PULNiX

TMC-7 / TMC-6
HIGH RESOLUTION
CCD COLOR CAMERA

OPERATIONS
MANUAL

REV. 7/6/95

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SECTION 1: OPERATION

1.1 OUTLINE

The TMC-7 (NTSC model) / TMC-6 (PAL model) is a compact, lightweight color video camera which uses a high resolution solid state image sensor - the Charge Coupled Device (CCD). The CCD camera produces less geometrical distortion and has higher resistance to vibration and shock when compared with a camera using a pickup tube. These features make the camera suitable for both industrial and CCTV surveillance applications. It is also suitable as an input device in an image processing system since the TMC-7N offers superb color reproduction.

The TMC-7 series cameras feature separate outputs for the RGB signals (when used with CCA-7) and Y/C output in addition to the standard VBS output.

All models have external access switches to enable or disable the AGC, and auto-white balance. The TMC-7 series uses complementary stripe color filters of Cy, Gr, Ye to generate all color variations. The complementary color system has the advantage of better sensitivity than the primary color system of R, G, B.

All models use C-mount lenses and have a back focus adjustment and auto iris output. The remote imager option is designed with a C-mount to achieve a tiny remote color camera with changeable lenses. Remote capability up to 2 meters is available.

1.2 SPECIAL CHARACTERISTICS OF A CCD

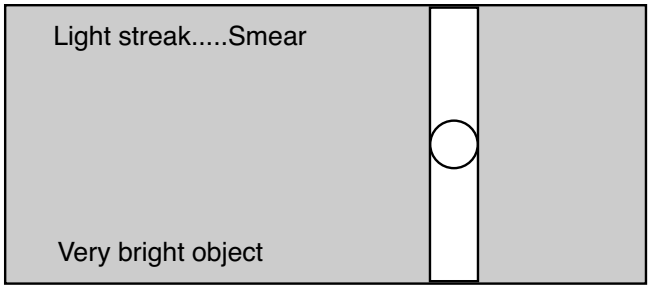
Smear phenomenon

This phenomenon occurs when shooting a very bright object (such as electronic light, fluorescent lamp, the sun or a strong reflection.) Due to the interline-transfer organization of the CCD image sensors (Refer to the "The Interline-Transfer Organization of the CCD Image Sensors", Section 3.3), this phenomenon is caused by the electronic charges generated beneath the photosensors by a light with a long wavelength, such as an infrared light.

NOTE: PULNiX color cameras contain a filter to minimize smear. Smear should only occur under extremely bright, and point light source conditions.

Patterned noise on the picture at high temperature

Dark current (thermal noise) is inherent in semiconductors. At room temperature, the amount of dark current in all photosensors is very close. However, as the temperature rises, the amount of dark current increases. As a result, the relative difference between the dark current of each photosensor increases. This difference also causes the patterned noise on the picture.



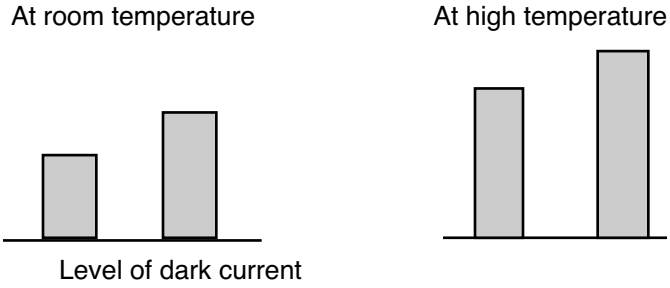
False signal

When vertical stripes or straight lines are shot, they may look wavy (Moire effect).

Blemish-free imagers

CCD photosensor elements generate electronic charges which ultimately produce horizontal and vertical rows in the CCD image sensor. Thus, any malfunctioning photosensor element could eventually cause a blemish on the monitor screen. However, all the PULNiX TMC-7/TMC-6 cameras have blemish-free CCDs to avoid this problem.

Consult the specifications in "Comprehensive Specifications" for details on the blemishes of the TMC-7/TMC-6.



SECTION 2: COMPREHENSIVE SPECIFICATIONS

Model	TMC-7 (NTSC)	TMC-6 (PAL)
Imager	1/2" interline transfer CCD (6.4 x 4.8 mm)	
Pixel	768(H) x 494(V)	752(H) x 582(V)
Cell size	8.4μm(H) x 9.8μm(V)	8.6μm(H) x 8.3μm(V)
Color filter	Cy, Ye, Mg, G complementary color filter	
Scanning	2:1 interlaced, field mode scanning	
	525 lines, 59.94 Hz	625 lines, 50 Hz
Sync	Internal sync only fH = 15.734 KHz fV = 59.94 Hz	 fH = 15.625 KHz fV = 50.00 Hz
TV resolution	460(H) x 400(V) TV lines	450(H) x 450(V) TV lines
S/N ratio	50 dB (AGC off)	
Min. illumination	2 Lux F = 1.4 (AGC on)	
Video output	VBS = 1.0 Vp-p at 75 Ω (NTSC and PAL) Y (B/W) = 1.0 Vp-p with sync, Chroma = 285 mV at 75 Ω (Y/C or S-VHS)	
Color balance	Through-the-lens auto white balance: memory (std) or auto-tracking (option) and manual hue adjustment	
AGC	Max. 32 dB AGC, on-off switchable, manual gain control	
Gamma	0.45	
Lens mount	C-mount	
Power req.	12 V DC, 330 mA	
Operating temp.	-10°C to +50°C	
Vibration & shock	Vibration: 7 G (200Hz to 2000Hz), Shock: 70G	
Size (W X H X L)	42 x 32 x 133 mm 1.65" x 1.26" x 5.24"	
Weight	210 grams (7.3 oz)	
Power cable	12P-02 for NTSC/PAL and Y/C, KC-10 for NTSC/PAL only	
Power supply	12VDC, 500mA	
Auto iris connector	Auto iris lens output and shutter control (SC-7)	
Functional options	Up to 16 fields integration output, auto-tracking white balance	
Accessories	SC-7 shutter control, C-mount mini lenses	

SECTION 3: THEORY OF OPERATION

3.1 OPERATION PRINCIPLES OF THE CCD

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

Photoelectric conversion (photo sensor)

Incandescent light generates electrical charges on the MOS capacitors, with the quantity of charge being proportional to the brightness.

Accumulation of electrical charges

When the voltage is applied to the electrodes of the CCD, an electrical potential well is formed in the silicon layer. The electrical charge is accumulated in this well.

Transmission of electrical charge

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

3.2 MECHANISM OF THE CCD ELECTRICAL CHARGE TRANSMISSION

The TMC-7 uses a 4-phase drive method CCD. For simplicity, a 2-phase drive method CCD is explained below.

Figure 1 shows an example of the changes which can occur in potential wells in successive time intervals.

At t1, the electrode voltages are fH1>fH2, so the potential wells are deeper toward the electrode at the higher voltage fH1. An electrical charge accumulates in these deep wells.

At t2, the clock voltages fH1 and fH2 are reversed; now the wells toward the electrode at voltage fH2 become deeper while those toward the electrode at fH1 become shallower. So the wells at fH2 are deeper than those at fH1 and the signal charge flows toward the deeper wells.

At t3, the electrode voltages have not changed because of t2, so the signal charge flows into the wells toward the electrode at fH2; one transmission of electrical charge is completed. This action is repeated over and over to execute the horizontal transmissions.

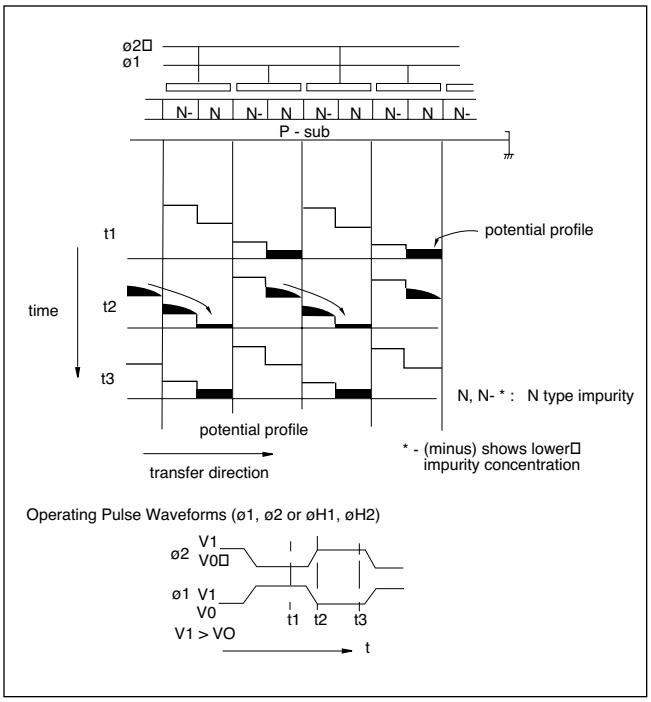


Figure 1

Vertical transfer

The vertical shift register transfers charges using a four-phase drive mode. Figure 2 shows an example of the changes which can occur in potential wells in successive time intervals. At tO, the electrode voltages are (V1 = V2)>(V3 = V4), so the potential wells are deeper toward the electrode at the higher voltages V1 and V2. Charges accumulate in these deep wells.

At t1, the electrode voltages are (V1 = V2 = V3)>(V4), so the charges accumulate in the wells toward the electrode at V1, V2 and V3.

At t2, the electrode voltages are (V2 = V3)>(V4 = V1), so the charges accumulate in the wells toward the electrode at V2 and V3. Electrode voltage states at t3 and after are shown below.

t3(V2 = V3 = V4)>(V1)
t4(V3 = V4)>(V1 = V2)
t5(V4>(V1 = V2 = V3)
t6(V4 = V1)>(V2 = V3)
t7(V4 = V1 = V2)>(V3)
t8(V1 = V2)>(V3 = V4) (Initial state)

These operations are repeated to execute the vertical transfer.

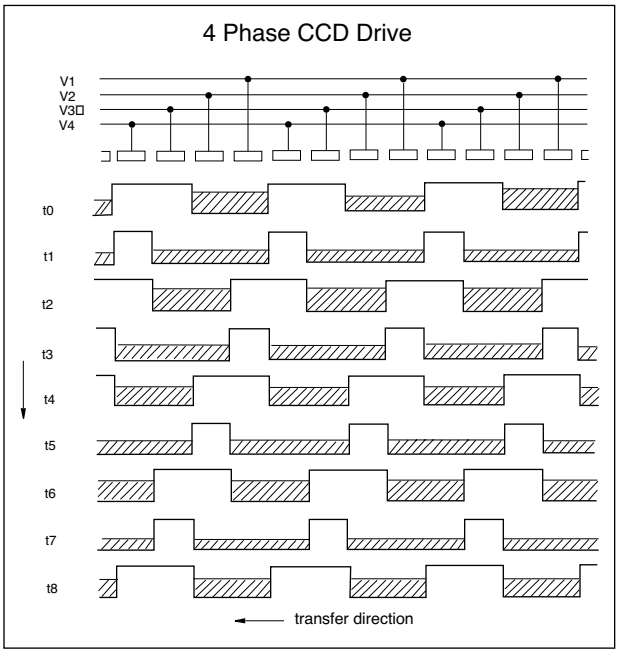
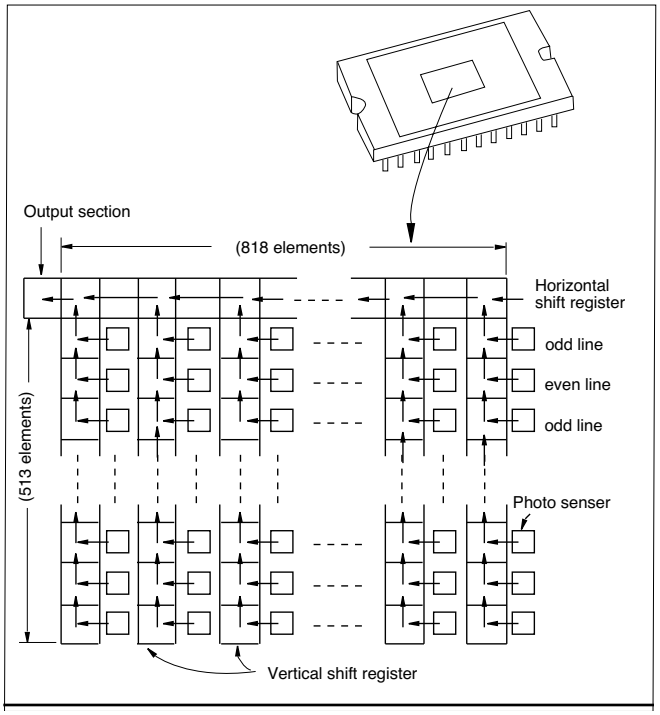


Figure 2

3.3 THE INTERLINE-TRANSFER ORGANIZATION OF THE CCD IMAGE SENSORS

The TMC-7 CCD video camera module adopts an interline-transfer organization in which the precisely aligned photosensor and vertical transmission section are arrayed interlinearly.

A horizontal shift register links up with the vertical transmission section. Light variations are sensed by the photosensors which generate electronic charges proportional to the light intensity. The generated charges are fed into the vertical shift registers all at once. The charges are then transferred from the vertical transmission section to the horizontal shift registers successively and finally reach the output amplifier to be read out successively.



3.4 INSTRUCTIONS FOR POWERING THE TMC-7/TMC-6

Connectors

The TMC-7 requires 12 V DC (330mA). The power is obtained through the 12-pin connector located at the rear of the camera. PULNiX offers a 4-conductor power cable with mating connector (model# C-10). For Y/C output, use a 12-pin connector to supply the power.

Optional output

Each pin has to be designated for various options such as Y/C output, integration control, etc. The customer will be required to assign option numbers.

Warning

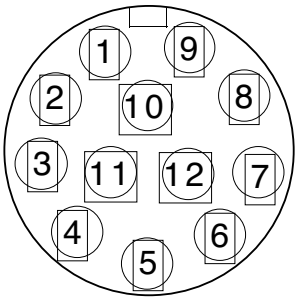
The TMC-7 must use either the 12P Series or C-10 cable. When applying power to the camera, make sure that none of the exposed leads on the multiple conductor cable are touching. This may cause damage to the camera. Besides the power connector, there is a standard BNC video connector on the rear of the camera.

3.4.1 12-PIN CONNECTOR AND POWER CABLES

12-Pin Connector

TMC-7/TMC-6	12P-02 Cable
1. GND	Gray
2. +12V DC In	Yellow
3. GND	Red Shield
4. Video Out (VBS)	Red Coax Signal
5. GND	Orange Shield
6. N/C	Orange Coax Signal
7. Chroma	Black Coax Signal
8. GND	White Shield
9. Y (B/W)	White Coax Signal
10. N/C	Brown
11. N/C	Blue
12. N/C	Black Shield

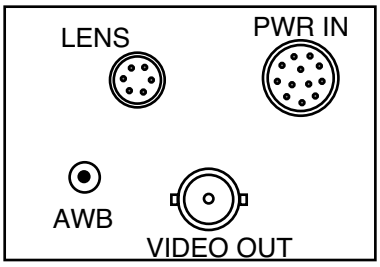
12-Pin Figure Power Connector



12P Series cables available:

12P-02 2 meters
12P-05 5 meters
12P-10 10 meters
12P-15 15 meters
12P-25 25 meters
12P-X Custom length
12P-02 8-conductor cable for RGB
12P-02MF RGB separator cable (for use with CCA-7 Signal Separator only)

3.4.2 BACK PANEL ASSEMBLY



Back Panel Assembly

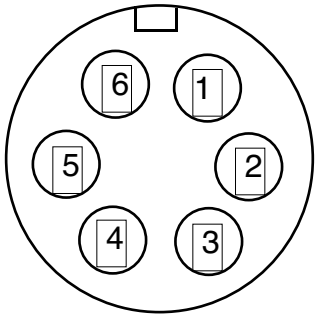
3.4.3 COLOR BALANCE ADJUSTMENT

The TMC-7/TMC-6 cameras feature an advanced color balancing system which utilizes an internal memory. The camera will automatically determine the best color balance upon powering up. Special comparator circuitry will compensate for less than perfect power up color conditions. The camera then retains color balance without the need to continually adjust. The memory feature will achieve excellent color balance for most routine shooting conditions. The user may reset the balance at any time by pushing the RESET button located on the left side of the camera.

For users wishing the more conventional AUTO TRACKING mode, a solder jumper at W2 located inside the camera will convert the camera to auto tracking. This function allows the camera to continually balance the color based on the prevailing scene, and not in reference to the memory. (See page 7)

3.4.4 AUTO IRIS CONNECTOR

The TMC-7 has a 6-pin auto iris connector located on the back of the camera. A mating 6-pin connector (PC-6P) may be obtained from PULNIX. The lens mount of the camera is a standard C-mount, and most standard 1/2" auto iris lenses may be used with the TMC-7/TMC-6.



6-Pin Connector (Auto Iris Lens connector)

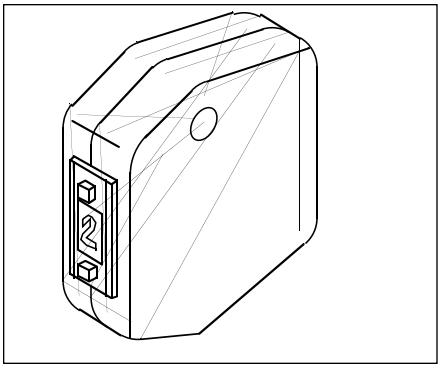
1. D2
2. GND
3. Iris (Video)
4. +12V DC out
5. D0
6. D1

D0, D1, D2 are used for shutter speed control. The SC-7 provides external manual shutter speed control.

Warning:
Do not unplug the auto iris lens from the camera while the camera is powered. This may damage the lens.

3.4.5 SC-7 SHUTTER CONTROL

The SC-7 is the controller for the shutter speed. It connects to the 6-pin connector of the TMC-7/TMC-6. (Note: The TMC-7 uses a different controller than all other PULNiX shutter cameras).



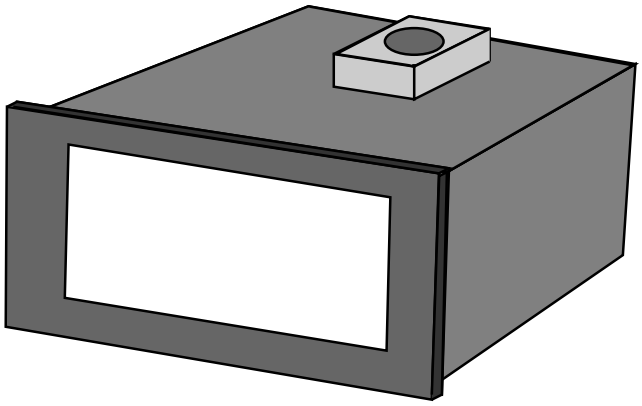
SPEED CONTROL

	0	1	2	3	4	5	6	7
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
Shutter speed	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000	1/10000
Integration (option)	2FLD	4FLD	6FLD	8FLD	10FLD	12FLD	14FLD	16FLD

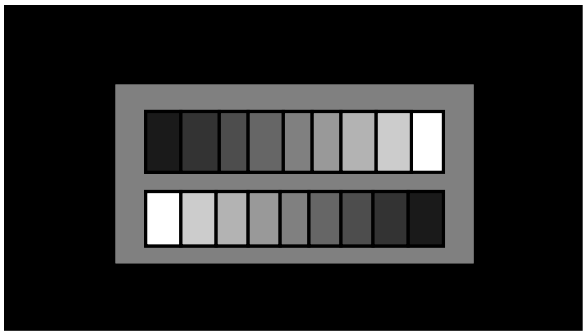
SECTION 4 : ALIGNMENT AND ADJUSTMENT

4.1 EQUIPMENT

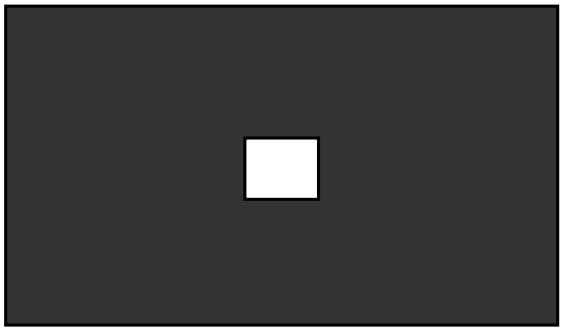
1. Light source for test chart.
   Pattern Box PTB-500 (90-130V)
   PTB-220 (190-240V--not used in U.S.)



2. For video level and gamma adjustment.

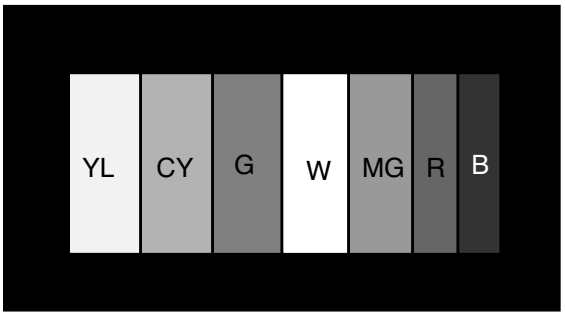


Grayscale Chart



White Window Chart

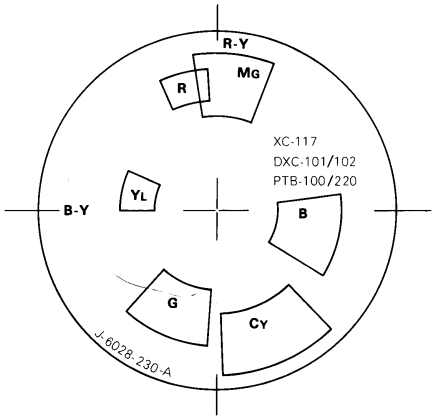
3. For color adjustment.
   (Use color bar chart)



Color Bar Chart

4. For signal adjustment.
   Vector scope
   Waveform monitor
   Oscilloscope

5. Standard Pattern Frame



4.2 PREPARATION

4.2.1 MECHANICAL BACK FOCUS ADJUSTMENT

Subject: Resolution chart

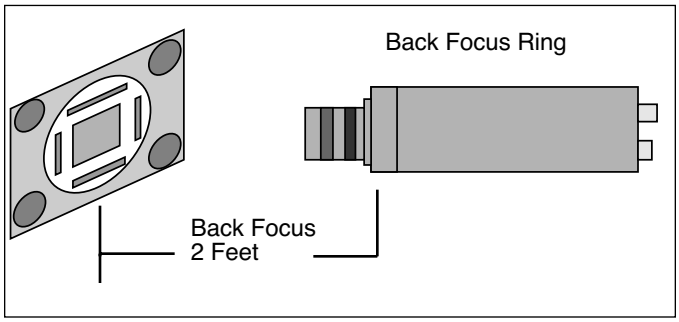
1. Mount the manual lens (i.e. Cosmicar 25mm, F=1.4).

2. Open the lens iris completely and set lens focal length to minimum for the lens used (e.g. 2 ft.).

3. If image is not focused properly, set back focus as follows.

4. Unscrew the M2x3 hex screw on the Front Panel until the focus ring is loose.

5. Adjust the silver back focus ring until the image is focused.
6. Repeat steps 4 and 5 if needed.



4.3 TMC-7 ADJUSTMENT PROCEDURES

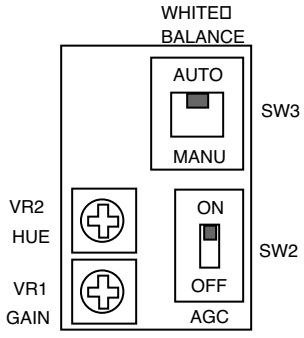
4.3.1 PRESET

Note: The following controls for the external control board can be accessed by removing the access port on the left side of the TMC-7. All other presets and adjustments are accessed by removing camera cover.

Preset each potentiometer as follows:

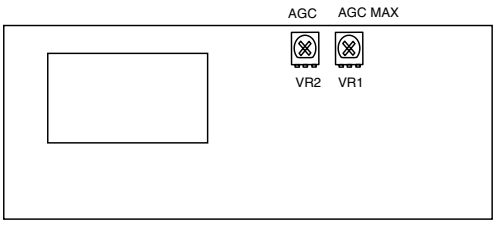
Matrix board

VR1	MGC	= 2.5 V
VR2	W/B (Hue)	= 4.0 V



Driver Board

VR2	AGC	= 2.0 V
VR1	AGC MAX	= 3.0 V

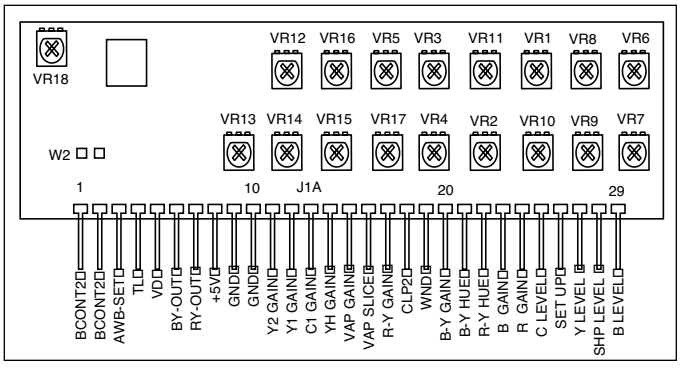


Auto-White Balance Board

VR6	B LEVEL	= 3.4 V
VR7	SHP LEVEL	= 3.4 V
VR1	CHR LEVEL	= 2.3 V
VR2	R-Y HUE	= 3.5 V
VR3	B-Y HUE	= 3.0 V
VR4	B-Y GAIN	= 2.4 V
VR5	R-Y GAIN	= 3.2 V
VR14	Y1 GAIN	= 2.0 V
VR8	Y LEVEL	= 3.0 V
VR9	SET UP	= 3.0 V
VR12	C1 GAIN	= 3.4 V
VR11	B GAIN	= 4.0 V
VR10	R GAIN	= 4.0 V
VR15	YH GAIN	= 3.2 V
VR16	VAP GAIN	= 1.8 V
VR17	VAP SLICE	= 1.5 V
VR18	HOLE	= 2.0 V

Jumper setting

W2	Open (factory setting)



4.3.2 FUNCTION TEST

With above settings, the camera will output a good picture and you can proceed to the fine tuning process.

4.3.3 WHITE BALANCE

Equipment: Color bar chart (3200°K),
Vector scope, Wave form monitor.

Set AGC and White balance switches to Manual side (push down).
Use standard Fujinon lens (Calibrated) and set the iris to F=8.

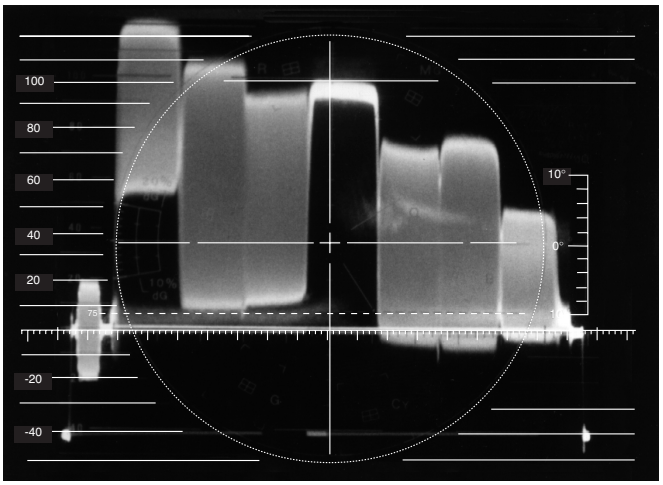
Burst level

Adjust VR6 so that burst level on Vector scope is on the 75 % line or 286±15mV. If Burst vector is not stable, add a 22pf capacitor to crystal capacitor. Make sure to select the right value of C5 located at Driver board.

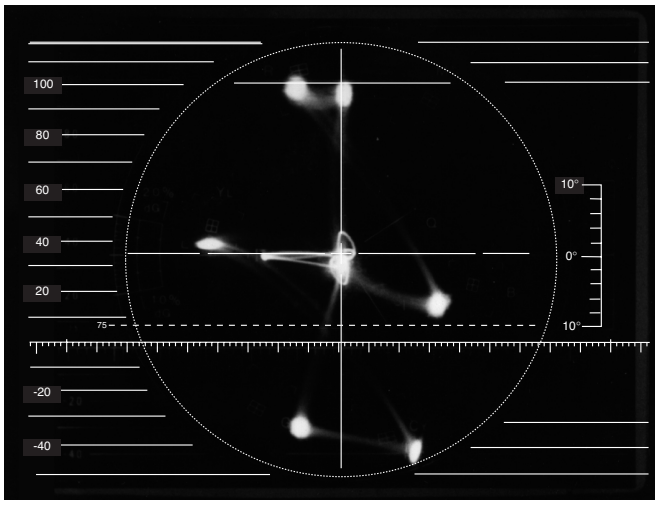
R gain, B gain
Adjust VR10 and VR11 so that the white spot on Vector scope is in the center.

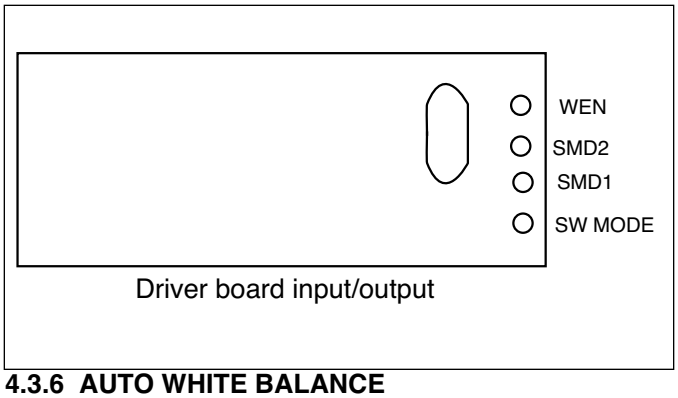
C1 gain
Adjust VR12 so that each color dot on the Vector scope combines into one spot.

4.3.4 Y LEVEL, SETUP LEVEL
Use Waveform monitor.
Observe the waveform and adjust VR8 to set the white level to 95 IRE.
Put lens cap on and adjust VR9 so that setup (Pedestal level) is 5 IRE.



4.3.5 R-Y GAIN, B-Y GAIN, R-Y HUE, B-Y HUE
Use Vector scope.
Adjust VR5 (R-Y gain), VR4 (B-Y gain),
VR2 (R-Y Hue), VR3 (B-Y Hue) to set each vector as shown below





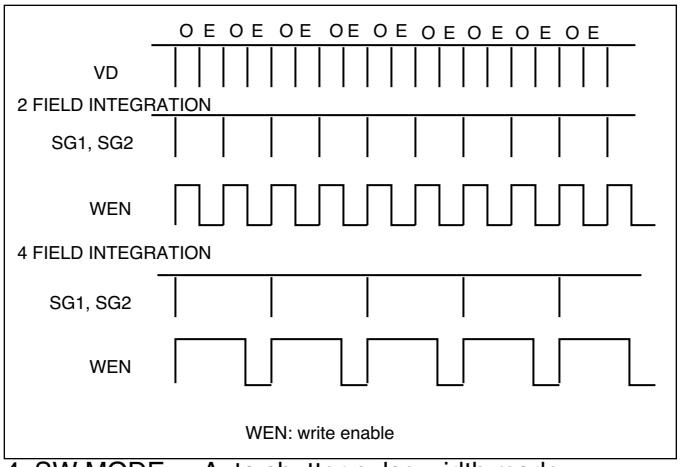
Driver board input/output

4.3.6 AUTO WHITE BALANCE
Make sure lens is closed. Probe TP2 and adjust VR18 so that the level is at 5V. Now turn lens to F/16, and make sure DC level goes down to zero. Optimize VR18 so that the above two conditions are satisfied.

4.3.7 AGC
Switch on to AGC side.
Adjust lens to see if AGC is functioning.
Observe the AGC threshold level and adjust AGC potentiometer if necessary.

4.3.8 SHUTTER CONTROL AND INTEGRATION CONTROL

1. WEN: Write enable output
2. SMD2: Select integration mode (Jumper to GND)
3. SMD1: Select shutter mode (Factory set)



4. SW MODE: Auto shutter pulse width mode

Shutter control
Select SMD1 low (GND) and SMD2 high (open).
This is factory set mode. If external control is required,

Speed control

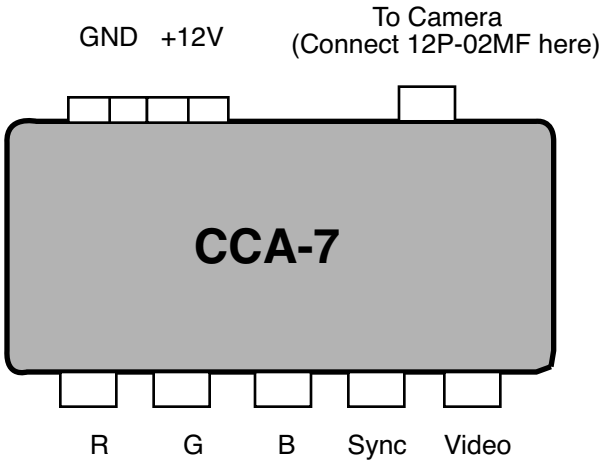
	0	1	2	3	4	5	6	7
D0	L	H	L	H	L	H	L	H
D1	L	L	H	H	L	L	H	H
D2	L	L	L	L	H	H	H	H
Shutter speed	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000	1/10000
Integration (option)	2FLD	4FLD	6FLD	8FLD	10FLD	12FLD	14FLD	16FLD

Continuous shutter
By applying a negative going TTL pulse to pin #8 TRIG input, the TMC-7 can operate with continuous shutter speed change. The input pulse must move within a field timing and the shutter speed is between the pulse edge and SG1, SG2. In order to activate this function, D0, D1, D2 must all be low (GND). Unless the TRIG pulse is applied, CCD charges are kept discharging and when the pulse is input, the discharge stops and integration starts up to the transfer gate timing (SG1, SG2).

SECTION 5: RGB OPERATION (Option)

5.1 CCA-7 RGB "BREAKOUT" MODULE

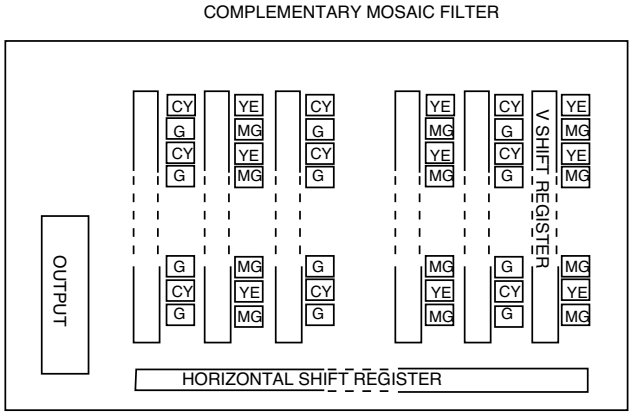
CCA-7 is a compact device designed to accept camera outputs via the 12P-02MF (2 - meter) cable from the camera, and then output the signals (R, G, B, Sync, and Video) via standard BNC connectors. It also accepts 12V DC input via a terminal for power.



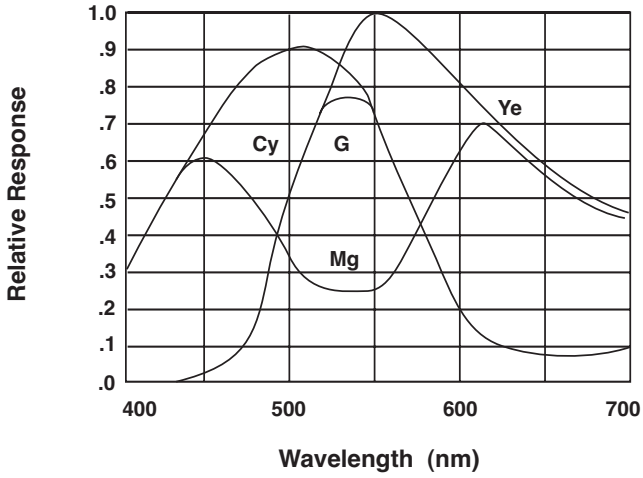
Note: RGB option is only available when TMC-7 is modified for use with CCA-7. Contact PULNiX for further assistance.

SECTION 6: IMAGER COLOR FILTERS

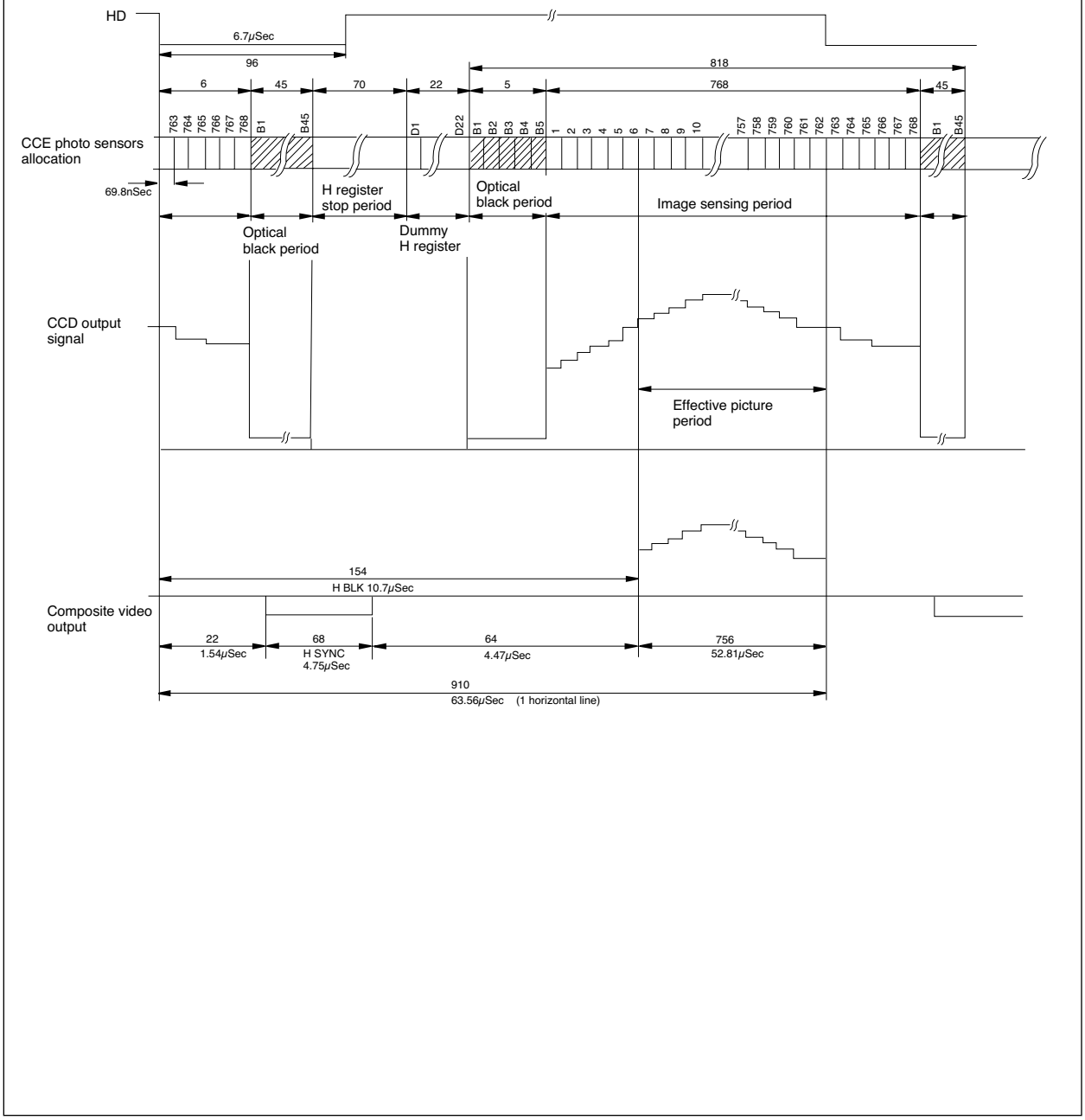
6.1 DIAGRAM OF COMPLEMENTARY STRIPE FILTER



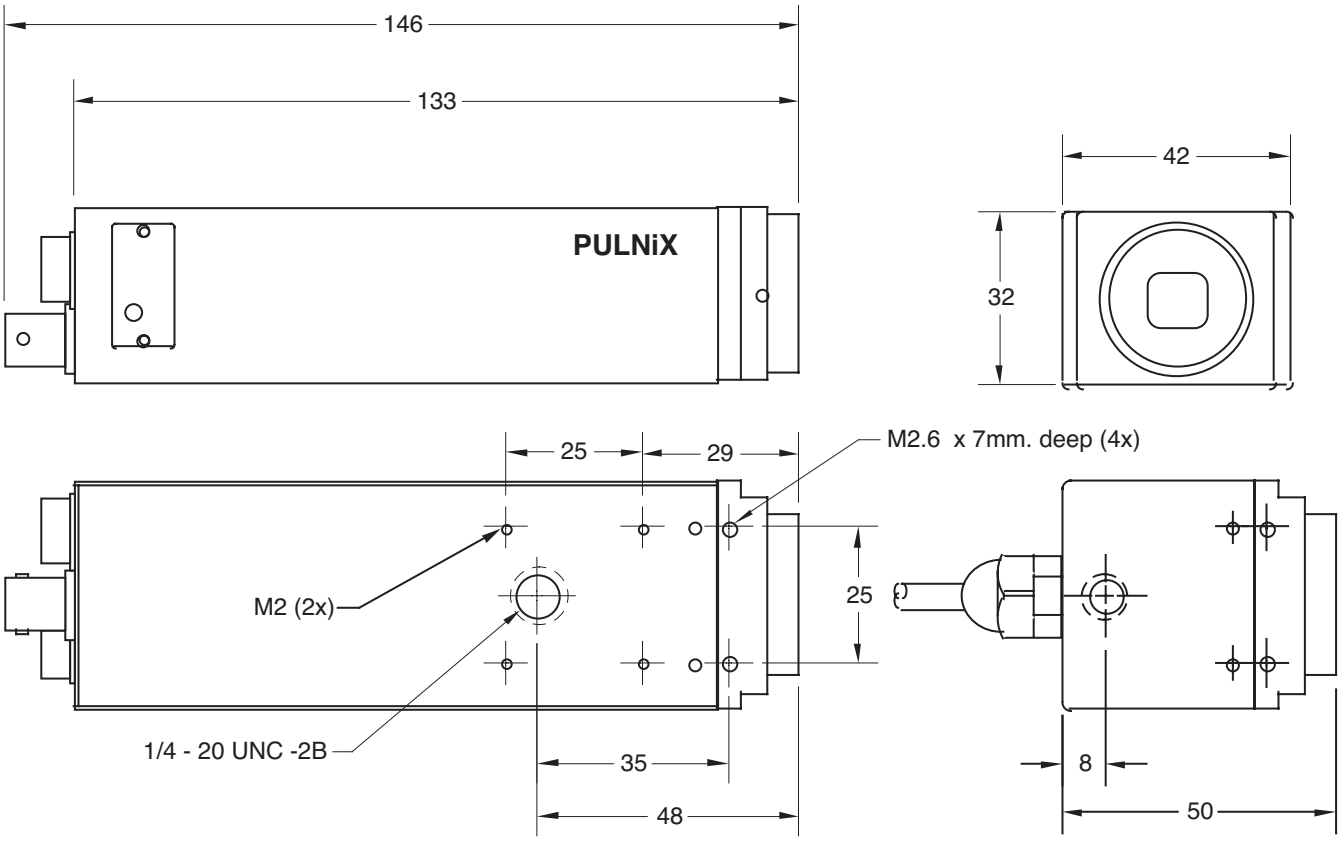
6.2 SPECTRAL RESPONSE WITH COMPLEMENTARY MOSAIC FILTER



SECTION 7: TIMING CHART FOR TMC-7/TMC-6



SECTION 8: MECHANICAL DRAWINGS
8.1 STANDARD & REMOTE CONFIGURATIONS



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