

# PULNiX TM-7/TM-6 Series

1/2" B/W CCD Cameras

## General Description

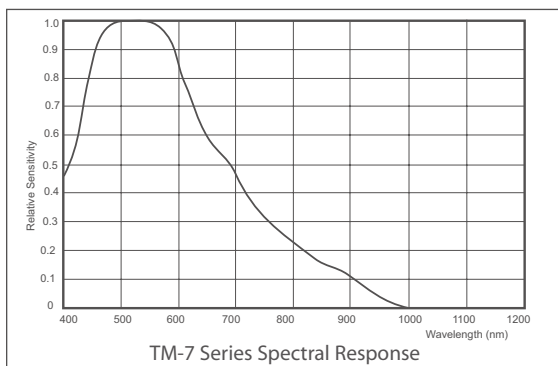
The TM-7/TM-6 series offers a high resolution interline transfer 1/2" CCD imager in a tiny, very rugged package. The miniature size of the TM-7/TM-6 series cameras eliminates the need for a remoted imager camera in all but the most confined spaces.

Designed to meet a variety of application requirements, the three models in the series have many standard features including high speed shutter capability and asynchronous reset. The most commonly needed adjustments, such as gain, gamma, AGC, and field/frame selection, are easily accessible on the rear camera panel. C-mount is also standard. Each model is available in both EIA format (the TM-7 series) and CCIR format (the TM-6 series).

The "CN" and "EX" versions allow for the external selection of eight different shutter speeds (1/60 sec. to 1/10,000 sec.) by attaching the SC-745 Shutter Controller to the 6-pin connector located on the rear of the camera. Pixel clock output is a standard feature on the "CN" version. Asynchronous shuttering is the key feature of the "AS", which also offers a rotary select switch to control shutter settings. The "AS" and "EX" versions accept external sync. The "CN" and "EX" models include auto iris outputs and accept simple reset that is asynchronous but without a shutter.

## Applications

- Machine vision
- Automated inspection
- Miniature inspection devices
- Remotely piloted vehicles
- Surveillance
- Microscopes
- Medical and scientific equipment



## TM-7AS/TM-6AS Shutter Switch Settings:

Manual Mode		Async Reset Mode	
TM-7AS		TM-7AS	TM-6AS
0	1/60	Normal 1/60	Normal 1/50
1	1/125	0.5H	1/31,000
2	1/250	1.5H	1/10,000
3	1/500	3.5H	1/4,500
4	1/1,000	6.5H	1/2,400
5	1/2,000	16.5H	1/950
6	1/4,000	32.5H	1/480
7	1/10,000	64.5H	1/245
8	N/C	128.5H	1/120
9	N/C	Shutter determined by double pulse	

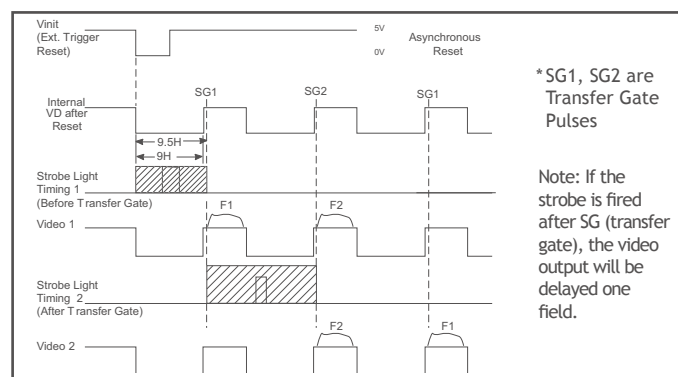


## Product Features

- 3 models: TM-7CN/6CN, TM-7AS/6AS, TM-7EX/6EX
- Advanced micro lens 1/2" interline transfer CCD
- High-resolution interlace scan
  - 768 H x 494 V (EIA)
  - 752 H x 582 V (CCIR)
- Super miniature size
- Shutter from 1/60 to 1/10,000
- Asynchronous reset (TM-7AS/TM-6AS)
- Simple reset (TM-7EX/6EX and TM-7CN/6CN)
- Externally adjustable manual gain, AGC, gamma, and field/frame select
- Ext. sync (TM-7EX and TM-7AS), clock and sync out

## Reset and Shuttering

### Asynchronous Reset Timing with Strobe Light or LED Flash



**Strobe Light Timing 1:** Strobe light fires before transfer gate pulse SG1. Both fields of the CCD array are exposed. SG1 transfers out first field F1 (may contain unfinished image from previous field before reset), and SG2 transfers out second field F2.

**Strobe Light Timing 2:** Strobe light fires after transfer gate pulse SG1. Both fields of the CCD array are exposed. SG2 transfers out field F2 and SG1 transfers out field F1 after F2.

**TM-7CN/6CN and TM-7EX/6EX Shuttering:** Controlled by the SC-745 Shutter Controller attached to the 6-pin connector.

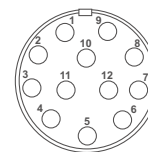
Setting	0	1	2	3	4	5	6	7
(sec)	1/60	1/25	1/250	1/500	1/1,000	1/2,000	1/4,000	1/10,000
D0	L	H	L	H	L	H	L	H
D1	L	L	H	H	L	L	H	H
D2	L	L	L	L	H	H	H	H

## Specifications

Model	TM-7EX (EIA)	TM-7CN	TM-7AS (EIA)
Imager	1/2" Interline transfer CCD, HAD type		
Pixel	768 (H) x 494 (V)		
Cell Size	8.4 μm x 9.8 μm		
Scanning	525 lines EIA		
Sync	Int./ext. auto switch	Internal crystal fH= 15.734 KHz ± 5% fV= 59.94 Hz ± 5%	Int./ext. auto switch
TV Resolution	570 (H) x 350 (V)		
S/N Ratio	50 dB min. AGC off		
Min. Illumination	0.5 lux (F=1.4)		
Video Output	1.0 Vp-p composite video, 75Ω		
AGC	ON/OFF back panel switch (16dB std., 32 db max.)		ON/OFF (Off Std.)
Gamma	1 or 0.45 back panel switch		Internal
Lens Mount	C-mount		
Power Req.	9-12 V DC, 220 mA (TM-7AS is 250 mA)		
Operating Temp.	-10°C to +50°C		
Vibration & Shock	Vibration - 7G (200 Hz to 2000 Hz); Shoc - 70G ("AS" 11 Hz to 200 Hz)		
Size (W x H x L)	45.8 x 39.4 x 66.3 mm 1.81" x 1.54" x 2.60"	45.8 x 39.4 x 61.3 mm 1.81" x 1.54" x 2.40"	45.8 x 39.4 x 66.3 mm 1.81" x 1.54" x 2.60"
Weight	177g (6.2 oz)	171g (5.9 oz)	190g (6.6 oz)
Power Cable	12P-02S		
Power Supply	K25-12V, DC-12N, PD-12 or PD-12P ("CN" model)		
Auto Iris Connector	PC-6P		None
Functional Options	3-1, 3-2, 7-1, 7-2, 21, 25	3-1, 3-2, 4-1, 21, 25	3-1, 4-2
Accessories	See current price list		
Model	TM-6EX (CCIR)	TM-6CN (CCIR)	TM-6AS (CCIR)
Imager	1/2" Interline transfer CCD		
Pixel	752 (H) x 582 (V)		
Cell Size	8.6 μm x 8.3 μm		
TV Resolution	560 (H) x 420 (V)		
Power Supply	P-15-12		
	All other specifications same as EIA models.		

## Connectors & Cables

### 12-Pin Connector



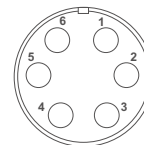
Pin#	"EX"	"CN"	"AS"
1	GND	GND	GND
2	+12VDC	+12VDC	+12VDC
3	GND	GND	GND
4	Video	Video	Video
5	N/C	N/C	N/C
6	Vinit in	Sync out	Vinit
7	VD in	Clock out*	VD in
8	GND	GND	GND
9	HD in	Vinit in	HD in
10	N/C	N/C	N/C
11	Int. control	N/C	Int. control
12	N/C	N/C	N/C

\* 14.3182 MHz external clock output

### 6-Pin Connector

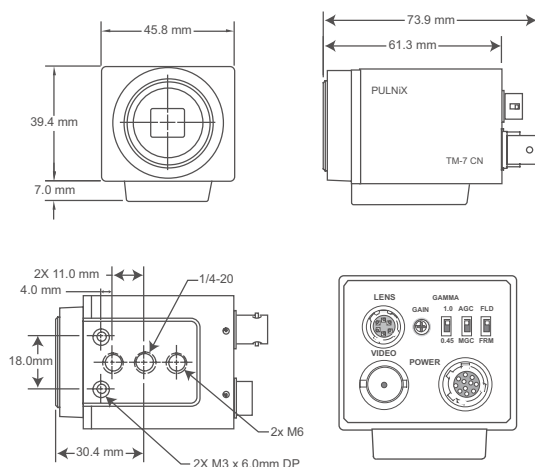
#### TM-7EX/TM-6EX TM-7CN/TM-6CN

Pin#	Function
1	D2
2	GND
3	Video
4	+12V (or 5V)
5	D0
6	D1

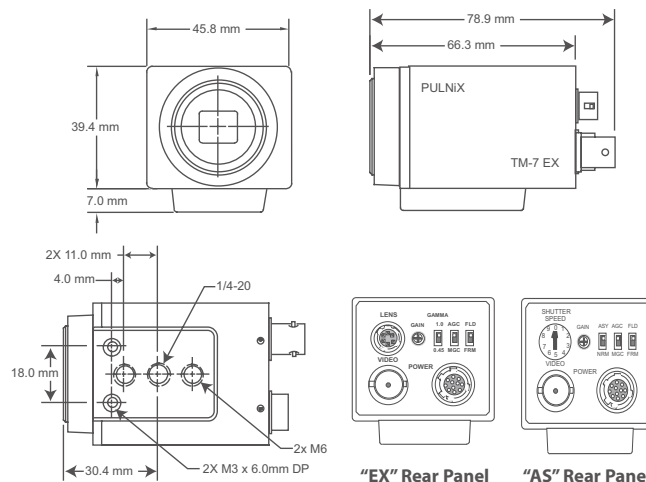


## Dimensions (mm)

### TM-7CN/TM-6CN



### TM-7EX/TM-6EX, TM-7AS/TM-6AS



"EX" Rear Panel

"AS" Rear Panel

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**PULNiX**  
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**TM-7CN / TM-6CN  
TM-7EX / TM-6EX  
TM-72EX/TM-62EX  
Miniature CCD Cameras**

**Operations Manual**

## PLEASE NOTE:

The specifications and instructions in this manual apply to the TM-72EX/TM-62EX, with the following exceptions.

Imager size: 2/3" interline transfer CCD

Pixels:

TM-72EX (EIA): 768 (H) x 493 (V)

TM-62EX (CCIR): 758 (H) x 581 (V)

Cell size:

TM-72EX (EIA): 11 $\mu$ m x 13 $\mu$ m

TM-62EX (CCIR): 11 $\mu$ m x 11 $\mu$ m

TV resolution:

TM-72EX (EIA): 570 (H) x 485 (V) lines

TM-62EX (CCIR): 560 (H) x 575 (V) lines

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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. For applications requiring external sync, the TM-7EX is used.

#### 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. The "CN" and "EX" model cameras have the capability to externally vary the electronic shutter rate via a manually controlled BCD switch from 1/60 to 1/10,000 sec. in discrete steps.

#### MINIATURIZED AND LIGHTWEIGHT

All PULNiX cameras are built with the same design principles: solid state technology; miniaturization (including lenses, housings, 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.**

#### 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.

#### 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 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. External sync is built into the TM-7EX series for applications where external sync is required.

#### AGC SELECTION, MANUAL GAIN CONTROL AND GAMMA ADJUSTMENT

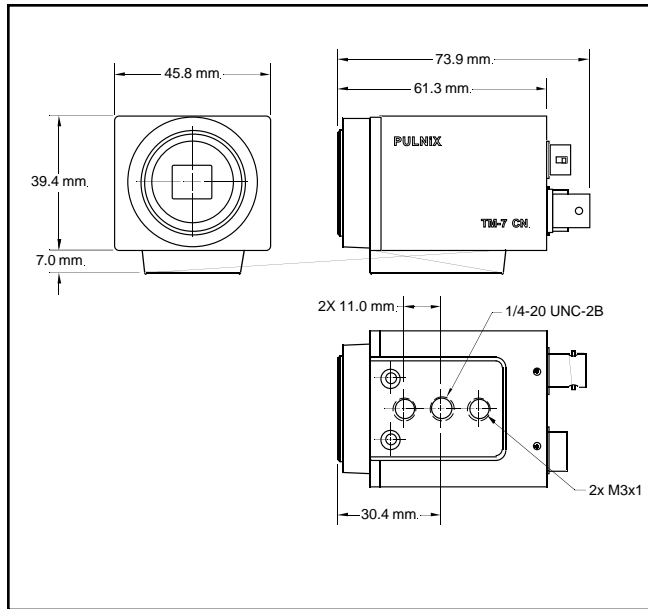
The AGC (automatic gain control) may be externally switched from automatic to fixed gain on the TM-7CN back plate. The manual gain is externally adjustable. Gamma may also be externally set either to 1 or 0.45. These adjustments are particularly important in vision system applications.

## SECTION 2 SPECIFICATIONS

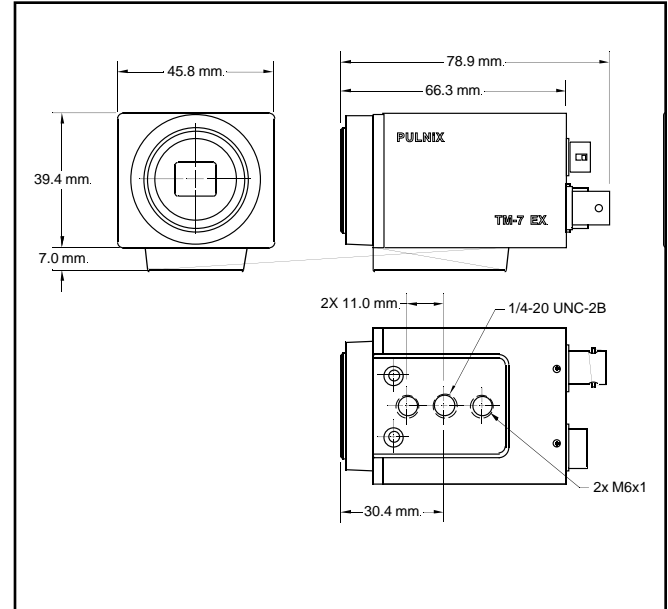
<b>Imager:</b>		1/2 inch interline transfer CCD	
Pixels		768 (H) x 494 (V) - TM-7 series	
		752 (H) x 582 (V) - TM-6 series	
Cell size		8.4 (H) x 9.8 (V) microns - TM-7 series	
		8.6 (H) x 8.3 (V) microns - TM-6 series	
Sensing area		6.41 (H) x 4.89 (V) mm	
Dynamic range		67dB	
		Low noise, blooming suppression	
Chip size		7.95 mm (H) x 6.45 mm (V)	
<b>Scanning:</b>		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	
		15.625 KHz - TM-6 series	
Vertical frequency		59.92 Hz - TM-7 series	
		50.0 Hz - TM-6 series	
<b>Sync:</b>		Int/Ext TM-7EX/TM-6EX	
<b>TV resolution:</b>		570(H) x 485(V) lines - TM-7	
		560(H) x 575(V) lines - TM-6	
<b>Video output:</b>		1.0V p-p composite video, 75Ω	
<b>S/N ratio:</b>		50 dB min.	
<b>Minimum illumination:</b>		1.0 lux (F=1.4) without IR cut filter	
<b>AGC:</b>		On (16dB standard, 32dB max) / Off	
<b>Gamma:</b>		0.45 or 1	
<b>Lens mount:</b>		C-mount	
<b>Power requirement:</b>		DC 12V, 2.5 W	
<b>Operating temperature:</b>		-10 °C to +50 °C	
<b>Storage temperature:</b>		-30 °C to +60 °C	
<b>Operating humidity:</b>		Within 70%	
<b>Storage humidity:</b>		Within 90%	
<b>Vibration:</b>		7G (200Hz to 2000Hz)	
<b>Shock:</b>		70G	
<b>Dimensions:</b>	TM-7CN	46mm (W) x 40mm (H) x 74mm (L)	1.81" (W) x 1.57" (H) x 2.95" (L)
	TM-7EX	46mm (W) x 40mm (H) x 79mm (L)	1.81" (W) x 1.57" (H) x 3.11" (L)

## SECTION 3 PHYSICAL DIMENSIONS

### TM-7CN/TM-6CN

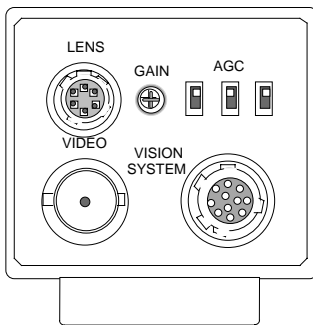


### TM-7EX/6EX



## SECTION 4 CAMERA SYSTEM ACCESSORIES

### 4.1 12-PIN CONNECTOR



#### 12-PIN #

#### TM-7CN

#### TM-7EX

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12

GND  
+12VDC  
GND  
Video  
N/C  
SYNC OUT  
CLK OUT  
GND  
VINIT  
N/C  
N/C  
N/C

GND  
+12V DC  
GND  
VIDEO  
N/C  
VINIT  
VD IN  
GND  
HD IN  
N/C  
INT CONT  
N/C

### 6-PIN CONNECTOR PINOUT

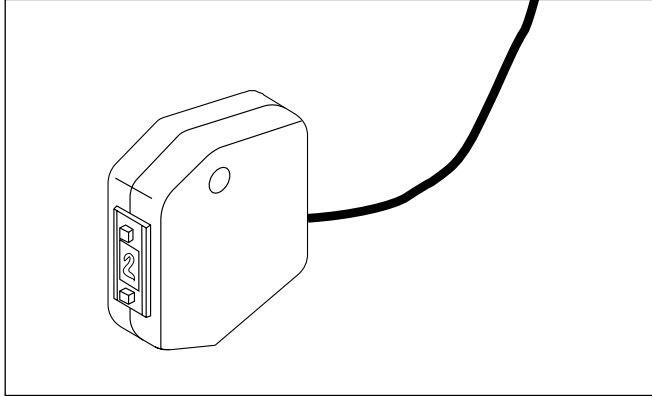
#### PIN #

#### FUNCTION

1  
2  
3  
4  
5  
6

D2  
GND  
IRIS  
+12V (5V OPTION)  
D0  
D1

**4.2 SHUTTER CONTROL UNIT (SC-745)**- consists of a manually controlled 8-position BCD switch that determines the exposure time of the sensor. It connects to the TM-7CN/TM-7EX via a cable with a PC-6P male connector that plugs into the 6-pin female connector socket on the back of the camera. The SC-745 shutter control is included with the camera.



SC-745 SHUTTER CONTROL

**4.3 POWER CABLES** - all power cables use a PC-12P female connector that fits into the 12-pin male connector on the back of the TM-7CN/TM-7EX camera. Due to the connector's miniature size, PULNiX recommends purchasing the following pre-assembled cables: KC-10 10 feet, 4 conductor cable (12V, GND); 12POX Variable length, 8 conductor cable (12V, GND, Video, Clock out, Sync out, Async Vinit input I)

**Note:** Consult PULNiX for custom cable assemblies.

**4.4 LENSES** - PULNiX offers a wide variety of 2/3 inch format mini lenses. Auto-iris lenses must have a cable equipped with a PC-6P connector mating into the 6-pin female connector on the back of the camera.

**Note:** Normally, the TM-7CN and TM-7EX series cannot do variable shuttering while using an auto-iris lens because these functions share one 6-pin socket. The user has to build his own interface in order to use both an auto-iris lens and a shutter control switch. This is done by separating the +12VDC, GND and video wires (for the auto-iris lens), and the D<sub>0</sub>, D<sub>1</sub>, and D<sub>2</sub> controls (for the BCD switch).

**4.5 POWER SUPPLIES** - 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

## SECTION 5 SETUP AND OPERATION

The operation of the TM-7 series requires a lens (mini or standard C-mount), a 12V DC regulated power supply, power and video cable assemblies and, if needed, a shutter control unit. Setup of the camera system is as follows:

**5.1 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.

### 5.2 POWER SUPPLY AND POWER CABLE SETUP

The TM-7CN/6CN and TM-7EX/6EX cameras use a 12-pin connector for power input. 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.

### 5.3 ATTACHING THE VIDEO OUTPUT

Most users utilize the BNC connector on the "CN" and "EX" versions for video output from the camera.

Connect the output from the camera to the input of your monitor, VCR, or switching device. The input of the monitor should be balanced for 75 $\Omega$  termination. Standard RG-59 type coaxial cable should carry a full video signal for up to 500 feet.

### 5.4 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.

#### 5.4.1 BACK FOCUSING LENSES

To backfocus the TM-7CN, TM-7EX cameras, 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.

#### 5.4.2 AUTO-IRIS LENS SETUP

Power down the camera before attaching auto-iris lens. Mount the auto-iris lens following the instructions above. Plug the connector provided on the lens into the connector on the rear of the camera marked AUTO-IRIS or simply LENS. You may now power up the camera. Point camera at a light area and then quickly towards a darker area. If everything is working properly, the iris should adjust for the light change.

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.

#### 5.5 SHUTTER CONTROL SETUP

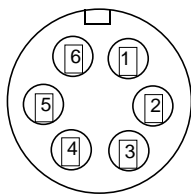
The SC-745 Shutter Controller is used to externally vary the shutter speed of the TM-7CN/6CN and TM-7EX/6EX. This controller plugs into the 6-pin connector on the rear of the camera normally used for auto-iris lenses. Switching the controller will obtain the desired shutter speed. See the key to controller speeds on the associated data sheet for the camera being shuttered. The SC-745 must remain attached to the camera to use the shutter feature of the camera unless the camera is specially modified to shutter internally. If at a single speed it is desired to use an auto-iris lens and SC-745 at the same time, a special 6-pin connector must be made up which breaks out the SC-745 and lens connections as separate outputs. See Section 6 for pin-outs and speed menu.

## SECTION 6 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.

### 6.1 BCD SHUTTER CONTROL

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

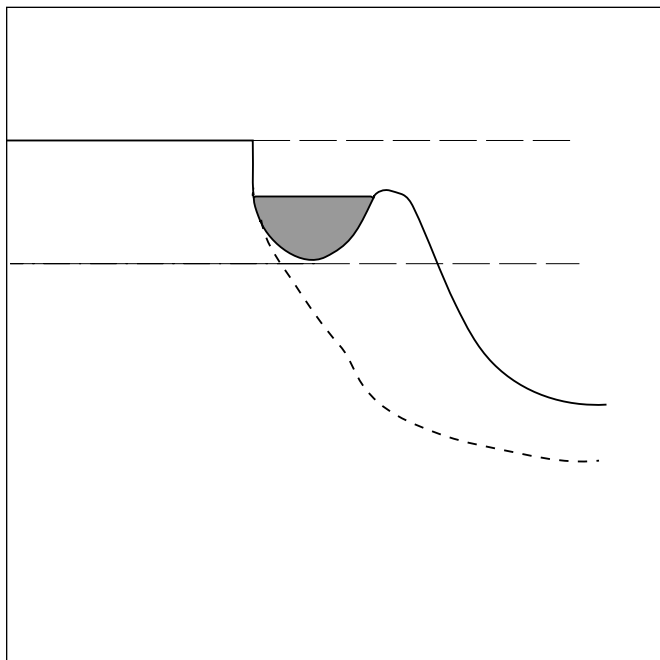


6 pin connector

- |                   |                   |
|-------------------|-------------------|
| 1. D <sub>2</sub> | 4. +12V           |
| 2. GND            | 5. D <sub>0</sub> |
| 3. Iris           | 6. D <sub>1</sub> |

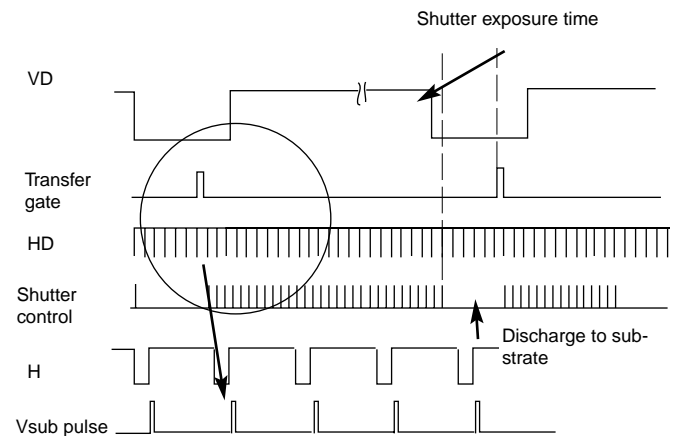
Control Setting	0	1	2	3	4	5	6	7
(sec)	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000	1/10000
D0	L	H	L	H	L	H	L	H
D1	L	L	H	H	L	L	H	H
D2	L	L	L	L	H	H	H	H

### 6.2 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.



### 6.3 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 7

### CCD CHARACTERISTICS AND OPERATION

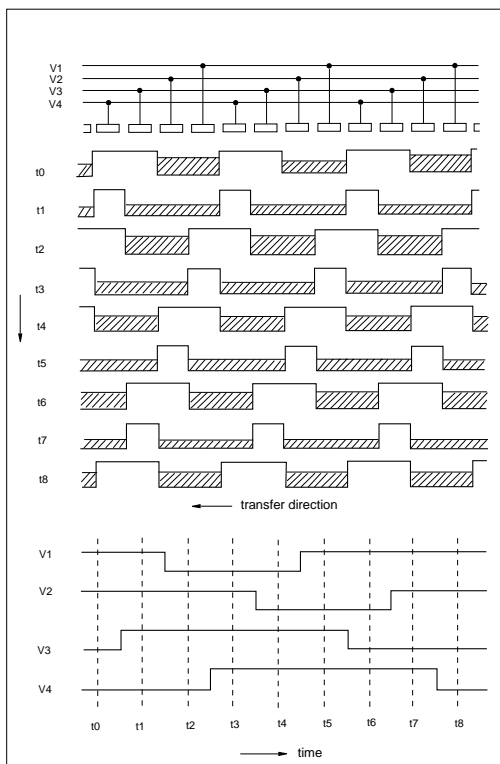
#### 7.1 THEORY OF OPERATION (Operation principle of the CCD)

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.



#### 7.2 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  $t_0$ , the electrode voltages are  $(V_1 = V_2) > (V_3 = V_4)$ , so the potential wells are deeper toward the electrode at the higher voltages  $V_1$  and  $V_2$ .

Charges accumulate in these deep wells. At  $t_1$ , the electrode voltages are  $(V_1 = V_2 = V_3) > (V_4)$ , so the charges accumulate in the wells toward the electrode at  $V_1$ ,  $V_2$  and  $V_3$ . At  $t_2$ , the electrode voltages are  $(V_2 = V_3) > (V_4 = V_1)$ , so the charges accumulate in the wells toward the electrode at  $V_2$  and  $V_3$ . Electrode voltage states at  $t_3$  and after are shown below.

$t_3(V_2 = V_3 = V_4) > (V_1)$

$t_4(V_3 = V_4) > (V_1 = V_2)$

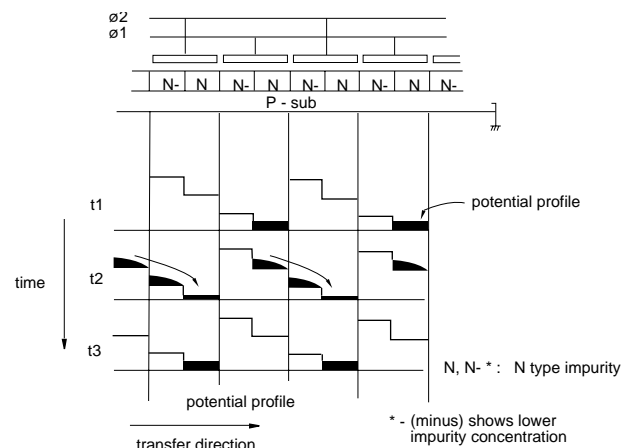
$t_5(V_4 > (V_1 = V_2 = V_3))$

$t_6(V_4 = V_1) > (V_2 = V_3)$

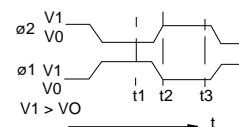
$t_7(V_4 = V_1 = V_2) > (V_3)$

$t_8(V_1 = V_2) > (V_3 = V_4)$  (Initial state)

These operations are repeated to execute the vertical transfer.



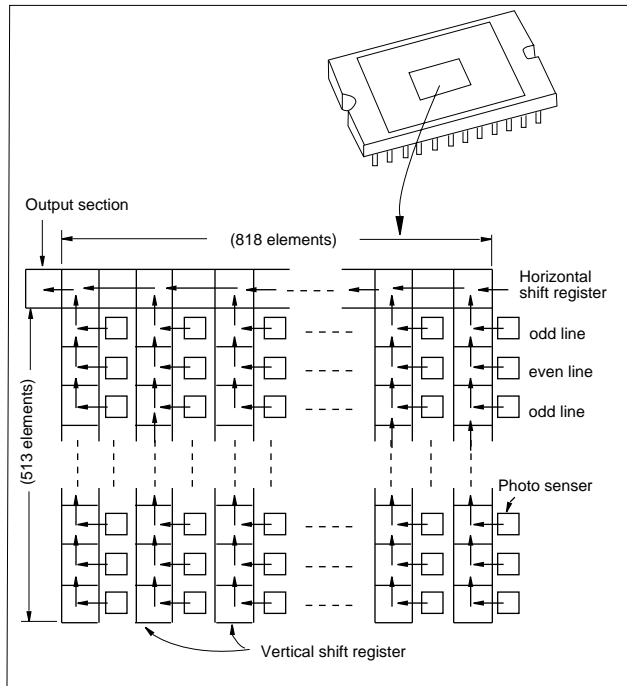
Operating Pulse Waveforms ( $\phi_1$ ,  $\phi_2$  or  $\phi_{H1}$ ,  $\phi_{H2}$ )



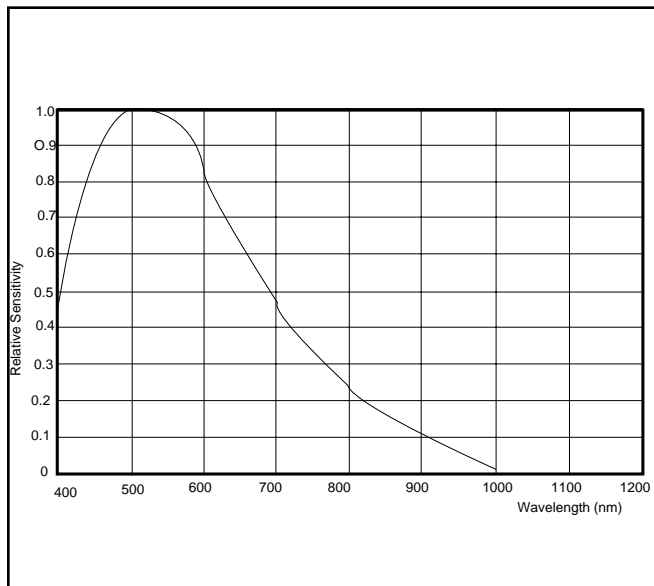
##### 2. Horizontal transfer

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  $t_1$ , the electrode voltages are  $H_1 > H_2$ , so the potential wells are deeper toward the electrode of the higher voltage  $H_1$ . The charges accumulate in these wells. At  $t_2$ , the electrode voltages  $H_1$  and  $H_2$  are inverted, the wells toward the electrode at voltage  $H_2$  become deeper while the wells toward the electrode at voltage  $H_1$  become shallower. So the wells at  $H_2$  are deeper than those at  $H_1$ , 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.



### 7.3 SPECTRAL RESPONSE



### 7.4 FIELD MODE AND FRAME MODE

Standard factory setting for this mode selection is FIELD MODE.

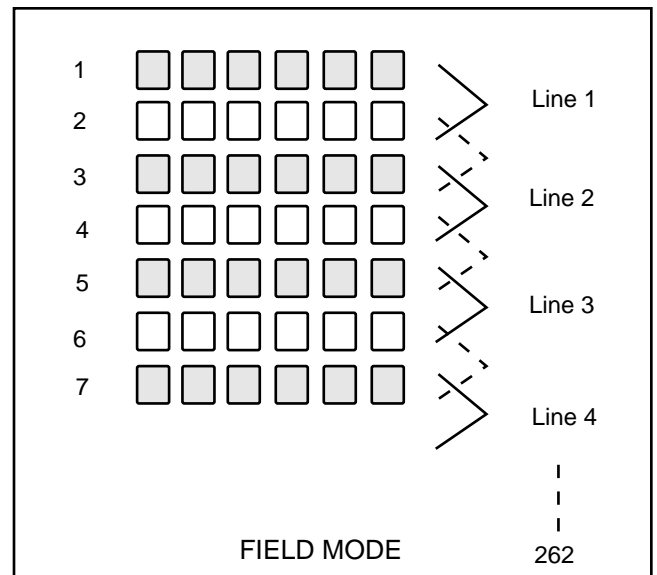
The difference of these two modes is as follows:

#### 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.

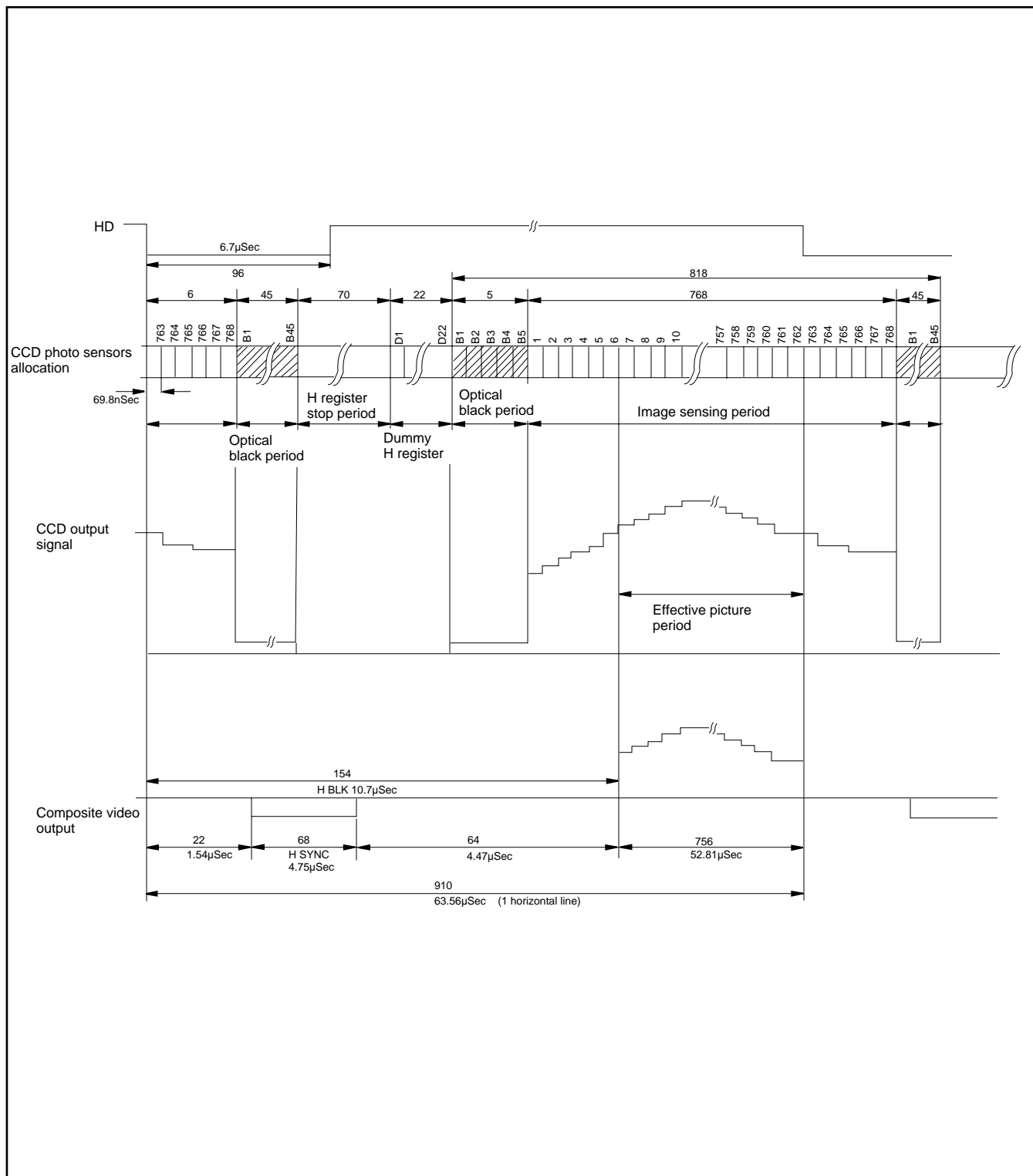


This mode has advantages when the shutter is often used as the sensitivity of the CCD is doubled for one field of integration ( For shutter, integration can not exceed one field ) therefore, it can obtain the same sensitivity as the FRAME MODE for half of the period. Because of alternating two row scanning, 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.

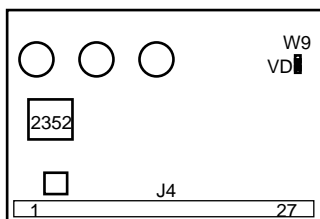
## SECTION 8 TIMING CHART



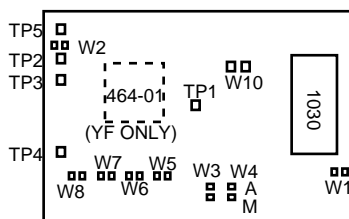
## SECTION 9 ADJUSTMENT PROCEDURE

### 9.1 Sync Gen Board

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



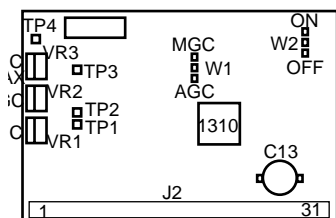
TM-7 SYNC GEN BOARD



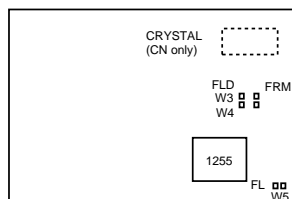
Jumper setting	standard	YF
W1 EIA/CCIR selection	Open (EIA)	Open
W2 INT Vinit	Short	Open
W3 Async mode	N/A	N/A
W4 Async/Man shutter	N/A	N/A
W5 - Open		
W8 Open		
W9 VD in	Short	Open
W10 Vinit selection	Open	Open

### 9.2 Processor Board

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



TM-7 PROCESSOR BOARD

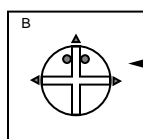


Jumper Setting	EIA	CCIR
W1 AGC/MGC	Ext. Switch	Open
W2 Gamma 1/0.45	Ext. Switch	Open
W3 Field/Frame	Ext. Switch	Open
W4 EIA/CCIR	Open	Short
W5 FL/0V	Open	Open

#### Voltage Setting

AGC Adjust VR1 (AGC) so that TP1 is  $2.0V \pm 0.1V$

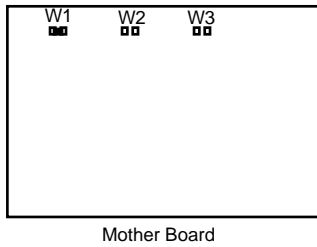
MGC Set VR2 (MGC) at mechanical center (2.5V at TP2). Then, set ext. gain pot. (rear panel) to 3.6V at TP2.



Mechanical center

AGC MAX. Adjust VR3 (AGC MAX) to  $3.0 \pm 0.1V$  at TP3.

### 9.3 Mother Board



	Standard	YF
W1	Short	Open
W2	Open	Open
W3	Open	Open

### 9.3 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

### 9.4 Factory Setting

AGC/MGC	EXT. Switch
GAMMA 1.0/0.45	EXT. Switch
FLD/FRM	EXT. Switch

## SECTION 10

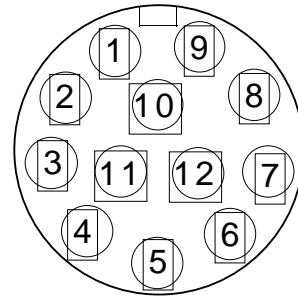
### External Sync Version For TM-7EX/TM-6EX Only

#### 10.1 External Sync Specification

Sync	Internal/External auto-switching
HD in	fHD = 15.734 KHz ± 5 % (EIA) fHD = 15.625 KHz ± 5 % (CCIR)
VD in	fVD = 59.94 Hz ± 5 % (EIA) fVD = 50.0 Hz ± 5 % (CCIR)
Input impedance	200Ω 75Ω (optional)

See connector board R1,R2,R3 for termination resistors.

### 10.2 Connector Pin Configurations



TM-7EX/TM-6EX	S-option
1 GND	GND
2 +12V IN	+12VIN
3 GND	GND
4 VIDEO OUT	VIDEO OUT
5 N/C	N/C
6 Vinit in	HD IN
7 VD IN	VD IN
8 GND	GND
9 HD IN	VINIT IN
10 N/C	N/C
11 INT. CONT	N/C
12 N/C	N/C

#### 10.3 Asynchronous Reset (Standard)

Asynchronous reset is available in all models. By providing reset input to Vinit pin, the TM-7 series camera can reset the scanning within 1 μsec. The reset is done for HD and VD together.

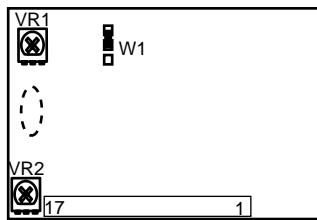
The reset pulse is TTL level and the negative going edge is the reset timing.

This feature is especially useful for strobing applications which generate full frame resolution at random reset. The captured image is always consistent with the order of odd and even fields. Asynchronous reset also eliminates "ghost image" which is caused by an overflow of charges when strong strobe lighting is applied during the middle of imager scanning.

Asynchronous reset and asynchronous shutter:  
Please refer to YF instruction.

## 10.4 Phase Adjustment

### TM-7EX GENLOCK BOARD



TM-7EX GENLOCK BOARD

#### Horizontal Lock

Apply HD to Genlock board and probe internal HD.  
Both External HD and Internal HD phase should line up. Observe jitter. It must be less than 20 nsec.  
Adjust VR2 to set the phase lock level so that TP1 DC level is  $4\text{ V} \pm 1\text{ V}$ .

#### Vertical lock

Apply VD to genlock board and probe internal VD.  
Adjust VR1 for vertical phase adjustment.  
Both External and Internal VD should line up.

Set W1 (Vertical Reset):

UP	Standard
DOWN	YF

	TM-7EX	75Ω-option	S-option
Pin 6	Vinit in	Open	75Ω R1 HD in
Pin 7	VD in	200Ω R2	75Ω R2
Pin 9	HD in	200Ω R3	75Ω R3
			Vinit(Open)

## 11.2 Jumper setting

	TM-7CN	TM-7EX	S-Option
W1	Short	Open	Open
W2	Short	Open	Open
W3	Open	T side	S side
W4	S side	T.C side	S side
W5	Open	Open	Short
W6	Open	Short	Short
W7	Open	Short	Open

## SECTION 11 CONNECTOR BOARD

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

## **NOTICE**

The material contained in this manual consists of information that is proprietary to PULNiX America, Inc., and may only be used by the purchasers of this product. PULNiX America, Inc. makes no warranty for the use of its products and assumes no responsibility for any errors which may appear or for damages resulting from the use of the information contained herein. PULNiX America, Inc. reserves the right to make changes without notice.

## **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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# **PULNiX**

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**TM-7 / TM-6  
TM-7CN / TM-6CN  
TM-7EX / TM-6EX  
TM-7X / TM6X  
MINIATURE CCD CAMERA  
(NEW VERSION)**

**OPERATIONS &  
MAINTENANCE MANUAL**

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TM7/3.7.94

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## FEATURES AND APPLICATIONS

**HIGH RESOLUTION, INTERLINE TRANSFER CCD**

The TM-7/TM-6 is a state-of-the-art CCD camera which uses a 1/2 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 asynchronous reset. It is designed to be a simple yet high quality camera 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 does not have external sync input since the majority of frame grabbers equip a phase lock loop circuit for video output. For applications requiring external sync, the TM-7EX is used.

**VARIABLE ELECTRONIC SHUTTER AND RANDOM CCD INTEGRATION**

The TM-7 / TM-6 has a substrate drain-type shutter mechanism which provides a superb picture at various speeds without smearing. The camera has the capability to externally vary the electronic shutter rate via a manually controlled BCD switch from 1/60 to 1/10,000 sec. in discrete steps.

**MINIATURIZED AND LIGHTWEIGHT**

All PULNiX cameras are built with the same design principles: solid state technology; miniaturization (including lenses, housings, 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 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-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.

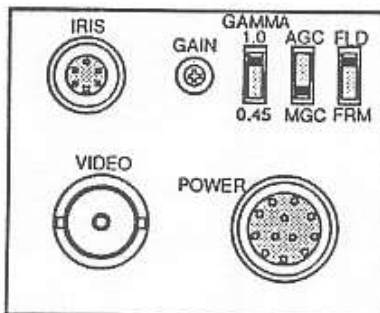
**GENLOCK CIRCUIT**

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. External sync is built into the TM-7EX series for applications where external sync is required.

**AGC SELECTION, MANUAL GAIN CONTROL AND GAMMA ADJUSTMENT (TM-7CN/TM6-CN)**

The AGC (automatic gain control) may be externally switched from automatic to fixed gain on the TM-7CN back plate. The manual gain is externally adjustable. Gamma may also be externally set either to 1 or 0.45. These adjustments are particularly important in vision system applications.

<b>Imager:</b>	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
Chip size	Low noise, blooming suppression 7.95 mm (H) x 6.45 mm (V)
<b>Scanning:</b>	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
<b>Sync:</b>	Int/Ext TM-7EX/TM-6EX
<b>TV resolution:</b>	570(H) x 485(V) lines - TM-7 560(H) x 575(V) lines - TM-6
<b>Video output:</b>	1.0V p-p composite video, 75Ω
<b>S/N ratio:</b>	50 dB min.
<b>Minimum Illumination:</b>	1.0 lux (F=1.4) without IR cut filter
<b>AGC:</b>	On (16dB standard, 32dB max) / Off
<b>Gamma:</b>	0.45 or 1
<b>Lens mount:</b>	C-mount
<b>Power requirement:</b>	DC 12V (9V min. ), 2.5 W
<b>Operating temperature:</b>	-10 °C to +50 °C
<b>Storage temperature:</b>	-30 °C to +60 °C
<b>Operating humidity:</b>	Within 70%
<b>Storage humidity:</b>	Within 90%
<b>Vibration:</b>	7G (11Hz to 200Hz)
<b>Shock:</b>	70G
<b>Dimensions:</b>	
TM-7	45mm (W) x 39mm (H) x 60.4mm (L) 1.77" (W) x 1.54" (H) x 2.38" (L)
TM-7CN	45mm (W) x 39mm (H) x 75mm (L) 1.77" (W) x 1.54" (H) x 2.95" (L)
TM-7X	32mm (Dia.) x 84.5mm (L) 1 1/4" (Dia.) x 3 5/16" (L)
TM-7EX	45mm (W) x 39mm (H) x 80mm (L) 1.77" (W) x 3.15" (H) x 3.15" (L)



TM-7 CN/EX BACK PLATE

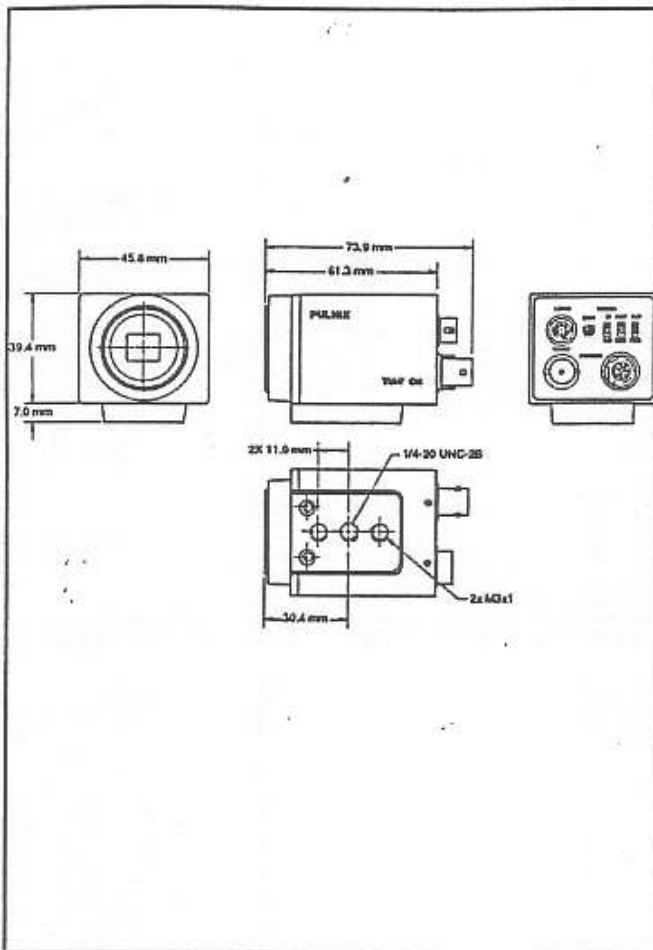
12 PIN CONNECTOR (TM-7CN)	CABLE (TM-7)	6 PIN (TM-7CN/EX) CONNECTOR
1 GND	Gray	1 D2
2 +12VDC	Yellow	2 GND
3 GND	Red coax shield	3 Video
4 Video	Red coax	4 +12V(or 5V)
5 GND	Orange coax shield	5 D0
6 Sync out	Orange coax	6 D1
7 Clock out*1	Black coax	
8 N/C	White shield (N/C *2)	
9 Vinit in	White coax	
10 N/C	Brown (5V)	
11 N/C	Blue (D2 .... 1/1000 sec *3)	
12 GND	Black coax shield	

\*1 28.6363 MHz external clock input (RV option)

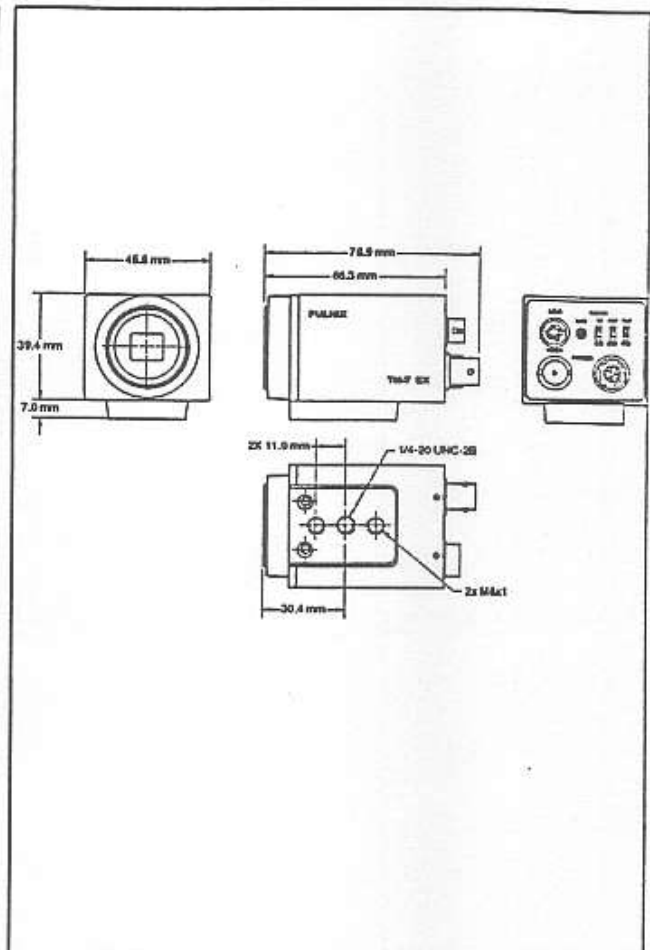
\*2 Auto-iris control output optional

\*3 Can be set any speed between 1/60 through 1/10,000 sec.

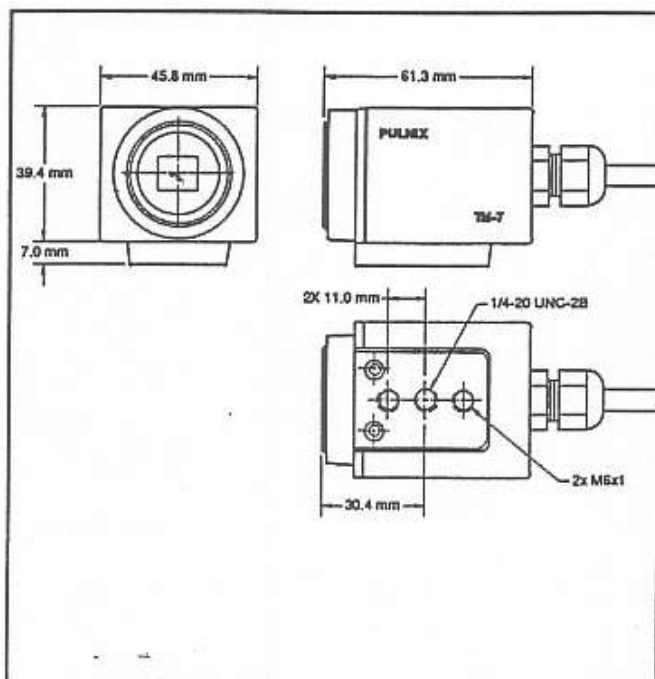
### 3.1 TM-7CN/TM-6CN



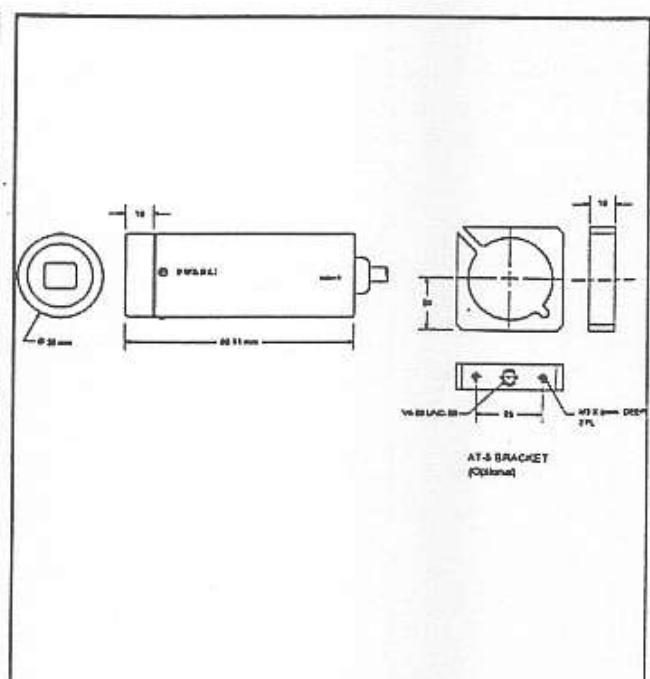
### 3.2 TM-7EX/6EX



### 3.3 TM-7/TM6



### 3.4 TM-7X/TM6X

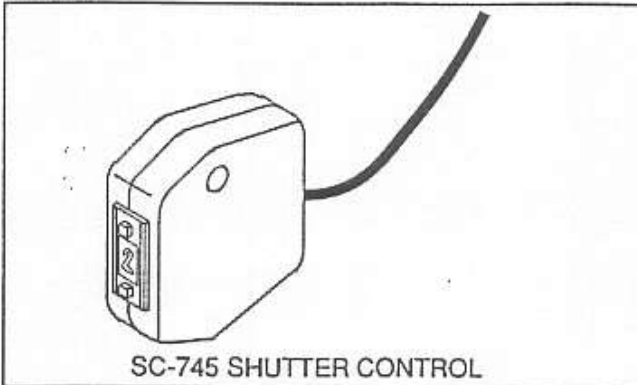


## SECTION 4

### CAMERA SYSTEM ACCESSORIES

The TM-7CN and TM-7EX consist of the camera body and the lens mount. Additionally, PULNiX offers the following accessories:

**4.1 SHUTTER CONTROL UNIT (SC-745)**- consists of a manually controlled 8-position BCD switch that determines the exposure time of the sensor. It connects to the TM-7CN/TM-7EX via a cable with a PC-6P male connector that plugs into the 6-pin female connector socket on the back of the camera. The SC-745 shutter control is included with the camera. The TM-7 and TM-7X do not accept an external shutter control.



**4.2 POWER CABLES** - all power cables use a PC-12P female connector that fits into the 12-pin male connector on the back of the TM-7CN/TM-7EX camera. Due to the connector's miniature size, PULNiX recommends purchasing the following pre-assembled cables: KC-10 10 feet, 4 conductor cable (12V, GND); 12POX Variable length, 8 conductor cable (12V, GND, Video, Clock out, Sync out, Async Vinit input I)

**Note:** Consult PULNiX for custom cable assemblies.

#### Connectors and cables

		CABLE (TM-7X)
1	GND	Gray
2	+12VDC	Yellow
3	GND	Red coax shield
4	Video	Red coax
5	GND	Orange coax shield
6	Sync out ("CN", "X") H <sub>D</sub> in ("EX")	Orange coax
7	Clock out*1 ("CN", "X") V <sub>D</sub> in ("EX")	Black coax
8	N/C	White shield (N/C *2)
9	Vinit in	White coax
10	N/C	Brown (5V)
11	N/C	Blue (D2*3 .1/1000 sec)
12	GND	Black coax shield

\*1 28.6363 MHz external clock input (RV option)

\*2 Auto-iris control output optional

\*3 Any shutter speed combination is available

The TM-7/TM-6 are mainly designed for custom length cables and PULNiX can assemble mating connectors for each customer's system connection.

**4.3 LENSES** - PULNiX offers a wide variety of 2/3 inch format mini lenses. Auto-iris lenses must have a cable equipped with a PC-6P connector mating into the 6-pin female connector on the back of the camera.

**Note:** Normally, the TM-7CN and TM-7EX series cannot do variable shuttering while using an auto-iris lens because these functions share one 6-pin socket. The user has to build his own interface in order to use both an auto-iris lens and a shutter control switch. This is done by separating the +12VDC, GND and video wires (for the auto-iris lens), and the D<sub>0</sub>, D<sub>1</sub>, and D<sub>2</sub> controls (for the BCD switch).

**4.4 POWER SUPPLIES** - 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

## SECTION 5 SETUP AND OPERATION

The operation of the TM-7 series requires a lens (mini or standard C-mount), a 12V DC regulated power supply, power and video cable assemblies and, if needed, a shutter control unit. Setup of the camera system is as follows:

**5.1 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.

### 5.2 POWER SUPPLY AND POWER CABLE SETUP

The TM-7CN/6CN and TM-7EX/6EX cameras use a 12-pin connector for power input. 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.

### 5.3 ATTACHING THE VIDEO OUTPUT

Most users utilize the BNC connector on the "CN" and "EX" versions for video output from the camera. Connect the output from the camera to the input of your monitor, VCR, or switching device. The input of the monitor should be balanced for 75 $\Omega$  termination. Standard RG-59 type coaxial cable should carry a full video signal for up to 500 feet.

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.

### 5.4 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.

#### 5.4.1 BACK FOCUSING LENSES

To backfocus the TM-7, TM-7CN, TM-7EX cameras, 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.

### 5.4.2 AUTO-IRIS LENS SETUP

Power down the camera before attaching auto-iris lens. Mount the auto-iris lens following the instructions above. Plug the connector provided on the lens into the connector on the rear of the camera marked AUTO-IRIS or simply LENS. You may now power up the camera. Point camera at a light area and then quickly towards a darker area. If everything is working properly, the iris should adjust for the light change. Auto-iris lenses which operate 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 lens.

### 5.5 SHUTTER CONTROL SETUP

The TM-745 Shutter Controller is used to externally vary the shutter speed of the TM-7CN/6CN and TM-7EX/6EX. This controller plugs into the 6-pin connector on the rear of the camera normally used for auto-iris lenses. Switching the controller will obtain the desired shutter speed. See the key to controller speeds on the associated data sheet for the camera being shuttered. The SC-745 must remain attached to the camera to use the shutter feature of the camera unless the camera is specially modified to shutter internally. If at a single speed it is desired to use an auto-iris lens and SC-745 at the same time, a special 6-pin connector must be made up which breaks out the SC-745 and lens connections as separate outputs. See Section 6 for pin-outs and speed menu.

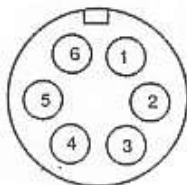
## SECTION 6

### TM-7/TM-6 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.

#### 6.1 BCD SHUTTER CONTROL

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

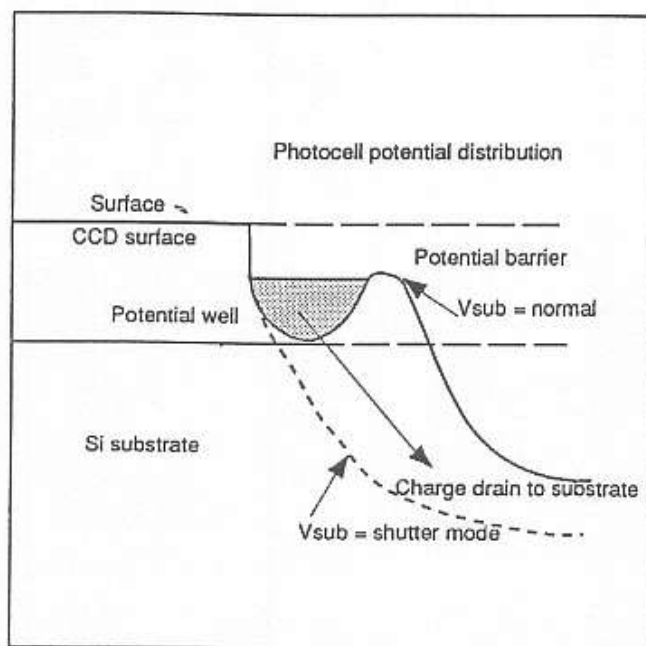


6 pin connector

- |         |         |
|---------|---------|
| 1. D2   | 4. +12V |
| 2. GND  | 5. D0   |
| 3. Iris | 6. D1   |

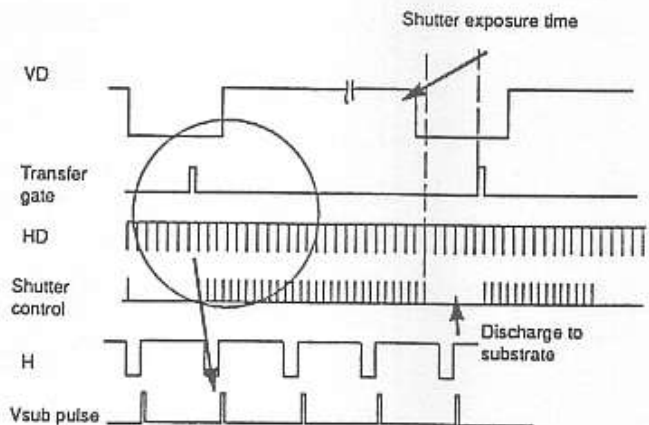
Control Setting	0	1	2	3	4	5	6	7
(sec)	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000	1/10000
D0	L	H	L	H	L	H	L	H
D1	L	L	H	H	L	L	H	H
D2	L	L	L	L	H	H	H	H

#### 6.2 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.



#### 6.3 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.

**RV option:** In order to control camera clock, external clock can be supplied as an (Option 7). The standard speed is 28.63 MHz. (40MHz max. and 1MHz min.)

## SECTION 7 CCD CHARACTERISTICS AND OPERATION

### 7.1 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:

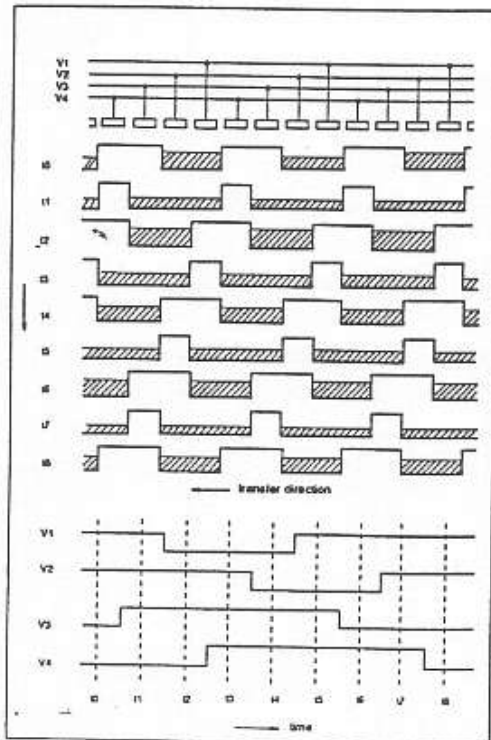
1. Photoelectric conversion (photosensor). Incident light generates charges on the MOS capacitors, with the quantity of charge being proportional to the brightness.

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.



### 7.2 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  $t_0$ , the electrode voltages are  $(V_1 = V_2) > (V_3 = V_4)$ , so the potential wells are deeper toward the electrode at the higher voltages  $V_1$  and  $V_2$ .

Charges accumulate in these deep wells. At  $t_1$ , the electrode voltages are  $(V_1 = V_2 = V_3) > (V_4)$ , so the charges accumulate in the wells toward the electrode at  $V_1$ ,  $V_2$  and  $V_3$ . At  $t_2$ , the electrode voltages are  $(V_2 = V_3) > (V_4 = V_1)$ , so the charges accumulate in the wells toward the electrode at  $V_2$  and  $V_3$ . Electrode voltage states at  $t_3$  and after are shown below.

$t_3(V_2 = V_3 = V_4) > (V_1)$

$t_4(V_3 = V_4) > (V_1 = V_2)$

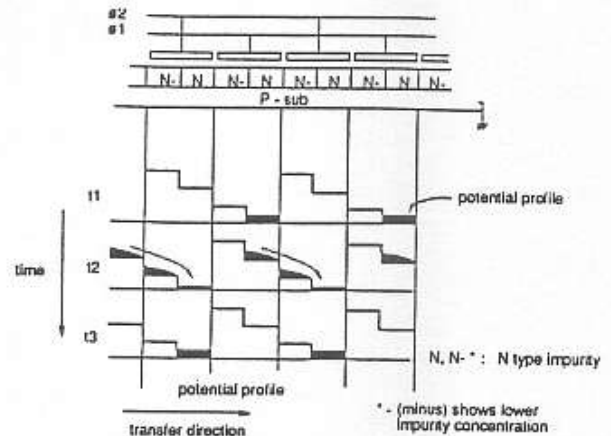
$t_5(V_4) > (V_1 = V_2 = V_3)$

$t_6(V_4 = V_1) > (V_2 = V_3)$

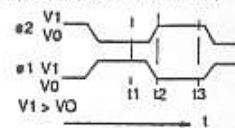
$t_7(V_4 = V_1 = V_2) > (V_3)$

$t_8(V_1 = V_2) > (V_3 = V_4)$  (Initial state)

These operations are repeated to execute the vertical transfer.



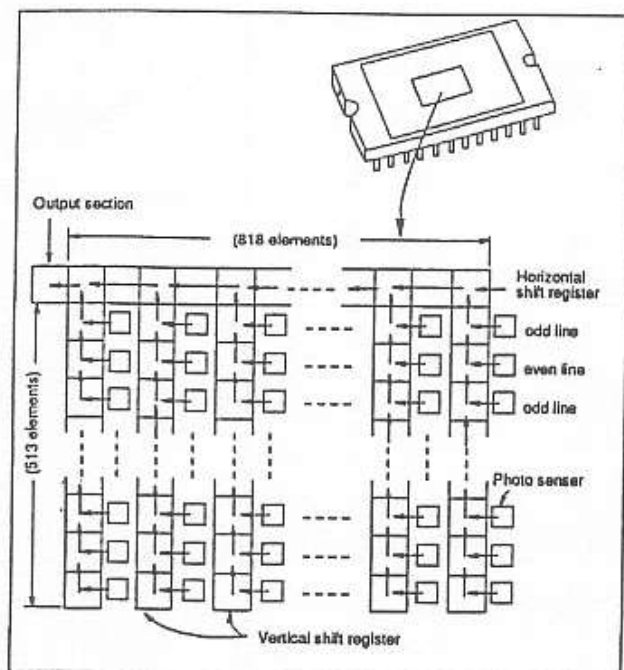
Operating Pulse Waveforms (#1, #2 or #H1, #H2)



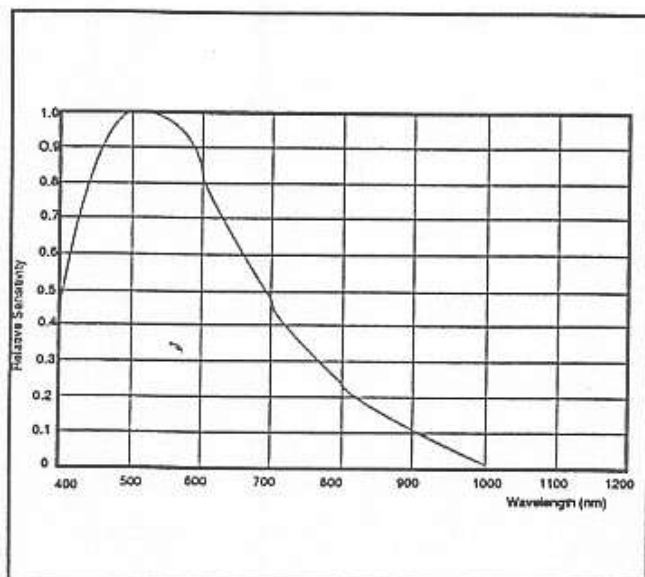
#### 2. Horizontal transfer

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  $t_1$ , the electrode voltages are  $H_1 > H_2$ , so the potential wells are deeper toward the electrode of the higher voltage  $H_1$ . The charges accumulate in these wells. At  $t_2$ , the electrode voltages  $H_1$  and  $H_2$  are inverted, the wells toward the electrode at voltage  $H_2$  become deeper while the wells toward the electrode at voltage  $H_1$  become shallower. So the wells at  $H_2$  are deeper than those at  $H_1$ , 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.



### 7.3 SPECTRAL RESPONSE



### 7.4 FIELD MODE AND FRAME MODE

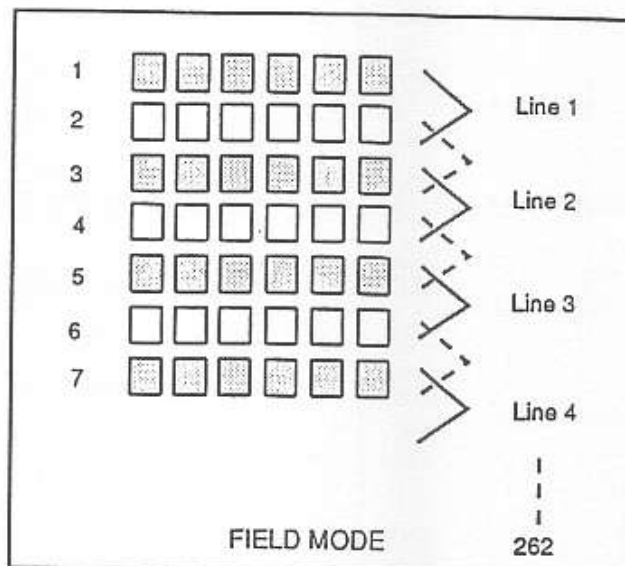
Standard factory setting for this mode selection is FIELD MODE.

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**

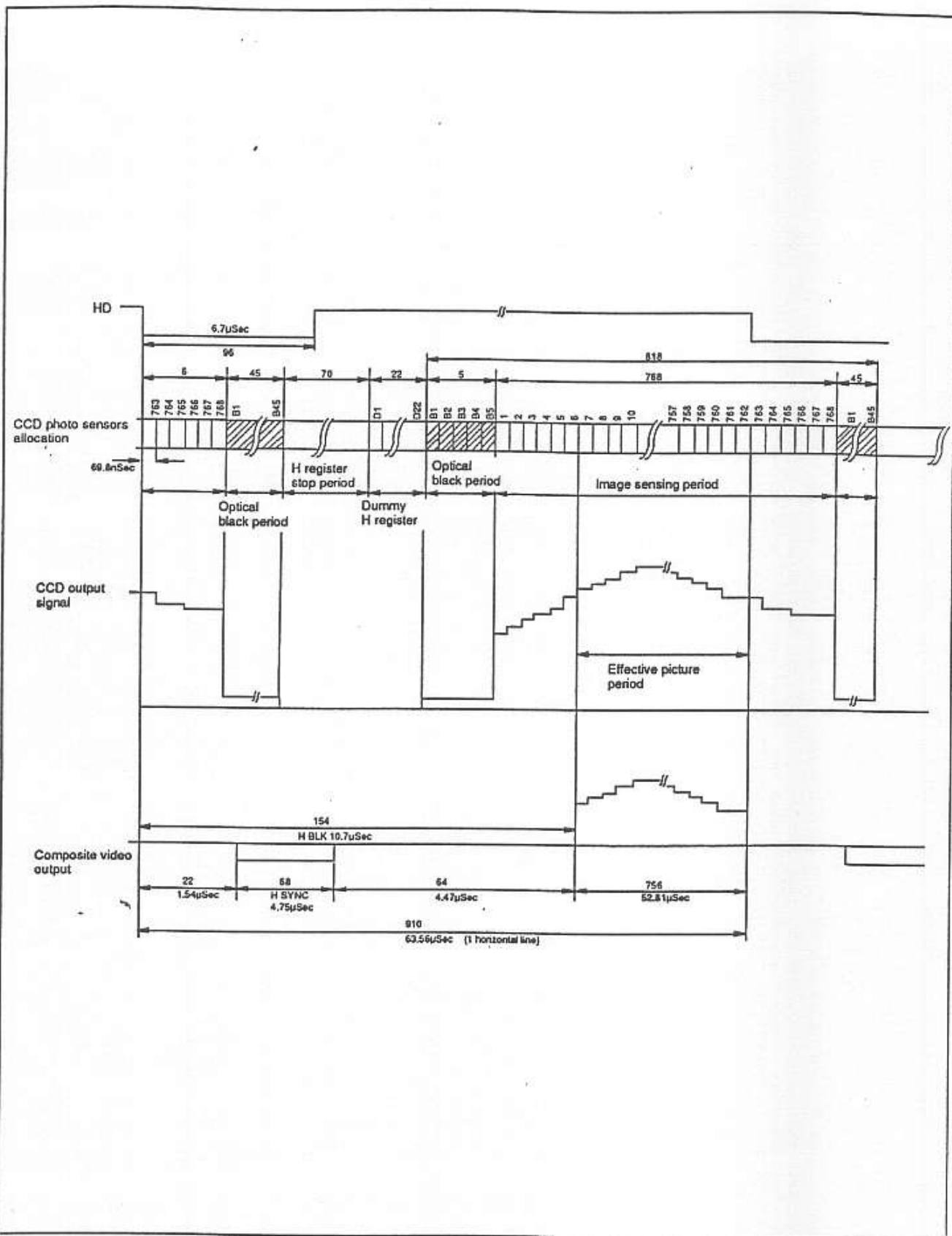
It scans two horizontal rows together and changes the pair at each interlace scanning.



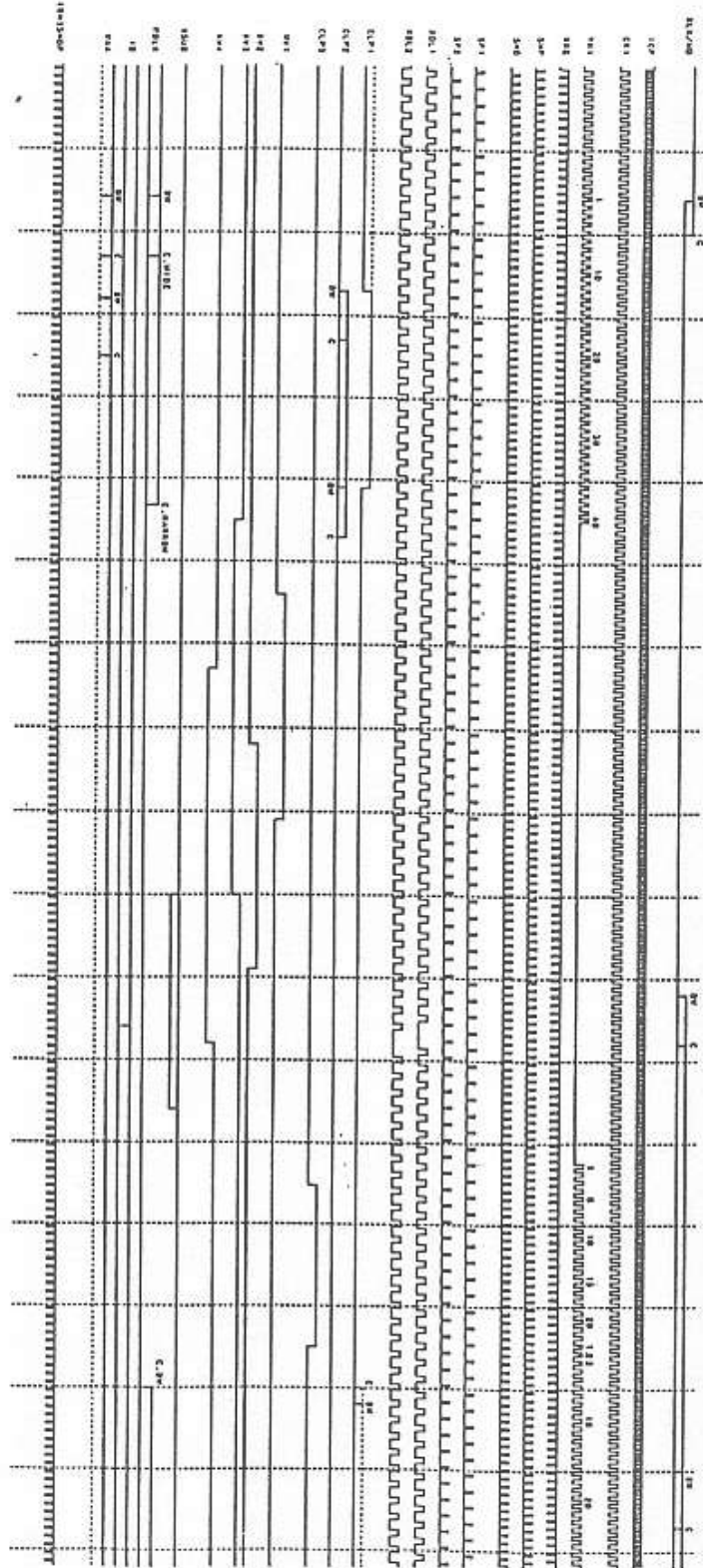
This mode has advantages when the shutter is often used as the sensitivity of the CCD is doubled for one field of integration ( For shutter, integration can not exceed one field ) therefore, it can obtain the same sensitivity as the FRAME MODE for half of the period. Because of alternating two row scanning, Moire is almost unnoticable 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.

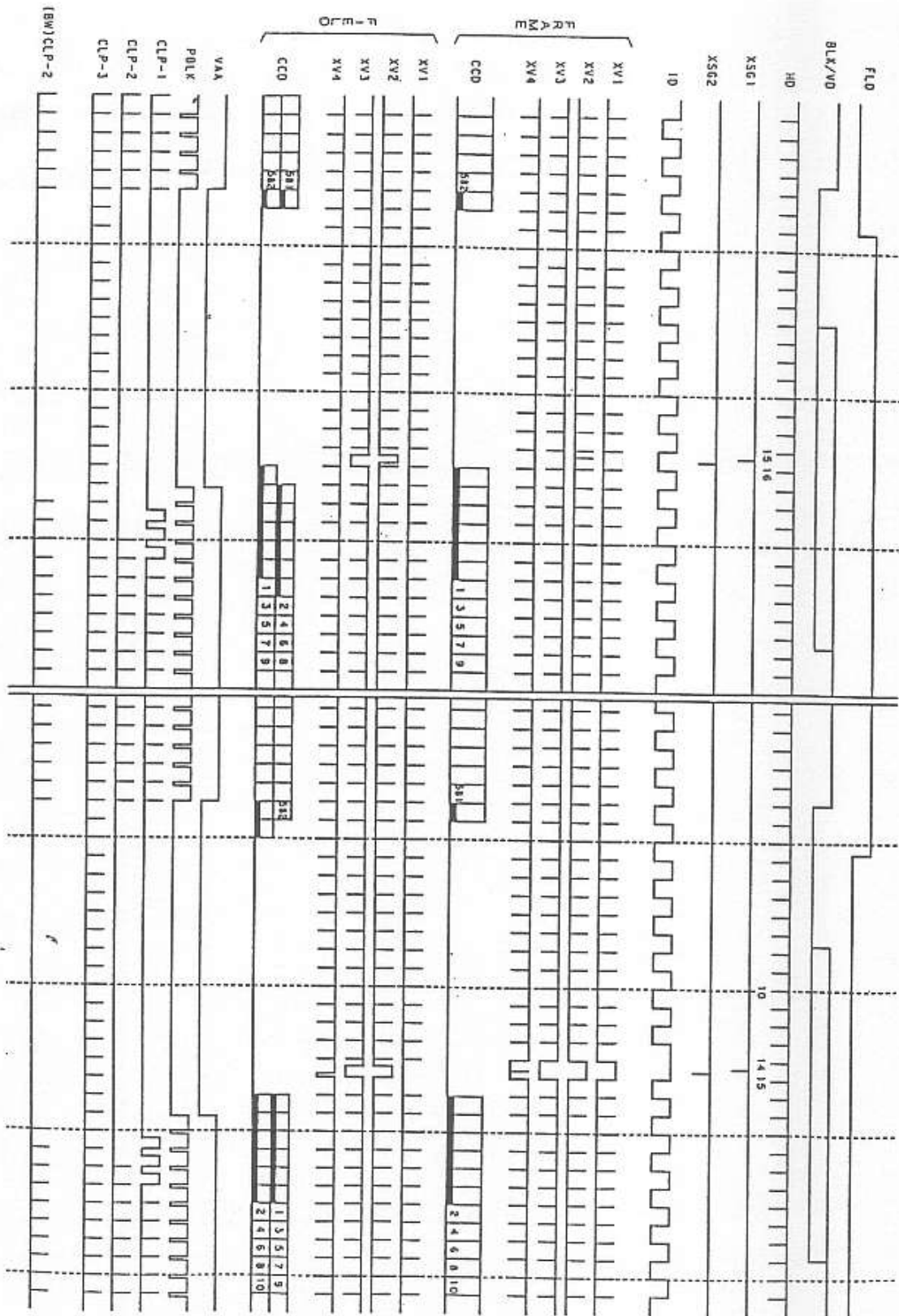
**NOTE:** The factory setting for the TM-7 series cameras is FIELD MODE. If FRAME MODE is required please contact PULNiX for the setting. The mode selection is solder jumper on the process board.



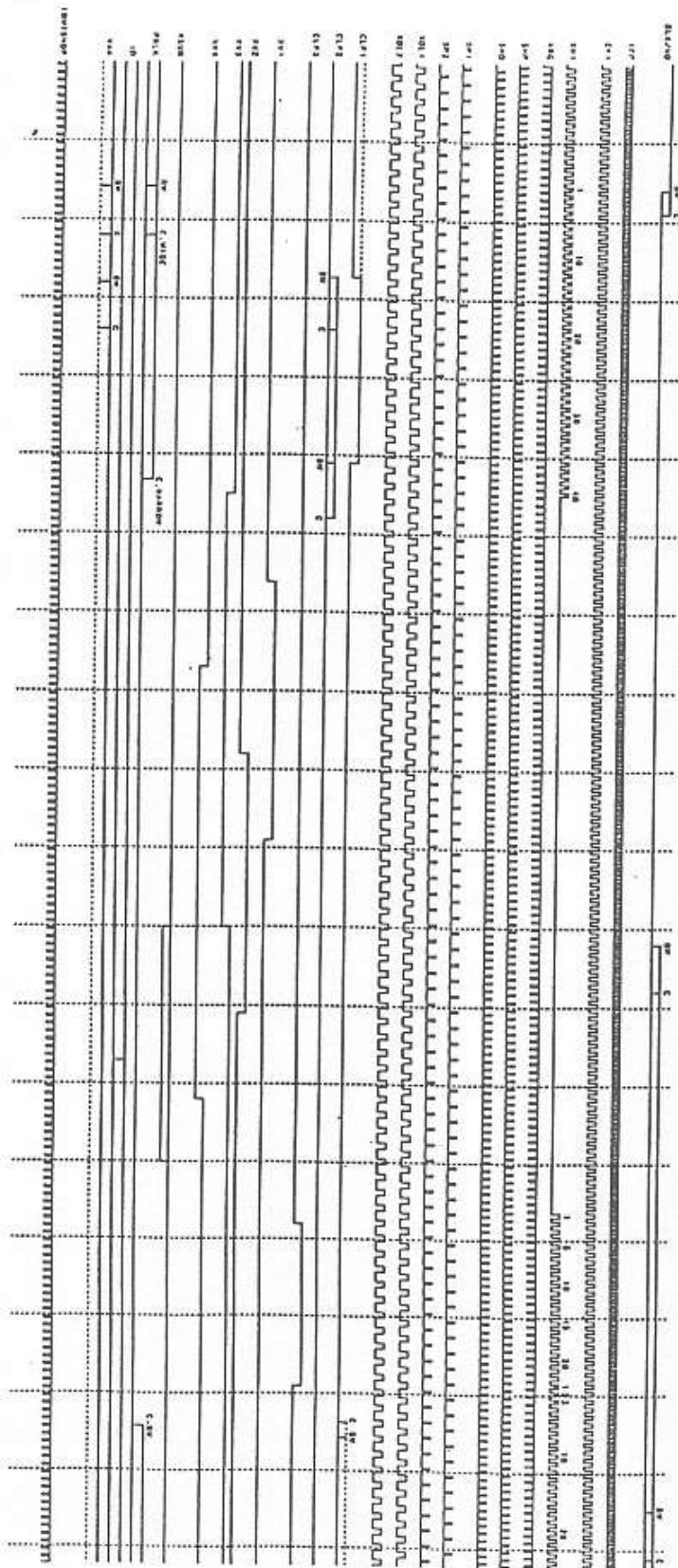




NTSC Horizontal Pulse Drawing



PAL Vertical Pulse Drawing



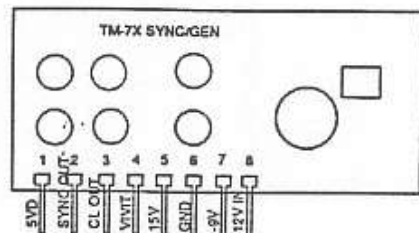
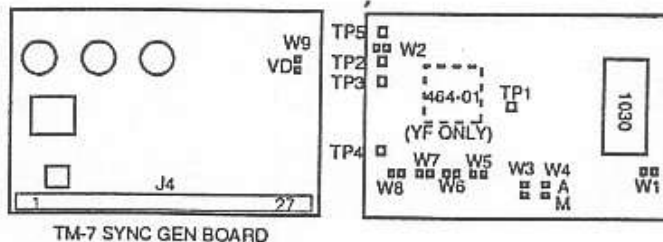
PAL Horizontal Pulse Drawing

# SECTION 9

## TM-7/TM-6, TM-7CN/TM-6CN, TM-7X/TM-6X ADJUSTMENT PROCEDURE

### 9.1 Power and Sync Gen board

Apply +12V DC to pin 8 and GND (#6).  
Measure 15V (pin#5) , VL=-9V (pin#7).



### Standard TM-7CN/EX

Jumper setting	standard	YF
W1 EIA/CCIR selection	standard	YF
W2 Async	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

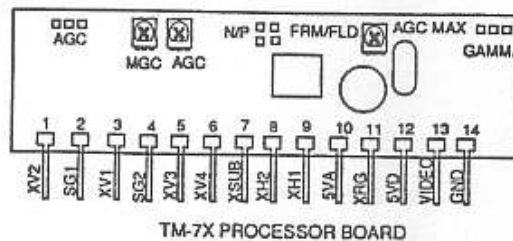
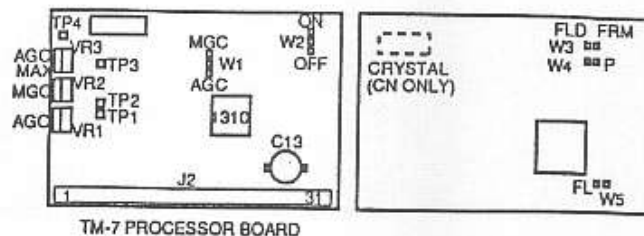
### 9.2 Imager Board (TM-7/TM-6, TM-7EX/6EX, TM-7CN/TM-6CN)

Use the TM-7 imager board test jig and check all imager functions. Adjust 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

### 9.3 Processor Board

Step 1. Apply +5V to 5D (pin#1) and confirm clock output.  
Step 2. Use test jig and check functions. It should operate at full function of video output.

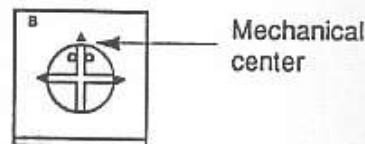


### 9.3.1 AGC

Adjust VR1 (AGC) so that TP1 is 2.0 V

### 9.3.2 MGC

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



### 9.3.3 AGC MAX.

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

### 9.4 Jumper Setting

For testing each board, set the jumpers as follows:

	EIA	CCIR
POWER	W1 none	P
DRIVER	W1 none	P
PROCESS	W1 AGC OFF	AGC OFF
	W2 GAMMA 1	GAMMA 1
	W3 FIELD (Open)	FIELD

After assembly the factory setting is,  
TM-7/TM-6 AGC ON, GAMMA=1  
TM-7X/TM-6X AGC ON, GAMMA=1  
TM-7CN/TM-6CN NO JUMPERS ON AGC AND GAMMA  
TM-7EX/TM-6EX Switch set is AGC OFF  
GAMMA=1

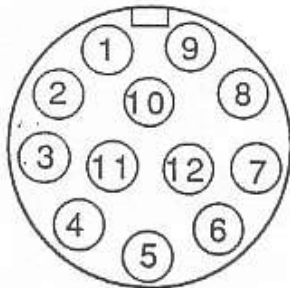
## 10.1 External Sync Specification

Sync Internal/External auto-switching  
 HD in fHD = 15.734 KHz  $\pm$  5 % (EIA)  
 fHD = 15.625 KHz  $\pm$  5 % (CCIR)  
 VD in fVD = 59.94 Hz  $\pm$  5 % (EIA)  
 fVD = 50.0 Hz  $\pm$  5 % (CCIR)

Input impedance 330 $\Omega$   
 75 $\Omega$  (optional)

See connector board R1,R2,R3 for termination resistors.

## 10.2 Connector Pin Configurations



## TM-7EX/TM-6EX

1 GND  
 2 +12V IN  
 3 GND  
 4 VIDEO OUT  
 5 N/C  
 6 Vinit in  
 7 VD IN  
 8 N/C  
 9 HD IN  
 10 N/C  
 11 N/C  
 12 N/C

## S-option

GND  
 +12VIN  
 GND  
 VIDEO OUT  
 N/C  
 HD IN  
 VD IN  
 N/C  
 VINIT IN  
 N/C  
 N/C  
 N/C

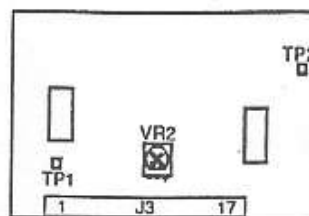
## 10.3 Asynchronous Reset (STANDARD)

Asynchronous reset is available in all models. By providing reset input to Vinit pin, the TM-7 series camera can reset the scanning within 1  $\mu$ sec. The reset is done for HD and VD together.

The reset pulse is TTL level and the negative going edge is the reset timing.

This feature is especially useful for strobing applications which generate full frame resolution at random reset. The captured image is always consistent with the order of odd and even fields. Asynchronous reset also eliminates "ghost image" which is caused by an overflow of charges when strong strobe lighting is applied during the middle of imager scanning.

Asynchronous reset and asynchronous shutter:  
 Please refer YF instruction

10.4 Phase Adjustment  
TM-7EX GENLOCK BOARD

TM-7 GENLOCK BOARD

## Horizontal lock

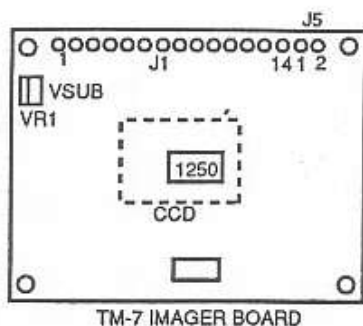
Apply HD to Genlock board and probe internal HD. Both External HD and Internal HD phase should line up. Observe jitter. It must be less than 20 nsec. Adjust VR2 to set the phase lock level so that TP1 DC level is 5 V  $\pm$  1 V.

## Vertical lock

Apply VD to genlock board and probe internal VD. Adjust VR1 for vertical phase adjustment. Both External and Internal VD should line up.

## SECTION 11 CONNECTOR BOARD

### 11.1 Impedance selection



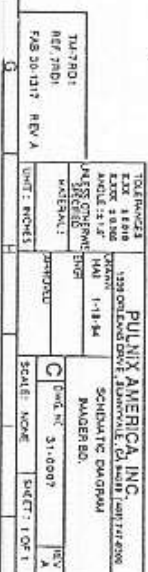
Standard input/output impedance for Pins 6, 7 and 9 of 12 pin connector is as follows,

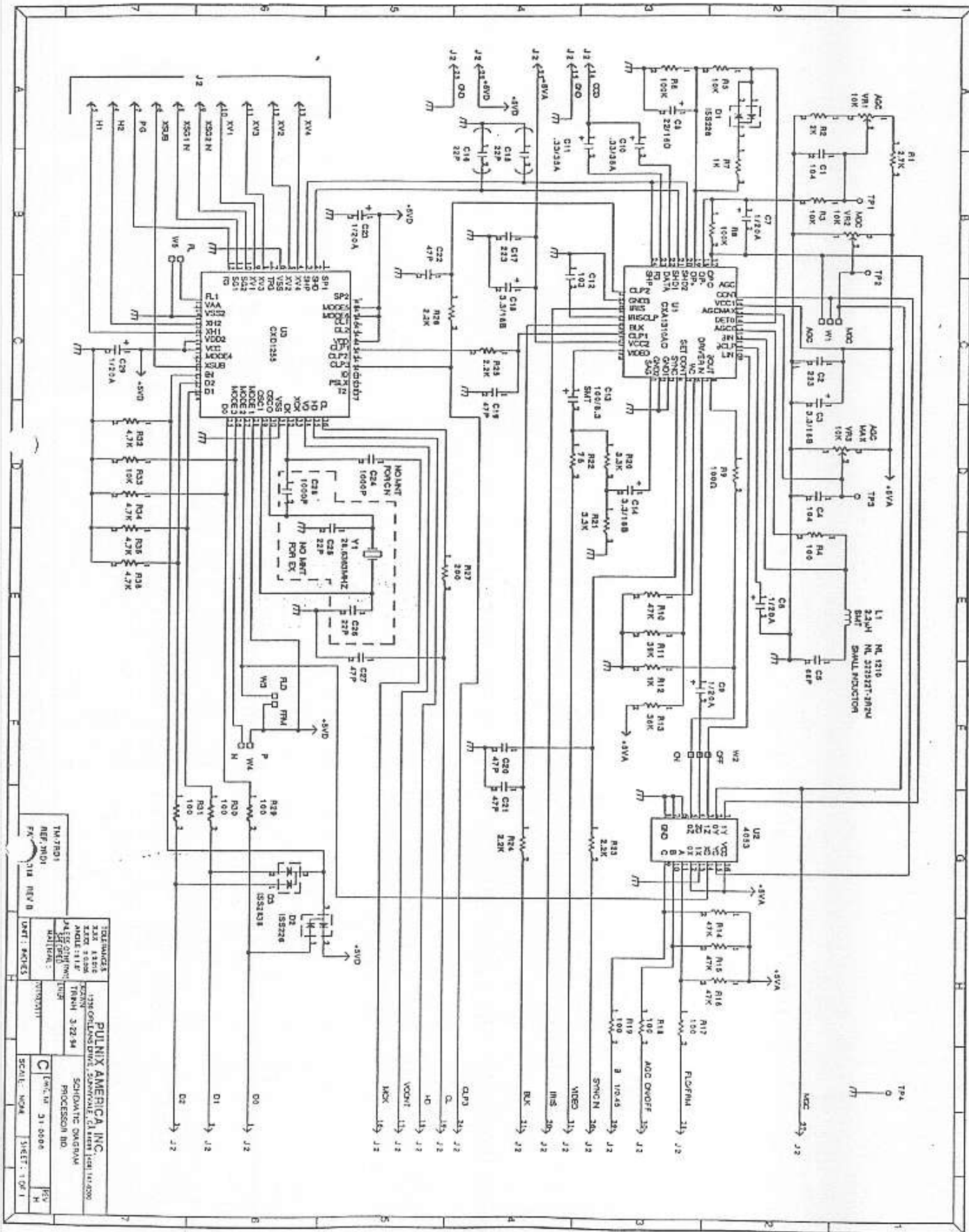
		TM-7 CN/TM-7	Option
Pin 6	Sync out	TTL (OPEN)	
Pin 7	Clock out	Emitter follower	50Ω on R2
Pin 9	Vinit in	300Ω R3	75Ω on R3

	TM-7EX	75Ω-option	S-option
Pin 6	Vinit in Open	Open	75Ω HD in
Pin 7	VD in 300Ω R2	75Ω R2	75Ω R2
Pin 9	HD in 300Ω R3	75Ω R3	Vinit(Open)

### 11.2 Jumper setting

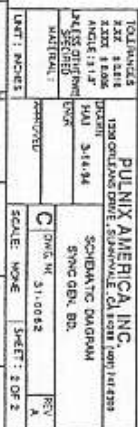
	TM-7CN	TM-7EX	S-Option
W1	Short	Open	Open
W2	Short	Open	Open
W3	N/A	T side	S side
W4	T.C side	T.C side	S side

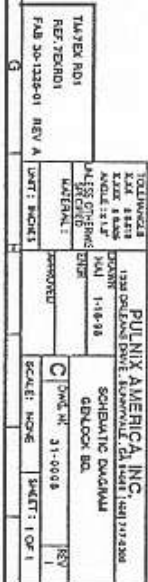


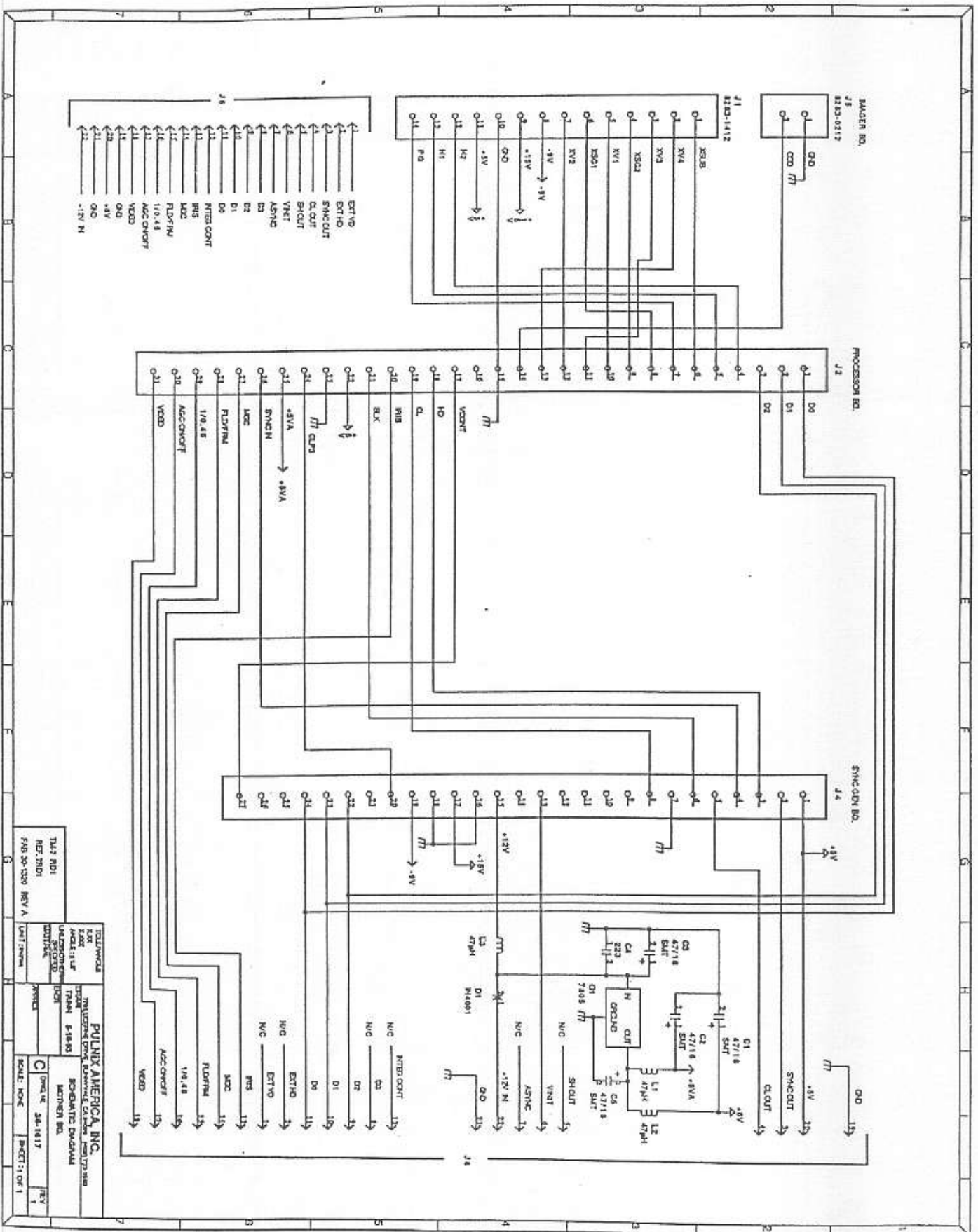




PULNIX AMERICA, INC.		TOTAL SALES	
1390 OAKLAND DRIVE, SUITE 100, CANTON, OH 44705		XXX \$243	
		XXXX \$1,000	
		AMOUNT \$11.57	
		PAID \$0.00	
		BALANCE \$11.57	
DATE: 11/28/84		MATERIAL:	
PERSON: J. D. W.		DATE: 11/28/84	
SCALE: NONE		MATERIAL: B	
MATERIAL: 1 OF 2			

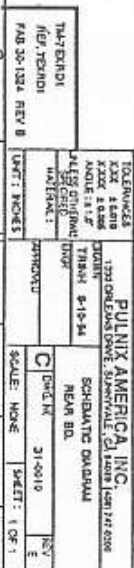


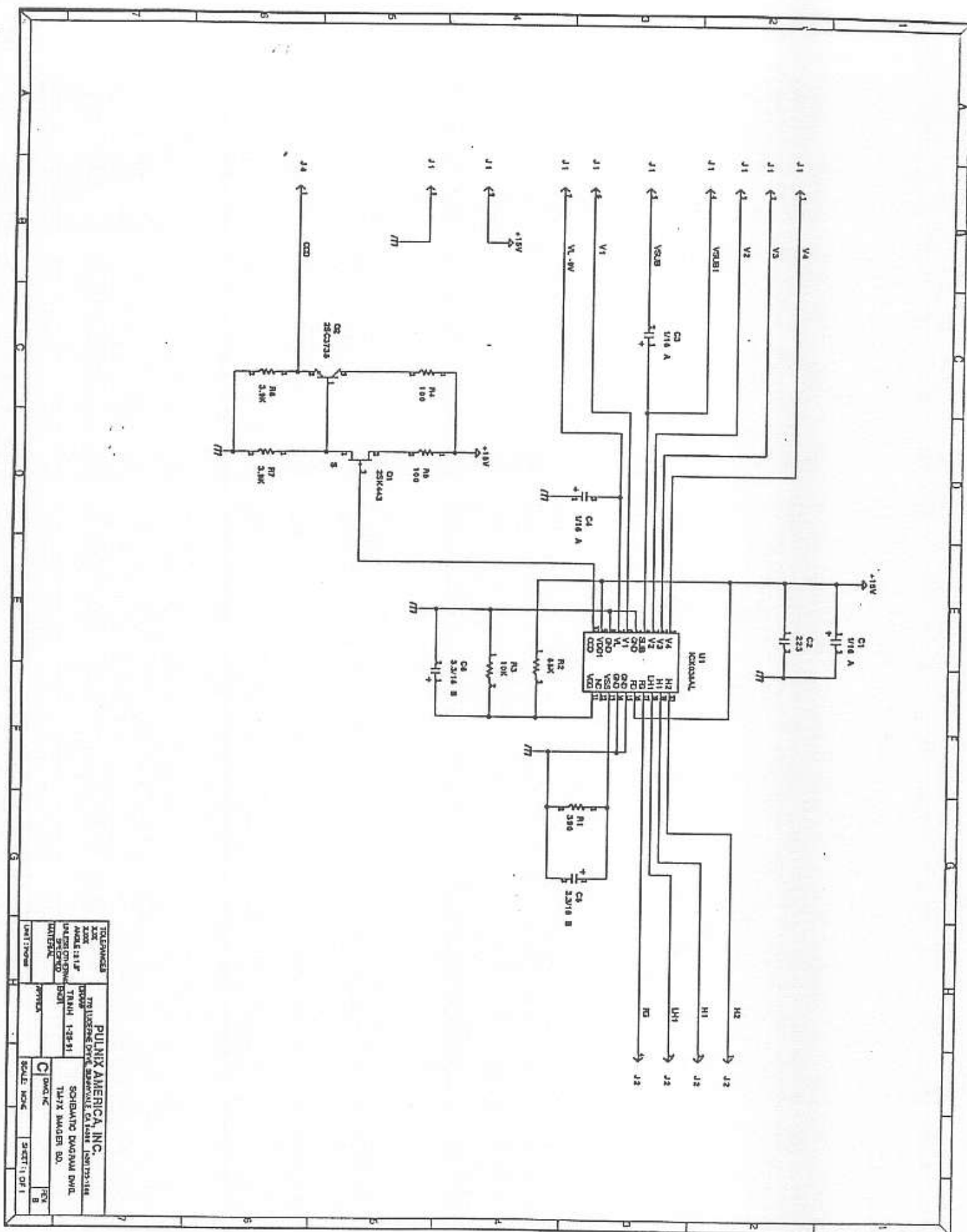


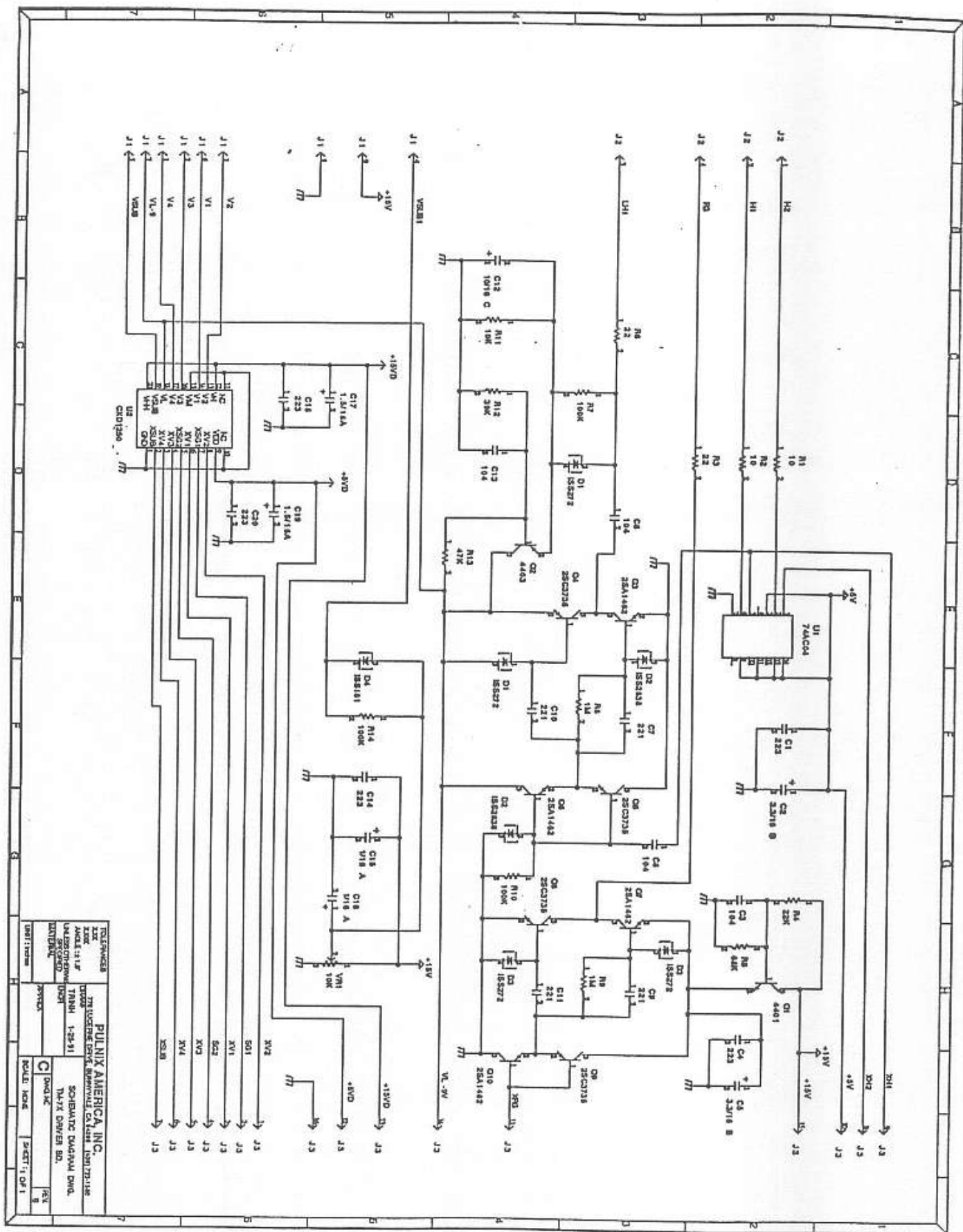


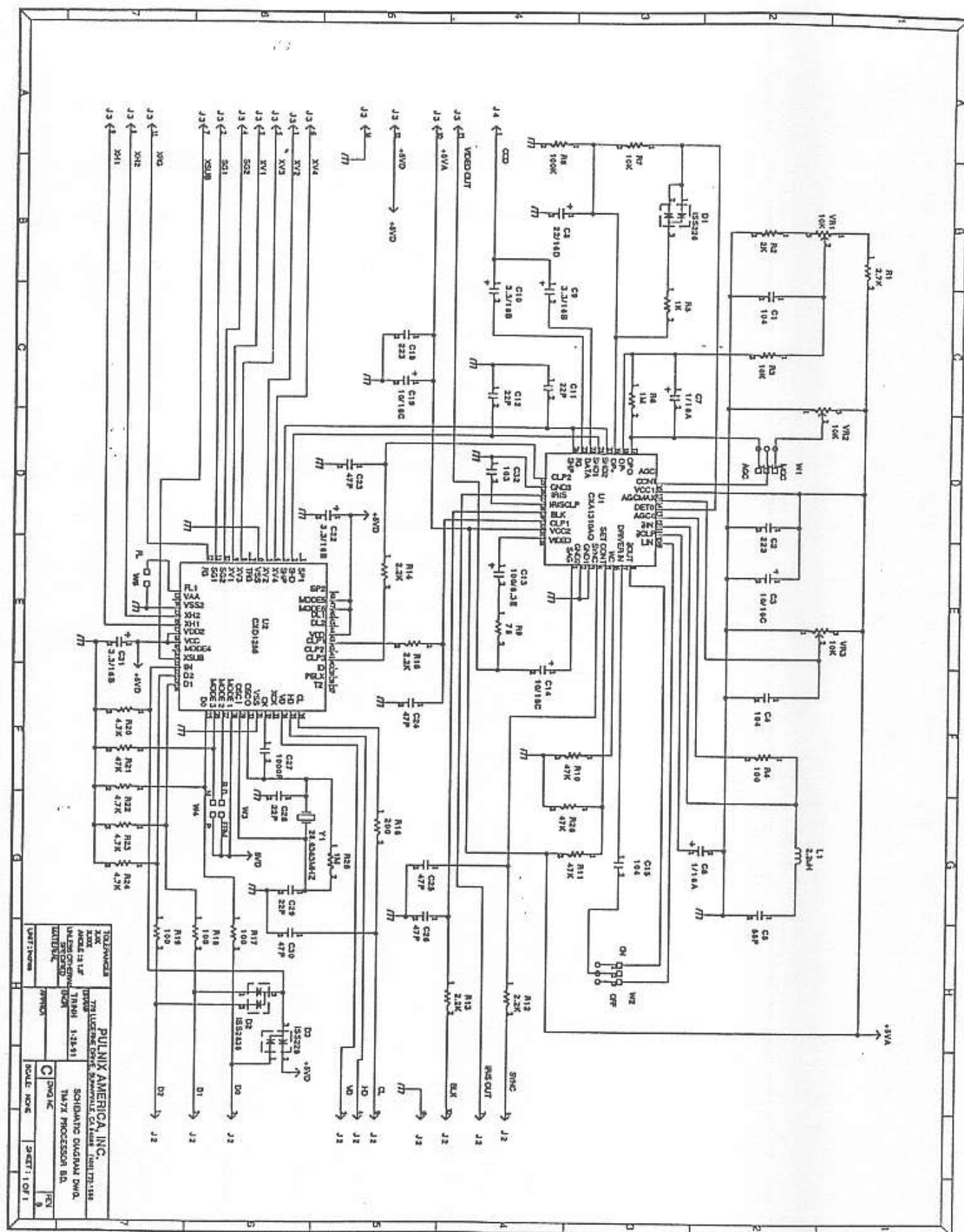
TULZ RD  
 REV A  
 PULNIX AMERICA, INC.  
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 TEL: 918-438-1111  
 FAX: 918-438-1112  
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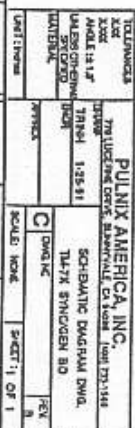


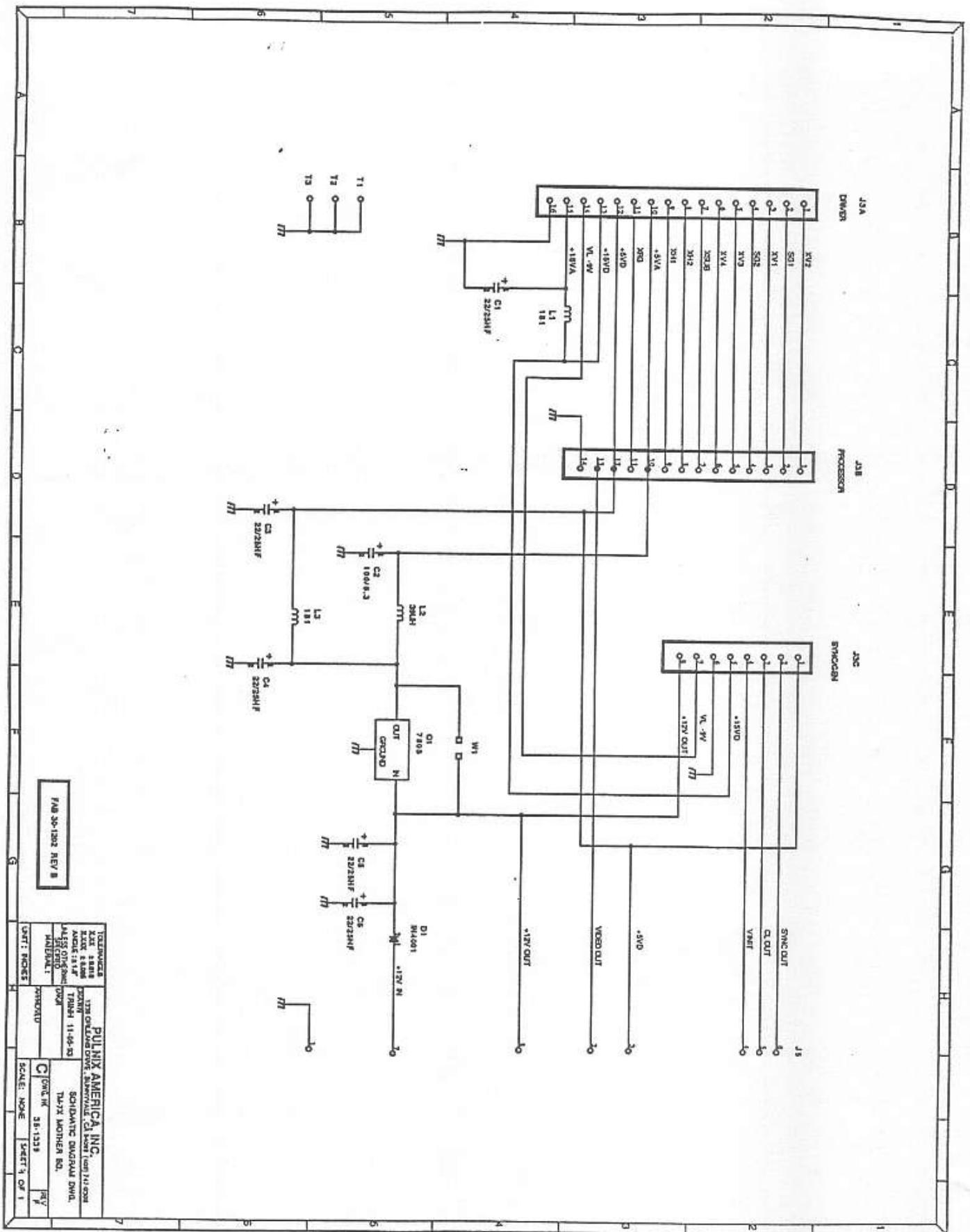














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