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PULNiX

TM-745i/TM-765i
AUTO SHUTTER CAMERA

OPERATIONS MANUAL

REV. 12/95

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SECTION 1 FEATURES AND APPLICATIONS

HIGH RESOLUTION, INTERLINE TRANSFER CCD

The TM-745i is a state-of-the-art CCD camera which uses a 2/3 inch high resolution imager. This unit offers outstanding compactness, high performance, long life, high stability as well as a number of technical innovations such as variable electronic shutter and random CCD integration. Its diversified features allow for versatile applications such as machine vision and image processing, robotics, medical, and surveillance applications.

AUTOMATIC ELECTRONIC SHUTTER AND RANDOM CCD INTEGRATION

The TM-745i has a substrate drain-type shutter mechanism which provides a superb picture at various speeds without smearing. The camera has the capability to adjust its shutter speed automatically in variable lighting conditions, as well as externally vary the electronic shutter rate via a manually controlled BCD switch from 1/60 to 1/10,000 sec. in discrete steps (1/31,000 sec. optional). Full frame integration is possible through special modifications.

MINIATURIZED AND LIGHTWEIGHT

All PULNiX cameras are built with the same design principles; solid state technology miniaturization (including lenses, housings, and cables), and specialization (such as remote imager and image intensified camera versions). The use of a CCD image sensor in the video camera module and the development of special mini C-mount lenses makes it possible to produce a very compact, lightweight, and robust series of cameras.

LONG LIFE: A THREE YEAR WARRANTY

The CCD solid state image sensor allows the camera to maintain a superior performance level indefinitely while requiring virtually no maintenance. PULNiX backs all of the TM series cameras with a three year warranty.
WARNING: Unscrewing the camera cover or opening the camera in any way will void this warranty.

PRECISE IMAGE GEOMETRY

On the CCD image sensor, the photosensor elements form exact rows both horizontally and vertically so that a very precise image geometry may be obtained. Moreover, the TM-765i version image sensor features uniform square pixels (11 x 11 microns) making it an obvious choice for use with computer image processing systems or for precise pattern measurements and gauging.

LOW LAG AND HIGH RESISTANCE TO IMAGE BURNING

Compared to the lag of conventional cameras which use a pickup tube, the lag of a CCD camera is considerably reduced so that a clear picture may be obtained when shooting a rapid moving object, or when shooting in a low illumination environment. Since the CCD is highly resistant to image burning, the camera may be exposed to bright objects for a long period of time. It must be noted that a "smear" phenomenon may occur when shooting a very bright object. An infrared cutoff filter is recommended to obtain a clear picture.

HIGH SENSITIVITY

The TM-745i is one of the most low light sensitive CCD cameras available today. This is especially important when using the faster shutter speeds. The CCD detects images into the near infrared. It requires only 0.5 lux of minimum illumination and 0.2 lux minimum illumination at maximum gain. In general, such a low light camera allows use of a higher lens F-value and provides greater depth of field and sharper images.

HIGH RESISTANCE TO MAGNETIC FIELDS AND VIBRATION/MECHANICAL SHOCK

Due to its ruggedized design, the CCD imager can withstand strong vibration and shock, and little or no noise will appear in the picture. Since the TM-745i camera is not influenced by a magnetic field, it will produce stable images even when placed next to objects such as electric furnaces, welding machines, or NMR scanners.

QUICK START-UP AND LOW POWER CONSUMPTION

No more than a half second is needed for the TM-745i to warm up, and shooting may begin within a second after turning on the camera. The power consumption is only 4.0W. This makes the cameras excellent for use with battery operated systems.

GENLOCK CIRCUIT

A genlock circuit is built into the TM-745i to accept external sync for industrial applications as well as for surveillance locking. This flexible genlock will take either interlace or non-interlace H and V sync.

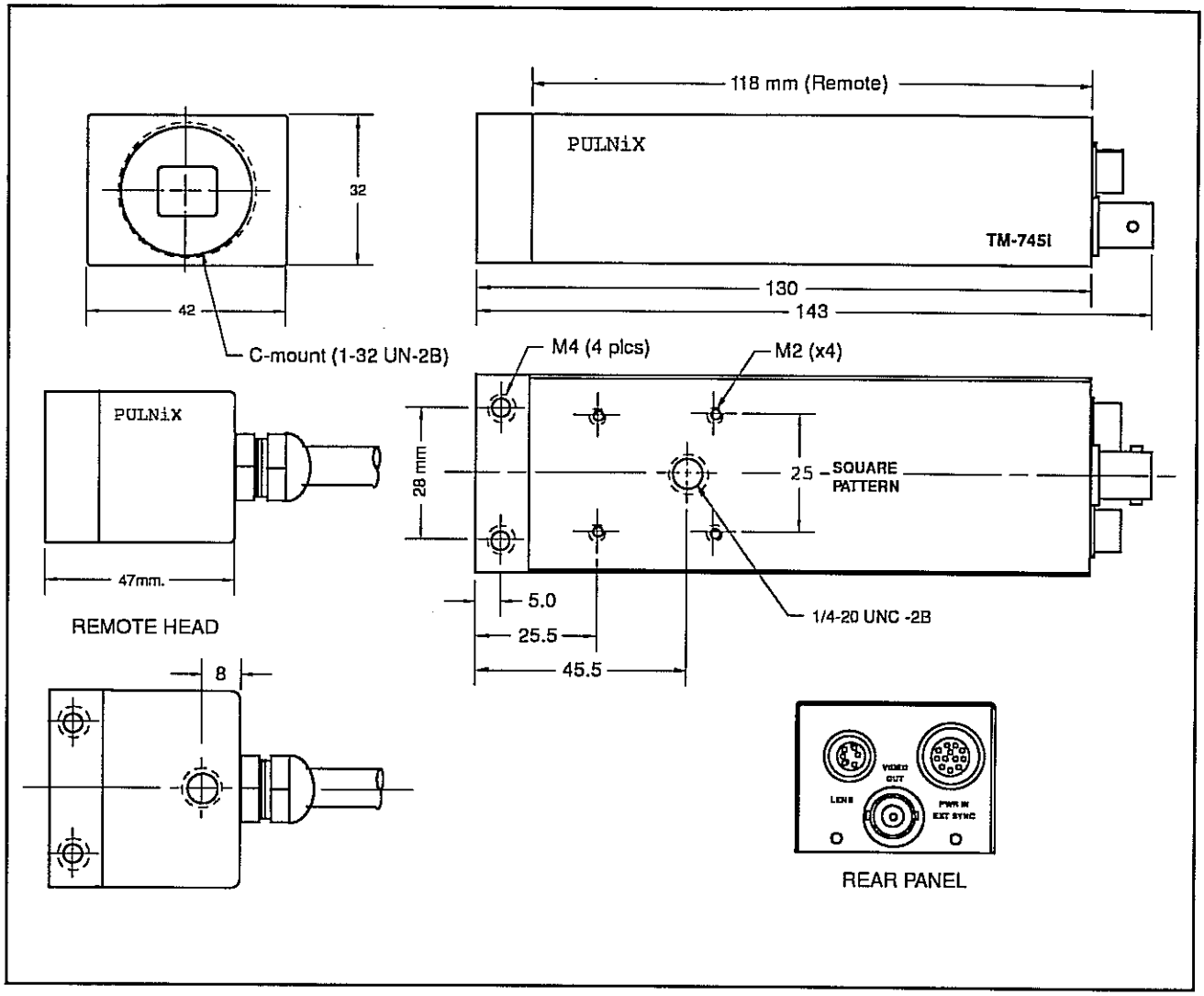
AGC SELECTION, MANUAL GAIN CONTROL AND GAMMA ADJUSTMENT

The AGC (automatic gain control) may be switched internally from automatic to fixed gain. Gamma may be set either to 1 or to maximum compensation 0.45.

SECTION 2 SPECIFICATIONS

Imager:	2/3 inch interline transfer CCD
Pixels	768 (H) x 493 (V) - TM-745i
	756 (H) x 581 (V) - TM-765i
Cell size	11.0 (H) x 13.0 (V) microns - TM-745i
	11.0 (H) x 11.0 (V) microns - TM-765i
Sensing area	8.8 (H) x 6.6 (V) mm
Dynamic range	67dB
	Low noise, blooming suppression
Chip size	10.0 mm (H) x 8.2 mm (V)
Scanning:	525 lines, 2:1 interlace - TM-745i (EIA)
	625 lines, 2:1 interlace - TM-765i (CCIR)
Clock	28.6363 MHz - TM-745i
	28.375 MHz - TM-765i
Pixel clock	14.31818 MHz - TM-745i
	14.1875 MHz - TM-765i
Horizontal frequency	15.734 KHz - TM-745i
	15.625 KHz - TM-765i
Vertical frequency	59.94 Hz - TM-745i
	50.0 Hz - TM-765i
Sync:	Internal/external auto switch
External sync:	H_D/V_D, 4.0V p-p, 4.7KΩ impedance
	Frequency tolerance - within ±5%
	Interlace/non-interlace
	Jitter within 20 nsec. Locking time within 2 sec. (when power is on)
TV resolution:	570(H) x 350(V) lines - TM-745i
	560(H) x 420(V) lines - TM-765i
Video output:	1.0V p-p composite video, 75Ω
S/N ratio:	50 dB min. (AGC = off)
Minimum illumination:	0.5 lux (F=1.4) without IR cut filter
AGC:	On (16dB standard, 32dB max) / Off
Gamma:	0.45 or 1
Shutter:	Automatic from 1/60 to 1/31000 sec
Lens mount:	Special mount with C-mount ring
Power requirement:	DC 12V ± 10%, 350mA
Operating temperature:	-10 °C to +50 °C
Storage temperature:	-30 °C to +60 °C
Operating humidity:	Within 70%
Storage humidity:	Within 90%
Vibration:	7G (200Hz to 2000Hz)
Shock:	70G
Dimensions:	42mm x 32mm x 130mm (1.65" x 1.26" x 5.12")
Weight:	190 grams

SECTION 3 PHYSICAL DIMENSIONS



SECTION 4 SETUP AND OPERATION

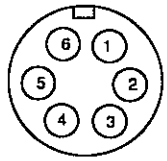
The operation of the TM-745i requires a lens (special or standard C-mount), a 12V DC regulated power supply, power and video cable assemblies and, if needed, a shutter control unit (optional shutter output is required). Setup of the camera system is as follows:

4.1 LENS MOUNT

The TM-745i cameras have a mini-bayonet mount or a C-mount adapter attached to the imager portion of the camera. C-mount lenses are mounted by carefully threading the lens into the mount in a clockwise direction. Turn the lens until completely seated on the mount. Most all standard C-mount lenses should fit the TM-745i. However, some specialized lenses may have an extremely long flange back which exceeds the mounting depth of the camera. Do not force a lens which does not appear to fully seat. Lens extension tubes such as the CR-5, CR-10, and CR-20 are used by attaching first to the lens and then mounting the entire assembly to the camera. CS style lenses, though they share the common C-mount thread, are not compatible with the standard TM-745i mount due to a different rear focus specification for the CS format. Consult PULNiX for further information.

4.2 AUTO-IRIS LENSES

Although the TM-745i has a built in auto shutter which works like an auto-iris lens, auto-iris lenses can be used Connect +12V DC, GND and Iris out to each pin as indicated in the following.



Auto-Iris output from 6-pin connector

4	Power to lens..... +12V out
3	Iris control..... IRIS OUT
2	GND ..... GND

*standard model only

4.3 SHUTTER CONTROL

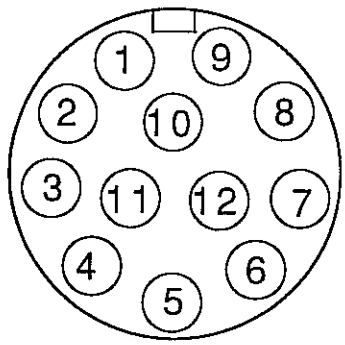
4.3.1 **Automatic mode:** Factory set mode for auto-shutter. It adjusts the shutter speed with the video signal level. The shutter speed range is 1/60 sec. to 1/ 31500 sec. AGC must be on.

4.3.2 **1/1000 sec. Hold mode:** When IDLE pin (#10 pin) of the power board is pulled down to GND, the shutter speed is kept at a fixed speed (1/1000 sec std.). This mode is useful when the camera is momentarily covered and then exposed to bright light. This speed is programmable as a custom spec.

4.3.3 **Manual mode:** When jumper W8 of the driver board is set to the " manual position", the shutter works as a standard manually switched shutter. (This is described on page 8.)

4.4 POWER CABLES AND POWER SUPPLIES (Standard model)

The TM-745i uses a 12-pin power connector (HR10A-10R-12P). Connect the #2 pin to the +12V of the power supply and connect #1 pin to the power supply's ground. Make sure all other leads are not touching as this will cause the camera to malfunction. When powering the camera, use only a regulated 12VDC power supply. The TM-745i has a voltage intake range of 11V to 16V max. If unregulated voltage or voltage lower than 11V is applied, noise will appear on the monitor.



12-PIN Connector

1. GND	7. V_D In
2. +12V DC	8. GND
3. GND	9. H_D In
4. Video Out	10. IDLE*
5. GND	11. Integration Control
6. VINIT	12. GND

NOTE: * IDLE: 1/000 sec. shutter when #10 is low.

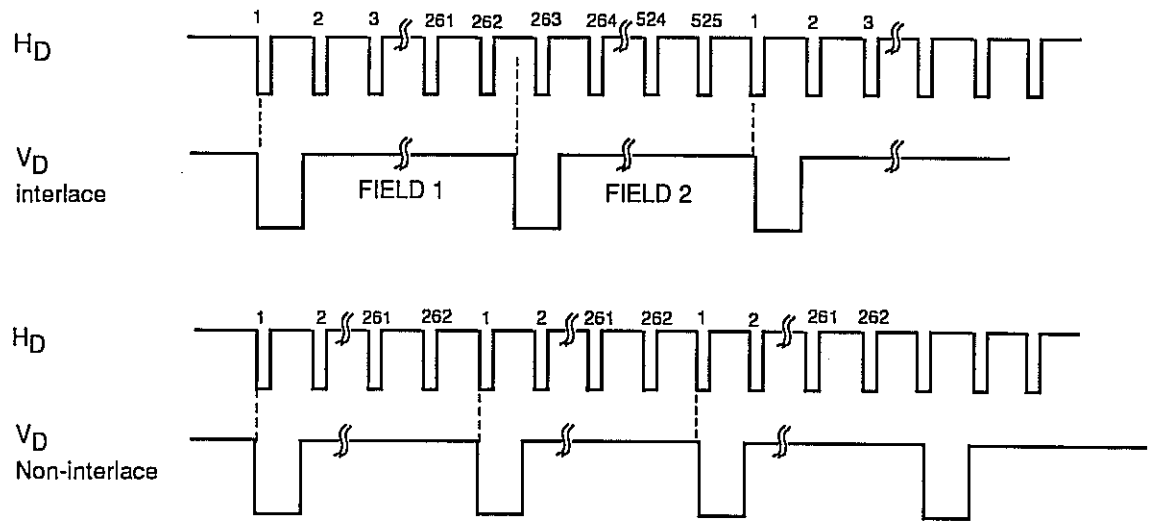
4.5 VIDEO OUTPUT

The video output impedance of the camera is 75Ω and requires a coaxial cable with matching impedance. The end of the video cable or the monitor must be terminated at 75Ω as well. Standard video cable with proper video connectors may be obtained at most electronics hardware stores. Connect one end of the video cable into the standard video connector located on the back of the camera and attach the other end of the cable to the CCTV monitor input.

4.6 EXTERNAL SYNC

The TM-745i does not require external sync in order to run directly into a CCTV monitor. However, some applications (such as multiple camera switching and some vision systems) will require that the camera be externally synced. The unit has a built-in genlock circuit which will accept an external H_D and V_D sync signal; the built-in phase lock loop (PLL) adjusts its internal frequency to lock the camera to the external sync by allowing the internal crystal oscillator to automatically switch to a voltage controlled oscillator. Pins 7 and 9 of the TM-745i's 12-pin connector accept external V_D and H_D.

4.7. INTERLACE/NON-INTERLACE



Interlace sync is a standard TV sync where the vertical sync alternates the odd and even fields of a frame of video. Non-interlace sync scans one field only. The pulse relationship is shown below.

The internal genlock of the camera operates in the interlace mode. When external sync is applied, operation can be performed in either interlace or non-interlace mode by changing the input condition of the VD signal as shown above.

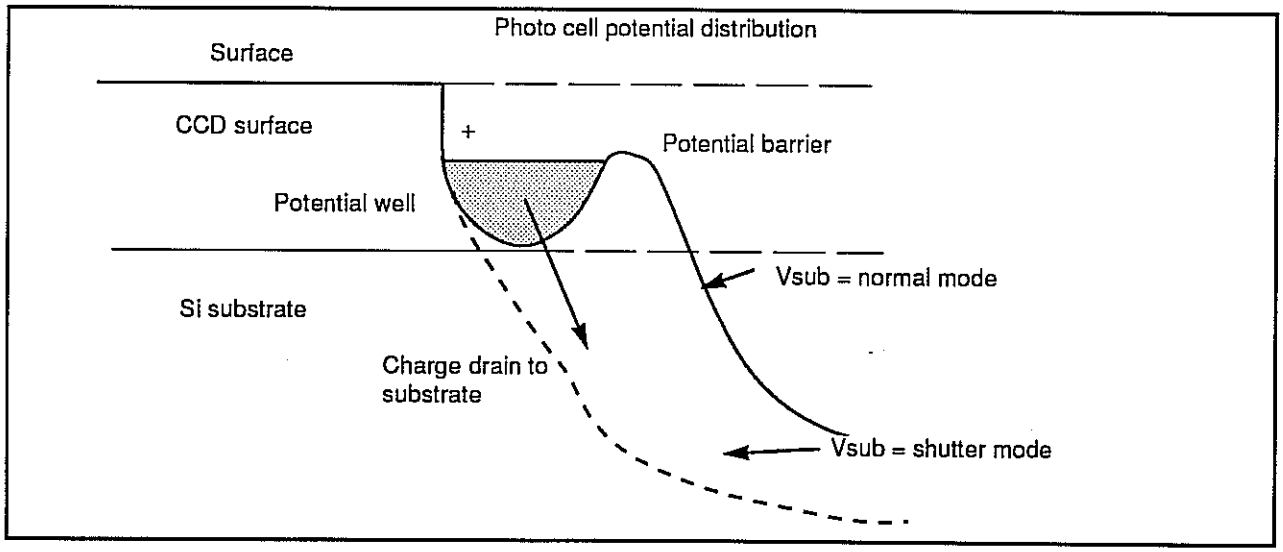
SECTION 5 TM-745i SHUTTER CAMERA INFORMATION

5.1 BCD SHUTTER CONTROL

By selecting D0, D1, D2 level high or low, the following shutter speed is obtained. PULNiX provides a shutter control (SC-745), but it is easily controlled from the computer, remote control unit, or fixed at a certain speed.

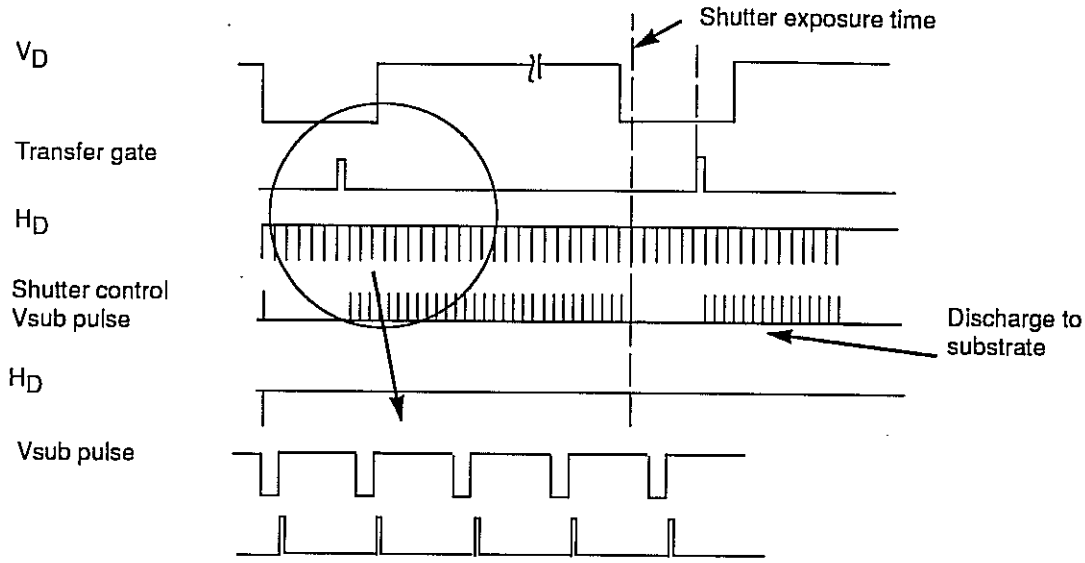
Controller Setting	0	1	2	3	4	5	6	7
sec	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000	1/10,000
D_0	L	H	L	H	L	H	L	H
D_1	L	L	H	H	L	L	H	H
D_2	L	L	L	L	H	H	H	H

Shutter control SC-745



5.2 SUBSTRATE DRAIN SHUTTER MECHANISM

Normal operation requires the CCD chip to construct an individual potential well at each image cell. These potential wells are separated from each other by a barrier. The barrier is sequentially removed to transfer the charge from one CCD to another by the pixel clock. This is the basic principle of CCD operation for interline transfer. The substrate drain vertically moves the charges. When excess potential is applied to substrate underneath each cell, a potential barrier is pulled down to release the charge into the drain. This can happen to all the cells simultaneously, whereas normal CCD shuttering is done with a horizontal charge shift to the drain area by interline transferring or reverse transferring of the frame transfer chip.



The discharge of the TM-745i is done in the horizontal blanking interval.

Note: Vertical resolution of the shutter mode is one field (244). Full frame shutter is not available. If the object is still, the interlace signal (2 fields) can generate full vertical resolution.

5.3 INTEGRATION

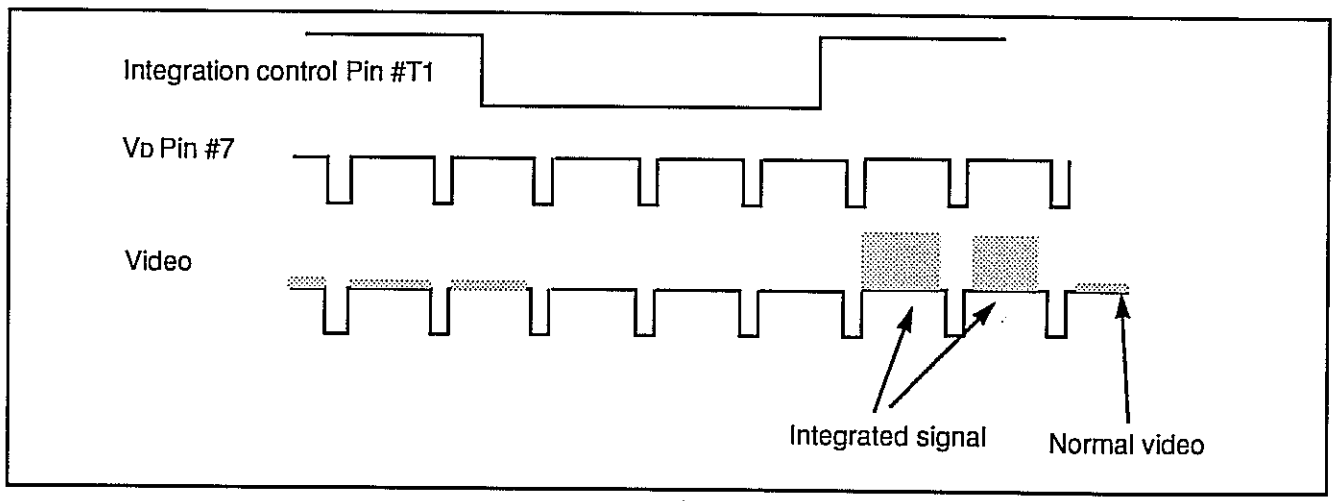
The TM-745i can operate with long exposures (Integration mode). Due to the interline transfer, full frame resolution is obtained. (Note: Full frame is not available in the shutter mode).

1. Select frame mode on driver PCB (Factory standard is FIELD MODE). If the setting is in the field mode, the shutter sensitivity can be enhanced by moving the solder jumper to the frame side.

2. Apply the integration control to low (GND) to pin #11 of the 12 pin connector. This allows the TM-745i to operate with integration.

3. Clamp pulse may need the modification based on integration period. Consult PULNiX for further information.

5.4 INTEGRATION CONTROL PULSE



SECTION 6 CCD CHARACTERISTICS AND OPERATION

6.1 THEORY OF OPERATION (Operation principle of the CCD)

A CCD (Charge Coupled Device) consists of MOS (Metal-Oxide-Semiconductor) capacitors arranged in a regular array. It basically performs three functions connected with handling charges.

1. Photoelectric conversion (photosensor)
Incident light generates charges on the MOS capacitors, with the quantity of charge being proportional to the brightness.

2. Accumulation of charges
When a voltage is applied to the electrodes of the MOS capacitors, an electric potential well is formed in the silicon layer. The charge is accumulated in this well.

3. Transmission of charge
When a high voltage is applied to the electrodes, a deeper well is formed; when a low voltage is applied, a shallower well is formed. In the CCD, this property is used to transmit the charge. When a high voltage is applied to the electrodes, a deep electric potential well is formed, and charge flows in from a neighboring well. When this is repeated over and over among the regularly arranged electrodes, the charge is transferred from one MOS capacitor to another. This is the principle of CCD charge transmission.

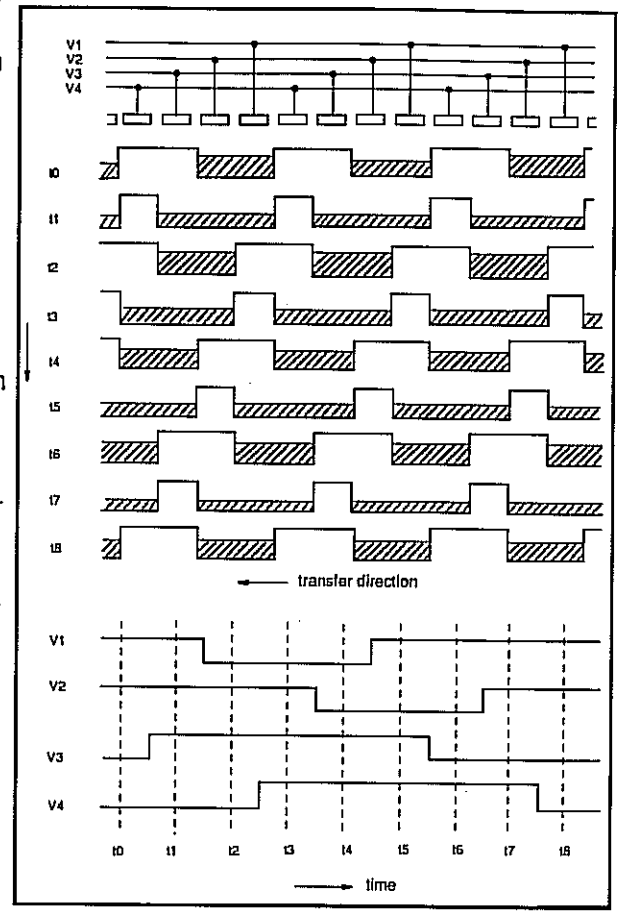


Fig. 1

6.2 MECHANISM OF CCD CHARGE TRANSFER

1. Vertical transfer
The vertical shift register transfers charges using a four-phase drive mode. Figure 1 shows an example of the changes which can occur in potential wells in successive time intervals. At tO, the electrode voltages are (V1 = V2)>(V3 = V4), so the potential wells are deeper toward the electrode at the higher voltages V1 and V2. Charges accumulate in these deep wells. At t1, the electrode voltages are (V1 = V2 = V3)>(V4), so the charges accumulate in the wells toward the electrode at V1, V2 and V3. At t2, the electrode voltages are (V2 = V3)>(V4 = V1), so the charges accumulate in the wells toward the electrode at V2 and V3. Electrode voltage states at t3 and after are shown below.
t3(V2 = V3 = V4)>(V1)
t4(V3 = V4)>(V1 = V2)
t5(V4>(V1 = V2 = V3)
t6(V4 = V1)>(V2 = V3)
t7(V4 = V1 = V2)>(V3)
t8(V1 = V2)>(V3 = V4) (Initial state)
These operations are repeated to execute the vertical transfer.

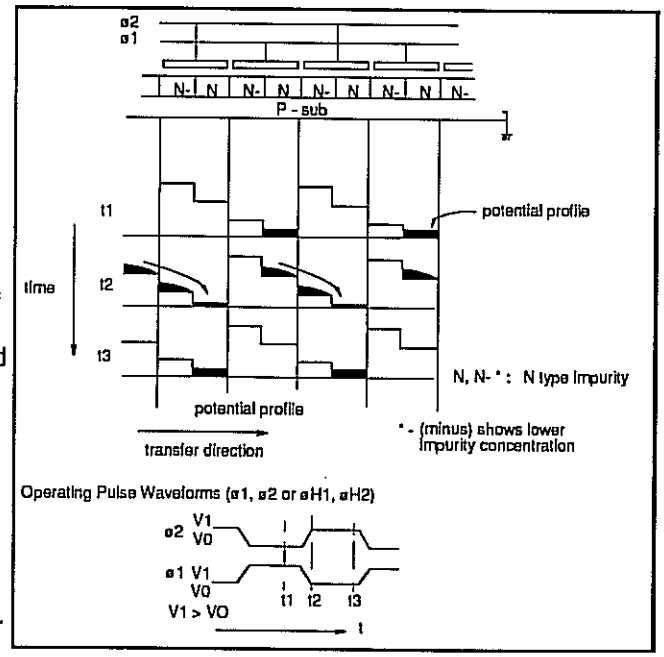
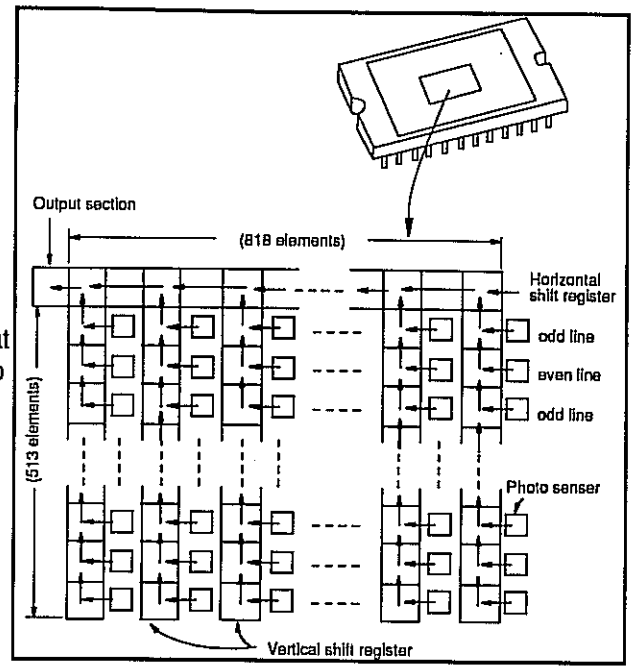


Fig. 2 The interline-transfer mechanism of the CCD

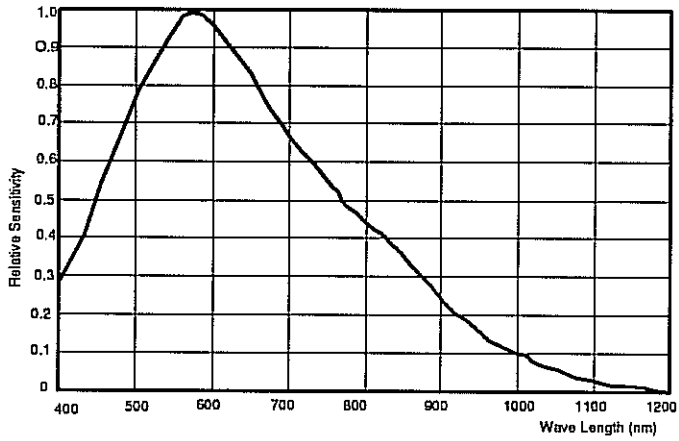
2. Horizontal transfer

The horizontal shift register transfers charges using a two-phase drive mode. Figure 2 shows an example of the changes which can occur in the potential wells in successive time intervals. At t1, the electrode voltages are H1>H2, so the potential wells are deeper toward the electrode of the higher voltage H1. The charges accumulate in these wells. At t2, the electrode voltages H1 and H2 are inverted, the wells toward the electrode at voltage H2 become deeper while the wells toward the electrode at voltage H1 become shallower. So the wells at H2 are deeper than those at H1, the charge flows into the deeper wells toward the electrode at H2. At t3, the electrode voltage has not changed since t2, so the charge flows into the wells at H2 and one transfer of charge is completed. These operations are repeated to execute the horizontal transfer.



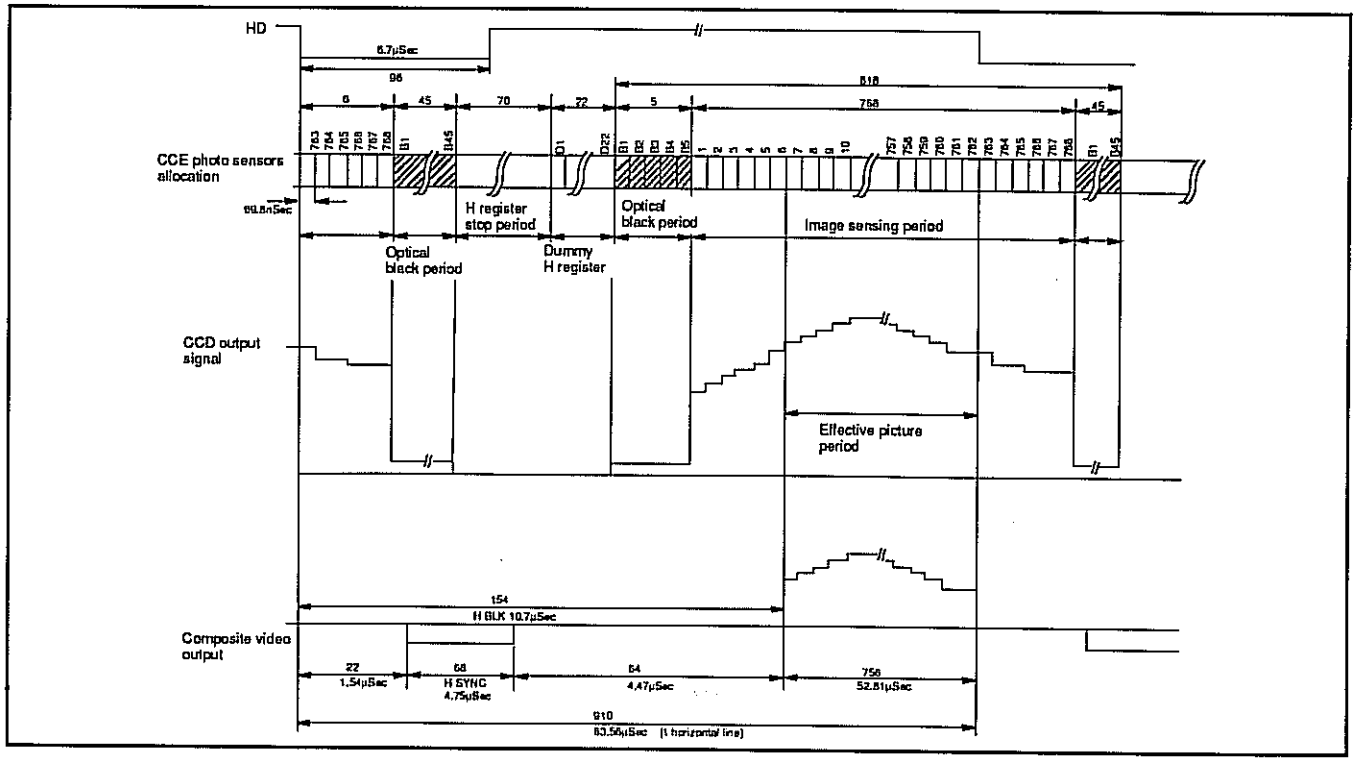
Two phase CCD charge transfer

6.3 SPECTRAL RESPONSE

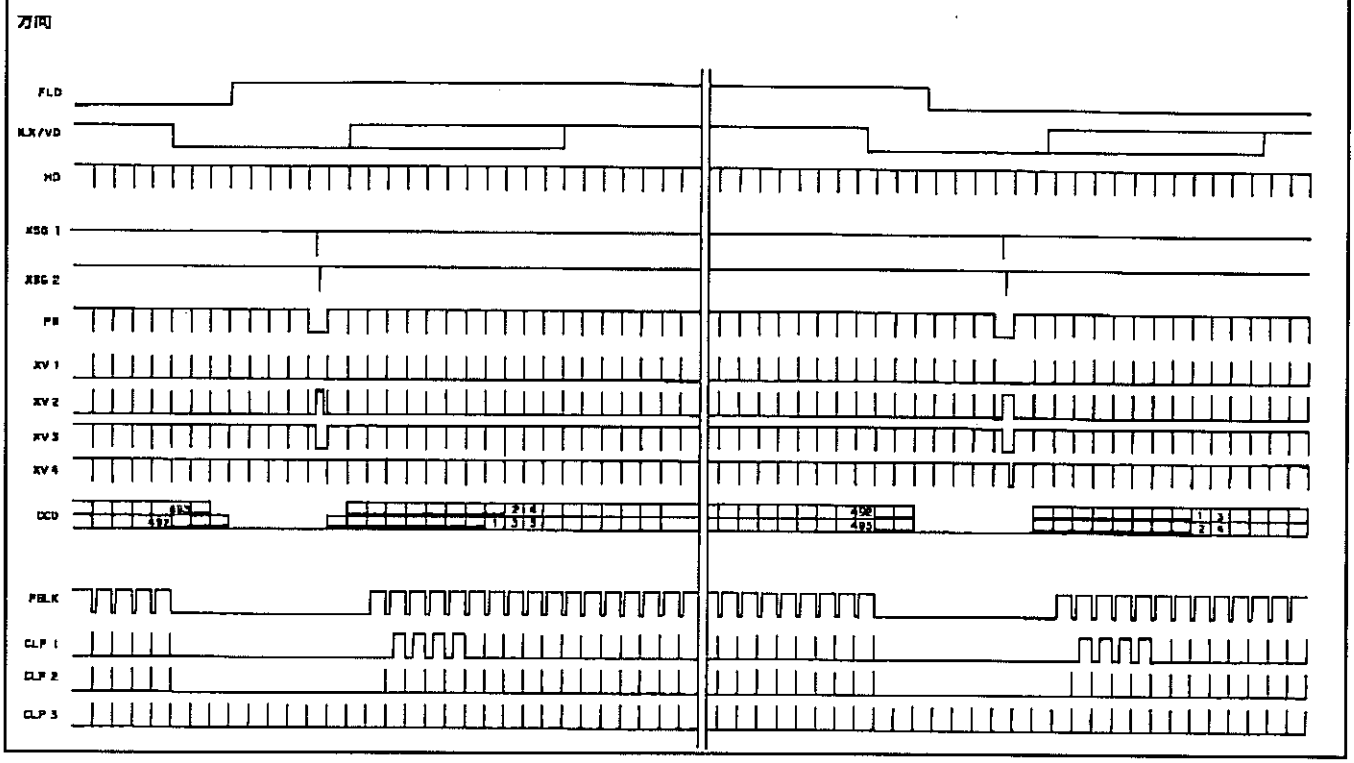


SECTION 7 TIMING CHARTS and SPECIAL FUNCTIONS

7.1 OUTPUT SIGNAL TIMING CHART

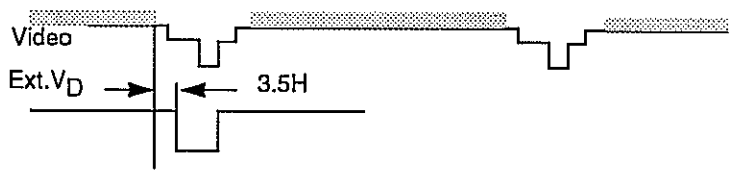


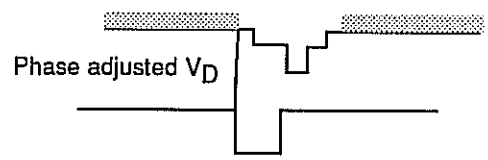
Timing chart vertical

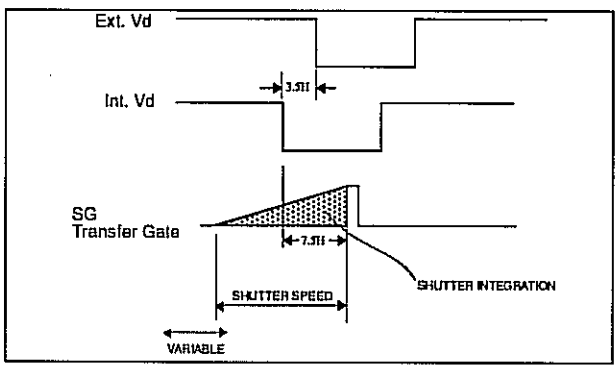


7.2 SPECIAL FUNCTIONS:

7.2.1 **SHUTTER** The TM-745i has a manual shutter control up to 1/10,000 sec. As an option, 1/31,500 sec. shutter speed is available. When this option is selected, V_D phase adjustment option is not available. V_D phase adjustment is used to align video vertical timing to external sync leading edge. Standard without adjustment is 3.5H (fixed).







The shutter timing is synchronized with the CCD transfer gate timing of each field. Because of the shutter principle, only one field image per shutter is output. If one frame of shutter image is captured, two separate images will be displayed due to object motion.

7.2.2 **INTEGRATION** Integration is a longer exposure than the standard 1/30 sec. of frame speed. The TM-745i provides a full frame of integration image. Pin #11 is used to control integration. The standard model is normally High (5 V), and when Pin #11 is Low(GND), the TM-745i maintains the integration until Pin #11 goes to High.

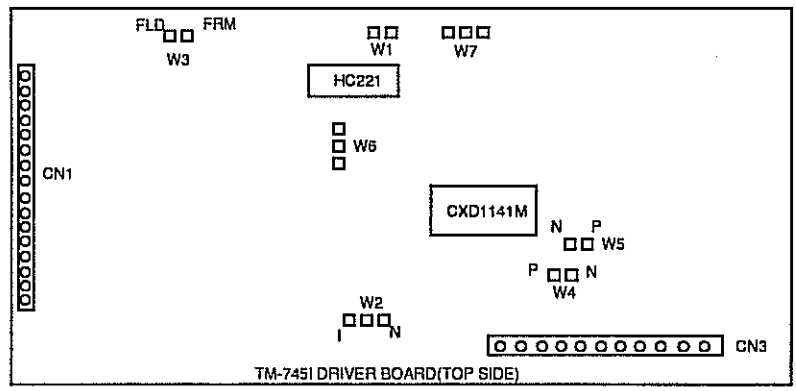
TM-745i signal processing keeps optical black level as reference black video to clamp the video level, and thermal noise during integration is cancelled off. Non-optical black clamping is also available as an option. Please consult PULNiX for special integration applications.

SECTION 8 FACTORY SETTING AND BOARD LAYOUTS

8.1 DRIVER BOARD (TOP SIDE)

Jumper Setting:

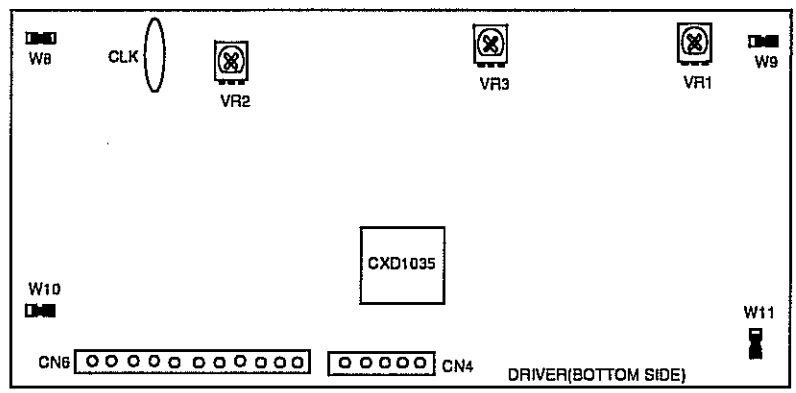
W1		Open
W2		Open
W3	FRM/FLD	Open(FLD)
W4	N/P	Open(EIA)
W5	N/P	Open(EIA)
W6		Open
W7		Open



8.2 DRIVER BOARD(BOTTOM SIDE)

Jumper Setting:

W8	Closed(GND)
W9	Closed(GND)
W10	Closed(GND)
W11	Closed(GND)



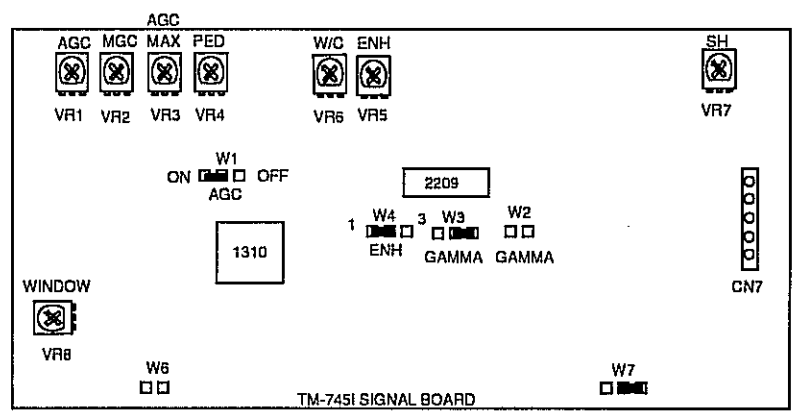
Voltage Setting:

VR1	Vsub	Optimize it by checking the picture, make sure there is no grainy picture.
VR2	PLL	Apply ext. HD to the camera, and probe int. HD. Adjust VR1 so that both ext. HD and int. HD phase will be lined up. The delay should be less than 20 nsec.
VR3	VD Phase	Apply ext. VD to the camera, and probe int. HD. Adjust VR2 so that both ext. vD and Int. VD will be lined up.

8.3 SIGNAL BOARD

Jumper Setting:

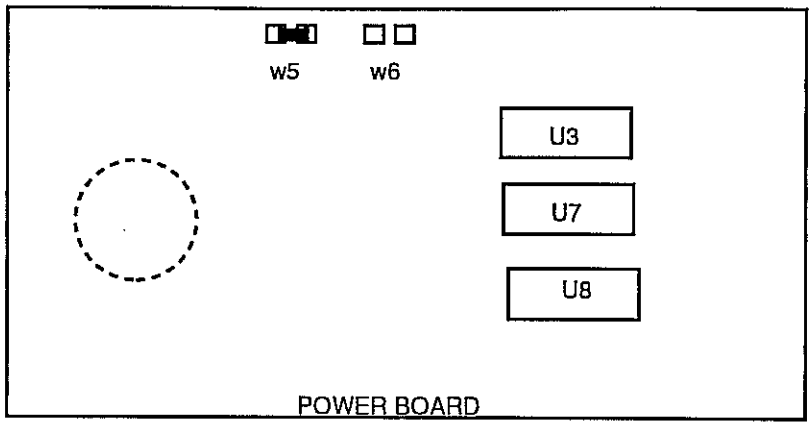
W1	AGC ON/OFF	AGC ON(LEFT)
W2	GAMMA 1/0.45	OPEN
W3	GAMMA 1/0.45	GAMMA 1(RIGHT)
W4	ENH ON/OFF	OFF(LEFT)
W6		OPEN
W7		RIGHT



Voltage Setting:

VR1	AGC	2.0±0.1V	VR5	ENH	0V
VR2	MGC	2.0±0.1V	VR6	W/C	0V
VR3	AGC MAX	1.5±0.1V	VR7	SH	OPTIMIZE
VR4	PED	50±0.1mV	VR8	WINDOW	OPTIMIZE

8.4 POWER BOARD

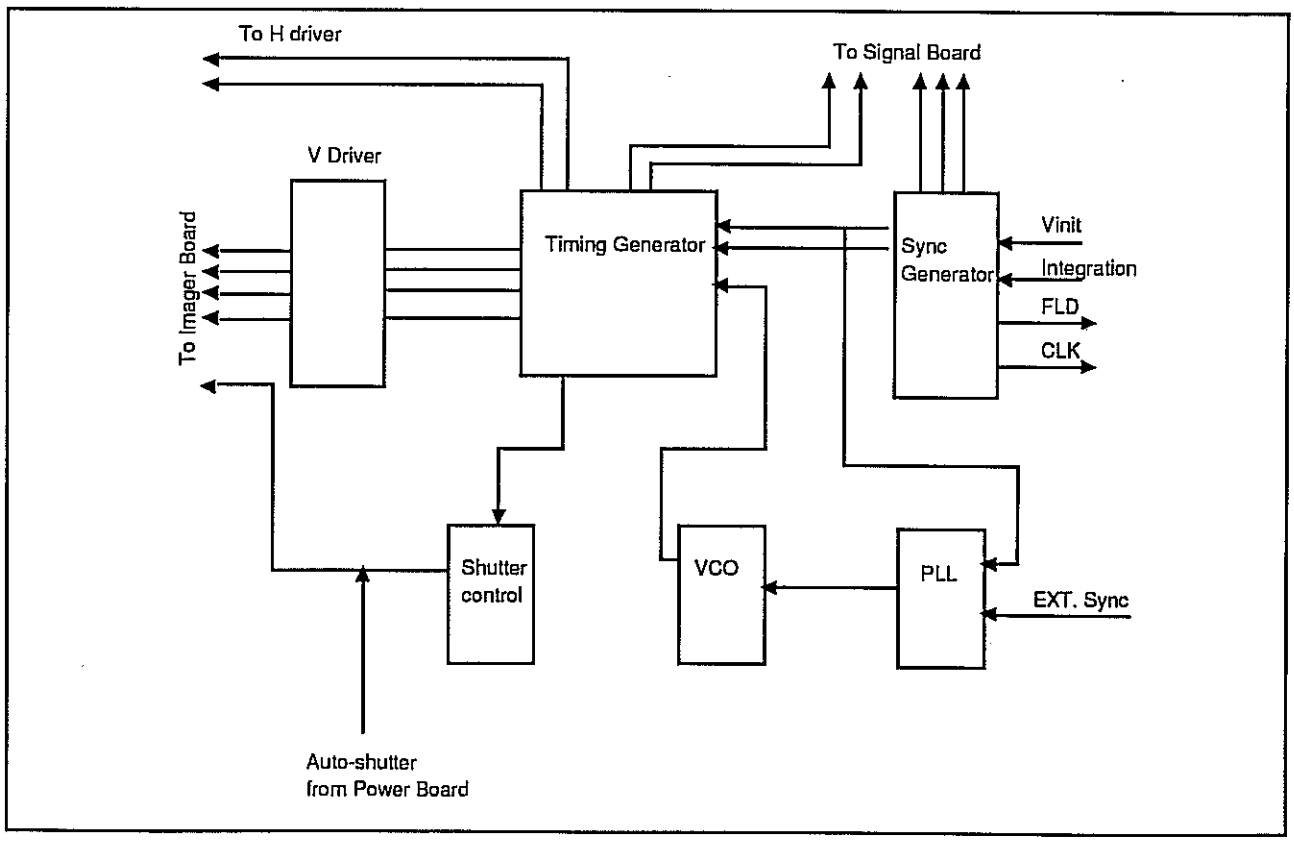


Jumper Setting

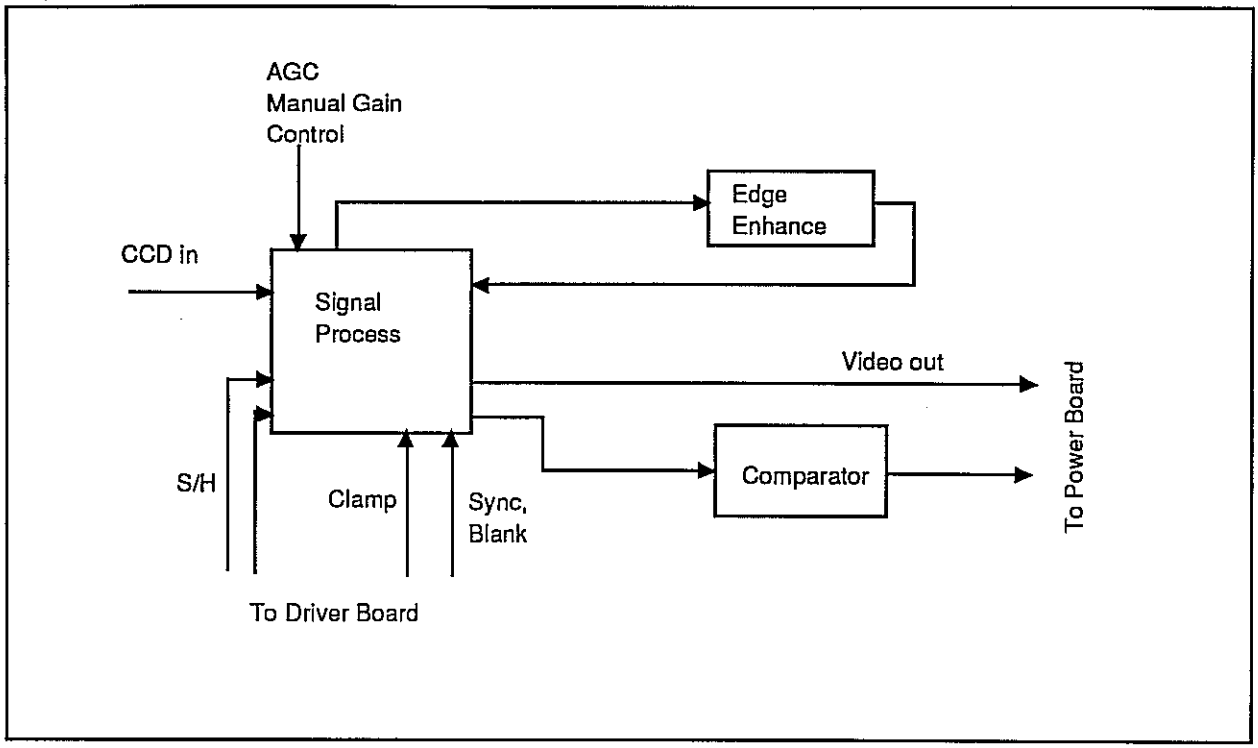
W5	N/P	Short(EIA)
W6	AUTO/MAN	Open(AUTO)

SECTION 9 PC BOARD FUNCTIONS

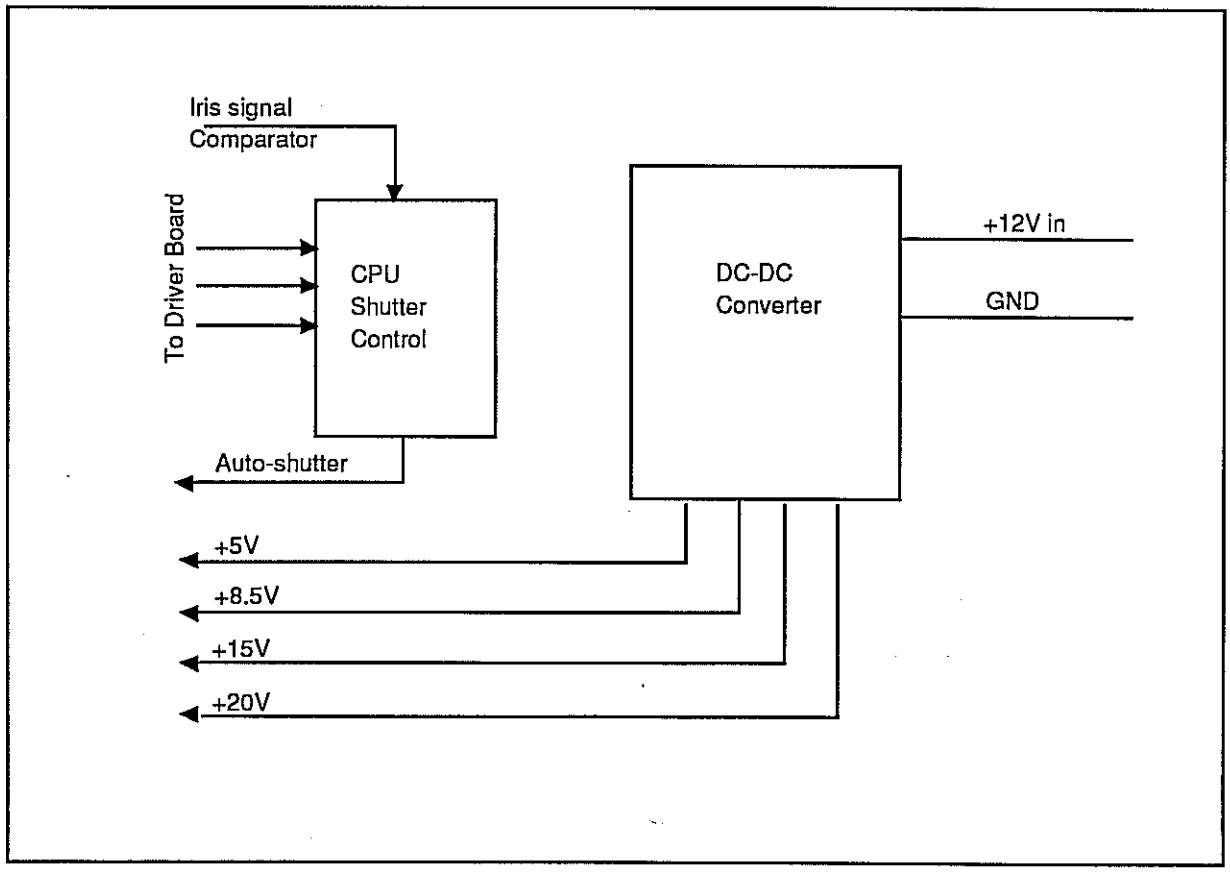
9.1 DRIVER BOARD



9.2 SIGNAL BOARD



9.3 POWER BOARD



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Revised Printing: December 1995

In Australia
PULNiX America Inc.
Unit 16, #35 Garden Road
Clayton, Vic 3168
Tel: 3-9546-0222
Fax: 3-9562-4892

In the U.K.
PULNiX Europe Ltd.
Aviary Court, Wade Road
Basingstoke, Hants RG24 8PE
Tel: 01256-475555
Fax: 01256-466268

PULNiX
Industrial Products Division

PULNiX America Inc.
1330 Orleans Drive
Sunnyvale, CA 94089
Tel: 408-747-0300
Tel: 800-445-5444
Fax: 408-747-0660

In Germany
PULNiX Europe Ltd.
Steinbruch 5
D-8755 Alzenau
Tel: 06023-4666
Fax: 06023-4667

In Japan
Takenaka System Co. Ltd.
7-1, Shinomiya Narano Cho
Yamashina-ku, Kyoto, 607
Tel: 075-593-9787

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