative Power Supply Voltage	–9.2	–9.0	–8.8	V	–
V_{IAV}	Analog Input Voltage – Video Signal	0.5	0.7	1.0	V_{P-P}	1
V_{IAS}	Analog Input Voltage – Sync Signal	0	–	0.3	VP-P	1, 2
V_{ISS}	Sync Signal Input Voltage	–	0.3	2.0	VP-P	3
V_{IDH}	Digital Input Voltage – High Level	+3.5	–	V_{SH}	V	4
V_{IDL}	Digital Input Voltage – Low Level	0	–	+1.5	V	
V_{ODH}	Digital Output Voltage – High Level	+4.0	–	–	V	5
V_{ODL}	Digital Output Voltage – Low Level	–	–	+0.4	V	
V_{CDC}	DC Bias Voltage of Common Electrode Driving Signal	–3.0	–1.5	0	V	6
V_{BRT}	Terminal Voltage for Brightness Adjustment	+0.7	+1.0	+1.5	V	–
F_H (N)	Horizontal Sync Signal Frequency – NTSC	15.13	15.73	16.33	kHz	–
F_H (P)	Horizontal Sync Signal Frequency – PAL	15.03	15.63	16.23	kHz	–
F_V (N)	Vertical Sync Signal Frequency – NTSC	–	60	–	Hz	–
F_V (P)	Vertical Sync Signal Frequency – PAL	–	50	–	Hz	–

NOTES:

1. Input impedance: >10 kΩ.
2. VRI, VGI, VBI, VR2, VG2, VB2 terminals (video signals).
3. $\overline{VBS}$ terminal
4. N/P, VSW terminals
5. $\overline{HSY}$, $\overline{VSY}$ terminals (Internal sync signals).
6. Adjusted for each module so as to attain maximum contrast ratio.

RECOMMENDED OPERATING CONDITIONS – BACKLIGHT DRIVING SECTION ($t_A = 25°C$)

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT	NOTE
V_L	Lamp Voltage	–	400	–	V_{RMS}	Just for reference
I_L	Lamp Current	–	5	–	mA_{RMS}	
f_L	Frequency	20	–	60	kHz	–
V_S	Kick-Off Voltage	–	–	1200	V_{RMS}	$t_A = 0°C$

NOTE:

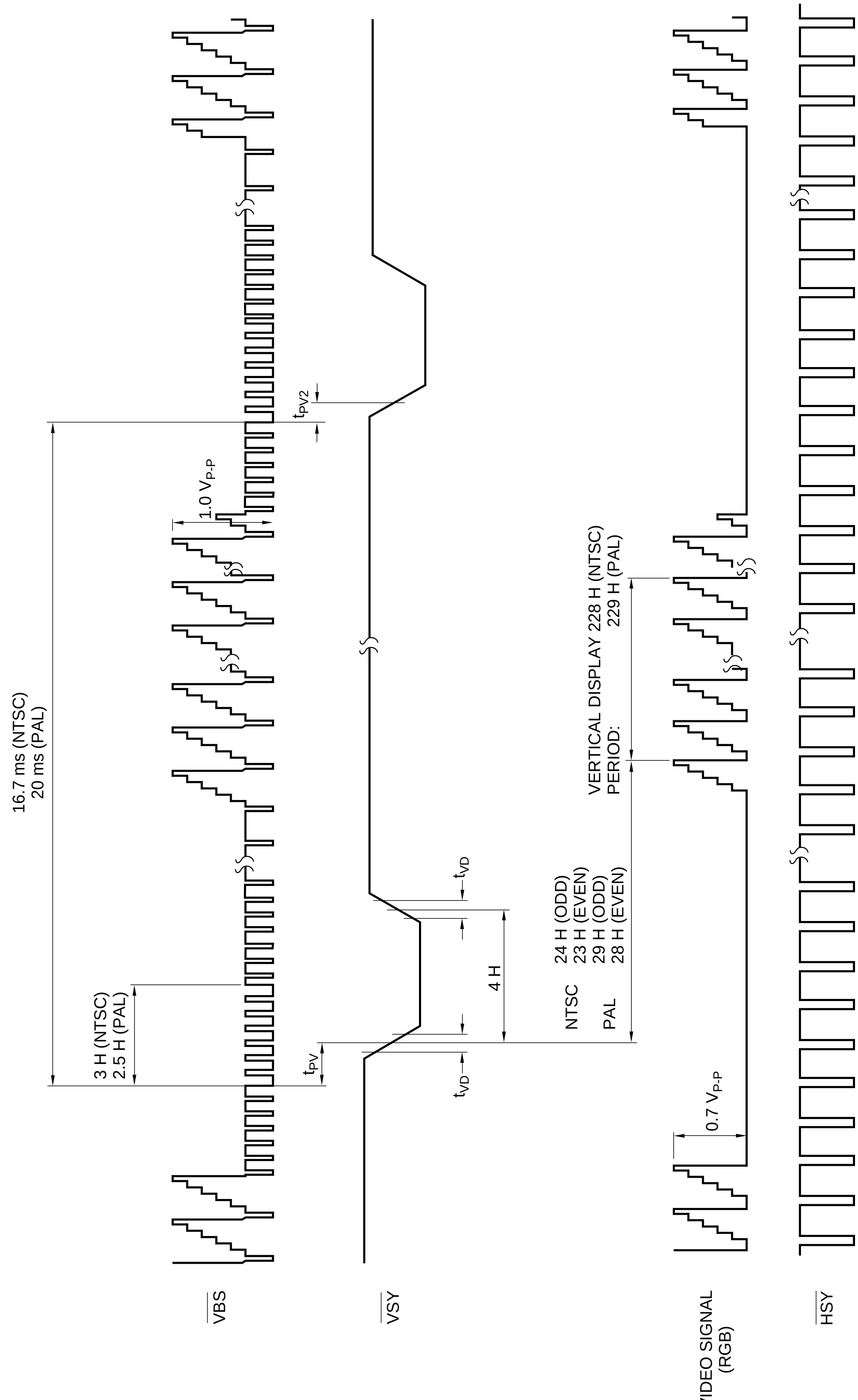
Backlight unit is composed of four tubes.

POWER CONSUMPTION (t_A = 25°C)

SYMBOL	PARAMETER		CONDITION	MIN.	TYP.	MAX.	UNIT	NOTE
I_{SH}	Power Consumption by the Panel Section	Positive Supply Current	V_{SH} = +5.0 V V_{SL} = –9.0 V	–	276	–	mA	–
I_{SL}		Negative Supply Current		–	–223	–	mA	–
W_S		Total		–	3.4	–	W	1
W_L	Power Consumption by the Fluorescent Tube Section		On rated lighting	–	8.0	–	W	2

NOTES:

1. Excludes power consumption by the backlight.
2. Calculated reference value ($I_L \times V_L$).



NOTE:
For the $\overline{VBS}$ signal, input standard composite video (or sync.) signal applicable to the operating mode selected by the N/P signal. A long time input of non-standard sync. signal may cause flicker or degradation of display quality.

Figure 5. Input/Output Signal Waveforms

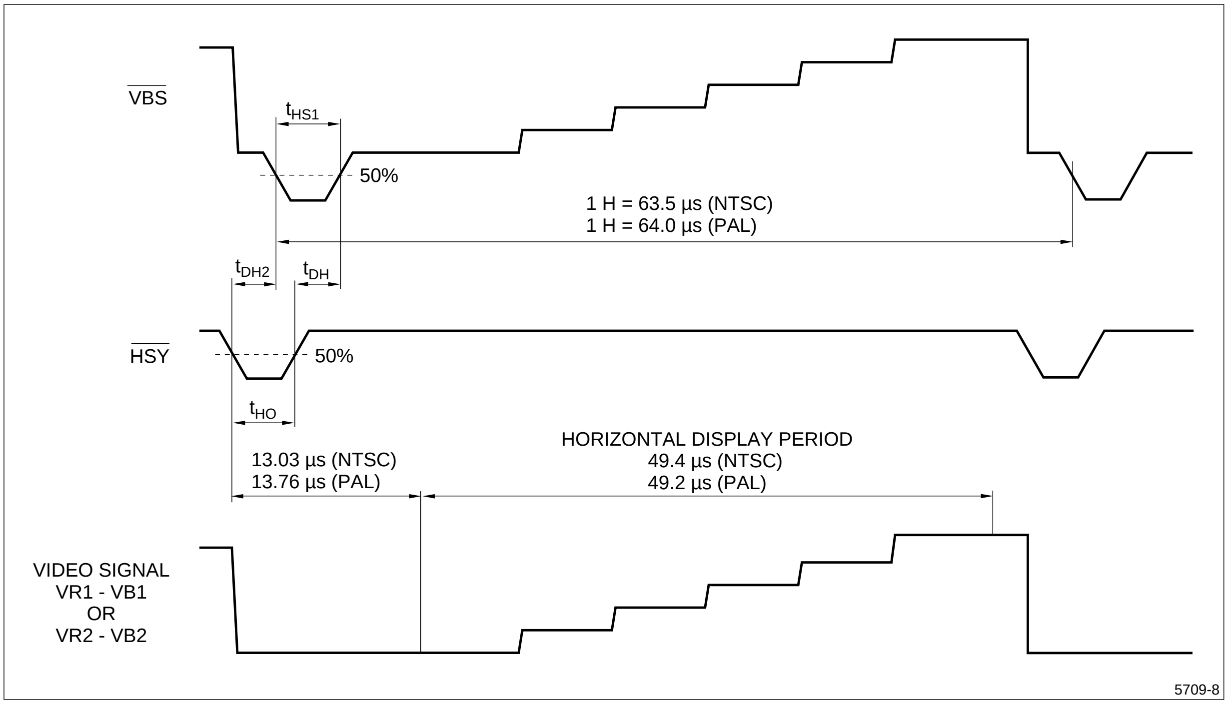


Figure 6. Input/Output Signal Timing Chart

TIMING CHARACTERISTICS – INPUT/OUTPUT SIGNALS (V_{SH} = +5.0 V, V_{SL} = –9.0 V) NTSC (M): (f_H = 15.7 kHz, f_V = 60 Hz), PAL (BG): (f_H = 15.6 kHz, f_V = 50 Hz)

SYMBOL	PARAMETER		CONDITION	MIN.	TYP.	MAX.	UNIT	NOTE
f_{HO}	Horizontal Sync Output Signal	Frequency	–	–	f_H	–	kHz	–
t_{HO}		Output Pulse Width	–	2.8	4.7	9.4	µs	1
t_{RHO}		Rising Time	–	–	–	0.5	µs	–
t_{RHO}		Falling Time	–	–	–	0.5	µs	–
t_{OH1}	H-Sync Phase Difference	Rising Edge of $\overline{HSY}$	–	–	2.3	–	µs	2
t_{OH2}		Falling Edge of $\overline{HSY}$	–	–	2.3	–	µs	–
f_{VO}	Vertical Sync Output Signal	Frequency	–	–	f_V	–	Hz	–
t_{VO}		Output Pulse Width	1H = 1/f_H	–	4H	–	µs	–
t_{RVO}		Rising Time	–	–	–	2	µs	–
t_{RVO}		Falling Time	–	–	–	2	µs	–
t_{DV1}	V-Sync Phase Difference	Odd Field	1H = 1/f_H	–	1H	–	µs	3
t_{DV2}		Even Field		–	1H	–	µs	

NOTES:

1. Will be changed by the variable resistor (H-POS).
2. Phase difference between $\overline{HSY}$ and $\overline{VBS}$ (positive when $\overline{HSY}$ proceeds $\overline{VBS}$).
3. Phase difference between $\overline{VSY}$ and $\overline{VBS}$ (positive when $\overline{VBS}$ proceeds $\overline{VSY}$).

Display Time Range

When sync signal of NTSC (M) system is applied (N/$\overline{P}$ = Hi):

- Horizontally: 13.03 µs – 62.42 µs from the falling edge of $\overline{HSY}$.
- Vertically: 25H – 252H (Odd field), 24H – 252H (Even field) from the falling edge of $\overline{VSY}$.

When sync signal of PAL (BG) system is applied (N/$\overline{P}$ = Lo):

- Horizontally: 13.76 µs – 62.97 µs from the falling edge of $\overline{HSY}$.
- Vertically: 30H – 303H (Odd field), 29H – 302H (Even field) from the falling edge of $\overline{VSY}$.

NOTE: the video signals of:
(3m + 29)H/Odd field (m = 1.2 . . . 91) and
(3n + 26)H/Even field (n = 1.2 . . . 92) are thinned on the module.

OPTICAL CHARACTERISTICS (t_A = 25°C)

SYMBOL	PARAMETER	CONDITION	MIN.	TYP.	MAX.	UNIT	NOTE
$\Delta\theta$ 11	Viewing Angle Range	CR ≥ 10	30	–	–	degrees	1, 2
$\Delta\theta$ 12			10	–	–		
$\Delta\theta$ 2			45	–	–		
CR_{MAX}	Contrast Ratio	Optimum viewing angle	60	–	–	–	2, 3
t_R	Response Time – Rise		–	30	60	ms	2
t_D	Response Time – Decay		–	50	100	ms	4
Y_L	Brightness	θ = 0°	80	110	–	cd/m^2	5
K_L	Color Temperature		–	9300	–	K	
x	White Chromaticity		–	0.283	–	–	
y			–	0.297	–	–	

NOTES:

1. Viewing angle range is defined in Figure 6.
2. Applied voltage for measuring optical characteristics:
   a. V_{CDC} must be adjusted by the Flicker measuring method or the Contrast measuring method described in ‘Adjusting Method of Optimum Common Electrode DC Bias Voltage.’
   b. Brightness adjusting terminal (BRT) should be opened.
   c. Video signal of reference black level and 100% white level must be input.
3. Contrast ratio is calculated with the following formula and as shown in Figure 8:
   $$\text{Contrast ratio (CR)} = \frac{\text{Photodetector output with LCD being ‘white’}}{\text{Photodetector output with LCD being ‘black’}}$$
4. Response time is obtained by measuring the transition time of photodetector output, when input signals are applied so as to make the area ‘black’ to and from ‘white’ (Figure 7).
5. I_L = 5mA RMS × 4 tubes.

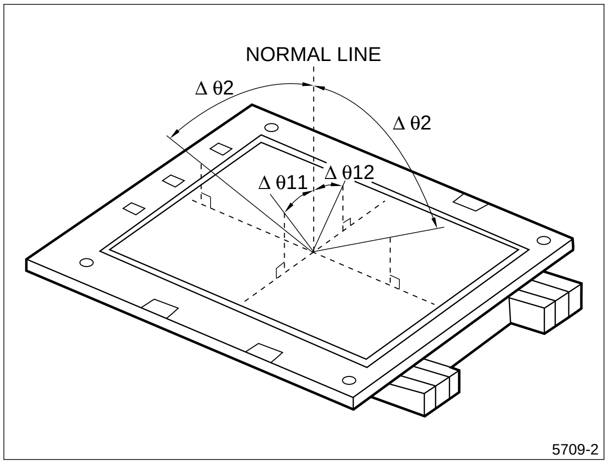


Figure 7. Viewing Angle Range

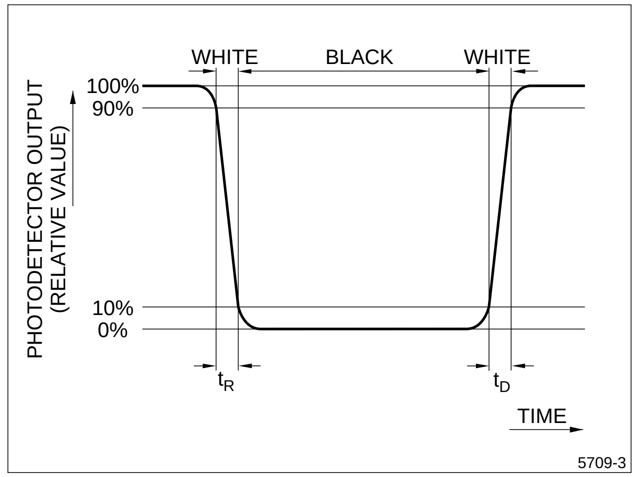


Figure 8. Definition of Response Time

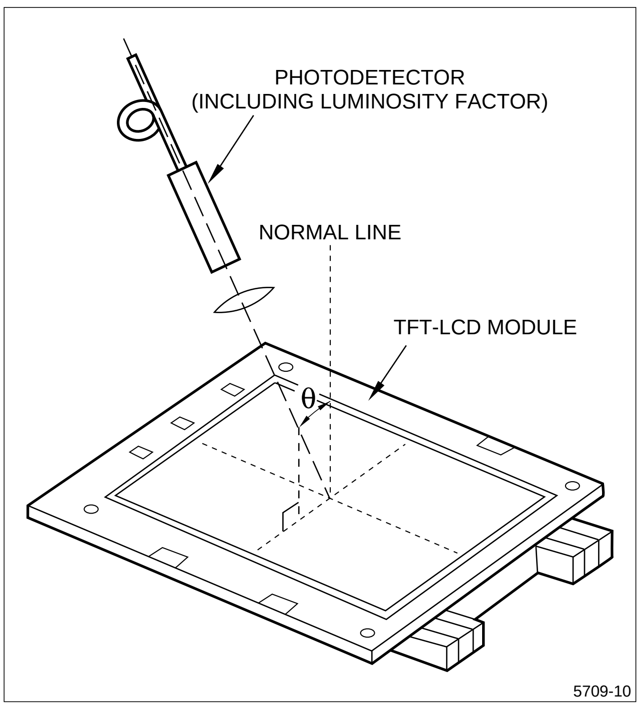


Figure 9. Optical Characteristics Measuring Method

MECHANICAL CHARACTERISTICS

External Appearance

There will not be any conspicuous defects. (See Outline Dimensions diagram.)

Panel Durability

The panel will not break when the panel center is pressed with 19.6 N force by a 15 mm diameter smooth flat surface.

CAUTION: The least force can cause functional troubles if it is applied on the active area for a long time.

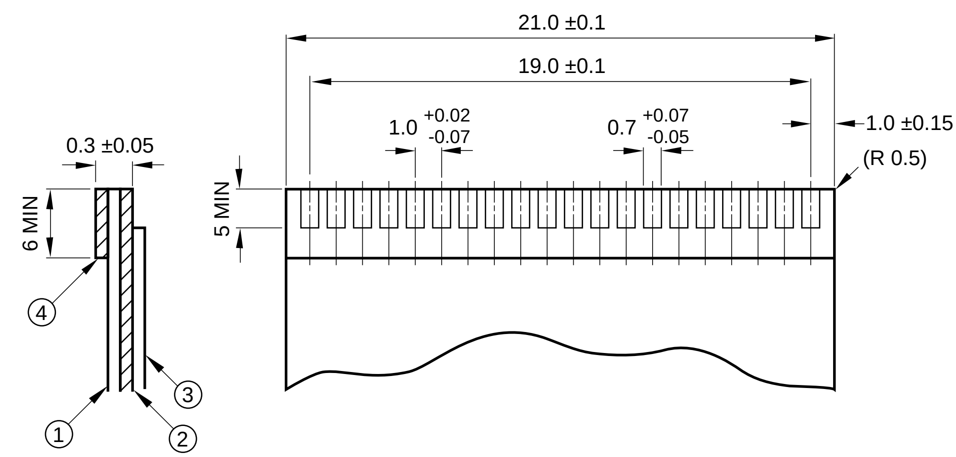
I/O Connector Performance

I/O connector of LCD panel driving circuit (FPC connector 20 pins):

- Applicable FPC: Shown in Figure 9.
- Terminal holding force: 0.98 N or larger/pin. (Each terminal is pulled out at a rate of 25 ±3 mm/minute).
- Insertion/pulling durability: Contact resistance not larger than double the initial value after applicable FPC is inserted and pulled out 20 times.

I/O Connector of Backlight Driving Circuit (EH Connector 2 Pins x 4 Pieces)

- Applicable connector housing: EHR-2 (produced by Japan Solderless Terminal).
- Terminal holding force: 0.98 N or more/pin. (Pulled out at a rate of 1 through 5 mm/second).
- Insertion/pulling durability: Contact resistance not larger than double the initial value after connectors are inserted and pulled out 20 times.



REFERENCE NUMBER	NAME	MATERIAL
①	Base Material	Polyimide or equivalent material (25 µm thick)
②	Copper foil	Copper foil (35 µm thick) solder plated in 2 µm to 12 µm thickness
③	Coverlay	Polyimide or equivalent material
④	Reinforcing plate	Polyester polyimide or equivalent material (188 µm thick)

5709-4

Figure 10. Applicable FPC for I/O Connector (1.0mm Pitch)

DISPLAY QUALITY

The display quality of the color TFT-LCD module shall be in compliance with the Delivery Inspection Standard.

HANDLING INSTRUCTIONS

Mounting of Module

The TFT-LCD module is designed to be mounted on equipment using the mounting tabs in the four corners of the module rear face. When mounting the module, use the M3 tapping screw (fastening torque is 0.490 through 0.588 Nm). Be sure to fix the module on the same plane, taking care not to warp or twist the module.

Precautions in Mounting

- The polarizer is made of soft material and susceptible to flaws. Handle carefully. A protective film (laminator) is applied on the surface to protect it against scratches and dirt. Remove the laminator just before using to avoid static electricity.

Precautions When Peeling off the Laminator

Working Environment

When the laminator is removed, static electricity may cause dust to stick to the polarizer surface. To avoid this, the following working environment is desirable:

- Floor: Conductive treatment of 1 MΩ or more on the tile or a conductive mat or conductive paint on the tile.
- Clean, dust-free room with an adhesive mat placed in the doorway.
- Humidity: 50% to 70% RH.
- Workers shall wear conductive shoes, conductive work clothes, conductive gloves, and a ground strap.

Working Procedures

- Direct the wind of the heat-ionized air discharging blower somewhat downward to ensure that the module is blown sufficiently. Keep the distance between the module and the discharging blower within 20 cm (Figure 10A).
- Attach adhesive tape to the laminator part near the discharging blower to protect polarizer against flaws (Figure 10B).
- Peel off laminator, pulling adhesive tape slowly to your side, taking five or more seconds.
- After peeling off the laminator, pass the module to the next work process immediately without getting the module dusty.
- Methods to remove dust from polarizer:
  - Blow off dust with N_2 blower for which static electricity preventive measures have been taken. Using an ionized air gun (Hugle Electronics Co.) is recommended.
  - Since the polarizer is vulnerable, wiping should be avoided. If wiping is unavoidable, wipe it carefully with a lens cleaning cloth, breathing on it. ‘Belleseime’ (Kanebo, Ltd.) is desirable.
- When metal parts of the TFT-LCD module (shielding lid and rear case) need cleaning, wipe them with a soft, dry cloth.
- Wipe liquid off immediately since it can causecolor changes or staining.
- The TFT-LCD module is made of glass plates.Use care when handling it to avoid breakage
- This unit contains CMOS LSIs which are sensitive to electrostatic charges. Protect the unit from electrostatic discharges by grounding the body.

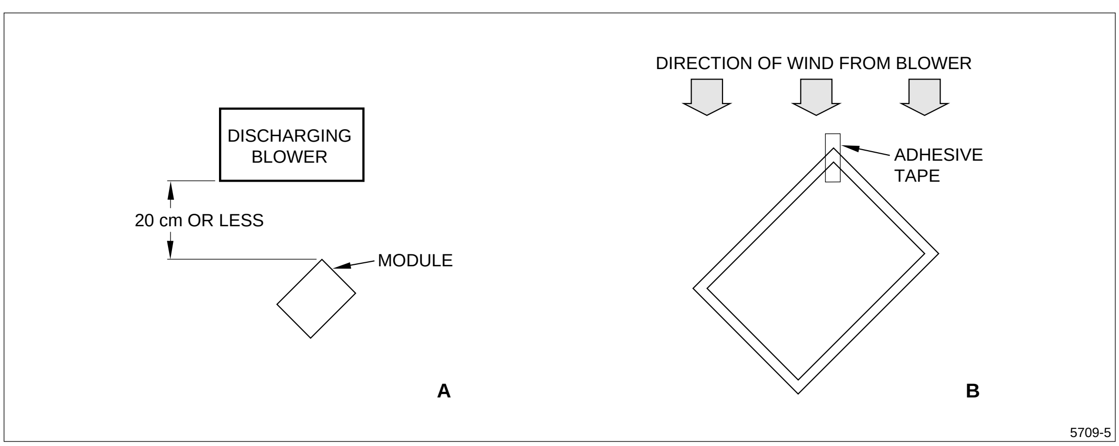


Figure 11. Heated Ionized Air Blower Precautions

Precautions in Adjusting Module

- Adjusting volumes on the rear face of the module have been set optimally before shipment. Therefore, do not change any adjusted values. If adjusted values are changed, the specifications described in this technical literature may not be satisfied.

Other Precautions

- Do not expose the module to direct sunlight or intensive ultraviolet rays for a prolonged time as liquid crystal is deteriorated by ultraviolet rays.
- Store the module at a temperature near room temperature. At lower than the rated storage temperature, liquid crystal solidifies, causing the panel to be damaged. At higher than the rated storage temperature, liquid crystal turns into isotropic liquid and may not recover.
- If the LCD panel breaks, the liquid crystal may escape from the panel. Liquid crystal is harmful, so do not put it into the eyes or mouth. When liquid crystal sticks to hands, feet, or clothes, wash it off immediately with soap.
- Observe all other precautionary requirements in handling general electronic components.

SHIPPING REQUIREMENTS

The packing form is shown in Figure 11.

Carton Storage Conditions

- Number of layers of cartons in pile: 10 layers maximum.
- Environmental conditions:
  - Temperature: 0°C to 40°C.
  - Humidity: 60% RH or less (at 40°C). No dew condensation even at a low temperature and high humidity.
  - Atmosphere: Harmful gases such as acid and alkali which corrode electronic components and wires must not be detected.
  - Storage Period: Approximately three months.
  - Opening of Package: To prevent the TFT-LCD module from being damaged by static electricity, adjust the room humidity to 50% RH or higher and provide an appropriate measure for electrostatic grounding before opening the package.

Result Evaluation Criteria

Under the display quality test conditions with normal operating state, there shall be no change which can affect practical display function.

OTHER INFORMATION

If any problem arises from this specification, the supplier and the user should work out a mutually acceptable solution.

Table 1. Reliability Test Items for TFT-LCD Module

NUMBER	TEST ITEM	CONDITIONS
1	High Temperature Storage Test	t_A = 60°C, 240 H
2	Low Temperature Storage Test	t_A = –25°C, 240 H
3	High Temperature and High Humidity Operating Test	t_A = 40°C, 95% RH, 240 H
4	High Temperature Operating Test	t_A = 40°C, 240 H
5	Low Temperature Operating Test	t_A = 0°C, 240 H
6	Electrostatic Discharge Test	±200 V, 200 pF (0 Ω), Once for each terminal
7	Shock Test	980m/s^2 (100 G), 6 ms, ±X/±Y/±Z, three times for each direction (JIS C7021, A-7 Condition C)
8	Vibration Test	Frequency range: 10 Hz to 55 Hz Stroke: 1.5 mm Sweep: 10 Hz to 55 Hz to 10 Hz two hours for each direction of X/Y/Z (six hours total) (JIS C7021, A-10 Condition A)
9	Heat Shock Test	–25°C to +60°C/5 cycles (1 hour/cycle) (0.5 H) (0.5 H)

NOTES:
t_A = Ambient Temperature
t_P = Panel Temperature

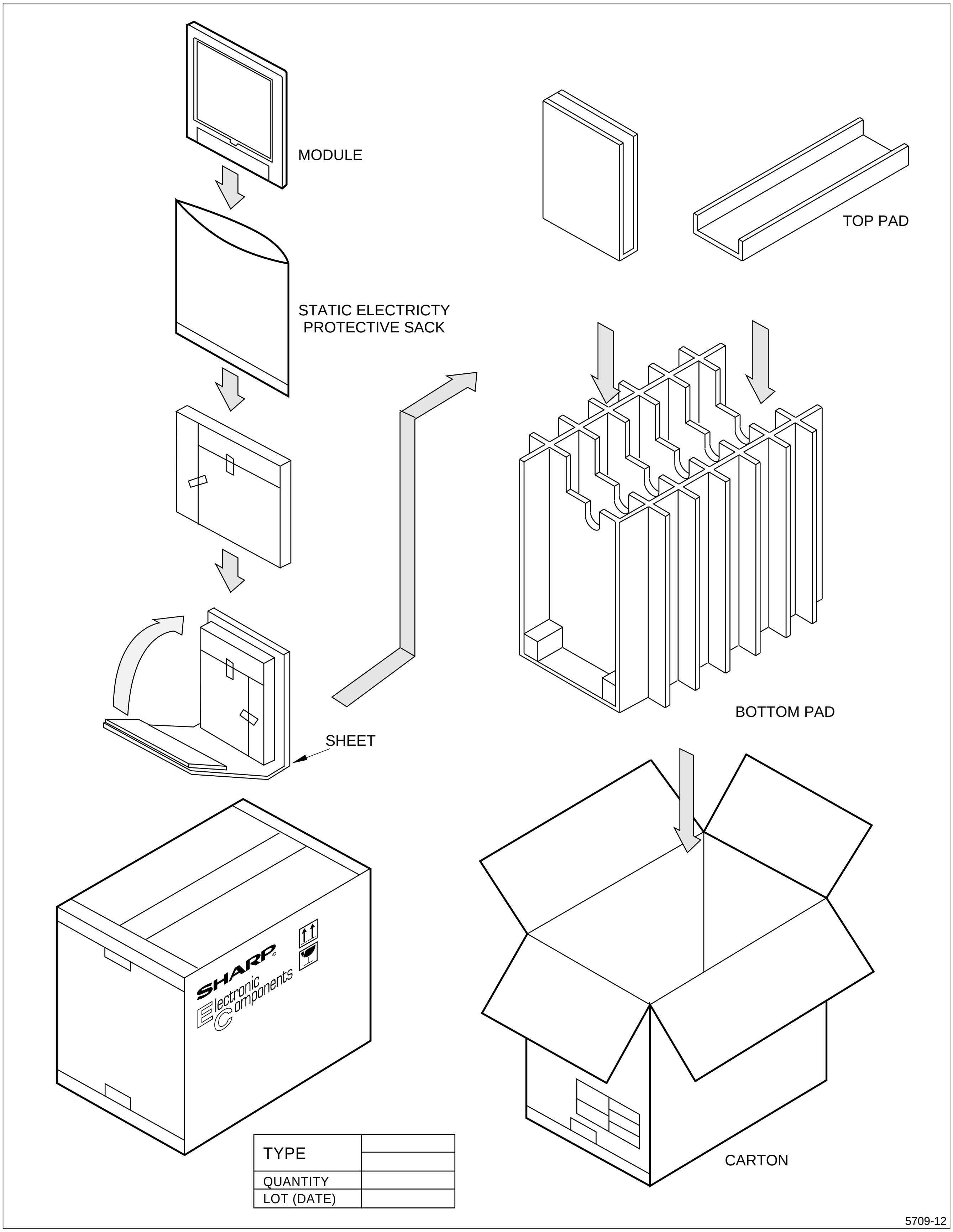


Figure 12. Packing Form

CONSTRUCTION OF TFT-LCD MODULE

The circuit diagram is shown in Figure 1.

TFT-LCD module is composed of an LCD panel, driver ICs, a control circuit for the driver ICs, a video signal processing circuit (video interface circuit) unique to the LCD, and a backlight (Figure 12).

The driver ICs are divided into two types: a source driver (data driver) which receives RGB signals and sends them sequentially by one horizontal line of the LCD panel, and a gate driver (scan driver) which scans 240 gate lines of the LCD panel.

The module displays an image on the LCD panel as it receives power supplies (V_{SH}, V_{SL}), composite video signal, RGB video signals, DC bias voltage of common electrode driving signal (V_{CDC}), selection signal of composite and RGB video signals (VSW), brightness adjusting DC voltage (BRT), color gain adjusting DC voltage (COL), tint adjusting DC voltage (TIN), and contrast adjusting DC voltage (CNT), from the exterior.

The composite video signal is subject to synchronous separation in the module and used to write a video signal accurately on each pixel on the module.

The control circuit receives composite synchronizing signal separated in the video interface circuit, generates clock pulses synchronized with the composite synchronizing signal and driving signals for gate and source drivers, and outputs internal horizontal synchronizing signal ($\overline{\text{HSY}}$), internal vertical synchronizing signal ($\overline{\text{VSY}}$), and polarity inversion signal (FRP).

The voltage level of RGB video signals applied to the liquid crystal layer of each pixel through the source driver IC and TFT is about 3.7 V_{P-P} from black to white level. In order to prevent the electro-chemical decomposition of the liquid crystal, it is necessary to apply AC voltage to the liquid crystal. For this purpose, the polarity of the video signals must be alternated. Since the amplification and polarity inversion of the video signals are performed in the video interface circuit in the module using the polarity inversion signal (FRP), composite video signal of 1.0 V_{P-P} or standard analog RGB signals of 0.7 V_{P-P} may be used for both of the inputs to the module.

Power supplies to this module are 5 V (V_{SH}), 0 V (GND), and –9 V (V_{SL}). Control IC operates on a 0 V to 5 V line so that it outputs $\overline{\text{HSY}}$ and $\overline{\text{VSY}}$ at 0 V to 5 V level. Power supplies to the video interface circuit are V_{SH} and V_{SL}.

VSW is used to select composite or RGB video signals. VSW selects composite video signal when it is 'High' or open, and selects RGB signals when it is 'Low'.

N/$\overline{\text{P}}$ is used to select display mode.

When it is 'High' or open, the module operates in NTSC (M) mode, and when it is 'LOW,' the module operates in PAL (BG) mode.

BRT and V_{CDC} are adjusted to the optimum value on shipping.

The module contains backlight (hot cathode fluorescent tubes) but not a driving circuit for the backlight. Therefore, it is necessary to install a DC/AC inverter for driving the fluorescent tubes.

EXAMPLE OF TFT-LCD TV

Figure 13 shows a block diagram example of the TFT-LCD module applied to a TV set. The block enclosed by the dotted line is the TFT-LCD module. Other signal-processing systems are the same as those in ordinary CRT-TVs.

The following seven signals must be supplied to this module from the exterior:

- Composite video signal: $\overline{\text{VBS}}$
- Standard analog RGB video signals in two sets
- Signal for selecting input video signals: N/$\overline{\text{P}}$
- Signal for selecting input video signals: VSW
- DC bias voltage of common electrode driving signal: V_{CDC}
- Brightness adjusting DC voltage: BRT

The following two signals are output from this module to the exterior:

- Internal horizontal synchronizing signal: $\overline{\text{HSY}}$
- Internal vertical synchronizing signal: $\overline{\text{VSY}}$

When this module is applied to a TV set, for example, $\overline{\text{HSY}}$ and $\overline{\text{VSY}}$ are used to display selected channel number and characters on the screen.

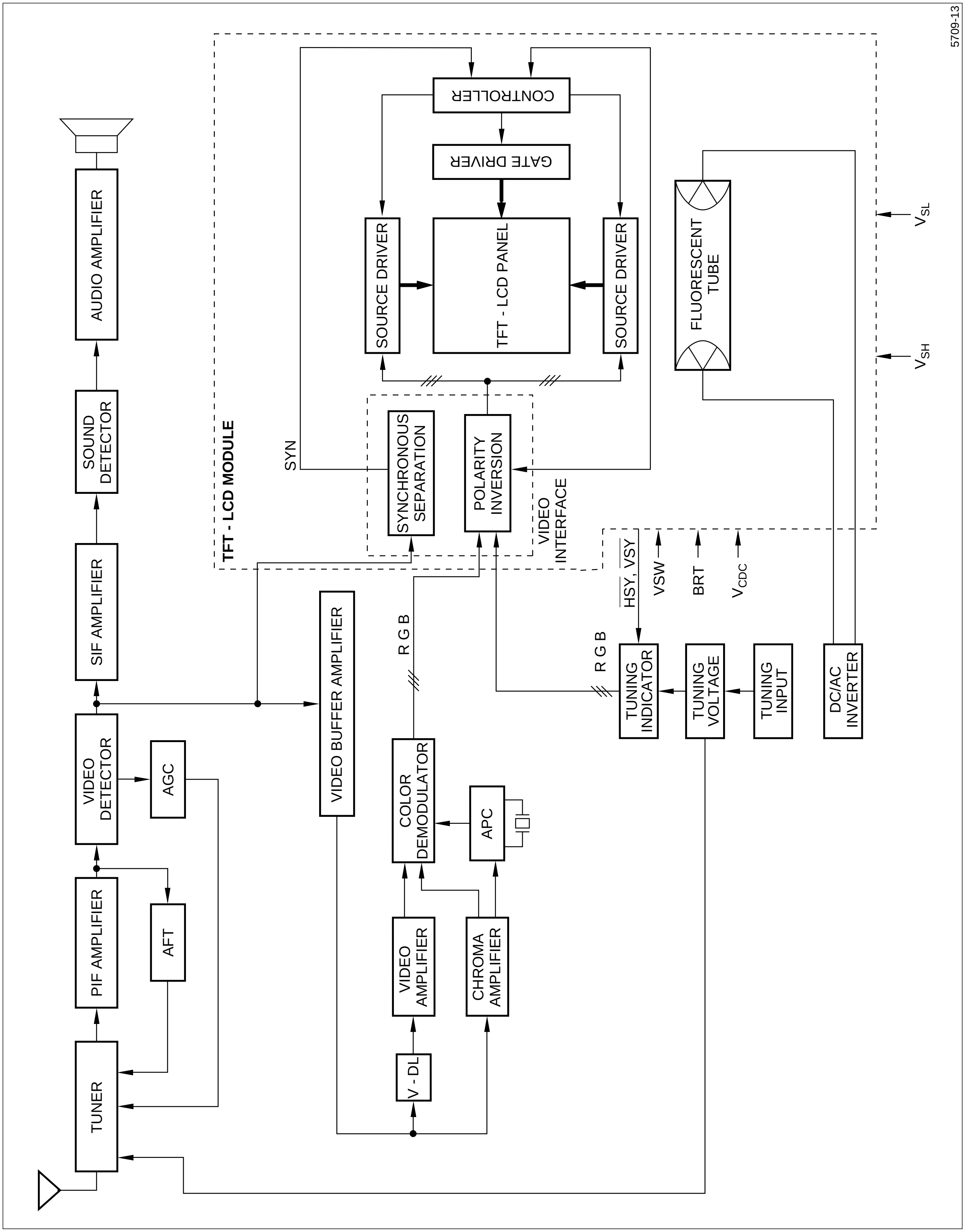


Figure 13. Block Diagram of TFT-LCD TV Set

ADJUSTING METHOD OF OPTIMUM COMMON ELECTRODE DC BIAS VOLTAGE

To obtain optimum DC bias voltage of common electrode driving signal (V_{CDC}), photoelectric devices are very effective, and the accuracy is within 0.1 V. (In a visual examination method, the accuracy is about 0.5 V because of the difference among individuals.)

To gain optimum common electrode DC bias voltage, there are two methods which use photoelectric devices. The value of optimum DC bias voltage is the same in both methods:

- Measurement of Flicker: DC bias voltage is adjusted to minimize NTSC: 50 Hz (30 Hz), PAL 50 Hz (25Hz) flicker.
- Measurement of Contrast: DC bias voltage is adjusted so as to minimize the photoelectric output voltage.

Measurement of Flicker

Photoelectric output voltage is measured by an oscilloscope in a system similar to that shown in Figure 14.

DC bias voltage must be adjusted to minimize the NTSC: 50 Hz (30 Hz), PAL: 50 Hz (25Hz) flicker with DC bias voltage changing slowly (Figure 15).

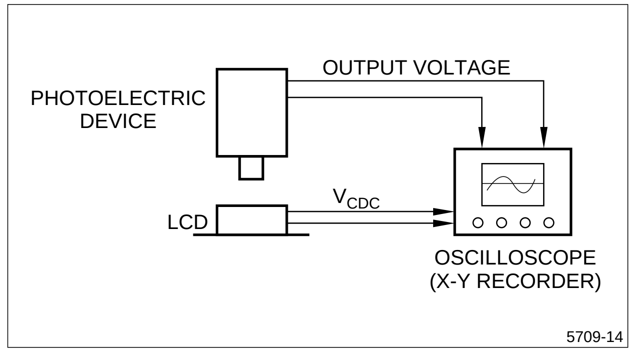


Figure 14. Measurement System

Measurement of Contrast

Photoelectric output voltage is measured by oscilloscope or X-Y recorder by using the test setup shown in Figure 14. Common electrode DC bias voltage must be adjusted to minimize the photoelectric output voltage with DC bias voltage changing slowly (Figure 16).

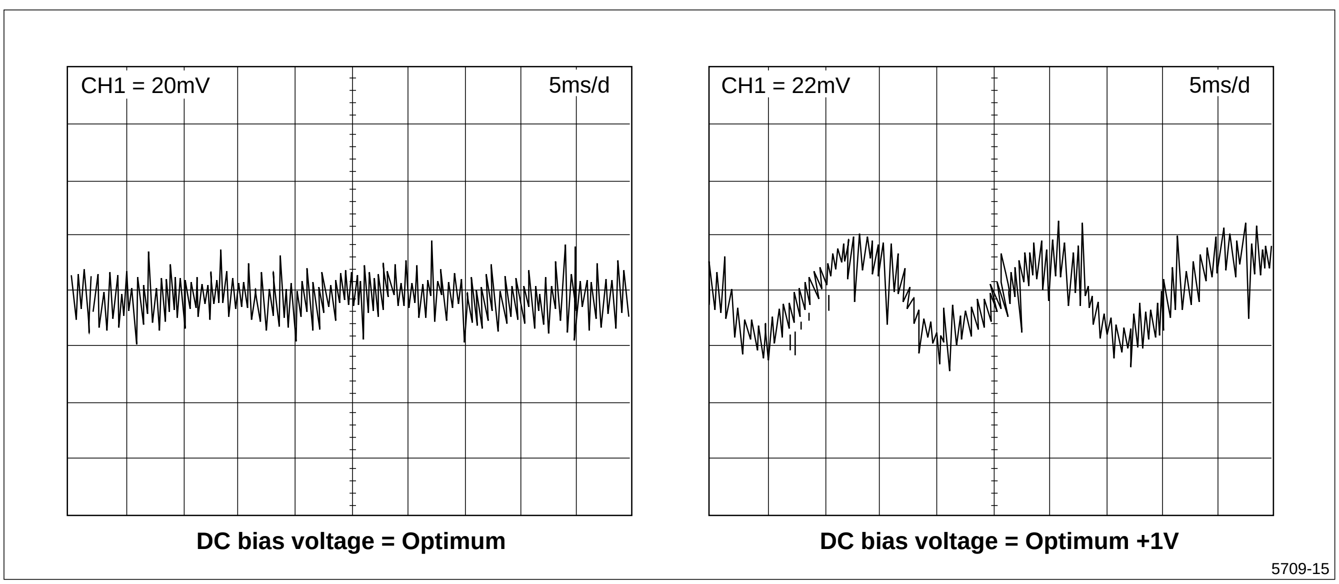
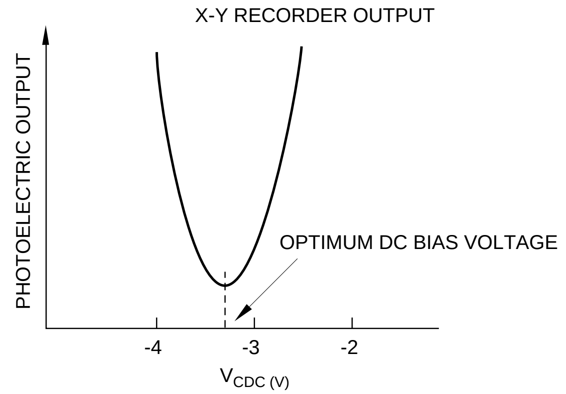


Figure 15. Waveforms of Flicker



NOTES:
1. Measurement is more accurate at half tone as compared with other gradation level. Change of photoelectric output is small at black level. (See Figure 17)
2. DC bias voltage must be adjusted slowly. The value of optimum common electrode DC bias changing fast is different from the one changing slowly because DC response is slow. (See Figure 18)
3. The final adjustment of DC bias voltage must be made by changing from positive to negative.

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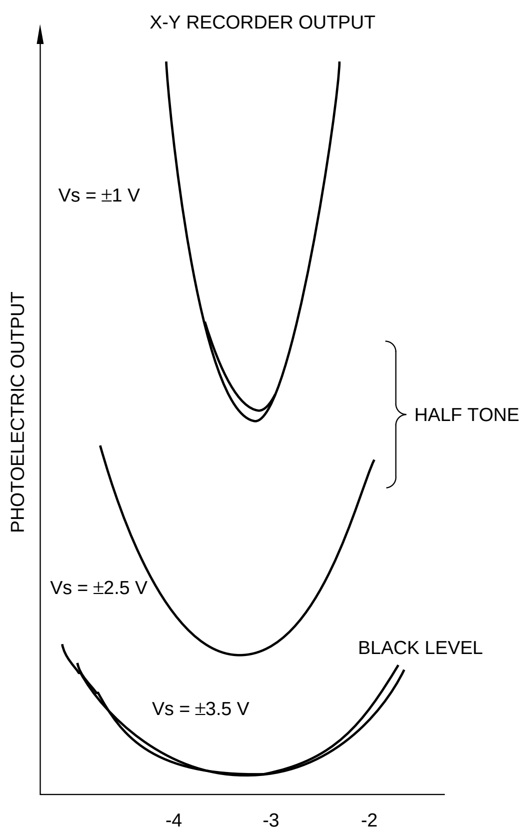
Figure 16. Optimum Common Electrode DC Bias Voltage by Measurement of Contrast



NOTE: Optimum common electrode DC bias voltage is almost equal between halftone and black level. It is difficult to decide the optimum point at black level.

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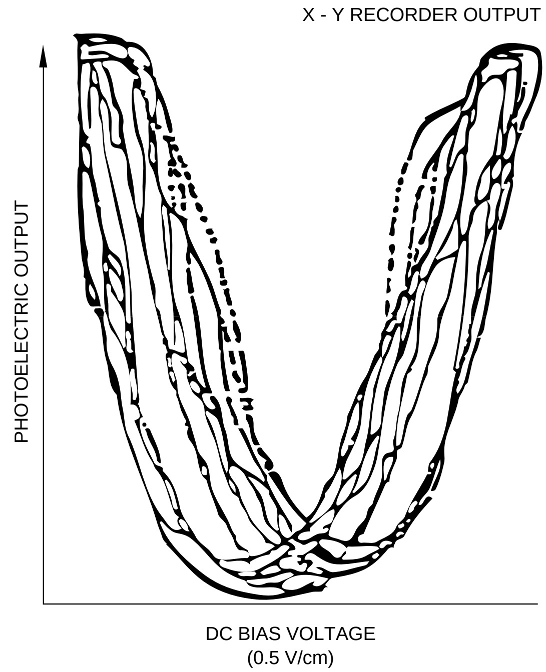
Figure 17. Relation Between Gradation Level and DC Bias Voltage



NOTE: The value of the minimum point is not definite because DC response is slow and the optimum point can not be attained.

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Figure 18. Output Voltage with DC Bias Voltage Changing Fast

OUTLINE DIMENSIONS