PULNiX

TM-7/ 6; TM-7X/6X
MINIATURE CCD CAMERA

OPERATIONS MANUAL

REV. 01/96

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SECTION 1 FEATURES AND APPLICATIONS

HIGH RESOLUTION, INTERLINE TRANSFER CCD

The TM-7/TM-6 series are state-of-the-art CCD cameras which use a 1/2 inch high resolution imager. These units offer outstanding compactness, high performance, long life, high stability as well as a number of technical innovations such as variable electronic shutter and asynchronous reset. They are designed to be simple yet high quality cameras for versatile applications such as machine vision and image processing, robotics, medical, and surveillance applications. The uniqueness of the TM-7 series is the size and resolution which is essential for the latest artificial intelligence. The TM-7, and TM-7X do not have external sync input since the majority of frame grabbers equip a phase lock loop circuit for video output.

VARIABLE ELECTRONIC SHUTTER AND RANDOM CCD INTEGRATION

The TM-7 / TM-6 series cameras have a substrate drain-type shutter mechanism which provides a superb picture at various speeds without smearing.

MINIATURIZED AND LIGHTWEIGHT

All PULNiX cameras are built with the same design principles: solid state technology; miniaturization (including lenses, housing, and cables); 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. The TM-7 series is the extension of this principle and makes the entire camera just like a remoted head.

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.

LOW LAG/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-7 series is one of the most low light sensitive 1/2 " 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 1.0 lux of minimum illumination and 0.5 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 FIELD 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-7 series 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 2 seconds are needed for the TM-7 series to warm up, and shooting may begin within a second after turning on the camera. The power consumption is only 3.0W. This makes the cameras excellent for use with battery operated systems.

GENLOCK CIRCUIT

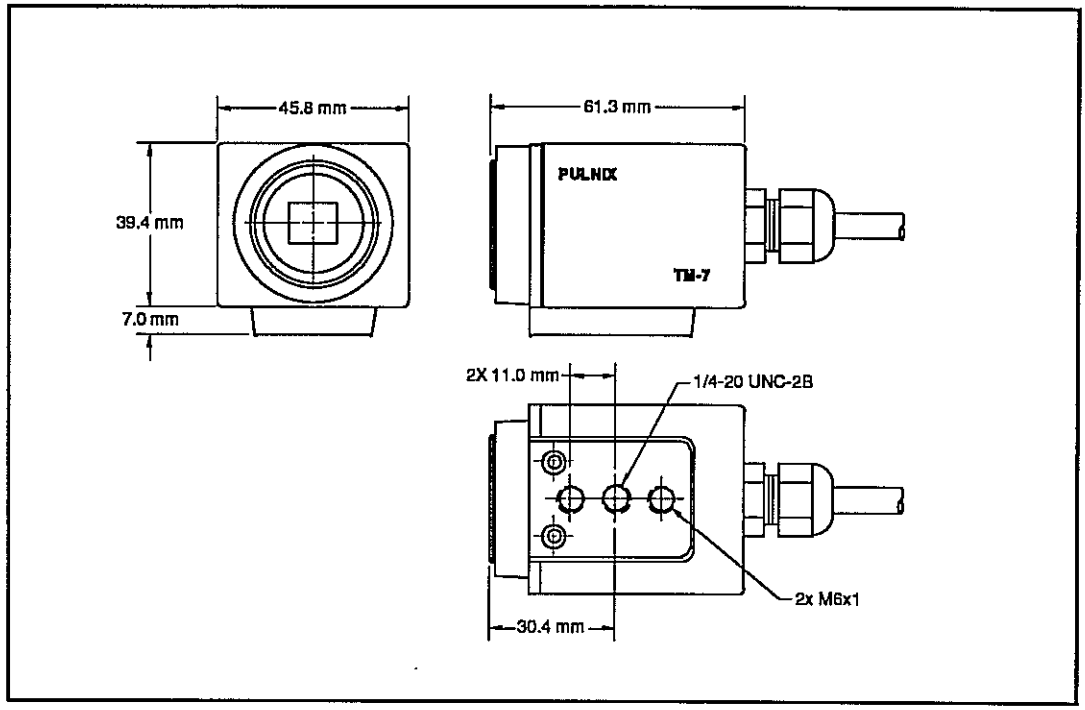
A genlock circuit is not built into the TM-7 series to accept external sync. The design principle of this type of camera is intended for numerous usages in simple but demanding applications which require compact, high resolution and high quality, but most importantly, low cost cameras.

SECTION 2 SPECIFICATIONS

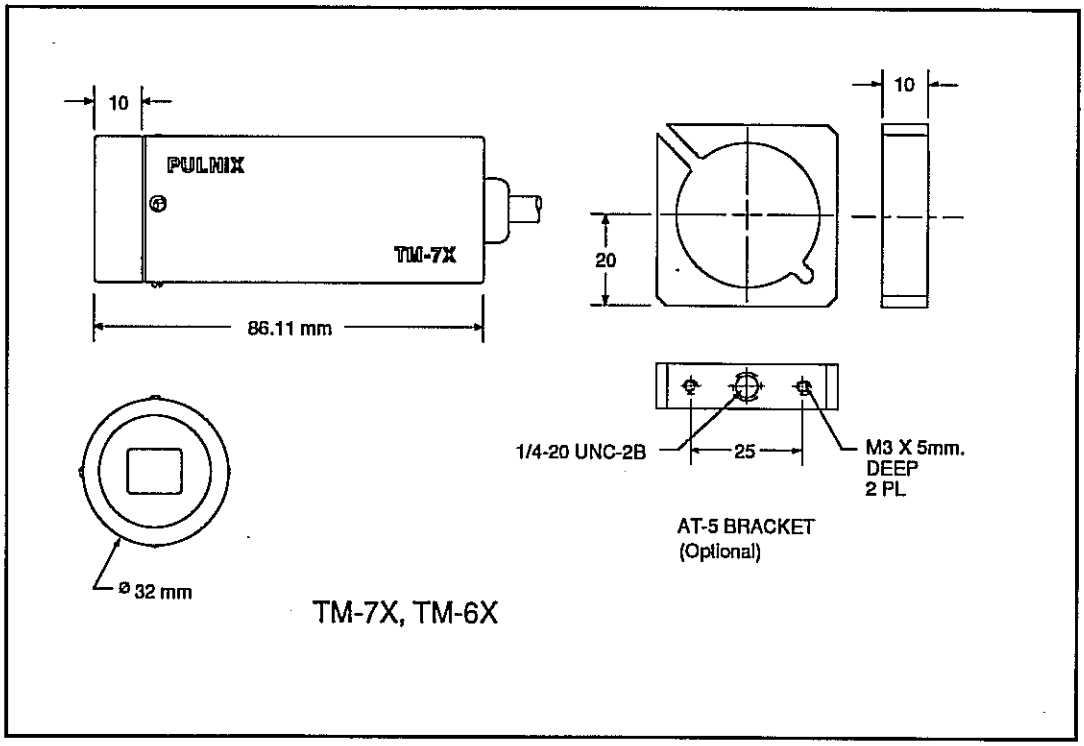
Imager:		1/2 inch interline transfer CCD	
	Pixels	768 (H) x 494 (V) - TM-7 series	
		752 (H) x 582 (V) - TM-6 series	
	Cell size	8.4 (H) x 9.8 (V) microns - TM-7 series	
		8.6 (H) x 8.3 (V) microns - TM-6 series	
	Sensing area	6.41 (H) x 4.89 (V) mm	
	Dynamic range	67dB	
		Low noise, blooming suppression	
	Chip size	7.95 mm (H) x 6.45 mm (V)	
Scanning:		525 lines, 2:1 interlace - TM-7 (EIA) series	
		625 lines, 2:1 interlace - TM-6 (CCIR) series	
	Clock	28.6363 MHz - TM-7 series	
		28.375 MHz - TM-6 series	
	Pixel clock	14.31818 MHz - TM-7 series	
		14.1875 MHz - TM-6 series	
	Horizontal frequency	15.734 KHz - TM-7 series	
		15.725 KHz - TM-6 series	
	Vertical frequency	59.92 Hz - TM-7 series	
		50.0 Hz - TM-6 series	
TV resolution:		570(H) x 485(V) lines - TM-7	
		560(H) x 575(V) lines - TM-6	
Video output:		1.0V p-p composite video, 75Ω	
S/N ratio:		50 dB min.	
Minimum illumination:		1.0 lux (F=1.4) without IR cut filter	
AGC:		On (16dB standard, 32dB max) / Off	
Gamma:		0.45 or 1	
Lens mount:		C-mount	
Power requirement:		DC 12V, 2.5 W	
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:	TM-7	46mm (W) x 40mm (H) x 61.3mm (L)	1.81" (W) x 1.57" (H) x 2.41" (L)
	TM-7X	32mm (Dia.) x 86.1mm (L)	1 1/4" (Dia.) x 3 5/16" (L)

SECTION 3 PHYSICAL DIMENSIONS

3.1 TM-7/TM-6



3.2 TM-7X/TM-6X



SECTION 4 SETUP AND OPERATION

4.1 GETTING STARTED - Please begin by checking your order to assure that you have received everything as ordered, and that nothing has been overlooked in the packing materials. It is a good idea to retain the original packing cartons for cameras and lenses should there be a need at a later date to return or exchange an item. It is also recommended that any equipment being sent to another location for field installation be bench tested to assure that everything is fully operational as a system. The following steps outline the setup procedure for PULNiX cameras.

4.2 POWER SUPPLY AND POWER CABLE SETUP
PULNiX recommends the following supplies:

K25-12	110V AC/12V DC,	2.1A power supply
P-15-12	220V AC/12V DC,	2.1A power supply
K50-12	110V AC/12V DC,	4.2A power supply
PD-12P	110V AC/12V DC,	0.5A power supply

Consult the data sheet packed with your camera. Generally Pin #1 is Ground and Pin #2 is +12V DC. The other pins may handle a number of other input and output functions; this will be discussed in subsequent sections. For users simply providing power through the 12-pin connector, the DC-12P and PD-12P power supplies are available with the 12-pin mating connector already attached to the leads from the power supply. For those using the PULNiX power cables such as the 12P-02, KC-10, etc., be certain that unused leads are not touching and that there is no possibility that leads can short because of exposed wire(s). The power connector may now be attached to the camera. The 12-pin power connector is keyed and will only fit in one orientation. Rotate the connector while applying slight pressure until the keyways line up. You may now press the connector into place until firmly seated.
The 110V AC line cord may now be placed in the mains receptacle, and the camera is now powered up.

4.3 CABLE FUCTION

GND	Gray
+12VDC	Yellow
GND	Red coax shield
Video	Red coax
GND	Orange coax shield
Sync out	Orange coax
Clock out	Black coax
GND	White coax shield*1
Vinit in	White coax
5V	Brown
D2	Blue (1/1000 sec)*2
GND	Black coax shield

*1 Auto-iris control output optional
*2 Shutter speed other than 1/1000sec. optional

4.4 ATTACHING THE VIDEO OUTPUT
The mini coaxial leads in PULNiX multi-conductor cables attached to the TM-7/6 and TM-7X/6X versions are designed for short runs of not longer than 100 feet. See the pinout and color code information in Section 2 for wiring. Be certain that no extraneous wires are visible which could cause a short.

4.5 LENSES
C-mount lenses are attached to the camera by carefully engaging the threads and rotating the lens clockwise until it firmly seats on the mounting ring. Do not force the lens if it does not seat properly. Some lenses with extremely long flangebacks may exceed the mounting depth of the camera. The TM-7 series cameras use 1/2" format lenses.

4.5.1 BACK FOCUSING LENSES
To backfocus the TM-7/6 camera, first attach a C-mount lens in the mount. Be certain that the lens is properly seated. Next set the lens focus to infinity (and if the lens is a manual iris, set the iris to a high f number while still retaining a well illuminated image). Try to obtain the best focus at this setting. Then loosen the two miniature hex head set screws locking the focus ring in place. Now turn the entire lens and focus ring assembly back and forth until the best image is obtained. This will set your backfocus. Once the best image is obtained, tighten the focus ring set screws. TM-7X/6X cameras do not have a provision for back focus.

4.5.2 AUTO-IRIS LENS SETUP
Auto-iris lenses with full video input can be used with the TM-7 and TM-7X; however no auto-iris input is supplied. Wire lens into terminal with output leads from camera.

NOTE: There is a small chance that damage could occur to the auto-iris lens by plugging or unplugging the lens into the LENS connector on the camera while the camera is still powered up. It is a good idea to always remove power from the camera before connecting or disconnecting the lens.

SECTION 5
SHUTTER OPERATION

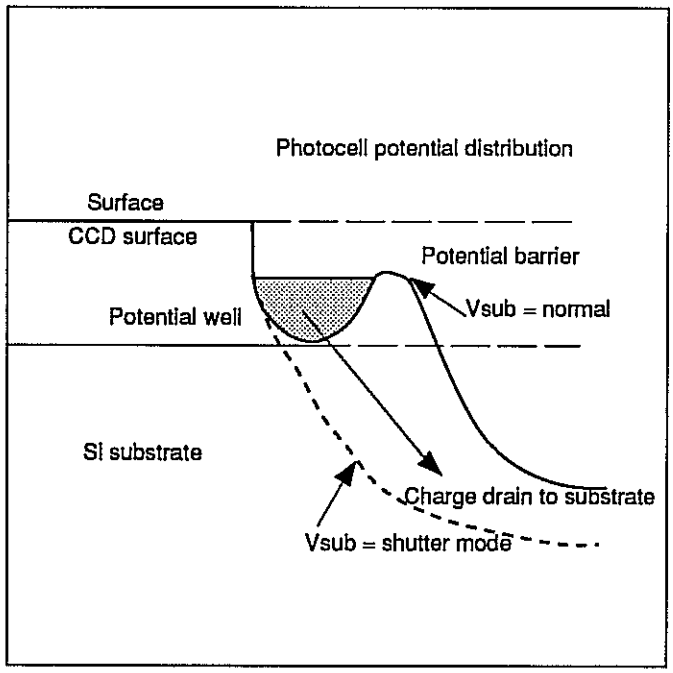
The TM-7/TM-6 series has a substrate drain type shutter mechanism which provides a superb picture at various speeds without smearing.

5.1 BCD SHUTTER CONTROL

By selecting D0, D1, D2 level high or low, the following shutter speeds are obtaineD. It is also easily controlled from a computer, remote control unit, or fixed at a specific speed.

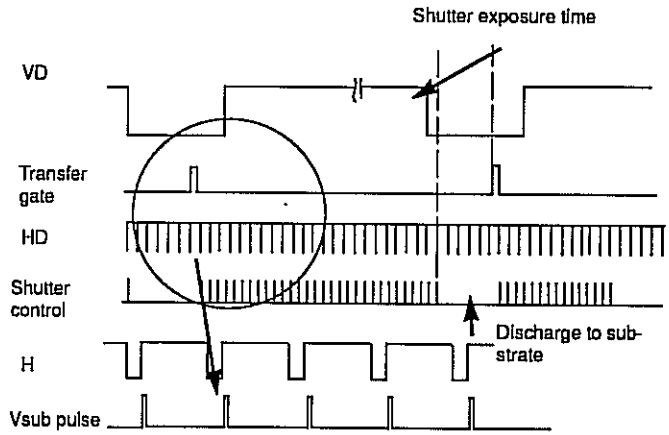
Control Setting	0	1	2	3	4	5	6	7
(sec)	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000	1/10000
D0	L	H	L	H	L	H	L	H
D1	L	L	H	H	L	L	H	H
D2	L	L	L	L	H	H	H	H

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 the 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-7/TM-6 chip is done in the horizontal blanking interval.

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



5.3 SYNC OUTPUT AND CLOCK OUTPUT

TTL level internal sync and buffered pixel clock output (14.31818MHz) are available from TM-7 series cameras. The signal is an emitter follower output and it requires a **termination resistor at end of cable.** The suggested value is from 75Ω to 330Ω. This is especially important for the TM-7 / TM-6 because of the cable.

SECTION 6 CCD CHARACTERISTICS AND OPERATION

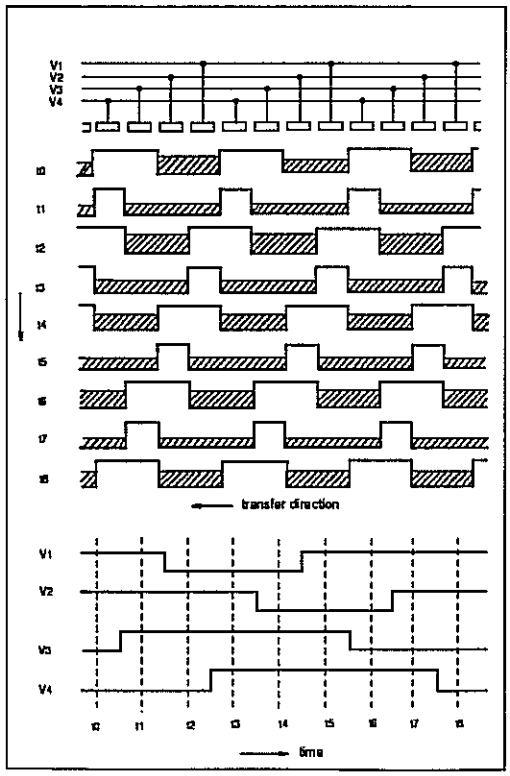
6.1 THEORY OF OPERATION (Operation principle of the CCD)

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.

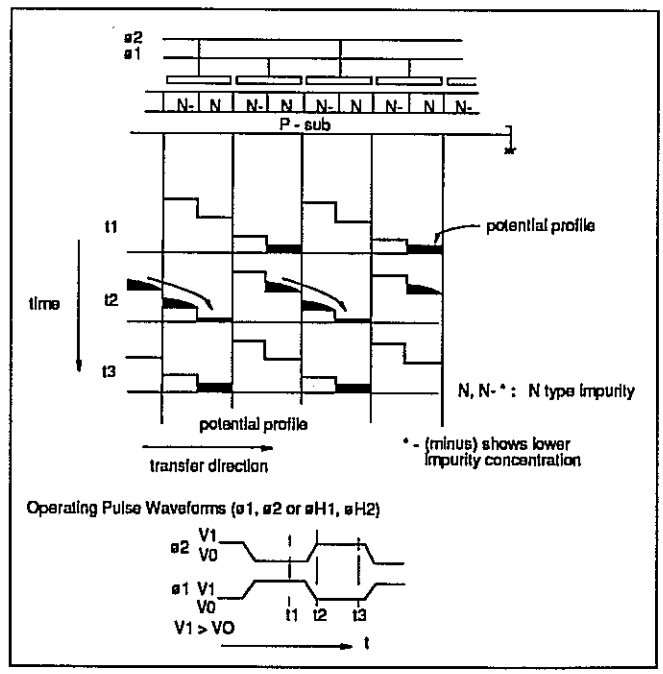
3. Transmission of charge
When a high voltage is applied to the electrodes, a deeper well is formed; when a low voltage is applied, a shallower well is formed. In the CCD, this property is used to transmit the charge. When a high voltage is applied to the electrodes, a deep electric potential well is 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.



6.2 MECHANISM OF CCD CHARGE TRANSFER

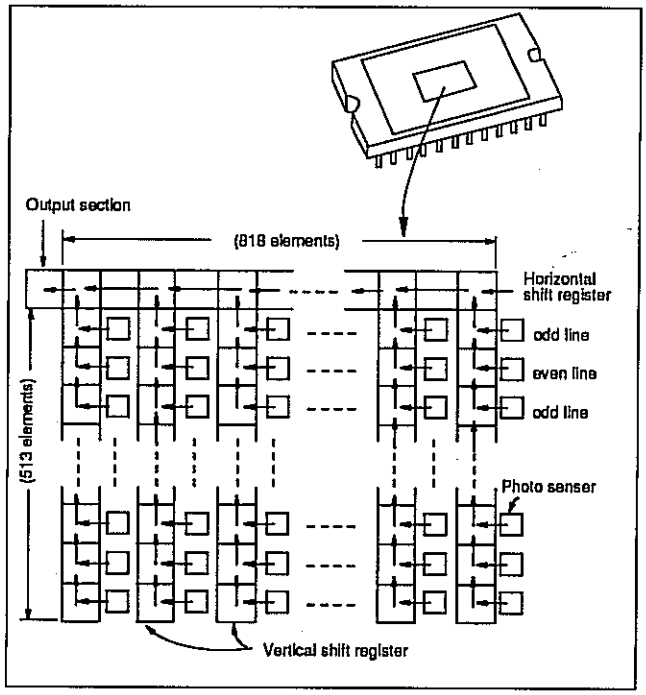
1. Vertical transfer
The vertical shift register transfers charges using a four-phase drive mode. Figure 1 shows an example of the changes which can occur in potential wells in successive time intervals. At t0, the electrode voltages are (V1 = V2)>(V3 = V4), so the potential wells are deeper toward the 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.

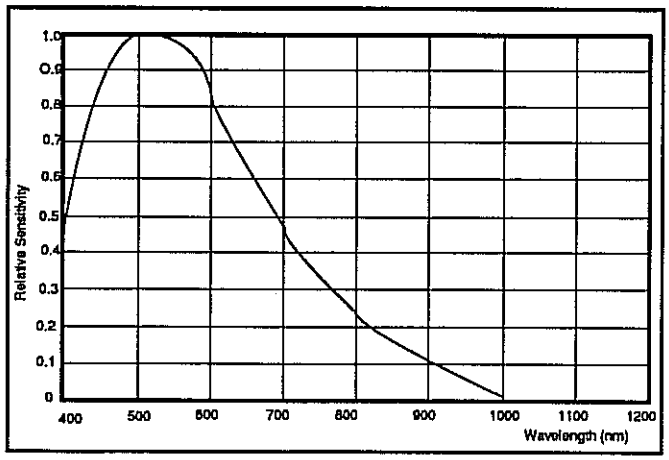


2. Horizontal transfer

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.



6.3 SPECTRAL RESPONSE



6.4 FIELD MODE AND FRAME MODE

Standard factory setting for this mode selection is FIELD MODE.

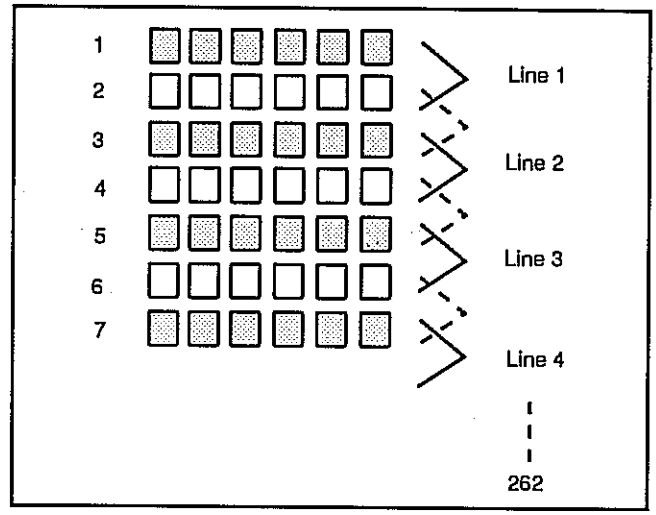
The difference of these two modes is as follows:

FRAME MODE

It scans each horizontal row as interlace scanning. During FRAME MODE, integration of each pixel is one frame period (32msec ...EIA, 40msec...CCIR). Vertical pixel resolution is good and exact location is obtained. It tends to show vertical Moire. For strobe lighting, it must use FRAME MODE in order to achieve full frame resolution.

FIELD MODE

It scans two horizontal rows together and changes the pair at each interlace scanning.



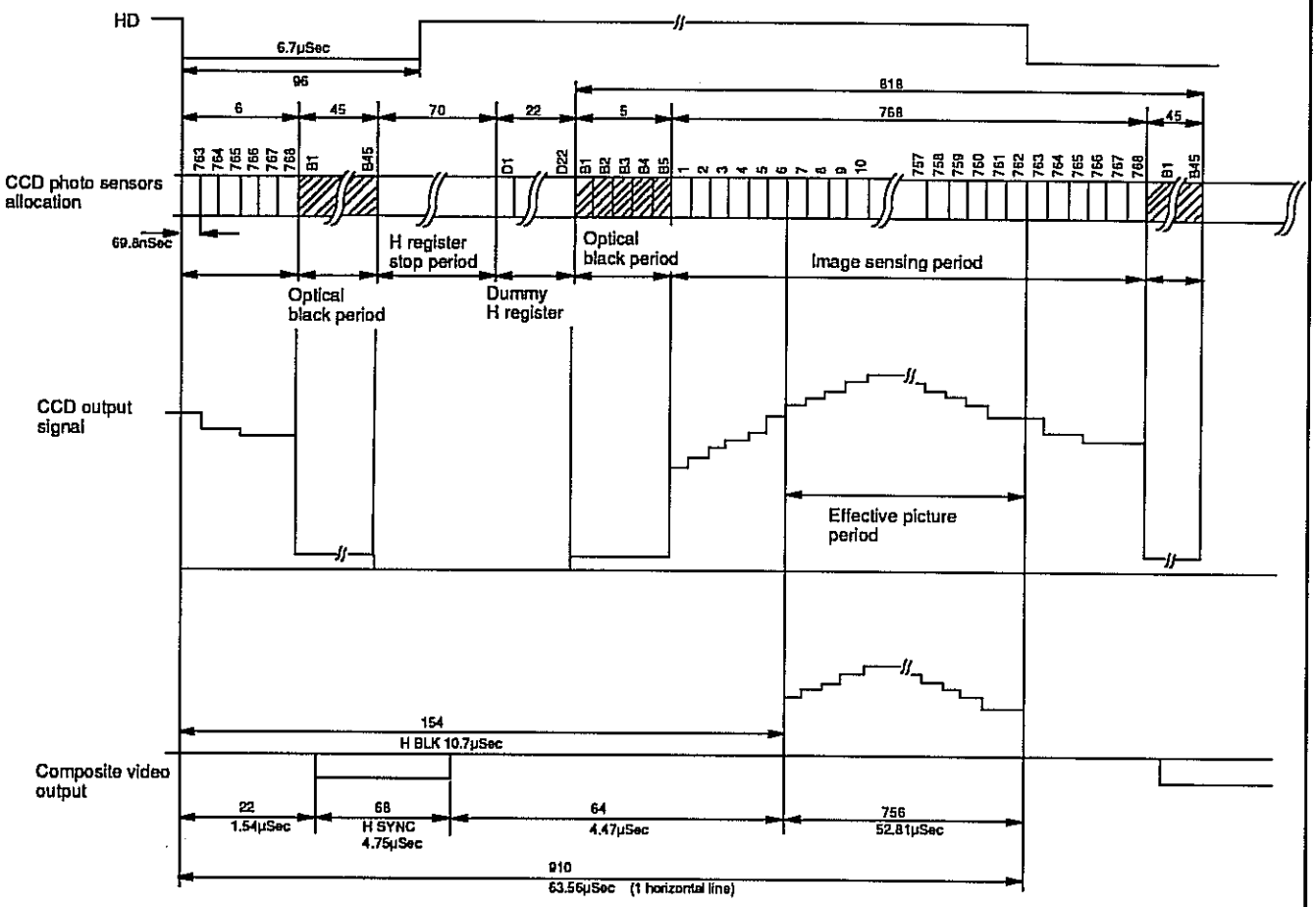
FIELD MODE

This mode has advantages when the shutter is often used as the sensitivity of the CCD is doubled for one field of integration (For shutter, integration can not exceed one field) therefore, it can obtain the same sensitivity as the FRAME MODE for half of the period. Because of alternating two row scanning, Moire is almost unnoticeable and even though the vertical resolution is not as good as in FRAME MODE it is sufficient to see the full vertical resolution of the TV format. FIELD MODE can not provide full frame resolution with strobe lighting application.

NOTE: The factory setting for the TM-7 series cameras is FIELD MODE. If FRAME MODE is required please contact PULNiX for the setting.

The mode selection is solder jumper on the process board.

SECTION 7 TIMING CHART

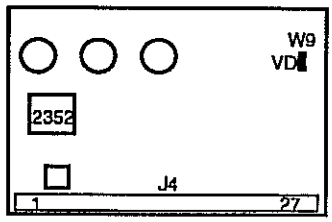


SECTION 8 ADJUSTMENT PROCEDURE

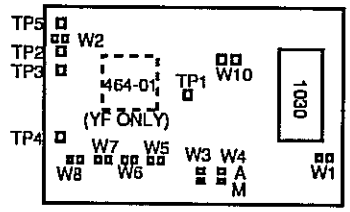
8.1 Sync Gen board

Connect Sync Gen board to test jig and check all the functions.

TM-7/6,

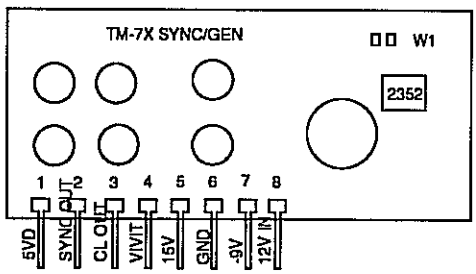


TM-7 SYNC GEN BOARD



Jumper setting		standard	YF
W1	EIA/CCIR selection	Open (EIA)	
W2	NT Vinit	Short	Open
W3	Async mode	N/A	
W4	Async/Man shutter	N/A	
W5 - W8	Test jumper		
W9	VD in	Short	Open
W10	Vinit selection	Open	Short

TM-7X/6X



Jumper Setting

W1 PAL/NTSC open (NTSC)

8.2 TM-7/TM-6 Imager Board

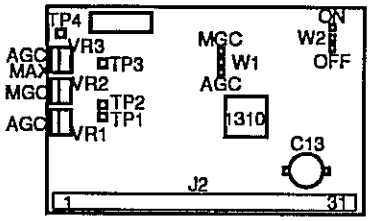
Connect imager board to test jig and check all the functions.

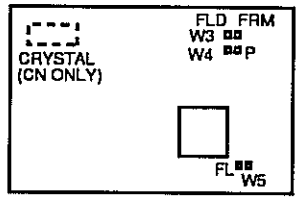
Adjust and optimize Vsub voltage to specified value on the imager back.

E	9.0V	F	9.5V
G	10.0V	H	10.5V
J	11.0V	K	11.5V
L	12.0V	M	12.5V
N	13.0V	P	13.5V
Q	14.0V	R	14.5V
S	15.0V	T	15.5V
U	16.0V	V	16.5V
W	17.0V	X	17.5V
Y	18.0V	Z	18.5V

8.3 TM-7/6 Processor Board

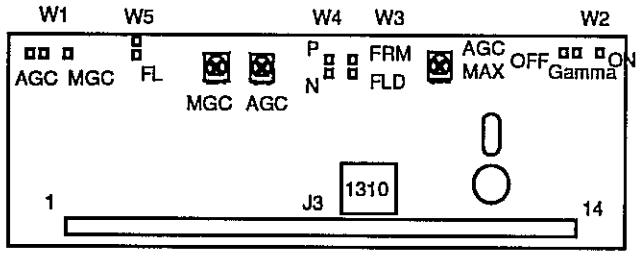
Connect Processor board to test jig and check all the functions.





Jumper Setting		EIA	CCIR	
W1	AGC/MGC	Open (AGC)	Open	
W2	Gamma 1/0.45	Open (Gamma 1.0)	Open	
W3	Field/Frame	Open (Field)		Open
W4	NTSC/PAL	Open	Short	
W5	FL/0V	Open	Open	

TM-7X/6X



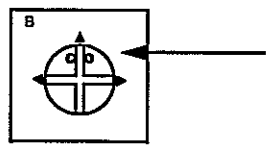
Jumper setting		EIA	CCIR
W1	AGC/MGC	Short (AGC)	Short
W2	Gamma 1/0.45	Short (1)	Short
W3	FLD/FRM	Open (FLD)	Open
W4	NTSC/PAL	Open (NTSC)	Short
W5	FL/0V	Open (FL)	Open

8.3.1 AGC

Adjust VR1 (AGC) so that TP1 is 2.0V.

8.3.2 MGC

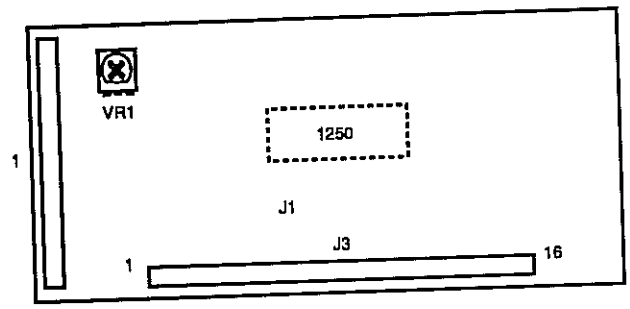
Set VR2 (MGC) at mechanical center (2.5V at TP2).



Mechanical center

8.3.3 AGC MAX.
Adjust VR3 (AGC MAX) to 2.0V at TP3. Re-set AGC MAX at final calibration. See calibration specification.

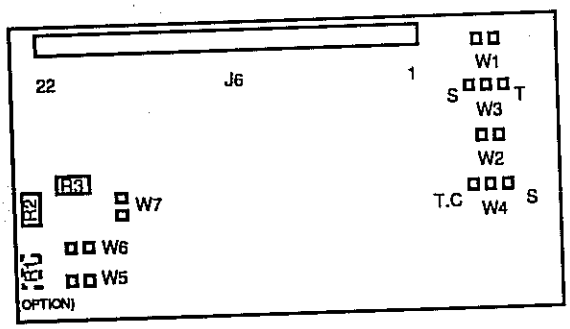
8.4 Driver Board (TM-7X only)



Connect Driver board to test jig and check all the
functions. Adjust and optimize Vsub voltage to specified value (same as Sec. 9.2)

SECTION 9 CONNECTOR BOARD

9.1 Impedance selection



TM-7 SERIES REAR BOARD

Standard input/output impedance for Pins 6, 7 and 9 of 12-pin connector is as follows:

		TM-7	Option
Pin 6	Sync out	TTL (OPEN)	Open
Pin 7	Clock out	Emitter follower	50Ω on R2
Pin 9	Vinit in	Open R3	75Ω on R3

NOTICE

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WARRANTY

All our solid state cameras have a full three year warranty. If any such product proves defective during this warranty period, Pulnix America, Inc. will repair the defective product without charge for parts and labor or will provide a replacement in exchange for the defective product. This warranty shall not apply to any damage, defect or failure caused by improper use or inadequate maintenance and use.

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