TM-9701 Progressive Scanning Full Frame Shutter Camera

Operations & Maintenance Manual

TM-9701-Microlens/Digital/Analog
TM-9701AN-Analog Only

PULNiX
Imaging Products

Rev. 5/02

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TM-9701 ASYNCHRONOUS RESET FULL FRAME SHUTTER CAMERA OPERATION

The TM-9701 is designed to accommodate an 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 CCD operation for charge transfer. The substrate drain vertically moves the charges. When excess potential is applied to substrate underneath each cell, a potential barrier is pulled down to release the charge into the drain. This can happen to all the cells simultaneously, whereas normal CCD shuttering is achieved with a horizontal charge shift to the drain area by interline transferring or reverse transferring of the frame transfer chip.

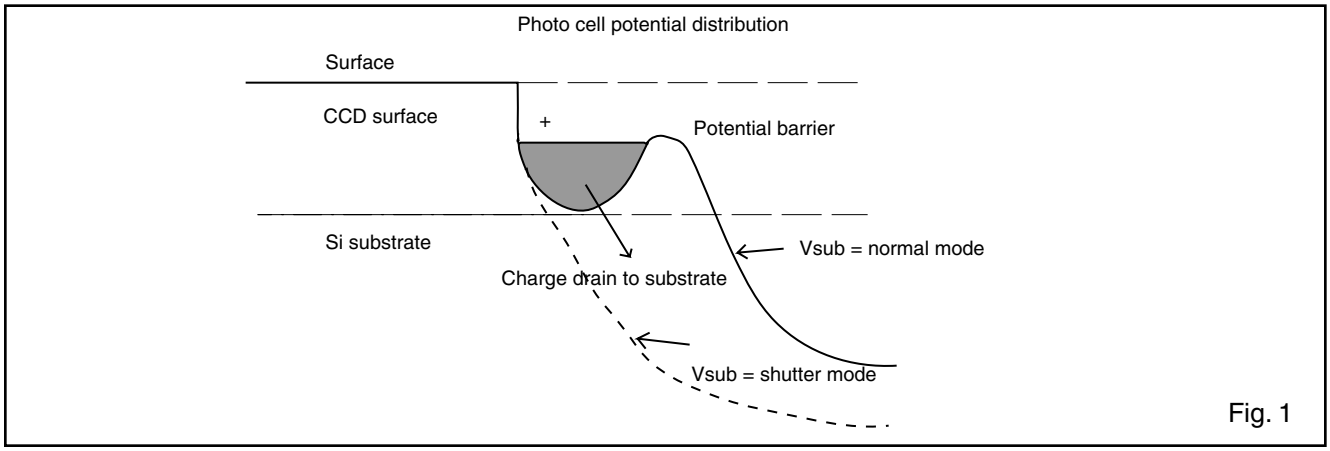


Fig. 1

1.2 **Asynchronous Shutter**

For Async Shutter mode, set jumper W4 of bottom board open and 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-9701 asynchronous camera outputs a full frame of shuttered video in progressive or interlace format from a frame buffer. The frame buffer is updated upon receiving negative reset pulse. Analog (RS-170) and 8-bit digital (EIA-422) outputs are available.

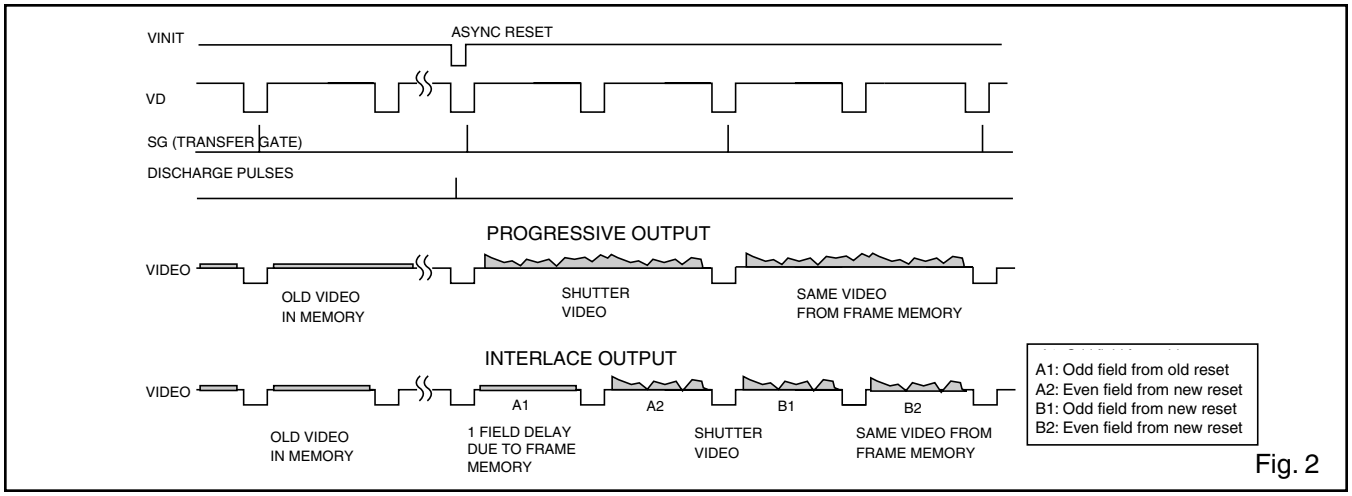


Fig. 2

2. Shutter Speed Control

2.1 External Double Pulse Mode

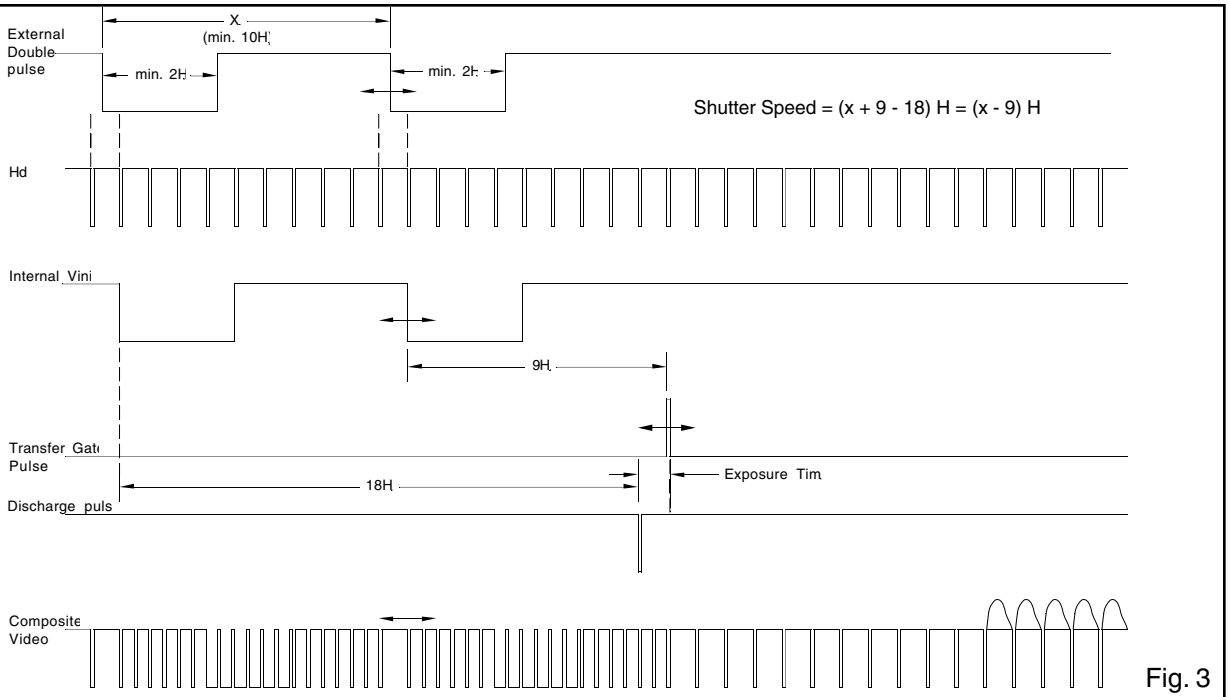


Fig. 3

For external double pulse mode, set dial switch to "9". Apply a double Vinit pulse signal, which can be generated from an external event trigger (see page 7), to the camera. Internal reset pulse will be latched to Hd. The duration from the first VINIT pulse (leading edge) to the second VINIT pulse, X, controls the shutter speed as follows:

Shutter speed ts = X + 9H - 18H ; 1H = 63.5 µsec; Min. duration (X) = 10H; Min. pulse width = 2H.

E.g: The fastest speed is given when the second pulse is set at 10H from the first pulse leading edge, the shutter speed is 63.5µsec (10H+9H-18H) or 1/16000 sec.

For 1/1000 sec shutter (1ms = 16 H), set the second pulse at 25H from first leading edge pulse (25H+9H-18H =16H).

One frame of video output will start from the second leading edge pulse for progressive format. For interlace format, there is one field delay due to frame memory. The camera will output the same video from memory when VINIT is kept high (5V) and update the image upon receiving next set of double pulse.

2.2 Internal Fast Reset Mode

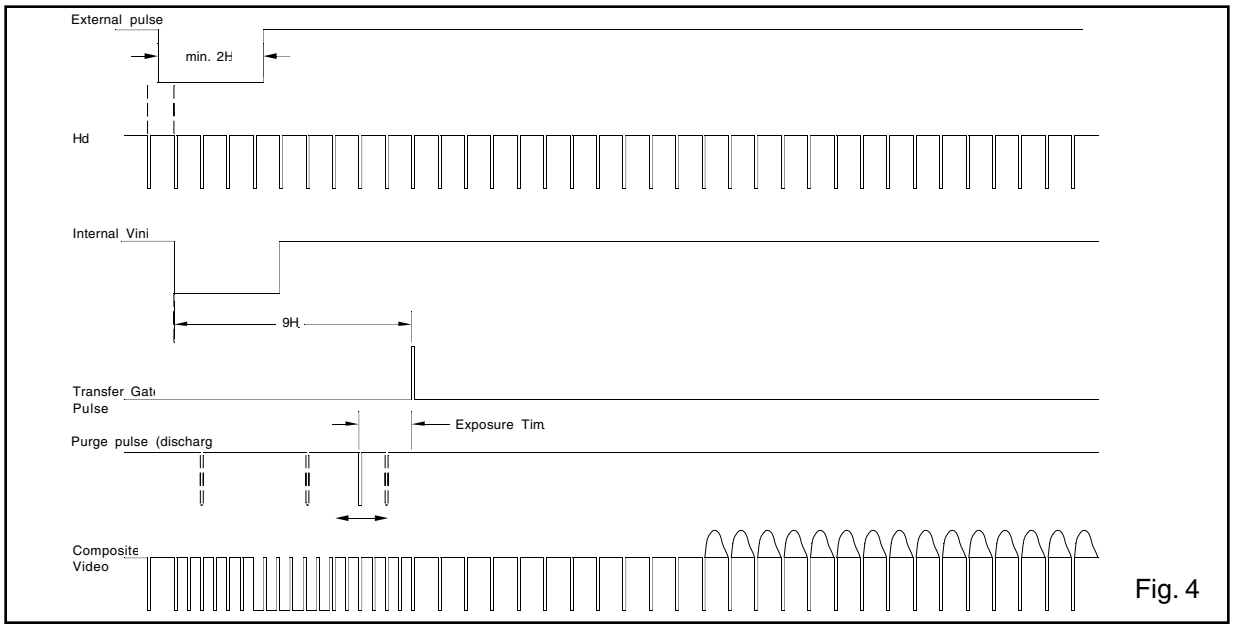


Fig. 4

For Internal Fast Reset Mode, set 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

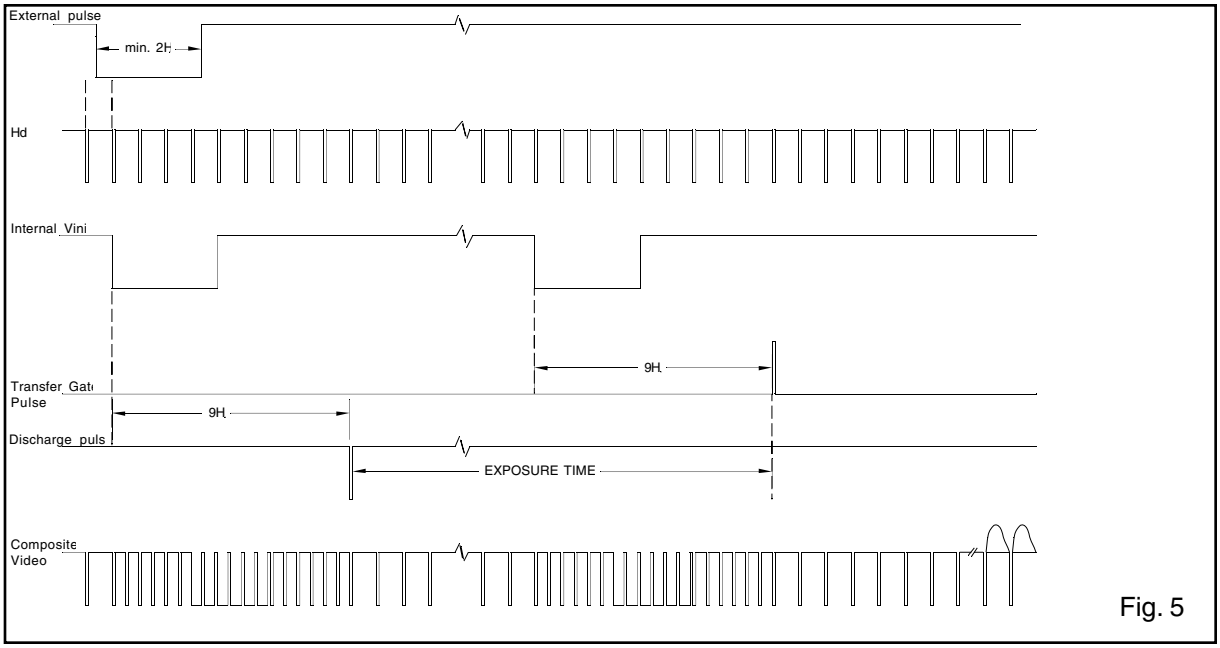
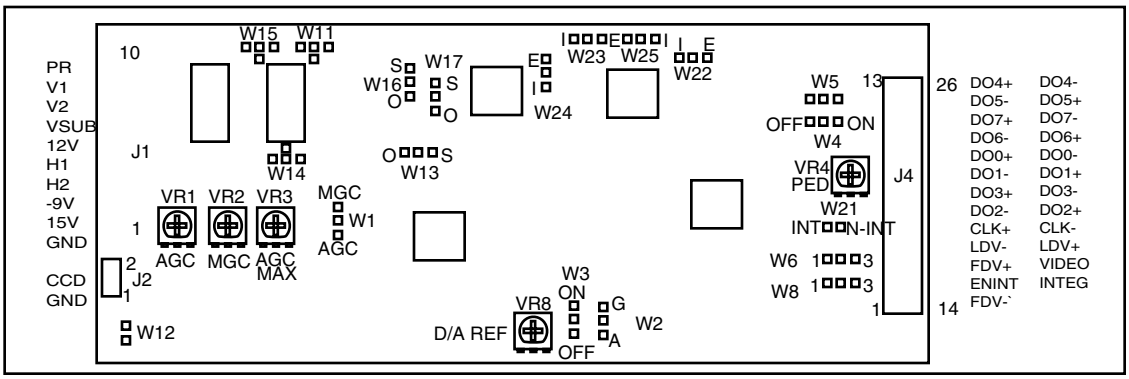


Fig. 5

With the Internal Slow Reset mode selected, the camera operates the reset and shutter in the same means 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, LPULSE output of 31-pin connector can be used.

3. Factory Setting and Board Layouts:

3.1 Top Board

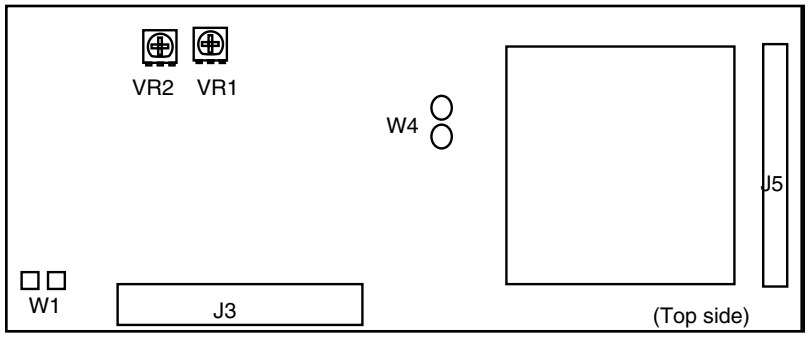


W1	AGC/MGC	Factory set: MGC
W2	A/D input	AGC out or Gamma out. Factory set: G
W3	Gamma	1 (off) or 0.45 (on). Factory set: OFF
W4	Direct Analog/Digital output	W4:On (Right) and W5: Open for Direct Analog W4:Open and W5: Right for Digital
W5	Test	Set to Right
W6	Sync select	1: Non-interlace 3: Interlace
W8	Blank select	1: Non-interlace 3: Interlace
W11,15	SHP/SHD phase	
W14	RG Phase	
W13,16,17	Phase	Set to O
W20,22,23,24	Internal/External memory control	Factory set: Internal
W21	Interlace/Non-interlace selection Pots	

VR1	AGC	Set at 2.0 V ±0.1 V
VR2	MGC	Set at 1.5 V p-p
VR3	AGC MAX	Set at 2.5 V ±0.1 V
VR4	PED	Adjust so that video pedestal level is 50 mV ± 15 mV.
VR7	A/D REF	Refer to Pulnix internal test procedure.
VR8	D/A GAIN	A/D = D/A

3.2 Bottom Board

Shutter speed control
Built in manual shutter control unit varies the shutter speed. Set jumper W1 to select manual shutter mode and asynchronous mode. Use dial switch to select built in shutter speed.



Potentiometers

VR1	VD phase adjust	Adjust VD phase so that Ext. VD and V blanking are lined up.
VR2	PLL	Set at mechanical center

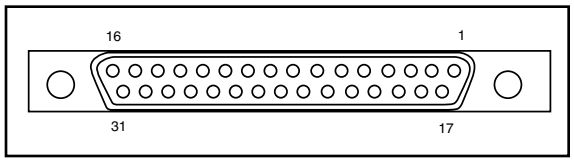
Jumper

W1	Manual shutter / Async shutter selection	Short: Manual	Open:Async

4. 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(14.318 MHz) output
	17	CLK-	"
2		LDV+	Line data valid
	18	LDV-	"
3		FDV+	Field 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	

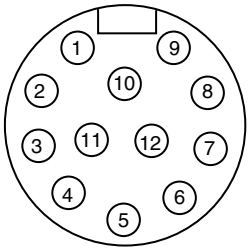


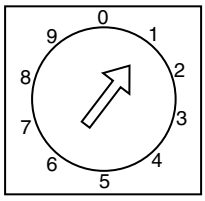
Digital output connector is optional.
Mating connector ordering information:

PULNiX part No.	15-1623	Airborn P/N: MP211-031-113-3400
Straight Backshell (cover):	15-1624	MM254-031-000-0000
Cable assembly:	Refer to P.13	

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

5. Connector Pin Configurations





SH CONTROL

12-PIN Connector

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

6. 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	Double pulse

Mode 0:	Normal mode
Async Mode1-4:	Fast mode
Async Mode 5-8:	Slow mode
Async Mode 9:	Double pulse mode

7. VINIT Double Pulse Generator

One of the advantages of the TM-9701 asynchronous camera is the external shutter speed control by providing a double pulse VINIT signal. The pulses are generally applied from a computer or the frame grabber system. The first pulse is synchronized with the external trigger edge to reset the camera. The second pulse is for shutter speed control and creates internal VD and frame grab timing of asynchronously reset video. Following is a simplified circuit example for external shutter speed control.

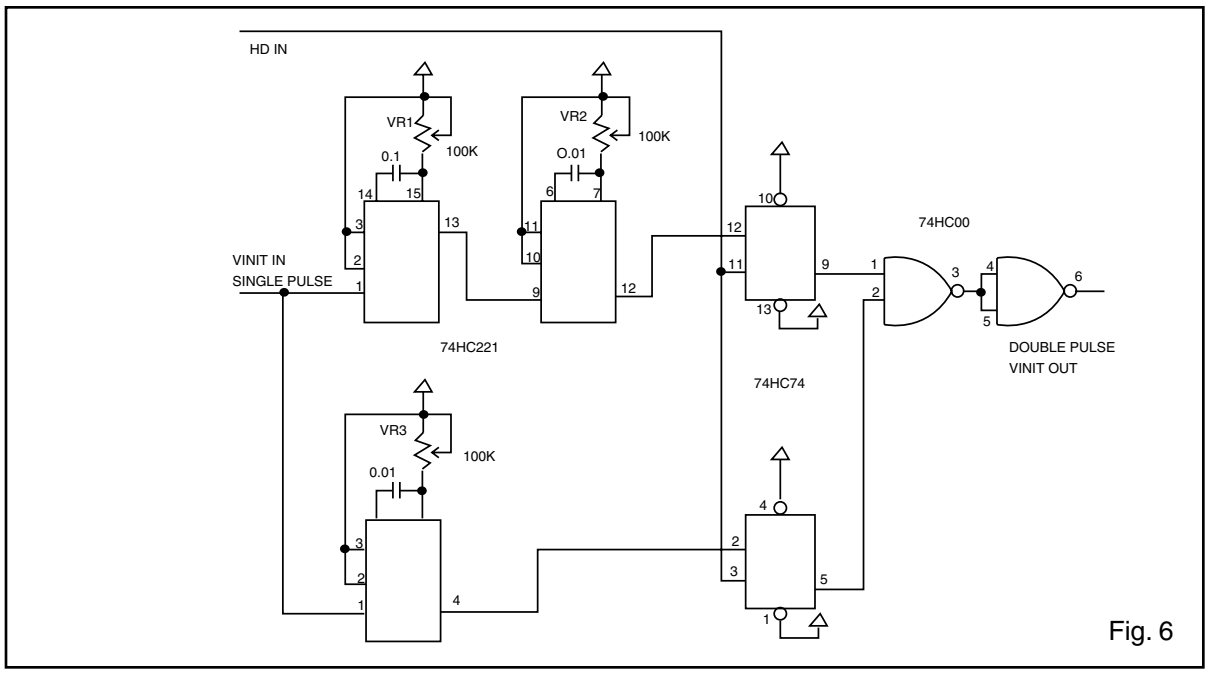


Fig. 6

VR1.....Pulse duration adjustment for shutter speed control

VR2.....Second pulse width adjustment. It is not important to keep any specific width but enough for frame grab timing. (Suggested to be >2H)

VR3.....First pulse width adjustment. In order to obtain effective shutter speed control, it is suggested to be less than 4H. Optimum width is 2H. 1H = 63.5 µsec.

8. Frame Memory

The TM-9701 has a built-in frame memory in order to convert progressive scanning images to RS-170 interlace scanning images. This feature provides the following advantages:

i) Asynchronously captured images are output as standard continuous video signals so that a normal monitor or frame grabber can display or process without special asynchronous video grabber.

ii) 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 blinking video signal. The TM-9701 memory keeps the stored image until the next image is completed so that there is no blank interval during integration.

iii) Digital format of the video output can be used as direct interface with computer. The format is interlace or progressive.

How to activate the frame memory?

A. Asynchronous Reset Mode (Select switch on back plate for ASYNC)

When External VINIT is high (5V), the TM-9701 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 is kept and output continuously during VINIT high. When the next VINIT pulse comes in, the next image is captured. If the switch is MAN (manual shutter) mode, the video output is real time. Because of the progressive scan to interlace scanning, the interlace video reacts slower to moving objects than with normal interlace cameras. (It converts 30 Hz frame into 60 Hz rate and since moving objects are captured at a slow rate, 60 Hz scanning cannot show faster motion.)

B. Integration

Activate ENINT (Enable Integration) of 31-pin connector (#22) by connecting to 0V (TTL GND) then input INTEG CONT as active low. During low, the TM-9701 keeps integrating and, upon the rising edge of the INTEG CONT pulse, it captures the frame and keeps it until next end of integration.

9. Progressive Scanning

Standard TV system scanning is 525 line interlace scanning as specified in RS170. Every other horizontal line (ODD lines and EVEN lines) are scanned at a 60 Hz rate per field, and completes scanning with two fields (one Frame) at 30 Hz rate. Because of the interlace scanning, vertical resolution of CCD cameras is limited at 350 TV lines regardless of horizontal resolution. When electronic shutter is applied, the CCD can hold only one field of charge at each exposure. Therefore, the vertical resolution of the electronic shutter camera is only 244 TV lines.

The TM-9701 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 (30 Hz). Like a non-interlace computer screen, it generates a stable crisp image without alternating lines and provides full vertical TV resolution of 484 instead of 350. 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 object motion.

The TM-9701 outputs the progressive scan image with electronic shutter in three different formats:

i) Progressive Scanning Analog Output (refer to P.5 for jumper setting)

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.

ii) Progressive Scanning Digital and Analog Output (refer to P.5 for jumper setting)

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 30Hz rate available from BNC and 12 pin connector. The digital output is available from 31-pin connector with EIA-422 format.

iii) Interlace Scanning Output (Digital and Analog)

By setting switch on the back plate to interlace mode, the TM-9701 outputs normal RS-170 video for standard monitor display or general purpose video frame grabbers. (Set jumpers W4 ON side). Since the interlace mode must use a frame memory, it can output captured images of async and integration video. The first field after asynchronous reset is the previous image. The second field is an even field, and the third field is an odd field. In orer to capture full frame, the frame grabber must capture the 2nd and 3rd fields. (See page 2, Fig. 2) Option 51 provides continuous (uninterrupted) video sync output for asynchronously captured images.

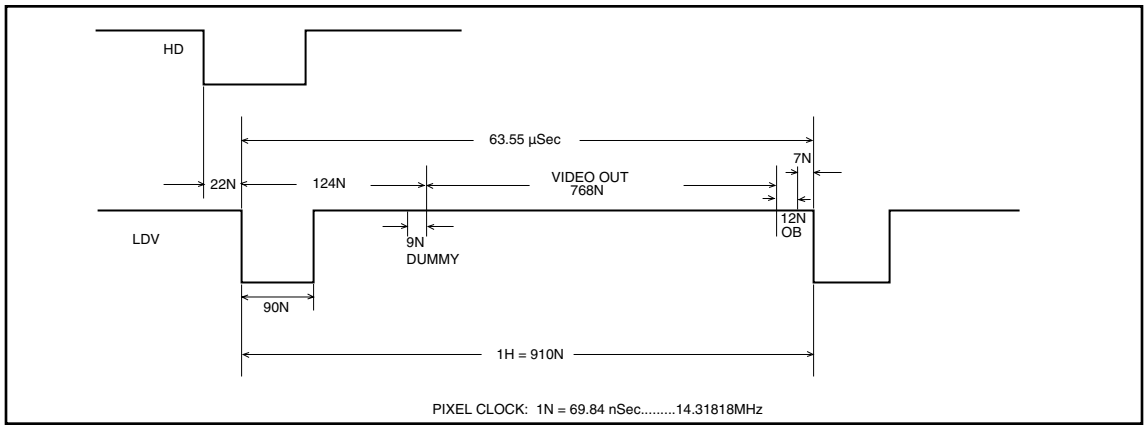
10. Digital Output Pulses

10.1 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: Airborn MP211-031-113-4300 (See page 4.)

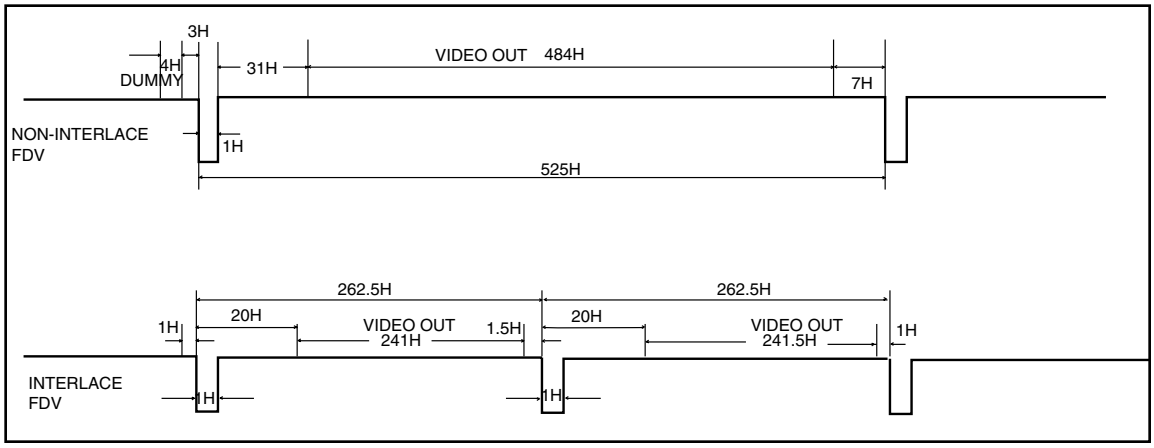
10.2 Line Data Valid (LDV)

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.



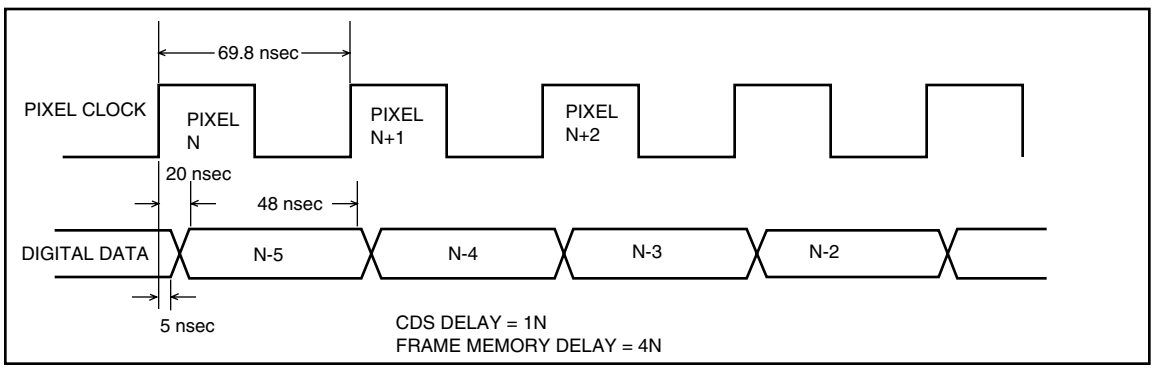
10.3 Frame Data Valid (FDV)

Differential line-driven signal with EIA-422 format. It is active high during the transfer of each frame data (or field data for interlace output).



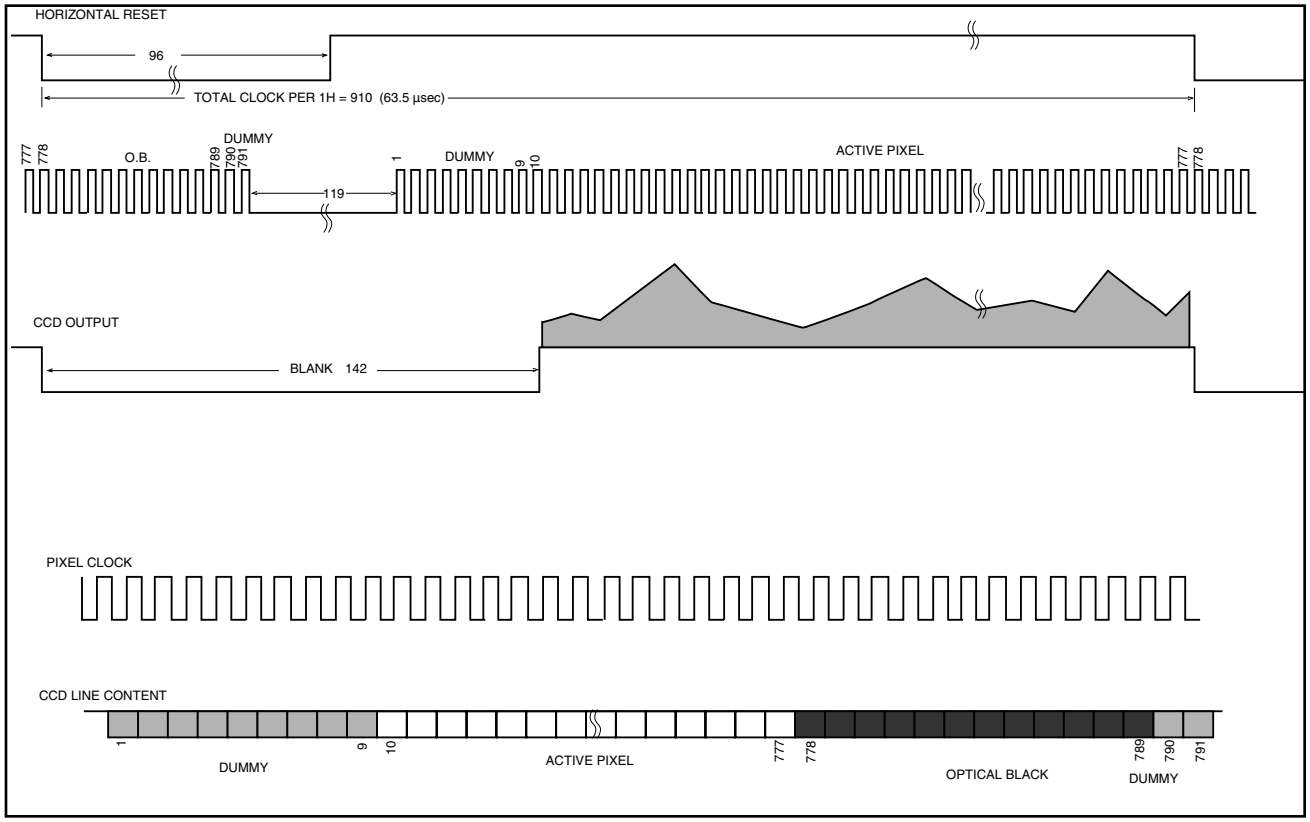
10.4 Pixel Clock

Differential line-driven signal with EIA-422 format. The frequency is 14.31818 MHz.

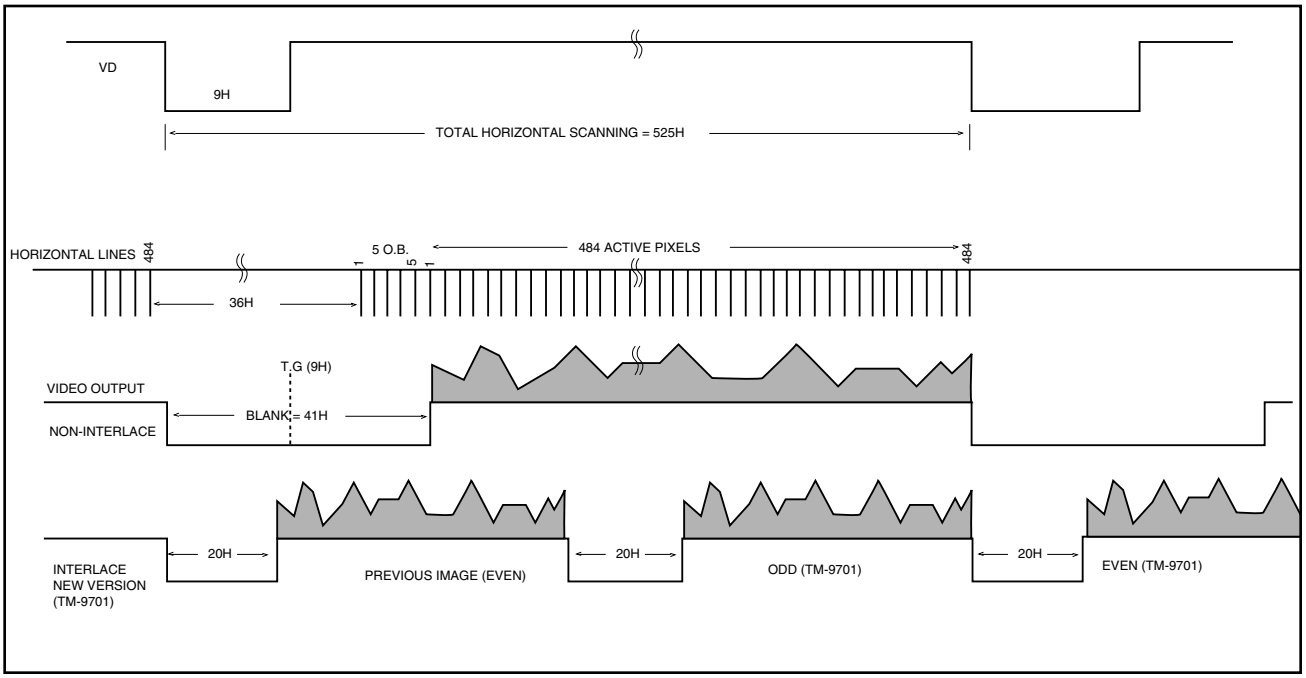


11. Progressive Scan Camera Pixel Map and Timing Chart

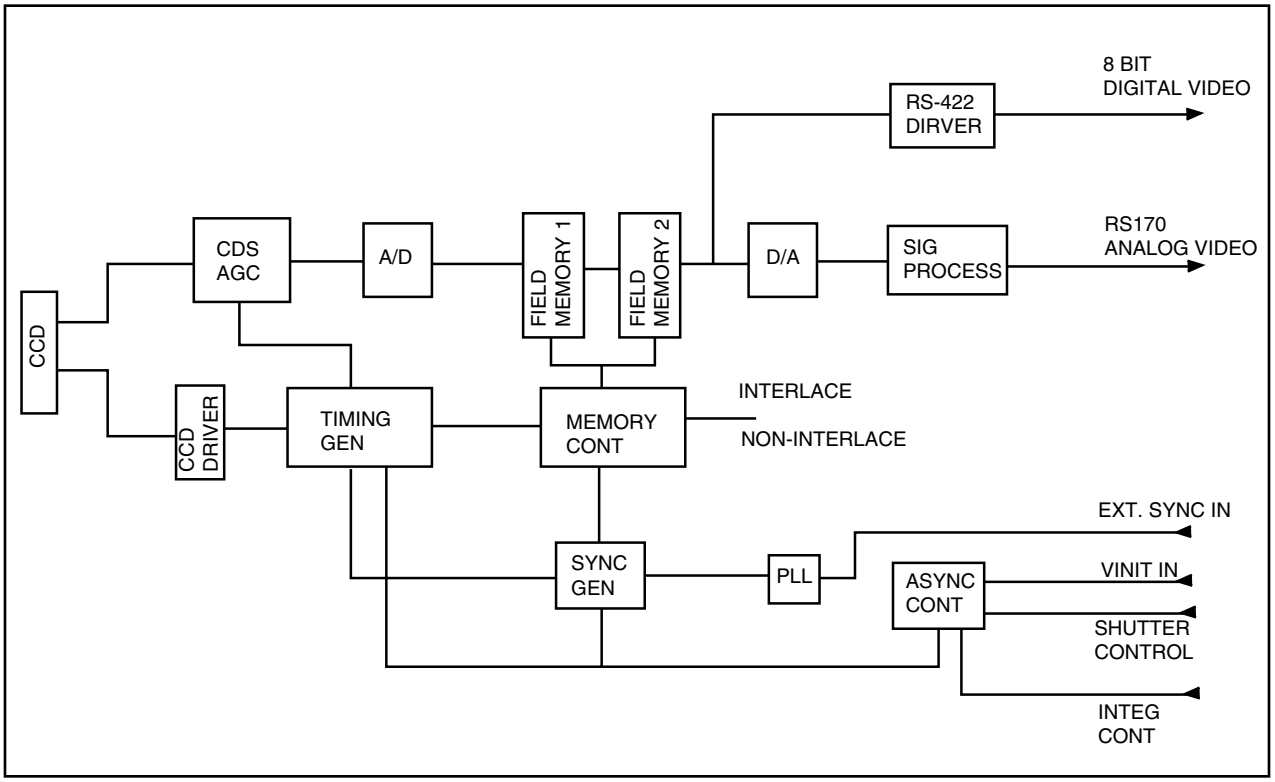
11.1 Pixel Mapping



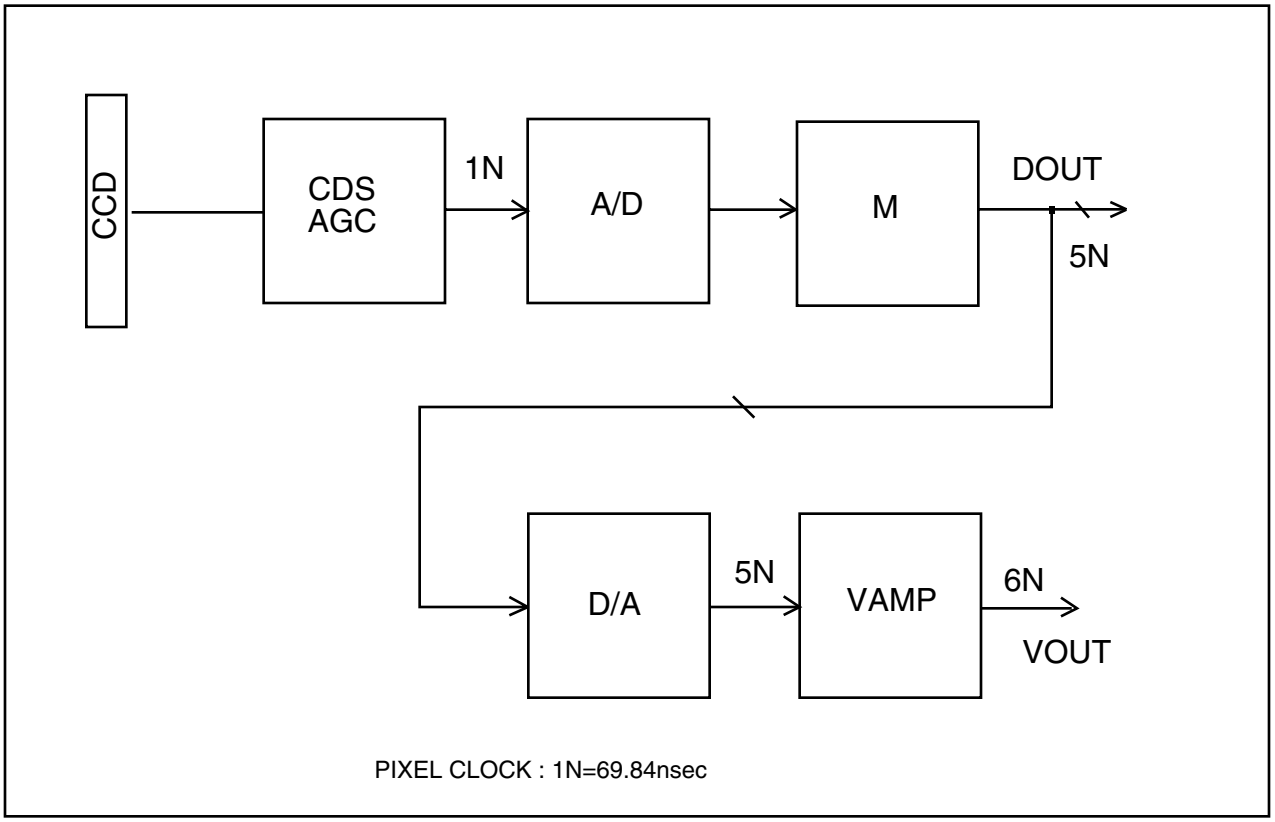
11.2 Vertical Frame Timing



12. Block Diagram



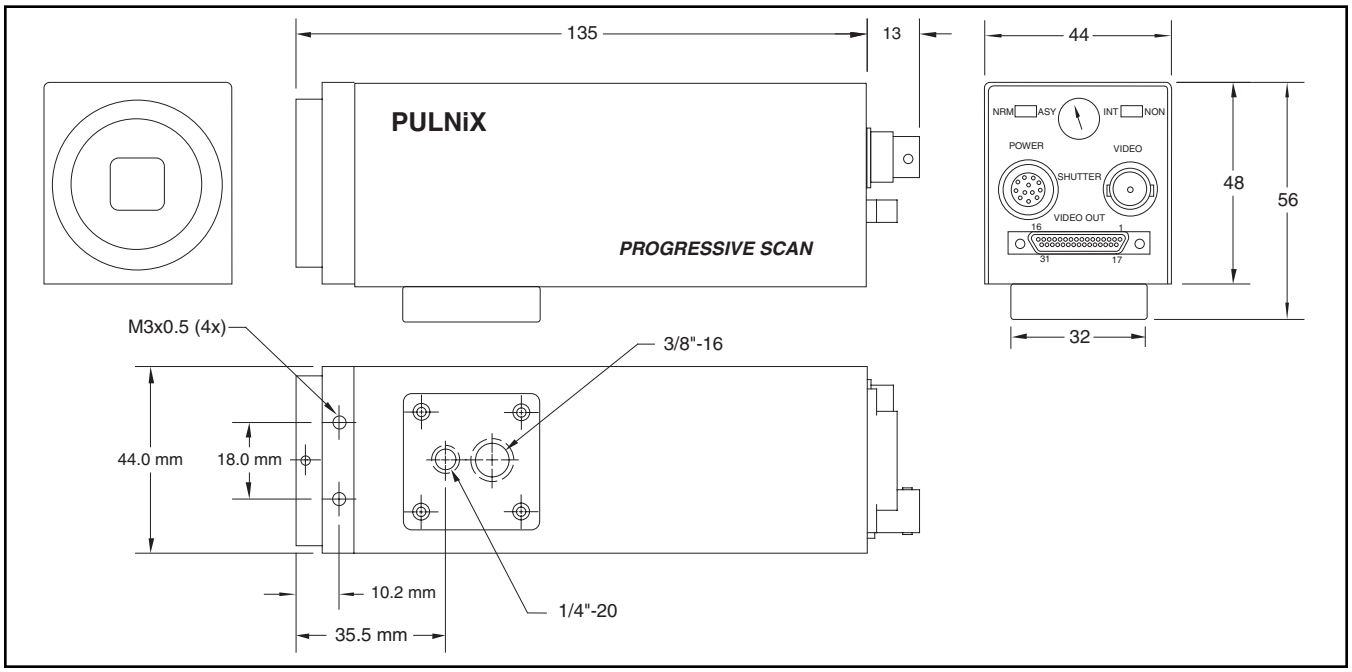
13. Signal Delay



14. Specification

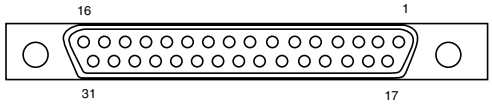
Imager:	2/3” inch progressive scanning interline transfer CCD
Pixels	768 (H) x 484 (V)
Cell size	11.6 (H) x 13.6 (V) microns progressive scan
Imager size	8.9 (H) x 6.6 (V) mm
Chip size	9.9 (H) x 7.7 (V) mm
Dynamic range	60dB
Output sensitivity	10 μV/electron
Dark noise	40 electrons
Dark current	< 1 nA/cm^2
Quantum efficiency	25%, 20%, 12% (450, 550, 650 nm); TM-9701 only
Scanning:	525 lines, 30 Hz or 60 Hz 2:1 interlace
Clock	28.6363 MHz
Pixel clock	14.31818 MHz
Horizontal frequency	15.734 KHz
Vertical frequency	59.94 Hz
TV resolution:	570(H) x 484(V) lines, digital resolution: 768 x 484
Video output:	1.0V p-p composite video, 75Ω and 8-bit RS 422 output
S/N ratio:	50 dB min. (AGC OFF)
Minimum illumination:	1.0 lux (F=1.4) without IR cut filter
AGC:	ON/OFF (OFF std.)
Gamma:	0.45 or 1.0 (1.0 std.)
Lens mount:	C-mount
Power requirement:	DC 12V, 500 mA
Weight:	330 grams (12oz.)
Operating temperature:	-10 °C to +50 °C
Storage temperature:	-30 °C to +60 °C
Operating humidity:	Max. 70%
Storage humidity:	Max. 90%
Vibration:	7 G (200Hz to 2000Hz)
Shock:	70 G
Dimensions:	44 mm x 48.5 mm x 136 mm (1.73” x 1.90” x 5.35”)

Physical Dimensions



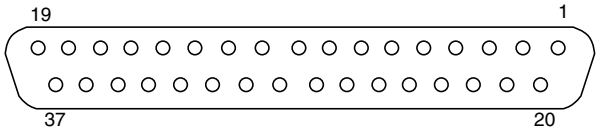
16. 30 Conductor Digital Cable Assembly

31 pin configurations



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

37 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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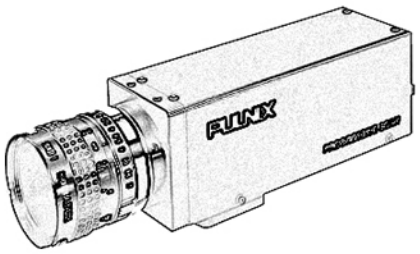

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