

# **PULNiX**

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**TM-1001-02  
1K X 1K HIGH RESOLUTION  
PROGRESSIVE SCANNING  
FULL FRAME SHUTTER CAMERA**

**(REV. 1)**

**OPERATIONS AND  
MAINTENANCE MANUAL**

## 1.1 Features and Applications

The TM-1001-02 is a state-of-the-art CCD camera which uses a 1 inch 1K x 1K progressive scan interline transfer CCD imager.

This CCD camera offers outstanding compactness, high resolution, built-in frame memory, asynchronous reset, electronic shutter, and digital output as well as analog video and a number of technical innovations. The camera's various features allow for versatile applications, such as high resolution image capturing, machine vision, computer graphics, gauging, avionics, microscopy, medical imaging, character and fine pattern recognition, document reading and high end surveillance.

### Miniaturized and Light Weight

All PULNiX cameras are built with the same design principles: Solid state technology; miniaturization; application-specific such as custom design, remote imagers, special functions for various application needs; robust design even for military applications.

### Imager

The TM-1001-02 uses a 1K x 1K progressive scan interline transfer CCD. The reason for such CCD is:

1. High resolution (1024 x 1024 active pixels)  
For very high resolution and image quality.
2. Square pixel (9.0 x 9.0  $\mu\text{m}$ )  
Precise dimensional measurement ability.
3. High speed electronic shutter capability  
High dynamic resolution of moving object and electronic iris control.  
Eliminates need for mechanical shutter.
4. Progressive scan  
Eliminates interlace deterioration of image.  
Ease of computer interface.
5. High sensitivity and low noise at fast scanning  
Can drive faster than 20 MHz pixel clock rate.  
Excellent S/N ratio (>50 dB).  
Micro lens built-in for TM-1001-02

### Asynchronous Reset

The TM-1001-02 can be reset with an external reset pulse (VINIT). When VINIT is enabled at the Async mode, the camera keeps discharging from the CCD and with VINIT leading edge (negative going pulse), it resets the internal timing and starts integrating the image for the preset period of shutter timing and outputs the async shutter video. This feature is especially important to capture moving objects at the precise location of the field of view such as a conveyer belt, fast event observation and still picture capturing.

### Frame Memory and Digital Output

The TM-1001-02 has a built-in frame grabber and a frame memory.

The 8-bit A/D converter provides 256 gray levels with maximized signal-to-noise ratio. The output can be real time digital output or a captured image (frozen picture). The digital output format is RS-422 differential output. Due to the speed limitation, display mode (double speed read out) is not available from the digital port.

### Asynchronous Image Capturing

The TM-1001-02 captures async reset images and provides continuous video output of the same image. This makes it simpler for an ordinary frame grabber to capture the async reset images.

### Integration

The TM-1001-02 is capable of capturing high resolution integration images. The integration can last from 1/15 sec. to a few seconds. For uniform and low noise integration, PULNiX offers a peltier-cooled CCD option.

### Display Mode

Since 1K x 1K cameras are not TV format (RS-170, etc.) the display of the video signal is only achieved by using a frame grabber and computer or special monitor.

The TM-1001-02 has a display mode feature which scans the frame memory read out two times per input frame. This way it converts the frame rate from 15 frame/sec. to 30 frame/sec. PULNiX PVM series monitors or equivalent B/W monitors can display 1000 by 1000 pixel counts. Consult PULNiX for display monitor information.

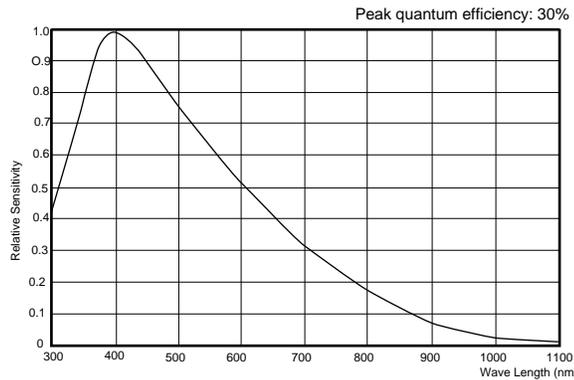
**NOTE: PLEASE ALLOW 5 SEC. DELAY BEFORE RESTARTING THE CAMERA BECAUSE OF THE PLD DOWNLOADING.**

## 2. SPECIFICATIONS

### Imager

Imager	1" Progressive scan interline transfer CCD		
Total pixels	1024 (H) x 1024 (V)		
Photosensitive pixels	1008 (H) x 1018 (V)	6 + 10 ob(H), 4 + 2 ob (V)	
Photosensitive area	9.1 (H) x 9.2 (V) mm		
Pixel size	9.0 (H) x 9.0 (V) $\mu$ m		
Output sensitivity	12 $\mu$ V/e-		
Micro lens	Built-in		

Blemish	Point defect	Cluster	Column
Class 0	No defect	0	0
Class 1	<5	0	0
Class 2	<10	<4	<2
Class 3	<20	<8	<4



TM-1000 SPECTRAL RESPONSE

### Camera

Scanning	1024 lines 15 Hz ( 30 Hz for display mode )		
Sync	Internal / External auto switch		
	HD / VD, 4.0 Vp-p impedance 4.7 K $\Omega$		
	fHD = 15.75 KHz		
	fVD = 15 Hz		
Pixel clock	20.034 MHz or 10.017 MHz ( optional )		
TV resolution	700 (H) x 800 (V)		
Minimum illumination	1.0 lux, f = 1.4 without IR cut filter		
S/N ratio	50 dB min. AGC = Off		
Video output	Analog	1.0 Vp-p composite video, 75 $\Omega$ , sync negative	
	Digital	8 bit RS-422 differential output	
		Data clock = 20.034 MHz or 10.017 MHz ( optional )	
Display mode video	Analog only fHD = 31.50 KHz, fVD = 30 Hz		
AGC	On / Off (off = std ) AGC is applicable		
MGC	Manual gain adjustable ( 6 dB to 26 dB )		
Gamma	0.45 or 1.0 ( 1.0 = std )		
Lens mount	C-mount: 1" lens format		
Power requirement	12 V DC 600 mA (800 mA for driving RS-422)		
Operating temperature	-10° C to +50° C		
Vibration and shock	Vibration: 7G (200Hz to 2000Hz), shock: 70G		
Size	44mm x 48.5mm x 136mm ( 1.73" x 1.91" x 5.35" )		
Weight	330 grams ( 11.6 oz )		
Power cable	12P-02		
Digital cable	30DG-02		
Power supply	K25-12V or PD-12		

# TM-1001-02 1K X 1K HIGH RESOLUTION ASYNCHRONOUS RESET FULL FRAME SHUTTER CAMERA

The TM-1001-02 is designed to accommodate a high resolution, ON-LINE inspection reset mechanism with full frame shutter. It takes external horizontal sync to lock the camera and VINIT pulse for resetting the camera asynchronously.

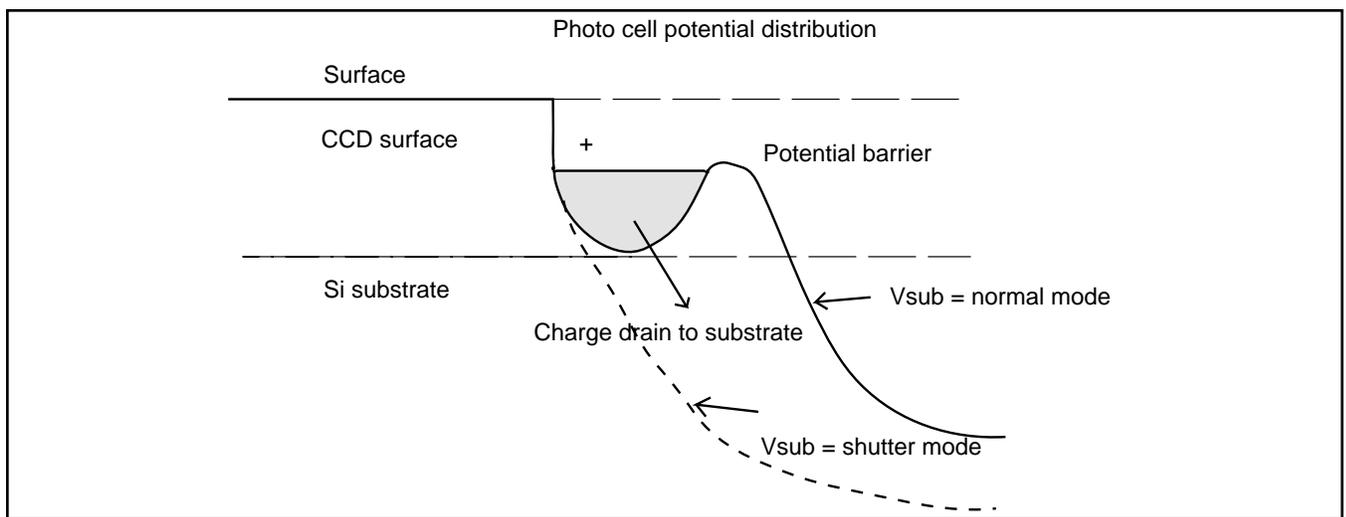
The shutter speed can be controlled by either an external double pulse or internal shutter speed control with a 10-position dial switch on the back panel.

## 1. Discharge Principle of CCD

### 1.1 Substrate Drain Shutter Mechanism

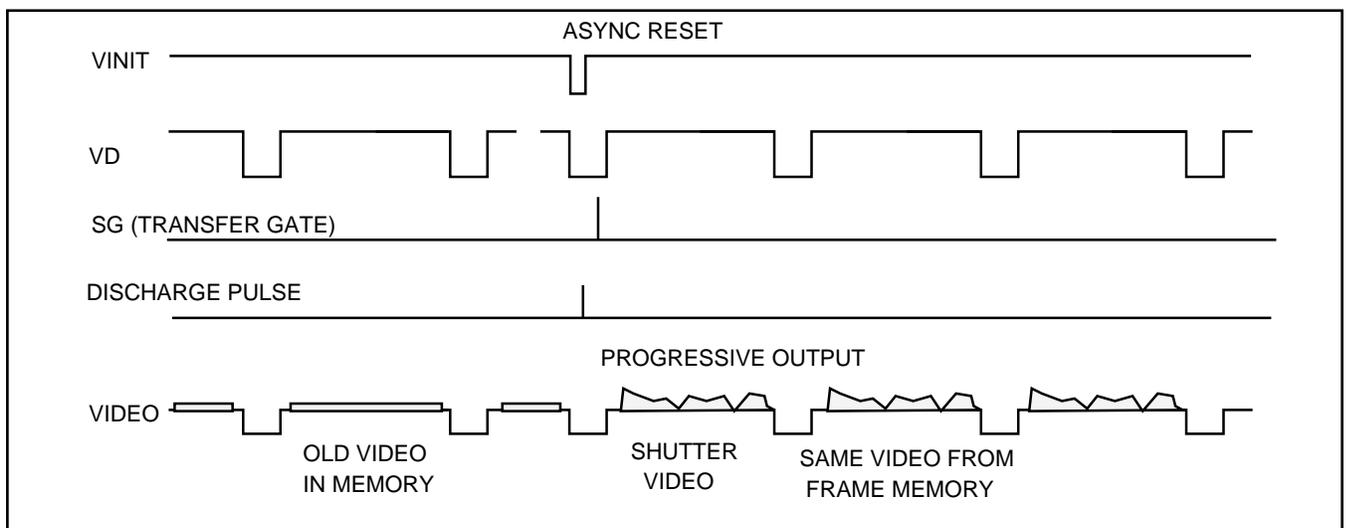
Normal operation requires the CCD chip to construct an individual potential well at each image cell. The potential wells are separated from each other by a barrier. The barrier is sequentially removed to transfer the charge from one cell to another by pixel clock. This is the basic principle of the CCD operation for charge 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 achieved with a horizontal charge shift to the drain area by interline transferring or reverse transferring of the frame transfer chip.



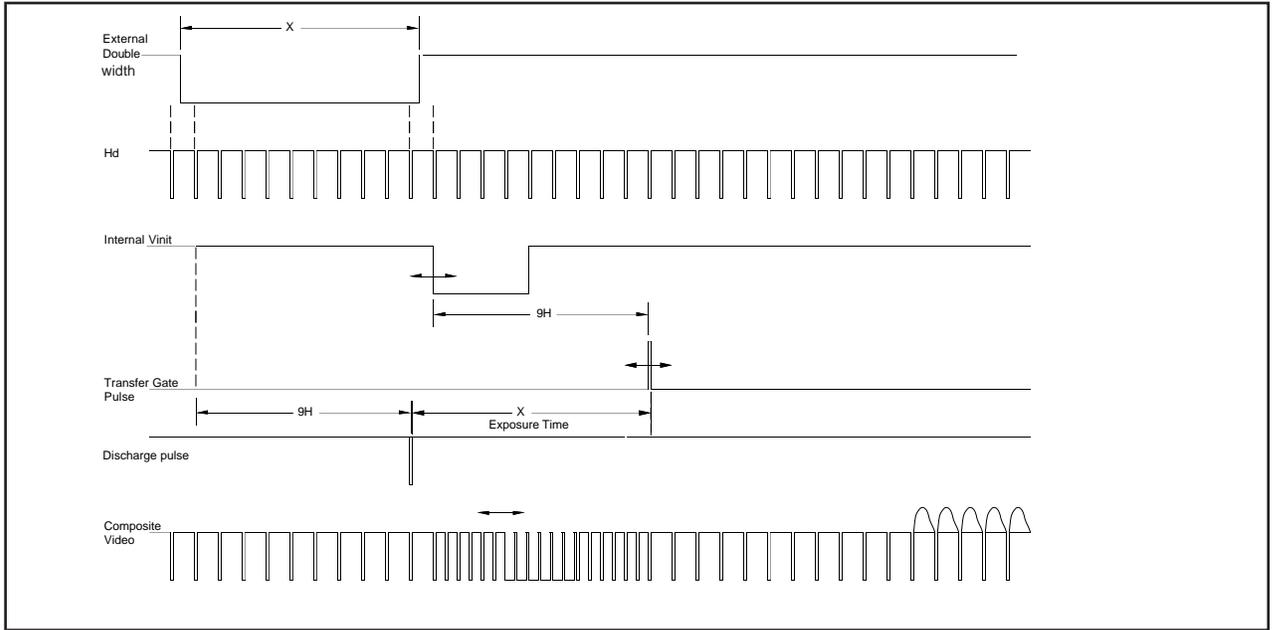
### 1.2 Asynchronous Shutter

For Async Shutter mode, provide external Hd for phase locking. When the negative going reset pulse is applied, the camera will latch the falling edge to its next horizontal drive and reset vertical sync timing immediately. Therefore, the horizontal phase won't be interrupted. The TM-1001-02 asynchronous camera outputs a full frame of shuttered video in progressive scanning format from a frame buffer. The frame buffer is updated upon receiving negative reset pulse.



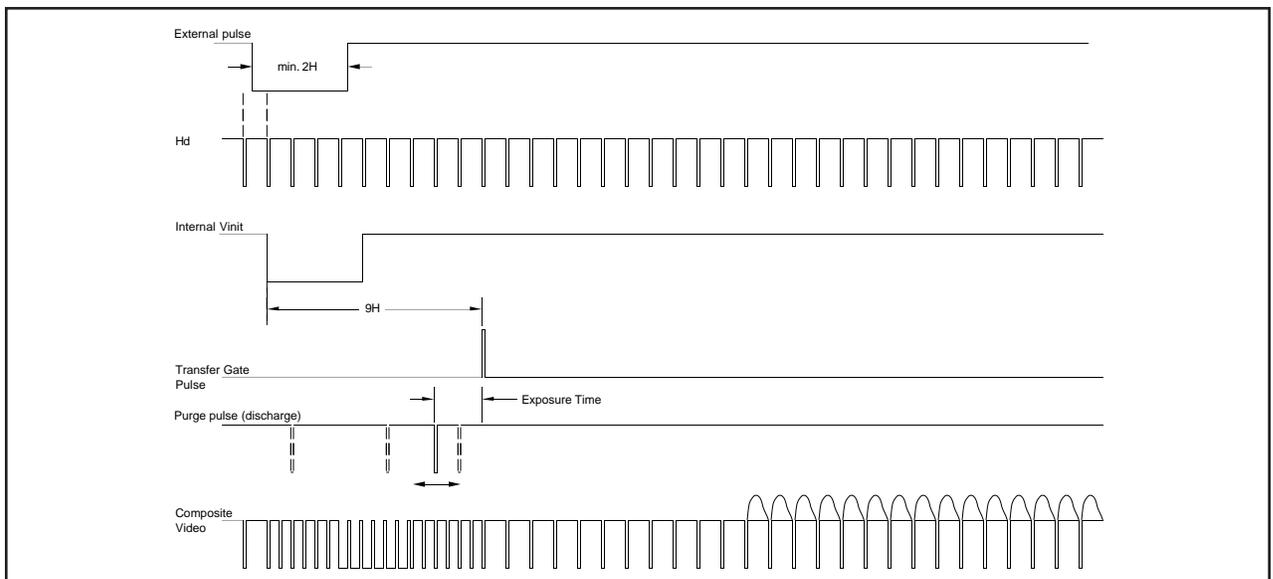
## 2. Shutter Speed Control

### 2.1 External pulse width control mode



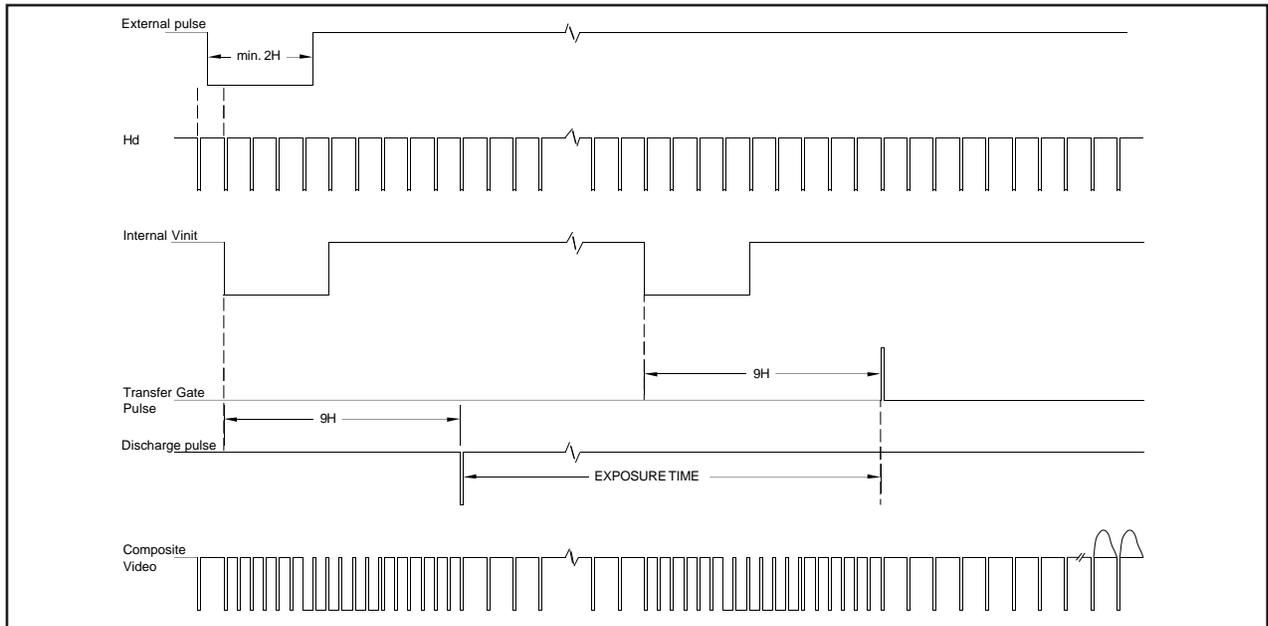
For External Pulse Mode, set dial switch to "9". Apply a pulse width control VINIT signal, which can be generated from an external event trigger, to the camera. Internal reset pulse will be latched to Hd and at the 9th Hd timing from an external pulse leading edge (negative going edge), CCD discharge pulse is generated to clear the images. The internal VINIT is generated at the following edge ( positive going edge ) of the external pulse and it resets internal timing including the video sync. The shutter speed is the same as the external pulse width but the integration delays  $9H$  from the leading edge. For immediate reset option, please contact PULNiX. One frame of video output will start from the rising edge of the pulse width control for progressive format. The camera will output the same video from memory when VINIT is kept high (5V) and update the image upon receiving next pulse. At async mode, with external pulse input high, the video output is disabled as the camera keeps discharging the CCD image and only provides black video.

### 2.2 Internal Fast Reset Mode



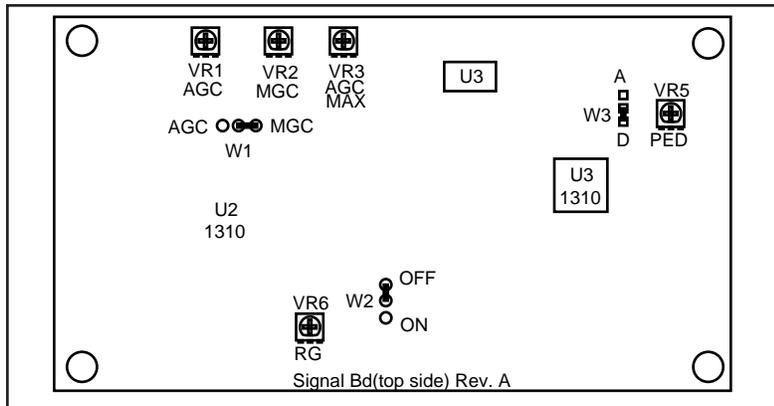
For Internal Fast Reset Mode, set the 10-position dial switch from "1" to "4". When fast reset mode is selected, the camera resets with internal VINIT timing, which is latched to Hd, and video output is also synchronized with internal VINIT timing without further delay. The shutter speed is controlled by the dial switch.

### 2.3 Internal Slow Reset Mode



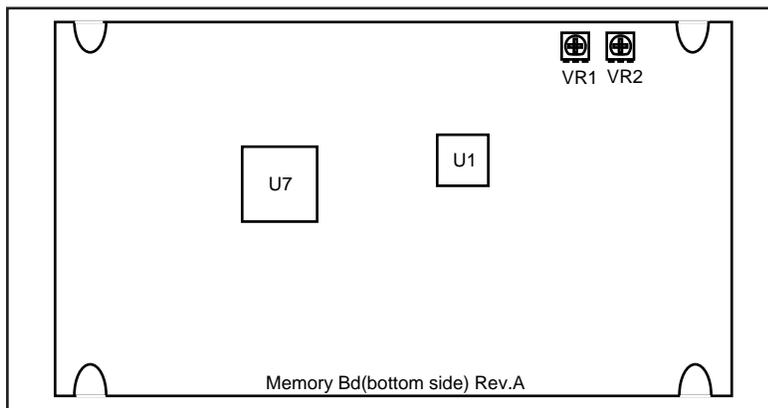
With the Internal Slow Reset mode selected, the camera operates the reset and shutter in the same manner as the external Double Pulse mode. When external VINIT pulse is applied, internal VINIT is latched to Hd and the second internal VINIT signal is generated to set up the shutter speed period. The shutter speed is controlled by setting the dial switch from "5" to "8". Video output timing starts right after the second internal VINIT. For the timing of the second internal reset, the LPULSE output of 31-pin connector can be used.

### 3. Signal Board Layout and Adjustment



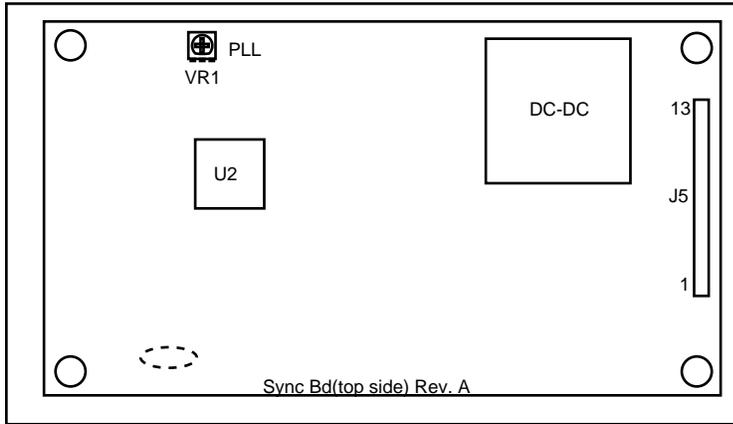
- |     |                |   |
|-----|----------------|---|
| W1  | AGC/MGC        | Left: AGC<br>Right: MGC                     |
| W2  | Gamma          | Down: On (0.45)<br>Up: Off (1.0)            |
| W3  | Analog/Digital | Up: Analog direct<br>Down: Through A/D, D/A |
| VR1 | AGC            | Set at 2.5 V                                |
| VR2 | MGC            | Set at 3.0V±0.4V                            |
| VR3 | AGC MAX        | Set at 1.5 V                                |
| VR5 | PED            | Set at 50 mV of video                       |
| VR6 | RG             | Factory adjustment only                     |

### Memory Board Layout and Adjustment



- |     |          |                               |
|-----|----------|-------------------------------|
| VR1 | A/D Vref | Factory set bit count at 10±4 |
| VR2 | D/A Vref | Set A/D input=D/A output      |

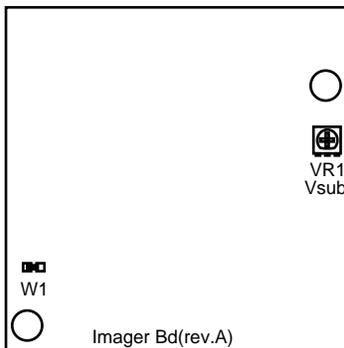
#### 4. Sync Board



#### Potentiometers

VR1 PLL  
Set at mechanical center

#### 5. Imager Board

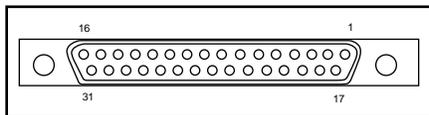


Jumper Setting  
Set W1 Short (GND)

Voltage Setting  
Set VR1 Vsub Factory Adjustment Only

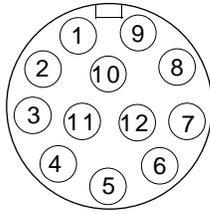
#### 5. Digital Output Connector

An EIA-422 digital output is available from 31-pin high-rel, micro-miniature connector (Airborn MP221-031-243-2200). The mating connector can be firmly secured to the receptacle for vibration and shock environments. A common D-sub connector was not used to prevent any vibration problems.



Pin No	Signal	Description
1	CLK+	Pixel clock (20.034 MHz) output
17	CLK-	"
2	LDV+	Line data valid
18	LDV-	"
3	FDV+	Frame data valid
19	FDV-	"
4	GND	
20	VINIT	External Vinit input (TTL)
5	EXT. HD	Ext. HD sync input (TTL)
21	EXT.VD	Ext. VD sync input (TTL)
6	INTEG. CONT	Integration control input active: Low(TTL)
22	ENINT	Enable integration for frame capture (TTL)
7	LPULSE	Last pulse for slow mode async pulse
23	GND	
8 - 15	DO0+ - DO7+	Digital video output ( 8-bit )
24 - 31	DO0 - - DO7-	"
16	GND	

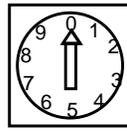
## 6. Connector Pin Configurations



### 12-PIN Connector

1. GND	7. V <sub>D</sub> In
2. +12V DC	8. GND
3. GND	9. H <sub>D</sub> In
4. Video Out	10. GND
5. GND	11. Integration Control
6. VINIT In	12. GND

### SH CONTROL



### Shutter Control Switch

	Manual shutter mode	Async reset mode
0	no shutter	no shutter
1	1/60	1.0H 1/16000
2	1/125	2.0H 1/8000
3	1/250	4.0H 1/4000
4	1/500	8.0H 1/2000
5	1/1000	16 H 1/1000
6	1/2000	32 H 1/500
7	1/4000	64 H 1/250
8	1/8000	128H 1/125
9	1/16000	Ext. pulse width

Mode 0:	Normal mode
Mode1-4:	Fast mode
Mode5-8:	Slow mode
Mode 9:	Ext. pulse width

## 7. Monitor Display Mode

One of the advantages of the TM-1001-02 is the built-in scan conversion circuit; so that even though the progressive scanning frequency is too slow to display on a monitor, the double speed output is provided as analog video format at 31.50 KHz horizontal and 30 Hz vertical frequency.

For the monitor information, select the switch on the back panel for DSP (double speed).

The double speed output is intended for analog output and it may not be operable with digital format as the double speed video frequency is too high for standard RS-422 output ( it may work through RS-422 but PULNiX cannot guarantee the performance ).

For digital output application, select the switch to NSP (normal speed).

### Non-interlace Black and White Monitors

PULNiX offers a slow-decay phosphor CRT type non-interlace monitor (42-5001).

Electrohome EVM942 /1242 or equivalent model can be used for TM-1001-02 display mode.

Some of these monitors may not accept 30 Hz vertical sync. Please contact PULNiX for the modification or information.

## 8. Frame Memory

The TM-1001-02 has a built-in frame memory which outputs progressive scanning images at 30Hz rate (30 frames per sec). This feature provides the following advantages:

1. Asynchronously captured images are output as standard continuous video signals so that a monitor or frame grabber can display or process without a special asynchronous video grabber.
2. Integration video is continuously output until the next capture. Normally, the camera cannot output the video signal during the integration, and the periodic integration causes a blinking video signal. The TM-1001-02 memory keeps the stored image until the next image is completed so that there is no blank interval during integration.
3. Digital format of the video output can be used as direct interface with the computer. The format is progressive.

## How to activate the frame memory?

### A. Asynchronous reset mode (Select switch on the back panel for ASY...async)

When External VINIT is high (5V), the TM-1001-02 expects the async pulse input. It resets at the negative going pulse edge and captures the frame regardless of the shutter speed (fast or slow mode). The video output is kept disabled as the CCD is discharged continuously during VINIT high. When the first VINIT pulse comes in, it resets the timing and captures the image. The captured image is kept until the next pulse is applied for a new image. If the switch is NRM (normal mode....manual shutter mode), the video output is real time with manual shutter.

### B. Integration

Activate EN INT (Enable Integration) of 31-pin connector (#22) by connecting to GND then input INTEG control(#6) as active low (TTL). When it is low, the TM-1001-02 keeps integrating and, upon the rising edge of the INTEG control pulse, it captures the frame and keeps it until next end of integration. When EN INT is high (open), video output is in real time without freezing and one frame of the integrated image appears upon ending of INTEG control pulse (during INTEG control low, it keeps the previous image but when INTEG is high it only holds one frame). FDV(Field Data Valid) is disabled during the integration and the vertical pulse starts when the image is output.

## 9. Progressive scanning

Standard TV system scanning is 525 line interlace scanning as specified in RS-170. Every other horizontal line (ODD lines and EVEN lines) is scanned at a 60Hz rate per field, and completes scanning with two fields (one Frame) at 30Hz rate. Because of the interlace scanning, the vertical resolution of CCD cameras is limited at 350 TV lines regardless of the horizontal resolution. When the electronic shutter is applied, the CCD can only hold one field of charges at each exposure. Therefore, the vertical resolution of the electronic shutter camera is only 244 TV lines.

This is the same situation for a HDTV format camera, since it is interlaced scanning and the vertical resolution of the shuttered image is 500 lines.

The TM-1001-02 uses a state-of-the-art CCD called a "Progressive scanning interline transfer CCD" which scans all lines sequentially from top to bottom at one frame rate (15Hz). Like a non-interlace computer screen, it generates a stable crisp image without alternating lines and provides full vertical TV resolution of 1000 lines (a monitor display may not be able to show 1000 lines due to monitor resolution of 30Hz scanning).

The interline transfer architecture is also important to generate simultaneous shuttering. This is different from full frame transfer architecture which requires a mechanical shutter or strobe light in order to freeze the object motion.

### The TM-1001-02 outputs the progressive scanned image with an electronic shutter in three different formats:

#### 1. Progressive scanning analog output (Jumper W3 of top board set on "A" side)

Straight forward signal output without going through 8-bit A/D, D/A converter. It is useful for higher gray level resolution than 8-bit (256 levels). It is a real-time CCD output through normal analog video processing into 75Ω 1Vp-p output format (15 Hz).

#### 2. Progressive scanning digital and analog output (Jumper W3 set on "D"side)

The CCD signal goes through A/D and D/A converters. The frame memory is capable of capturing async and integration video without having special frame grabbers.

The analog output is the same as 75Ω, 1Vp-p format at 15Hz rate available from BNC and 12-pin connector. The digital output is available from 31-pin connector with EIA-422 format (20MHz clock rate).

#### 3. Double speed scanning output (Display output)

By setting W13 jumper to double speed mode (open) on the top board, the TM-1001-02 outputs double speed video for monitor display. It repeats twice from one frame of input video. The digital output of the 31-pin connector is also at 30 Hz with a 40MHz pixel clock. When a digital cable is short in length it may be usable but PULNiX can not guarantee proper operation.

## 10. Digital output pulses

### Digital Video

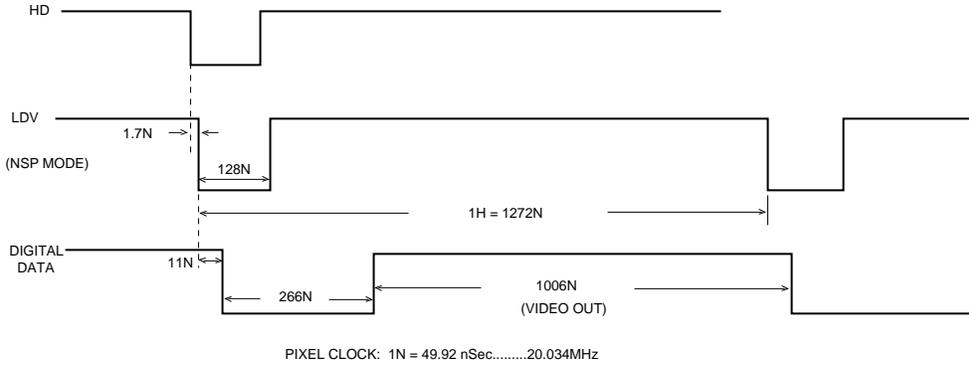
Differential line-driven, 8-bit parallel signal with EIA-422 format.  
 100Ω output termination impedance.

Output from 31-pin connector. The mating connector: Airborne MP211-031-113-4300  
 Please consult digital cable information. eg. 50-1301-01, 30DG-02, 2m cable

### Line Data Valid (preliminary)

Differential line-driven signal with EIA-422 format.

It is active high (+ side is higher than - side) during the transfer of each line of data.....Horizontal line read out.



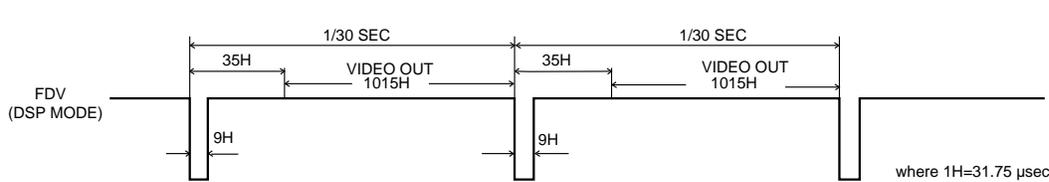
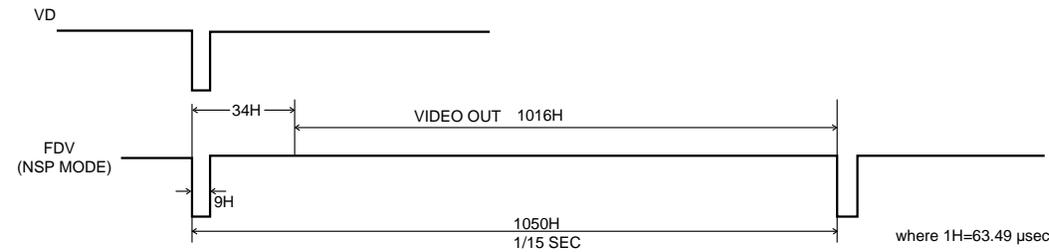
Note:  
 For OP.7-3, 10MHz clock,  
 1N = 99.83 nsec (10.017 MHz)  
 1H = 126.98 μsec (7.875 KHz)

### Frame Data Valid (preliminary)

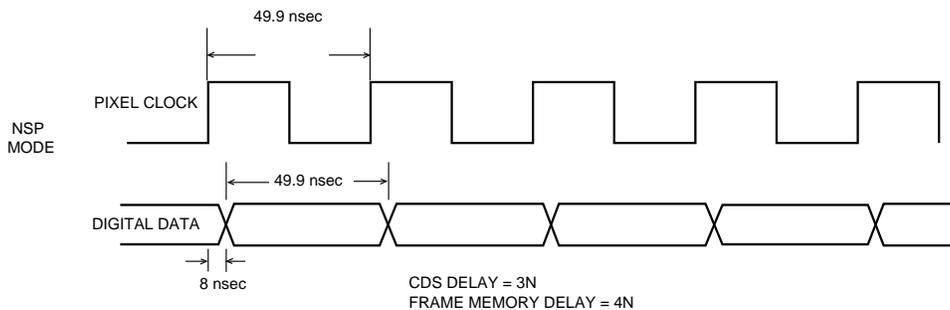
Differential line-driven signal with EIA-422 format. It is active high during the transfer of each frame data. During integration, both LDV and FDV are kept low and restart upon the completion of integration.

### Pixel clock

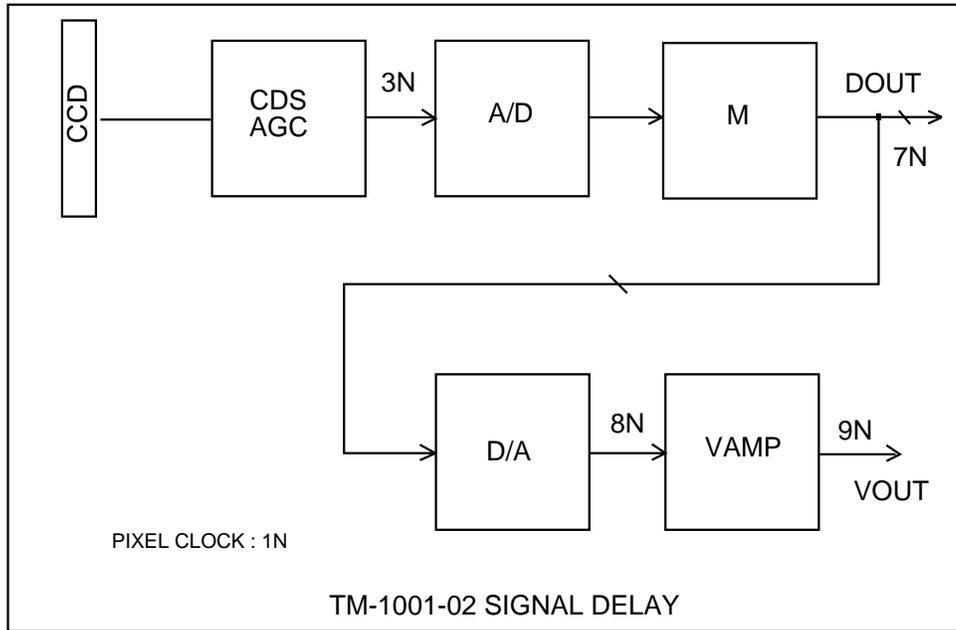
Differential line-driven signal with EIA-422 format. The frequency is 20.034 MHz (standard) or 40.068MHz (DSP).



For OP 7-3, the vertical frequency is 1/7.5 sec (NSP) and 1/15 sec (DSP)



## 11. Signal Delay



## 12. Connector and cable

Digital output connector is optional.

Mating connector ordering information: PULNiX part No. 15-1623

Airborne P/N: MP211-031-113-3400

Straight Backshell (cover):

15-1624

MM254-031-000-0000

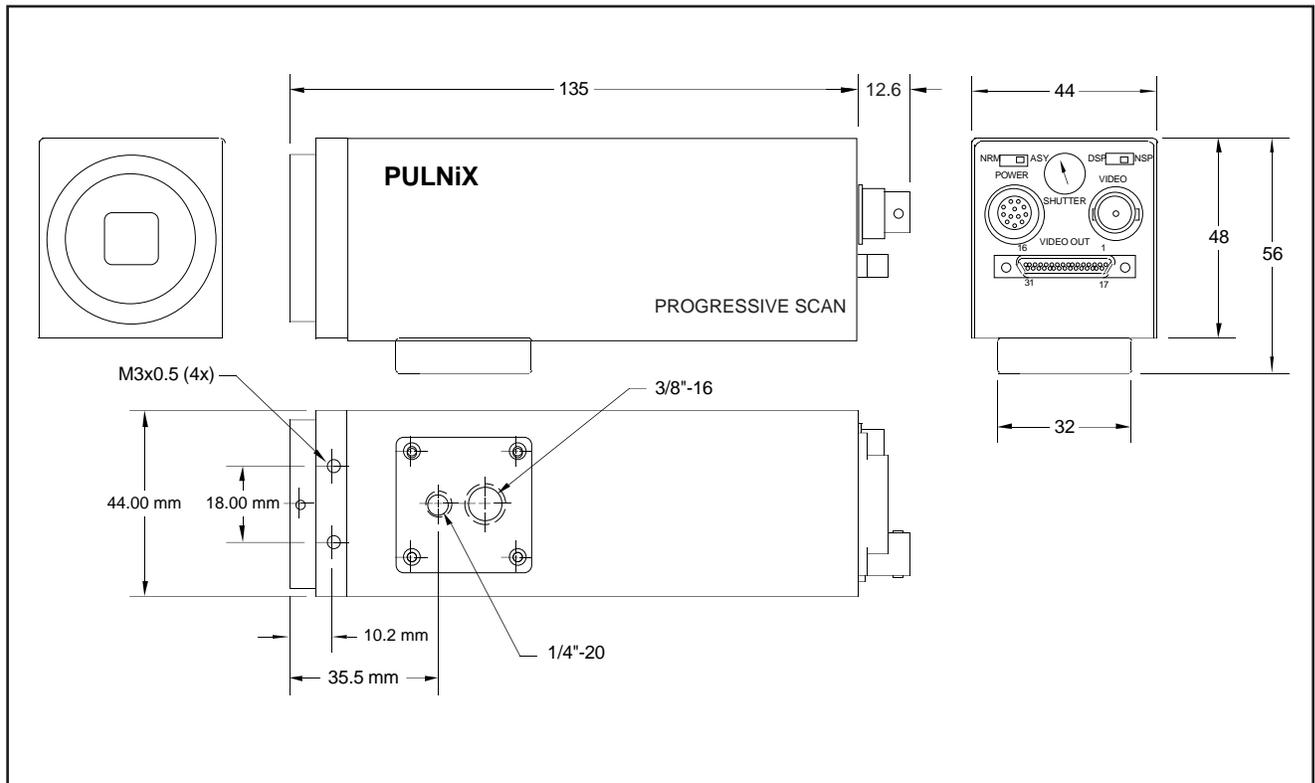
Cable assembly:

Digital cable 30DG-02

50-1301-03

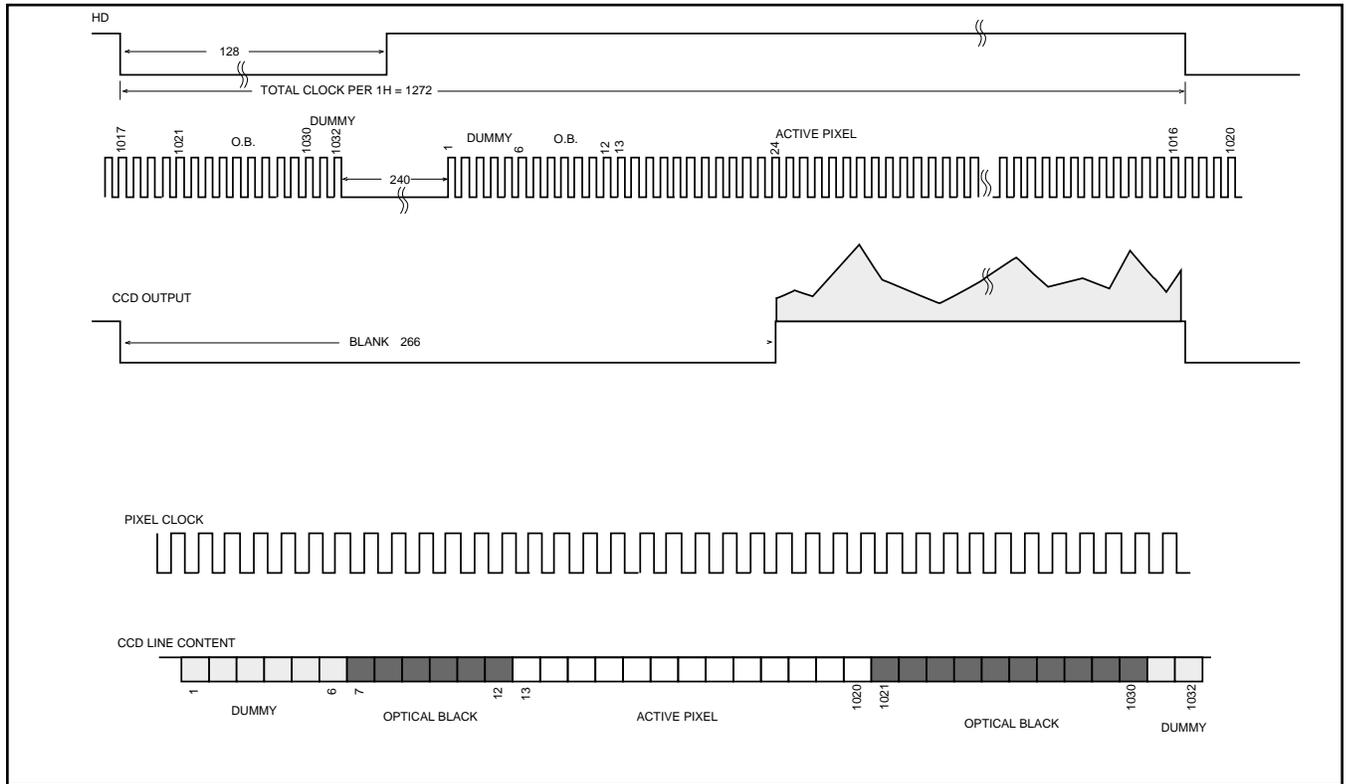
12-pin connector and cable: Standard cable is 12P-02 (2m, 8 conductor cable) for power and external controls.

## 13. Physical Dimensions

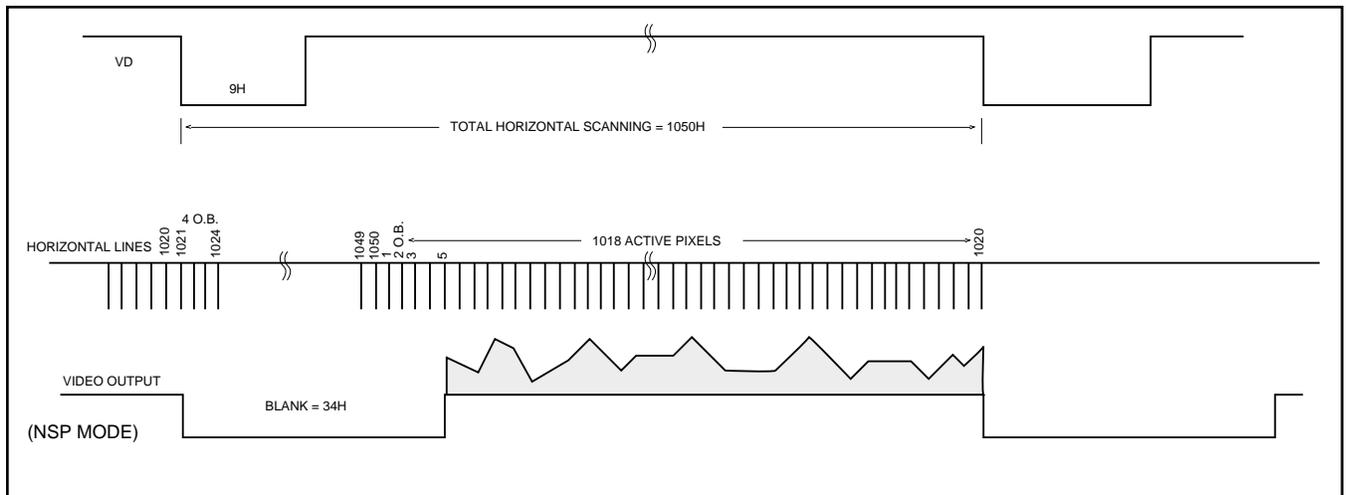


## 14. TM-1001 PIXEL MAP AND TIMING CHART

### 14.1 TM-1001 Horizontal pixel mapping



### 14.2 Vertical frame timing

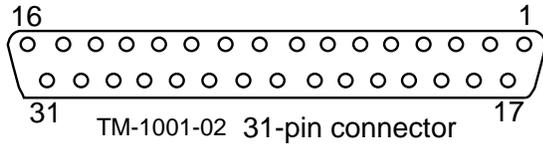


## DIGITAL CABLE ASSEMBLY

30DG-02

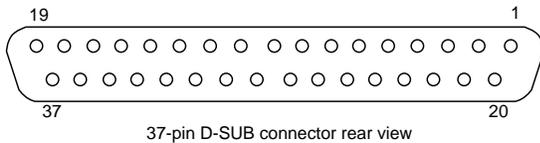
P/N 50-1301-03 Full function cable

### TM-1001-02 PIN CONFIGURATIONS



Pin	Signal	Cable	Pin	Signal	Cable
1	CLK+	OR 1RED	17	CLK-	OR 1BLUE
2	LDV+	GRY 1RED	18	LDV-	GRY 1BLUE
3	FDV+	WHT 1RED	19	FDV-	WHT 1BLUE
4	GND	YLW 1RED	20	VINIT	YLW 1BLUE
5	HD	PINK1RED	21	VD	PINK1BLUE
6	INTEG	OR 2RED	22	EN INTEG	OR 2BLUE
7	L PULSE	GRY 2RED	23	GND	GRY 2BLUE
8	D0+	WHT 2RED	24	D0-	WHT 2BLUE
9	D1+	YLW 2RED	25	D1-	YLW 2BLUE
10	D2+	PINK2RED	26	D2-	PINK2BLUE
11	D3+	OR 3RED	27	D3-	OR 3BLUE
12	D4+	GRY 3RED	28	D4-	GRY 3BLUE
13	D5+	WHT 3RED	29	D5-	WHT 3BLUE
14	D6+	YLW 3RED	30	D6-	YLW 3BLUE
15	D7+	PINK3RED	31	D7-	PINK3BLUE
16	N/C				

### 37-PIN D-SUB CONNECTOR PIN CONFIGURATIONS



Pin	Signal	Cable	Pin	Signal	Cable
1	CLK+	OR 1RED	20	CLK-	OR 1BLUE
2	LDV+	GRY 1RED	21	LDV-	GRY 1BLUE
3	FDV+	WHT 1RED	22	FDV-	WHT 1BLUE
4	N/C		23	GND	GRY 2BLUE
5	N/C		24	N/C	
6	N/C		25	N/C	
7	N/C		26	N/C	
8	D0+	WHT 2RED	27	D0-	WHT 2BLUE
9	D1+	YLW 2RED	28	D1-	YLW 2BLUE
10	D2+	PINK 2RED	29	D2-	PINK 2BLUE
11	D3+	OR 3RED	30	D3-	OR 3BLUE
12	D4+	GRY 3RED	31	D4-	GRY 3BLUE
13	D5+	WHT 3RED	32	D5-	WHT 3BLUE
14	D6+	YLW 3RED	33	D6-	YLW 3BLUE
15	D7+	PINK 3RED	34	D7-	PINK 3BLUE
16	GND	YLW 1RED	35	GND Shield	SHIELD
17	VINIT	YLW 1BLUE	36	N/C	
18	EN INTEG	OR 2BLUE	37	INTEG	OR 2RED
19	N/C				



### **Notice**

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### **Warranty**

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

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