RGB Color
Progressive Scan Camera

CV-M77

Operation Manual

Camera: Revision B
Manual: Version 2.1

Table of Contents

1. General

The CV-M77 camera is a compact RGB color progressive scan camera designed for automated imaging applications. The 1/3" CCD sensor with square pixels and primary mosaic filter offers a superb image quality and the built-in DSP assures high color reproduction.
The camera incorporates several triggered modes and various shutter functions to capture moving objects and to control the light. All camera mode settings can be controlled via an RS-232C interface or by the switch at the rear of the camera.
The CV-M77 camera is ideal for demanding color applications such as color inspection, gauging and color printing.

Revision B is updated with the high framerate read out mode.

The latest version of this manual can be downloaded from: www.jai.com .
The latest version of the Camera Control Tool software can be downloaded from: www.jai.com .

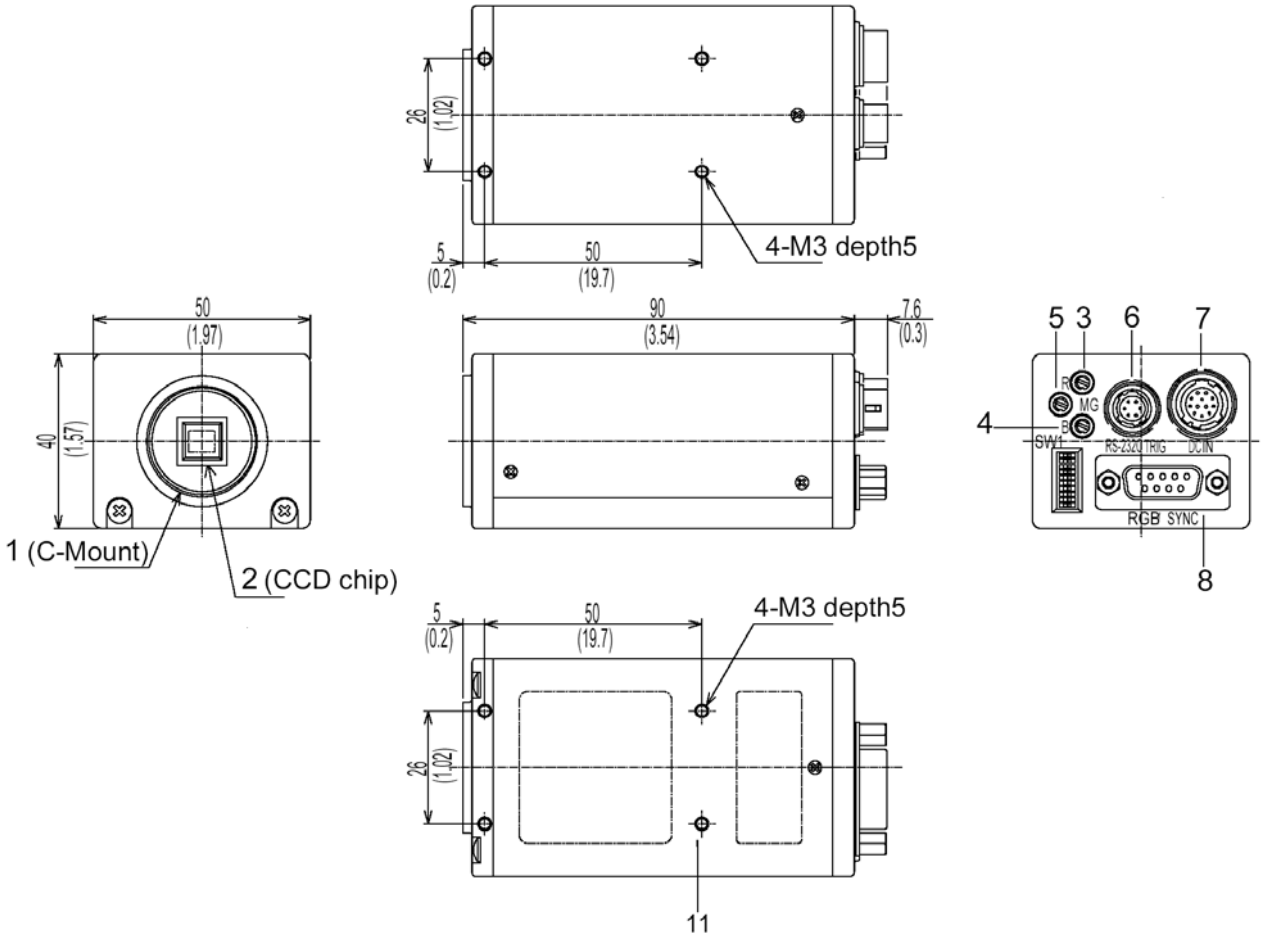
2. Standard Composition

The standard camera composition consists of the camera main body.

3. Main Features

- New 1/3" full frame progressive scan interline transfer CCD
- RGB Primary color mosaic filter(Bayer) and DSP for excellent color reproduction
- 1034 (h) x 779 (v) 4.65µm square pixels (1028 x 768 pixels read out) – XGA format
- 25 full frames 1028 (h) x 770 (v) RGB video output per second
- Fast frame readout of every third line in the full frame
- 74 fps 1028 (h) x 242 (v) RGB video output
- Internal, external HD/VD or random trigger synchronization
- Edge pre-select and pulse width controlled external trigger modes
- Programmable shutter speed from 1.5 H to 791 H
- Long time exposure with external VD pulse interval
- Frame delay readout for edge pre-select and pulse width controlled shutter
- Exposure enable EEN, write enable WEN and pixel clock output
- Short ASCII commands for fast mode setup via serial port
- Setup by Windows 98/NT/2000/XP software via RS 232C

4. Locations and Functions



1	Lens mount of C-mount type. *1)
2	1/3" CCD sensor with primary color mosaic filter. (Bayer filter).
3	R Gain Potentiometer. To adjust Red gain level manually.
4	B Gain Potentiometer. To adjust Blue gain level manually.
5	MG Gain Potentiometer. To adjust Master gain level manually.
6	6 pin connector for RS 232C signals, input of ext. trigger pulse and WEN output.
7	12 pin connector for +12V DC power and HD/VD input/output.
8	9 pin D-Sub connector for RGB video output, video sync. and pixel clock output.
9	Switch to set shutter speed and function mode.
10	Screw holes for tripod mounting plate (optional plate)
11	4 M3 mounting threads. *2)

1)* ***Note**: Rear protrusion on C-mount lens must be less than 6mm (0.24-inch approx.)*
2)* ***Note**: Notice depth of thread is only 5mm. Too long screws may harm inside electronics.*

Fig. 1. Locations

5. Pin Assignment

5.1. 12-pin Multi-connector (DC-IN/Trigger)

Type: HR10A-10R-12PB-01
(Hirose) male.
(Seen from rear of camera.)

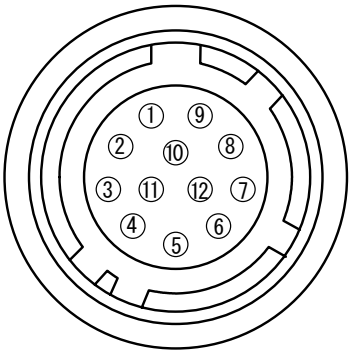


Fig. 2. 12-pin connector.

Pin no.	Signal	Remarks
1	GND	
2	+12 V DC input	
3	GND	
4	Iris video output	Video for lens iris control. (With comp sync.) Can only be used in normal continuous mode.
5	GND	
6	***HD input***/output	SW-S301.1 "ON" for 75Ω termination, SW-S303.1 "OFF" for HD output
7	***VD input***/output	SW-S301.2 "ON" for 75Ω termination, SW-S303.2 "OFF" for VD output
8	GND	
9	***NC***/Pclk out	PCLK out: JP305 "short", JP306 "open" Do not output Pclk if not used!
10	GND/NC/***WEN out***	NC: JP309 and JP310 "open". GND: JP308 "open" JP309 and JP310 "short"
11	***Trigger input*** /NC/+12V	NC: JP401 and JP301* "open". +12V DC JP401 "short" and JP301* "open"
12	GND	

Notes:

*Factory settings in **bold italic***
**1) Signals on pin no. 4 and 6 can be changed by jumpers.*
See "7. Configuring the Camera" for more information
**2) Do not input ext. VD in trigger modes*
**)JP301 is "short" by a capacitor*

5.2. 6 pin Multi-connector (RS-232C/Trigger)

Type: HR10A-7R-6PB (Hirose) male.
(Seen from camera rear.)

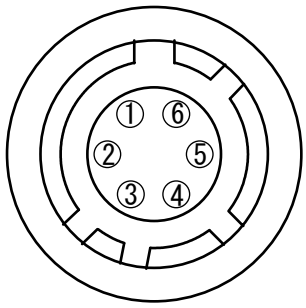


Fig. 3. 6-pin connector

Pin no.	Signal	Remarks
1	TXD out	RS-232C
2	RXD in	RS-232C
3	GND	
4	***NC***/GND	GND if JP402 short. *1)
5	Ext. Trig input	
6	***EEN out*** /WEN out	WEN out if JP312 open, JP311 short. *1)

Notes:

*Factory settings in **bold italic***
**1) Signals on pin no. 4 and 6 can be changed by jumpers.*
See "7. Configuring the Camera" for more information.

5.3. 9 pin D-sub connector (RGB/SYNC)

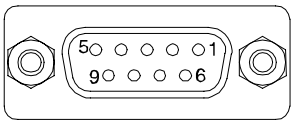


Fig. 4. 9-pin connector

Pin No.	Signal	Remarks
1	***NC***/VD in	VD input: JP303 "open" and JP304 "short"
2	GND	
3	R output	
4	***G output*** /Sync on G	Sync. on G: SW302-3 "ON" or SY=1
5	B output	
6	***HD input*** /HD output	HDinput: SW303-1 "ON". HDout: SW303-1 "OFF"
7	***Sync output*** /WEN output	WEN output: SW302-4 "ON" or WS=1
8	GND	
9	***NC***/Pclk	PCLK output: JP305 "open" and JP306 "short" Do not output Pclk if not used!

Notes:

*Factory settings in **bold italic***
**1) Signals on pin no.1, 4, 6, ,7 and 9 can be changed by jumpers. See "7. Configuring the Camera" for more information.*

5.4. Principle diagram for input and output jumpers

The below diagram shows the input output circuits with jumpers for alternative pin connections. It can be useful for control of jumpers and connections. Jumpers are shown in factory settings.

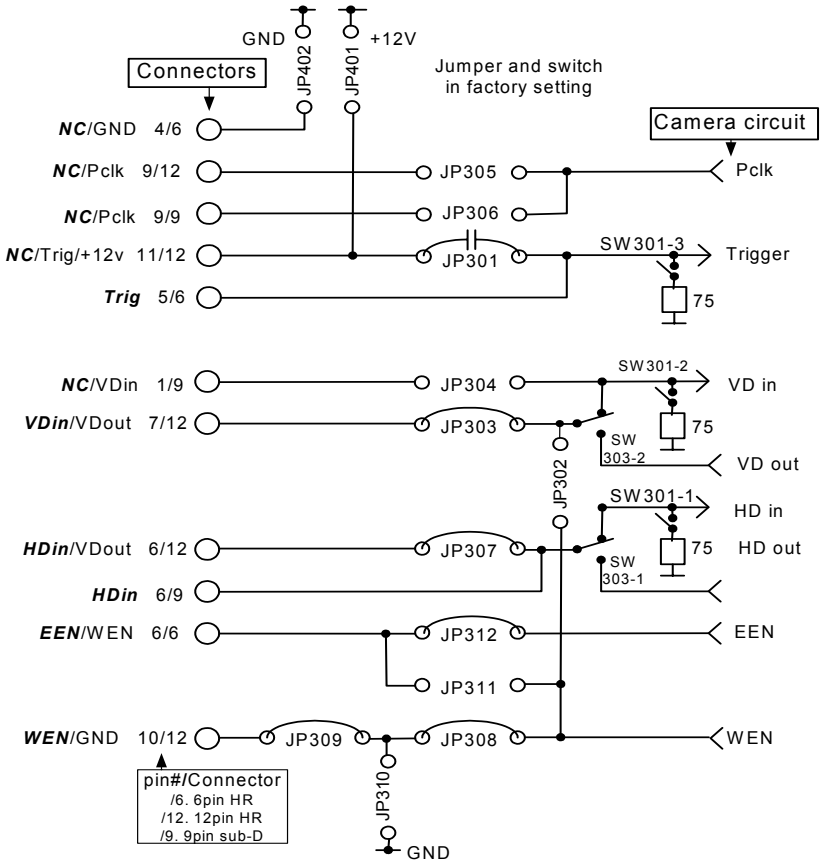


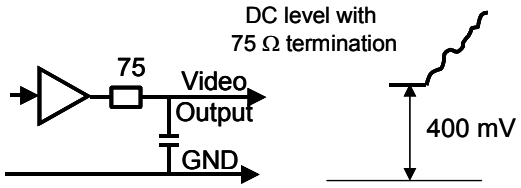
Fig. 5. Input and output jumpers and signals

5.4. Input output Circuits

In the following schematic diagrams the input and output circuits for video and timing signals are shown. For alternative connections refer to *"7. Configuring the Camera"*. Jumper settings are shown as for factory default.

RGB video output

The video output signal is a RGB video signal. The signal level is 0.7Vpp from 75Ω. The video output is DC coupled.
Composite sync. is selectable on the green video signal via software or the internal switch 302-3. The sync. signal level is 0.3Vpp.



Iris video output

A video signal for lens iris control is found on pin 4. 12-pin connector. The signal is with composite sync. It is ac coupled from a 75Ω source. It can only be used for iris control in normal continuous mode.

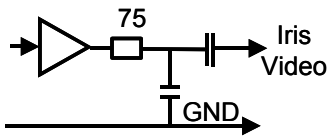


Fig. 6. Video outputs

Trigger input

The trigger input is AC coupled. To allow a long wide pulse width, the input circuit is a flip-flop, which is toggled by the negative and positive differentiated spikes cause buy the falling and rising edge. The input signal level is 4V ± 2V. The trigger input impedance is 1.2 kΩ or 75Ω selectable via the internal switch S301-3.

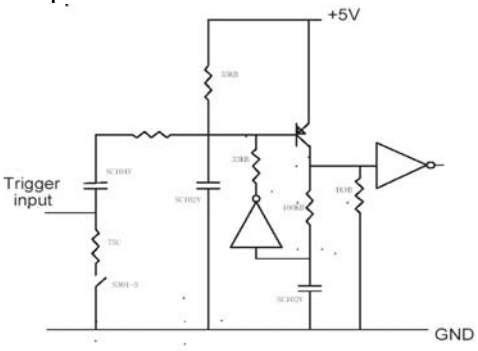


Fig. 7. Trigger input

HD and VD input

The HD and VD input circuit can be 75Ω terminated via the internal switch S301-1 and S301-2.
The input signal level is 4V ± 2V.

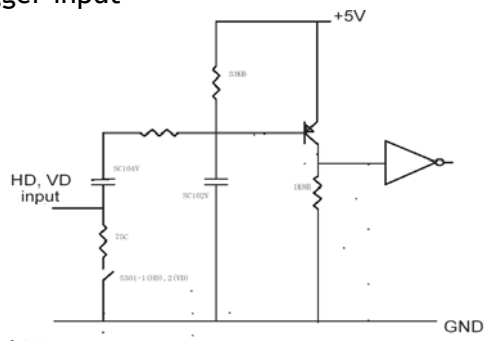


Fig. 8. HD and VD inputs

HD, VD, PCLK, WEN and EEN output

The output circuits for these signals are 75Ω complementary emitter followers. The single circuit delivers a TTL signal. The output level ≥ 4 V from 75Ω (no termination).

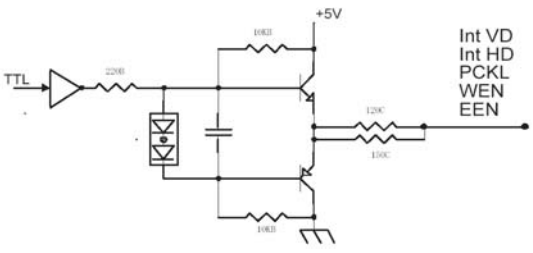


Fig. 9. HD, VD, PCLK and EEN output

6. Functions and Operations

6.1. Basic operation modes

Apart from the standard continuous operation mode, the CV-M77 features four external triggering modes and a long time exposure mode. In all modes the camera can be synchronized to an external sync. The shutter time can be selected from 12 fixed steps, or from 788 steps with 1H resolution. In triggered mode it can also be controlled by the trigger pulse width.
The frame delayed readout can operate in either edge pre-selected trigger, or pulse width controlled shutter mode.

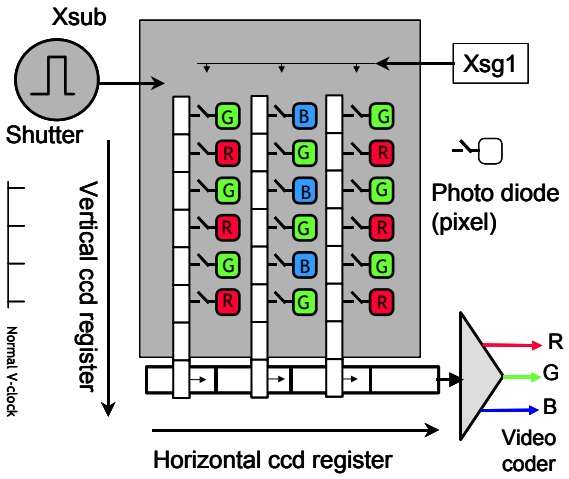
Switches can set most modes and functions locally. All modes and functions can be remote controlled by RS-232C control.
Alternative connections for input and output signals can be done by internal jumpers.
For details: refer to "7. Configuring the Camera".

6.1.1. High frame rate.

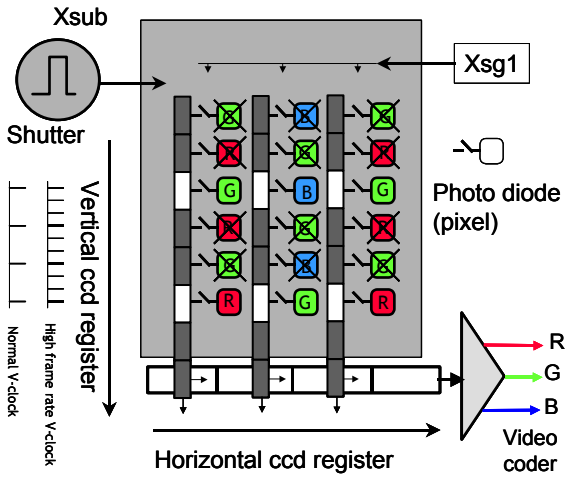
From revision C, the CV-M77 camera has a new readout mode. It is the high frame rate mode. Here only every third line is read out. The 2 lines between are dumped. In this way the Bayer RGB mosaic pattern is unchanged. The DSP interpolation algorithm for RGB color output can still be used.
The figures below shows the CCD sensor in normal mode and high frame rate mode. In high frame rate, the vertical ccd register is clocked with 3 times higher rate. But only the signals from every third line is transferred to the horizontal ccd register for read out. Signals from the lines between are dumped.
The horizontal resolution is unchanged, but the vertical resolution is reduced to 1/3.

The advantages are:

- Frame rate 3 times higher
- The image is sampled from the whole sensor area
- Horizontal resolution unchanged



CCD with normal readout.



CCD with high frame rate readout.

6.2. Input/Output of HD/VD Signal

6.2.1. Input of External HD/VD signals

This setting is factory pre-set. The video output is synchronized with external HD/VD signals if applied. If no ext. HD signal is input, the camera will switch to the internal X-tal controlled HD sync. If no ext. VD is connected, the camera will continue with its internal VD.
For details: refer to "7. Configuring the Camera".

To use this mode:

Set function:	SW 303.1 and 303.2 to ON for external HD/VD input. *Factory default.*
	SW 301.1 and 301.2 to OFF for TTL level for HD/VD. *Factory defaults*
	SW 301.1 and 301.2 to ON for 75 Ω termination of HD/VD..
Input:	Ext. HD in on pin 6 on 12-pin connector. 4.0 Vp-p ±2.0V.
	Ext. VD in on pin 7 on 12-pin connector. 4.0 Vp-p ±2.0V.

Important notes on using this mode

External sync system should follow the camera scanning system.
The ext. HD/VD phase relations should follow as shown in fig. 10.

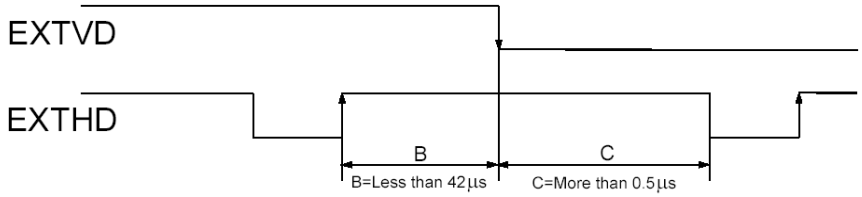


Fig. 10. External VD and HD phase relation

6.2.2. Output of Internal HD/VD signals

Internal HD/VD signals can be output for synchronizing external equipment.
For details: refer to "7. Configuring the Camera".

To use this mode:

Set function:	SW 303.1 and 303.2 to OFF for internal HD/VD output.
Output:	Int. HD out on pin 6 on 12-pin connector. 4.0 Vp-p from 75Ω source.
	Int. VD out on pin 7 on 12-pin connector. 4.0 Vp-p from 75Ω source.

6.3. Continuous operation

This mode is used for applications that do not require asynchronous external trigger, but run in continuous operation.
Mode setting and all other settings can be done via RS 232C control if rear switch SW1-10 is ON.
Mode setting and some other settings can be done by switch if rear switch SW1-10 is OFF.
For details: refer to "7. Configuring the Camera".

To use this mode:		*RS*	*SW1-*
Set function:	Trigger mode to "Normal"	TR=0	5, 6, 7 OFF
	Shutter to "Normal" or "Programmable"	SM=0, SM=1	
	"Shutter speed"	SH=0 through 11	1, 2, 3, 4
	"Programmable exposure"	PE=3 through 791	
	Other functions		
Input:	Ext. HD in on pin 6 on 12-pin connector. 4.0 Vp-p ±2.0V. *(If used).*		
	Ext. VD in on pin 7 on 12-pin connector. 4.0 Vp-p ±2.0V. *(If used).*		

Important notes on using this mode

External sync system should follow the camera scanning system.
The ext. HD/VD phase relations should follow as shown in fig. 10.
***1028** (h) effective pixels in continuous mode. **1016** (h) in trigger modes.*

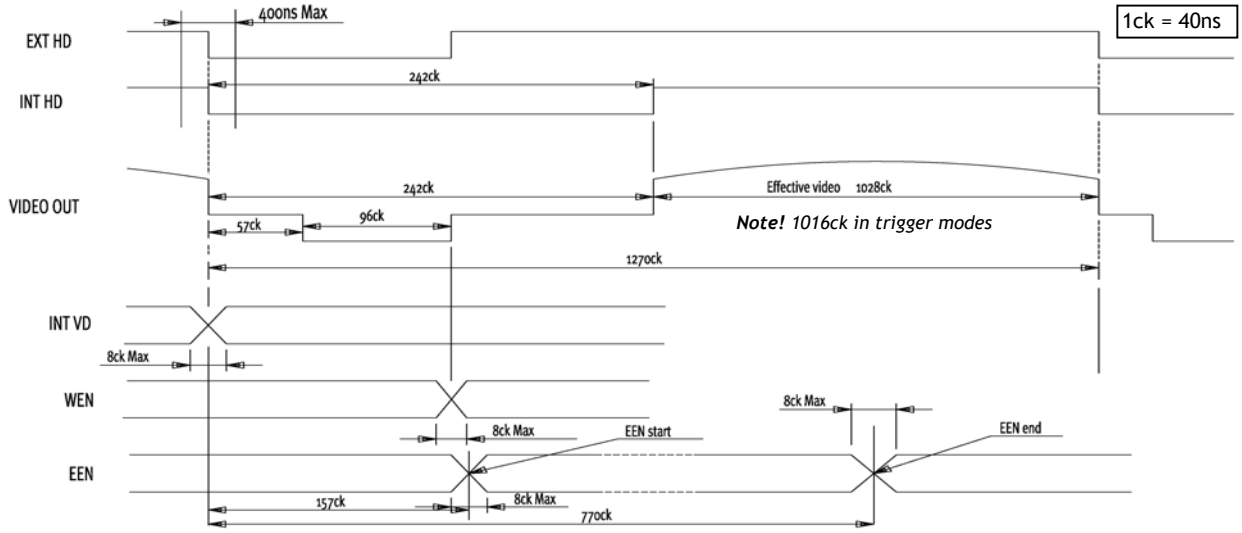


Fig. 11. Horizontal timing

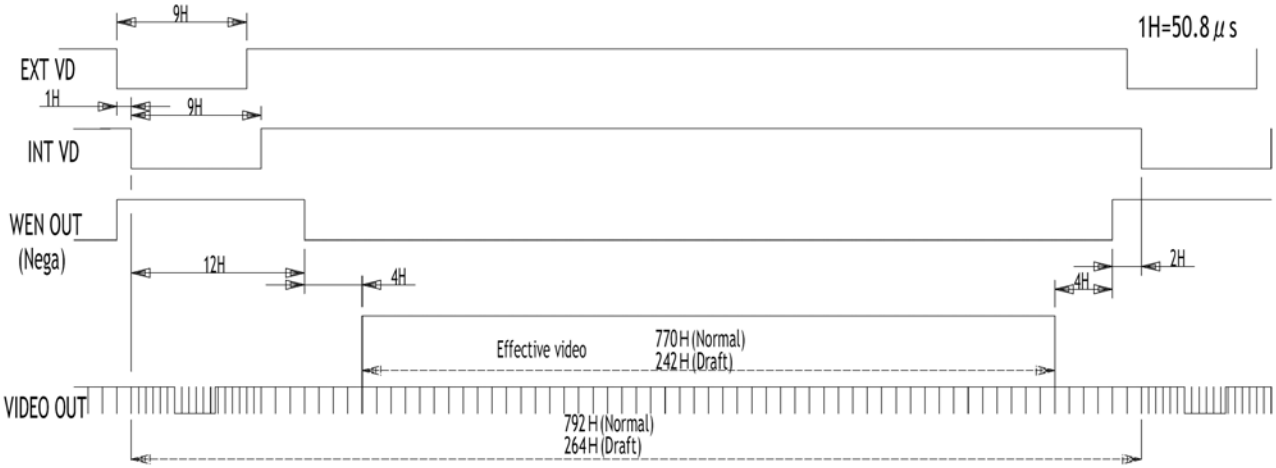


Fig. 12. Vertical timing

6.4. Trigger modes

The CV-M77 camera features 4 external triggering modes:

1 Edge Pre-Select. (EPS). Asynchronous reset and exposure start by an ext. trigger pulse.
2 Pulse Width Control. (PWC). Exposure control by the low period of the ext. trigger pulse.
3 Readout Delay EPS. Triggered EPS exposure. Readout controlled by external VD signal.
4 Readout Delayed PWC. Triggered PWC exposure. Readout controlled by external VD signal.

These external triggering modes operate with H non-reset. In H non-reset, the exposure will be synchronized to the internal HD, and the exposure will start at the first HD after the negative going edge of the trigger. Refer to fig. 13. The exposure stops 0.5 H after the last HD pulse. To avoid the <1H exposure jitter caused by this delay, it is recommended to synchronize the external trigger to HD as shown in fig. 14.

The trigger input can be TTL level or 75 ohm terminated by setting the specific S301 switch on the PK 8308 board to OFF or ON (see switch settings). When 75 ohm terminated the signal input level is 4.0 Vp-p ±2.0V.

Mode setting and all other settings can be done via RS 232C control if rear switch SW1-10 is ON. Mode setting and some other settings can be done by switch if rear switch SW1-10 is OFF.

For details: refer to "7. Configuring the Camera".

Important notes on using this mode

*Number of effective pixels per line in trigger modes are **1016** (h).*

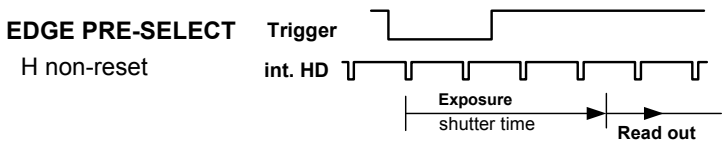


Fig. 13. H non –reset trigger

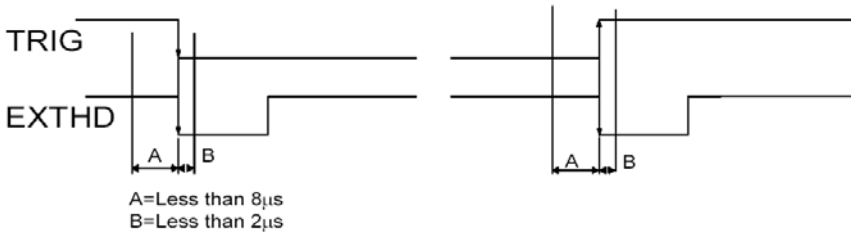


Fig. 14. External trigger and HD phase relation

6.4.1. Edge Pre-select Trigger

This trigger mode operates in H non-reset mode. In H non-reset mode the exposure will start at the first internal HD after the trigger. The trigger input should be longer than or equal to 2 HD (102 μsec.). The external trigger pulse initiates the capture, and the exposure time (accumulation time) is governed by the fixed shutter speed set up by the rear panel DIP-switches or via RS-232C control. The EEN pulse indicates the actual exposure time. The resulting video signal will start to be read out after the selected shutter time. The WEN pulse indicates the start of valid video signal. Refer to timing charts for details. A new trigger pulse must not be applied before the video read out has finished. If the camera is synchronized to an external HD signal, there are some requirements to the phase between the ext. HD and the Ext. trigger. The falling edge of the trigger should be less than 8 μsec before the falling edge of the ext. HD and less than 2 μsec after the falling edge of the ext. HD (see fig. 14.). Otherwise the jitter will be too high.

Mode setting and all other settings can be done via RS 232C control if rear switch SW1-10 is ON. Mode setting and some other settings can be done by switch if rear switch SW1-10 is OFF. *For details: refer to "7. Configuring the Camera".*

To use this mode:		*RS*	*SW1-*
Set function:	Trigger mode to "Edge Pre-Select"	TR=1	5 ON, 6, 7 OFF
	Shutter to "Normal" or "Programmable"	SM=0, SM=1	
	"Shutter speed"	SH=0 through 11	1, 2, 3, 4
	"Programmable exposure"	PE=3 through 791	
	Polarity and other functions		
Input:	Ext. trigger in on pin 5 on 6-pin con. (Or 11 on 12 pin). 4.0 Vp-p ±2.0V.		
	Ext. HD in on pin 6 on 12-pin connector. 4.0 Vp-p ±2.0V. *(If used)*.		

Important notes on using this mode

- The start of exposure will start synchronized to the internal H signal. The start may be shifted max 1H. To avoid this shift (1H jitter), synchronize the camera to an external HD and make sure that the trigger pulse aligns to the HD as shown in fig. 14.
- The trigger pulse width should be >2H to <2000H.
- A new trigger must not be applied before WEN is high.

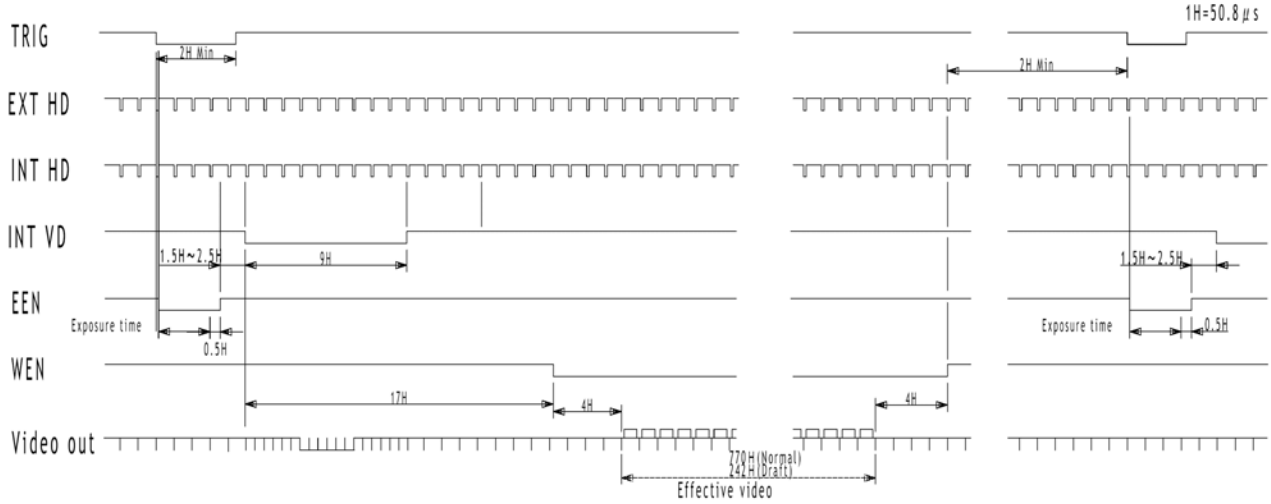


Fig. 15. Vertical timing for Edge Pre-select

6.4.2. Pulse Width Control Trigger

This trigger mode where the length of the trigger pulse determines the exposure time operates in H non-reset mode. In H non-reset mode the trigger pulse and the HD signal are synchronized. The exposure will start at the first HD pulse after the falling edge of the external trigger signal. The exposure ends 0.5 H after the HD following the rising edge of the external trigger signal. The trigger pulse must be longer than >1H (51μsec) and shorter than 2000 H. To avoid jitter the camera should be synchronized to an external HD. There are some requirements to the phase between the ext. HD and the Ext. trigger. The falling edge of the trigger should appear in the interval less than 8 μsec before the falling edge of the ext. HD and less than 2 μsec after the falling edge of the ext. HD and the rising edge off the trigger should be fall in the interval 8 μsec before the rising edge of the ext. HD and 2 μsec after rising edge of the ext. HD. (See figure 14.).
The EEN pulse indicates the actual exposure time.
The resulting video signal will start to be read out after the rising edge of the external trigger signal. The WEN pulse indicates the start of valid video signal. Refer to timing charts for details. A new trigger pulse must not be applied before the video read out has finished.

Mode setting and all other settings can be done via RS 232C control if rear switch SW1-10 is ON.
Mode setting and some other settings can be done by switch if rear switch SW1-10 is OFF.
For details: refer to "7. Configuring the Camera".

To use this mode:		*RS*	*SW1-*
Set function:	Trigger mode to "Pulse Width Control" Polarity and other functions	TR=2	1, 2 ON, 3 OFF
Input:	Ext. trigger in on pin 5 on 6-pin con. (Or 11 on 12 pin). 4.0 Vp-p ±2.0V. Ext. HD in on pin 6 on 12-pin connector. 4.0 Vp-p ±2.0V. *(If used)*.		

Important notes on using this mode

- The start of exposure will start synchronized to the internal H signal. The start may be shifted max 1H. To avoid this shift (1H jitter), synchronize the camera to an external HD and make sure that the trigger pulse aligns to the HD as shown in fig. 14.
- The trigger pulse width should be >1H to <2000H.
- A new trigger must not be applied before WEN is high.

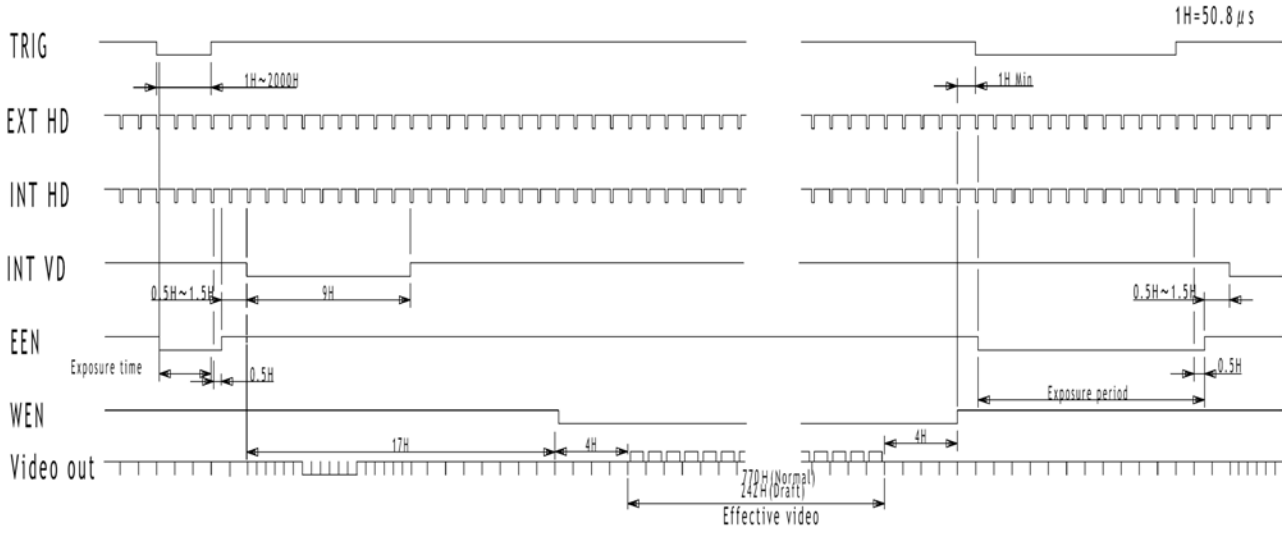


Fig. 16. Vertical timing for Pulse Width Control

6.4.3. Frame Delay Readout EPS

This trigger mode operates in H non-reset mode. In H non-reset mode the exposure will start at the first internal HD after the trigger. The trigger input should be longer than or equal to 2 HD (102 μsec.). The external trigger pulse initiates the capture, and the exposure time (accumulation time) is governed by the fixed shutter speed set up by the rear panel DIP-switches or via RS-232C control. The EEN pulse indicates the actual exposure time.
The resulting video signal will first start to be read out after the input of an external VD signal. The readout delay should not be to long due to visible dark current noise generated in the CCD sensor. The WEN pulse indicates the start of valid video signal. Refer to timing charts for details. A new trigger pulse must not be applied before the video read out has finished.
If the camera is synchronized to an external HD signal, there are some requirements to the phase between the ext. HD and the Ext. trigger. The falling edge of the trigger should be less than 8 μsec before the falling edge of the ext. HD and less than 2 μsec after the falling edge of the ext. HD (see fig. 14.). Otherwise the jitter will be too high.

Mode setting and all other settings can be done via RS 232C control if rear switch SW1-10 is ON.
Mode setting and some other settings can be done by switch if rear switch SW1-10 is OFF.
For details: refer to "7. Configuring the Camera".

To use this mode:		*RS*	*SW1-*
Set function:	Trigger mode to "Fame Delayed readout EPS"	TR=3	1 ON, 2 OFF, 3 ON
	Shutter to "Normal" or "Programmable"	SM=0, SM=1	
	"Shutter speed"	SH=0 through 11	1, 2, 3, 4
	"Programmable exposure"	PE=3 through 791	
	Polarity and other functions		
Input:	Ext. trigger in on pin 5 on 6-pin con. (Or 11 on 12 pin). 4.0 Vp-p ±2.0V.		
	Ext VD on pin 7 on 12 pin con. (Or 1 on 9 pin). 4.0 Vp-p ±2.0V.		
	Ext. HD in on pin 6 on 12-pin connector. 4.0 Vp-p ±2.0V. *(If used).*		

Important notes on using this mode

- The start of exposure will start synchronized to the internal H signal. The start may be shifted max 1H. To avoid this shift (1H jitter), synchronize the camera to an external HD and make sure that the trigger pulse aligns to the HD as shown in fig. 14.
- The trigger pulse width should be >2H to <2000H.
- External sync system should follow the camera scanning system.
- A new trigger must not be applied before WEN is high.

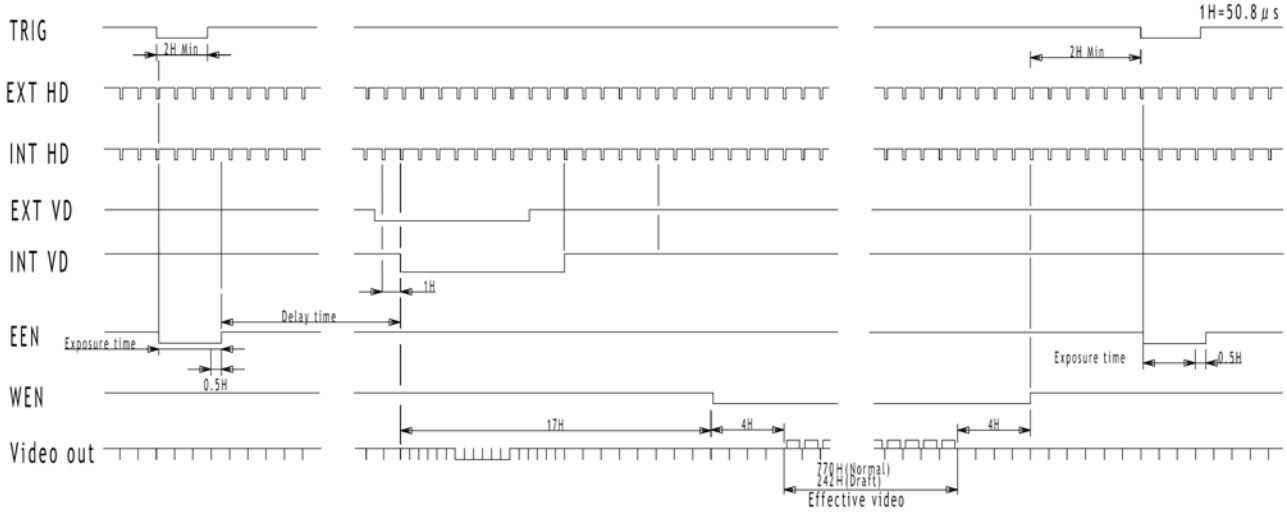


Fig. 17. Vertical timing for Frame Delay readout EPS

6.4.4. Frame Delay Readout PWC

This trigger mode operates in H non-reset mode. In H non-reset mode the trigger and HD is synchronized. The exposure will start at the first HD pulse after the falling edge of the external trigger signal. The exposure ends 0.5 H after the HD following the rising edge of the external trigger signal. The trigger pulse must be longer than >1H. To avoid jitter, the camera should be synchronized to an external HD. There are some requirements to the phase between the ext. HD and the Ext. trigger. The falling and rising edge off the trigger should be within 8 μsec. before the falling and rising edge of the ext. HD pulse and not later than 2μsec after the falling and rising edge of the HD pulse (see fig. 14.). The EEN pulse indicates the actual exposure time. The resulting video signal will first start to be read out after the input of an external VD signal. The readout delay should not be to long due to visible dark current noise generated in the CCD sensor. The WEN pulse indicates the start of valid video signal. Refer to timing charts for details. A new trigger pulse must not be applied before the video read out has finished.

Mode setting and all other settings can be done via RS 232C control if rear switch SW1-10 is ON. Mode setting and some other settings can be done by switch if rear switch SW1-10 is OFF. *For details: refer to "7. Configuring the Camera".*

To use this mode:		*RS*	*SW1-*
Set function:	Trigger mode to "Frame Delayed readout PWC"	TR=5	1, 2, 3 ON
	Polarity and other functions		
Input:	Ext. trigger in on pin 5 on 6-pin con. (Or 11 on 12 pin). 4.0 Vp-p ±2.0V.		
	Ext VD on pin 7 on 12 pin con. (Or 1 on 9 pin). 4.0 Vp-p ±2.0V.		
	Ext. HD in on pin 6 on 12-pin connector. 4.0 Vp-p ±2.0V. *(If used)*.		

Important notes on using this mode

- The start of exposure will start synchronized to the internal H signal. The start may be shifted max 1H. To avoid this shift (1H jitter), synchronize the camera to an external HD and make sure that the trigger pulse aligns to the HD as shown in fig. 14.
- The trigger pulse width should be >2H to <2000H.
- External sync system should follow the camera scanning system.
- A new trigger must not be applied before WEN is high.

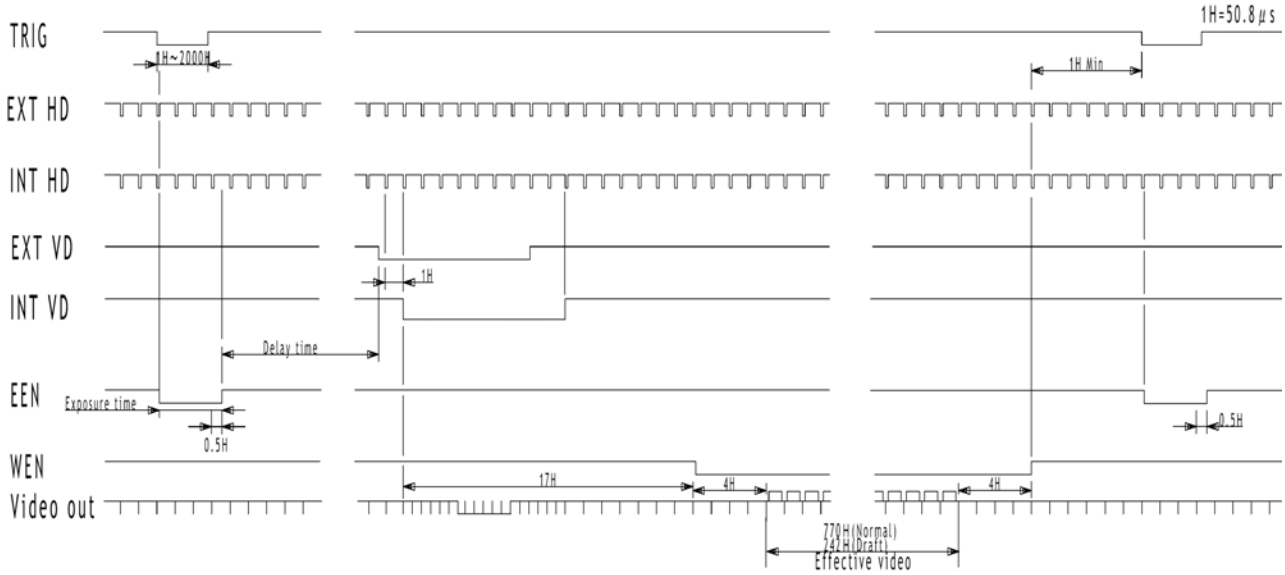


Fig. 18. Vertical timing for Frame Delay readout PWC

6.4.5. Long Time Exposure

The exposure time is the interval between 2 ext. VD pulses sent to the VD input of the camera. The exposure starts after input of the first ext. VD pulse, and ends after the next input of the ext. VD pulse, which again starts a new exposure.
The long time exposure is a continuous process where each external VD pulse will synchronize the camera, stop on exposure, start a new exposure and read out the previous accumulated signal. The exposure can be selected in intervals of complete vertical timing periods (=792H) This long time exposure mode operates in H non-reset mode. In H non-reset mode the external VD signal and the internal HD signal are synchronized. The exposure will start at the first HD pulse after the falling edge of the external trigger signal. See figure 14. for the phase relationship between ext. HD and ext. VD pulses.

Mode setting and all other settings can be done via RS 232C control if rear switch SW1-10 is ON.
This mode can not be set by switch!
For details: refer to "7. Configuring the Camera".

To use this mode:		*RS*
Set function:	Trigger mode to "Long Time Shutter"	TR=4
	Polarity and other functions	
Input:	Ext VD on pin 7 on 12 pin con. (Or 1 on 9 pin). 4.0 Vp-p ±2.0V.	
	Ext. HD in on pin 6 on 12-pin connector. 4.0 Vp-p ±2.0V. *(If used)*.	

Important notes on using this mode

- External sync system should follow the camera scanning system.
- External VD and HD phase relation should follow as shown in fig. 10.
- Depending of the temperature, it is not recommended to use integration >2 seconds.

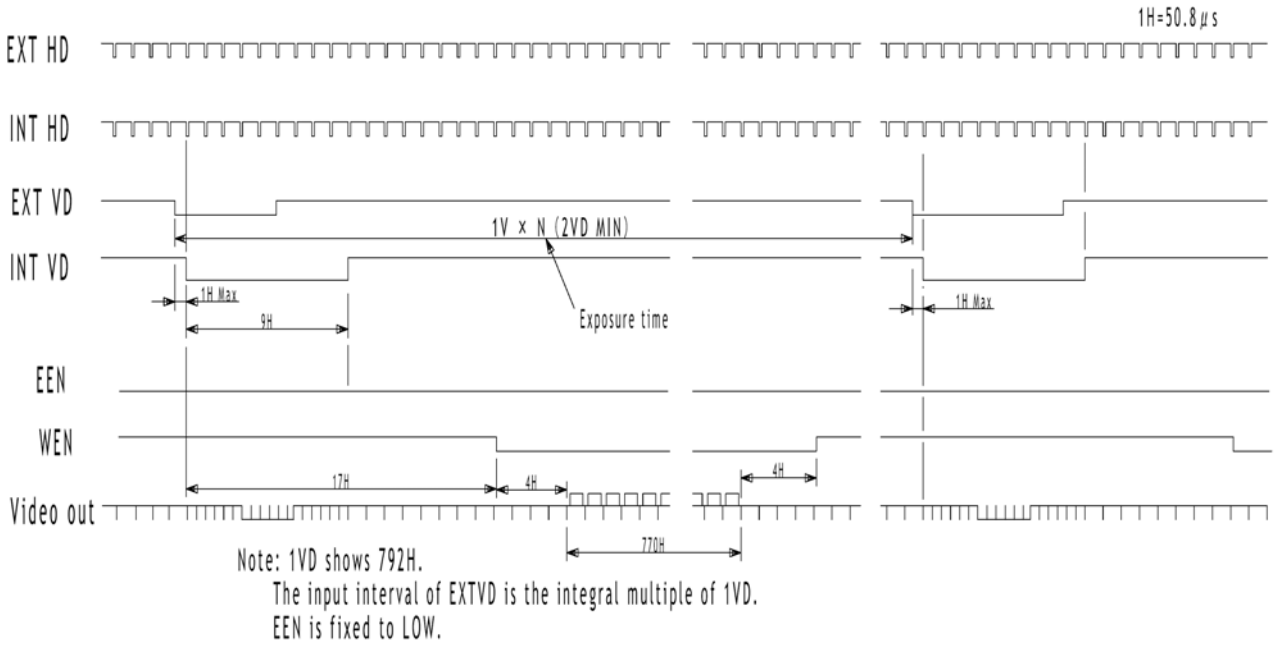


Fig. 19. Vertical timing for Long Time Exposure

6.5. Other functions

Mode setting and all other settings can be done via RS 232C control if rear switch SW1-10 is ON.
Mode setting and some other settings can be done by switch if rear switch SW1-10 is OFF.

For details: refer to "7. Configuring the Camera".

!! Do not adjust analogue settings unless you have knowledge to video adjustments!!

Shutter Mode. SM.
This function will select if the shutter time is selected from the 12 fixed values with Shutter, or from the 788 steps in Programmable exposure.

Shutter. SH.
Selects the shutter time from a list with 12 fixed values. *(Also by switch.)*

Programmable Exposure. PE.
Select the shutter time with 1H (51μs) steps from a list with 788 steps.

High frame rate. DR. *(Draft mode).*
In this mode only every third lines is read out. The lines between are dumped. The resulting frame rate is about 3 times higher.

WEN polarity. WP.
Will invert the WEN output polarity. Default is active low.

EEN polarity. EP.
Will invert the EEN output polarity. Default is active low.

WEN/SYNC. WS.
Switch between WEN or composite sync on pin #7 on 9pin sub-D connector. *(Also by switch.)*

G on SYNC. SY.
If SY=1, the green output video will have composite sync added. pin #4 on 9pin sub-D connector. *(Also by switch.)*

AGC. AS.
This command will switch the gain control between manual and automatic gain control (AGC). With manual gain, the gain level is adjusted with Master gain. (Red gain and Blue gain for color balance). With AS=1 (Auto) the video output level is automatic controlled by an AGC circuit. It will try to keep the video output level constant. The reference for this level is set by the AGC parameter AG.

AGC level. AG.
This parameter is the reference for the automatic gain control if AS=1.

Master Gain. GA.
This parameter adjust the RGB video output level if AS=0.

Red Gain. RG.
This parameter adjust the manual color balance with the red video level if WB=0.

Blue Gain. BG.
This parameter adjust the manual color balance with the blue video level if WB=0.

White balance. WB.
This function selects the color balance. Manual, Auto or 2 fixed values. *(Also by switch.)*

Auto white balance. AW.
If the white balance is set to automatic (WB=1), the white balance will be automatic adjusted every time the command AW=0 is received.

Master set-up level. SU.
This parameter adjust the RGB video set-up level.

Red set-up level. RS.
This parameter is for fine adjust of the red set-up level.

Blue set-up level. BS.
This parameter is for fine adjust of the blue set-up level.

White clip level. WC.
This parameter sets the clipper level for RGB video output. It will prevent signal peaks from highlighted spots to be output. The normal clip level is set to 0.8 volt on a 75Ω terminated video output.

Gamma select. GS.
This commands selects the video gamma to be 1 of 3 values.

6.6. Request functions.

The following commands are for transmission and identification.

Echo Back. EB=1.
If on, the camera will echo back the RS-232C transmission.

Version Number. VN.
If received, the camera will send back its firmware version number as a 3 digits number.

6.7. Save and Load functions

The following commands are for store and load camera settings in the camera EEPROM.

Load settings. LD.
This command will load previous stored settings to the camera. 1 user setting can be stored in the camera EEPROM. 1 factory setting is also stored in the camera. The settings stored in the user area, is used as default settings at power up.

Save Settings. SA.
This command will store the actual camera settings to a user area in the camera EEPROM.

EEPROM Area. EA.
The command will return the last used area. (Factory or user).

7. Configuring the Camera

Before changing any switch settings or jumper settings turn off the power.

7.1. Setting by Switch and Jumper

7.1.1 Rear Switch

The factory setting for the SW-1 switch on the rear panel of the camera is OFF: The electronic shutter is OFF, the external trigger modes are OFF, gamma is OFF (=1.0), the AGC is OFF and the RS-232C control is disabled.

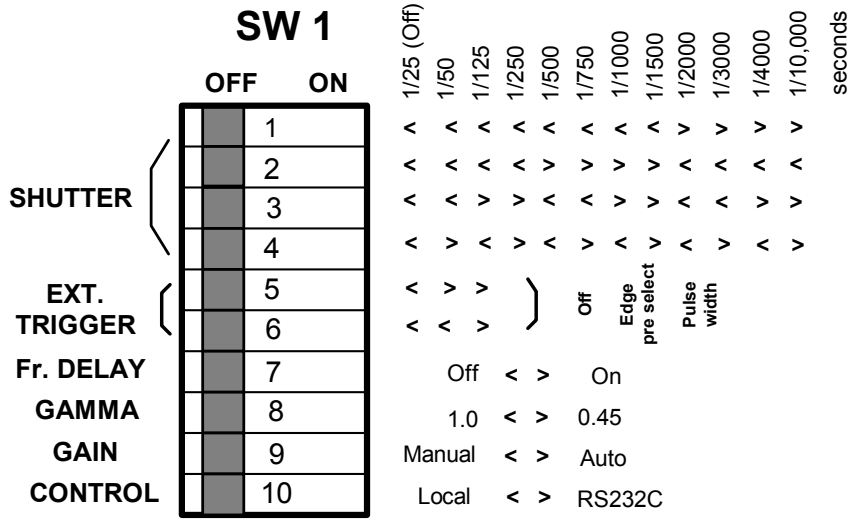


Fig. 20. Rear switch setting

7.1.2. Internal Switch setting

On the PK8308 board inside the camera three switches exist. S301, S302 and S303.
The switch settings determine

- Termination of external trigger, VD and HD signals
- Color temperature
- Composite sync. on green video signal
- WEN OFF/ON at DSUB connector
- Input/Output of VD and HD signals

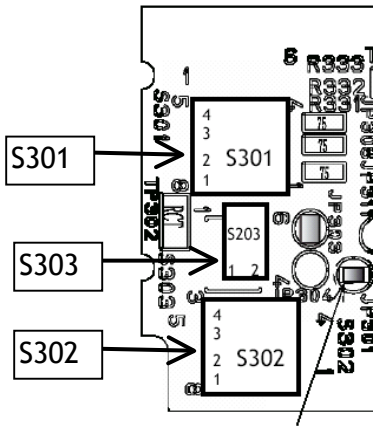


Fig. 21. Internal switch position on PK8303A

SW301

The SW301 switches (1-3) in "ON" position activates 75Ω termination of ext. HD and ext. VD signals and it activates 75Ω termination of an ext. trigger signal. The factory setting is "OFF" enabling TTL signal termination for all three signals.

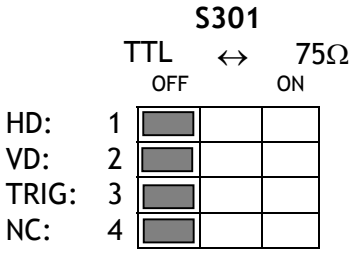


Fig. 22. Switch 301 HD, VD and trigger termination

SW302

The SW302 switch has the following functions: The switches (1-2) determines the color temperature, the switch (3) activates Composite sync. on the green video signal and the switch (4) outputs the WEN signal at the DSUB connector.
The white balance is dependent on the color temperature of the light.
The available settings are shown in the below table.

S302-1	S302-2	Color temperature
OFF	***OFF***	***Manual***. 2600-6000K (factory setting)
OFF	ON	Invalid setting
ON	OFF	4600K
ON	ON	5600K

Fig. 23. Switch 302. White balance, sync on G and WEN

The S302-3 switch adds in "ON" position the composite sync. signal to the green video signal. The factory setting is "OFF" leaving the green RGB signal without sync. signals.

The S302-4 switch outputs in "ON" position the WEN signal via pin 7 of the 9-pin DSUB connector. The factory setting is "OFF". In the "OFF" position the camera outputs the composite sync. signal via pin 7 of the 9-pin DSUB connector.

SW303

The SW303 switch switches between output of internal HD/VD signals and input of external HD/VD signals. The factory setting is input of external HD/VD signals (SW303-1 and SW303-2 in "ON" position). The "ON" position is towards switch SW301.

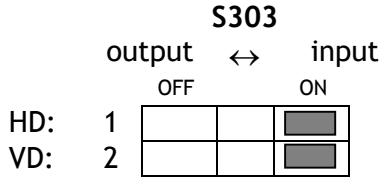


Fig. 24. Switch 303. HD/VD input/output

7.1.3. Jumper settings

Before changing any switch settings or jumper settings turn off the power.

Jumper locations.

The jumpers are located on two boards, the PK8309A board and the PK8308A board:
The PK8309A board have two jumpers of interest: JP401 and JP402.
Factory setting:

- JP401 and JP402 are "open".

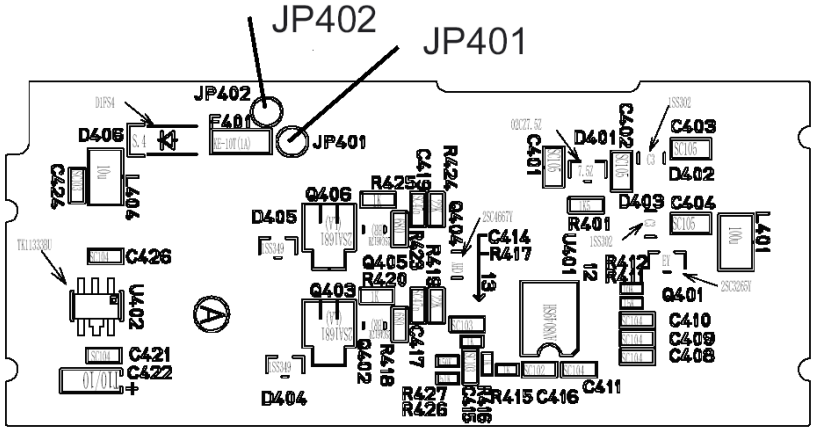


Fig. 25. Jumpers on PK8309A

The PK8308A board has 12 jumpers of interest: JP301-JP312.
Factory setting:

- At JP301 is mounted a capacitor to protect the trigger circuit against +12V DC.
- JP303, JP307, JP308, JP309 and JP312 are "short".
- JP302, JP304, JP305, JP306, JP310 and JP311 are "open".

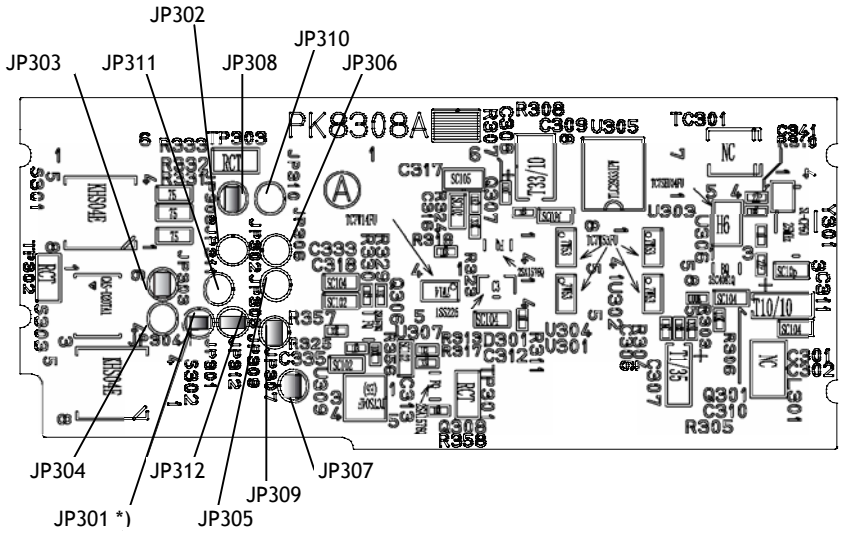


Fig. 26. Jumpers on PK8308A

7.1.4. Jumper table

Jumper settings versus connector pin configuration.

Pin#	Function	JP301	JP302	JP303	JP304	JP305	JP306	JP307	JP308	JP309	JP310	JP311	JP312	JP401	JP402
12-pin Hirose connector															
6	Ext. HD input							Short							
6	Int. HD output							Short							
7	Ext. VD input		Open	Short	Open										
7	Ext. VD output		Open	Short											
9	NC					Open									
9	PCLK output					Short	Open								
10	WEN		Open						Short	Short	Open				
10	NC									Open	Open				
10	GND								Open	Short	Short				
11	Trigger	Capaci													
11	NC	Open												Open	
11 *)	+12V DC	Open												Short	
6-pin Hirose connector															
4	NC														Open
4	GND														Short
6	WEN		Open									Short	Open		
6	EEN											Open	Short		
9-pin DSUB connector															
1	NC				Open										
1	VD input		Open	Open	Short										
6	HD input							Open							
6	HD output							Open							
9	NC						Open								
9	PCLK output					Open	Short								

NOTE: When using the HD/VD, PCLK and WEN signals (input or output) from the 12 pin connector do not use the same signals (input or output) from the 9 pin D-SUB connector and vice versa.

*) The external trigger pulse or DC +12V can be input at pin No.11 of the 12 pin Hirose connector by changing the jumper setting on PK8308 and PK8309. A capacitor is mounted at jumper JP301 to avoid feeding the trigger circuit with +12V DC. If this capacitor is removed from JP301 for some reason make sure JP301 is open before feeding the camera with +12V DC at pin No.11 of the 12 pin Hirose connector.

*) Greyed out jumper settings are factory settings.

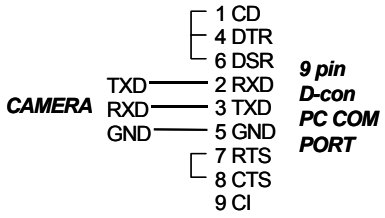
7.2. RS-232C control

All configuration of the CV-M77 camera can be done via the RS-232C port on the 6 pin HR connector if the rear switch SW1-10 is ON (RS-232C).
The camera can be set up from a PC running terminal emulator software, or using JAI´s camera control software.
Below is the description of the ASCII based short command protocol.

Communication setting.

Baud Rate	9600 bps
Data Length	8 bit
Start Bit	1 bit
Stop Bit	1 bit
Parity	None
Xon/Xoff Control	None

RS 232C cable



Protocol.

Transmit setting to camera:
NN=[Parameter]<CR><LF> (NN is any kind of command. Capital or small letters.)
The camera answers:
COMPLETE<CR><LF>

To have all communication visible on the emulator screen, start with:
EB=1<CR><LF>
The camera answers:
COMPLETE<CR><LF>

Transmit request command to camera:
NN?<CR><LF> (NN is any kind of command.)
The camera answers:
NN=[Parameter]<CR><LF>

Invalid parameters send to camera: (99 is an invalid parameter)
SH=99<CR><LF>
The camera answers:
02 Bad Parameters!!<CR><LF>

To see firmware number.
VN?<CR><LF>
To see camera ID. It shows the manufacturing lot number.
ID?<CR><LF>

7.3. Command Protocol

	Command Name	Format	Parameter	Remarks
A - General settings and useful commands.				
EB	Echo back	EB=[Param.]<CR><LF>	0 = Echo off 1 = Echo on	Set to 'off' at power on.
VN	Firmware program version request	VN?<CR><LF>		Response is 3 letter (ex) 104
B - Timing and shutter related commands.				
SM	Shutter mode	SM=[Param.]<CR><LF>	0 = Normal 1 = Programmable exposure	Available when TR=0, TR=1 or TR=3
SH	Shutter speed	SH=[Param.]<CR><LF>	0 = OFF(1/25) 6 = 1/1000 1 = 1/50 7 = 1/1500 2 = 1/125 8 = 1/2000 3 = 1/250 9 = 1/3000 4 = 1/500 10 = 1/4000 5 = 1/750 11 = 1/10000	Available when SM=0 and TR=0 or 1or 3.
PE	Programmable exposure	PE=[Param.]<CR><LF>	3 - 791 H in 1H increments 3 = 1.5H (0.076ms) 791 = 789.5H (40.107ms)	H = 50.8μs Available when SM=1 and TR=0, TR=1 or TR=3
TR	Trigger mode	TR=[Param.]<CR><LF>	0 = Normal 1 = Edge pre-select 2 = Pulse width control 3 = EPS Frame delay readout 4 = Long time shutter 5 = PWC Frame delay readout	
DR	High Frame Rate (Draft mode)	DR=[Param.]<CR><LF>	0 = Normal 1 = High frame rate	Only every third line is read out
WP	WEN polarity	WP=[Param.]<CR><LF>	0 = Active_L 0 = Active_L	
SY	G on SYNC	SY=[Param.]<CR><LF>	0 = OFF 1 = ON	
EP	EEN polarity	EP=[Param.]<CR><LF>	1 = Active_H 1 = Active_H	
WS	WEN/Sync switch	WS=[Param.]<CR><LF>	0 = WEN 1 = Sync	
C - Gain and analogue signals settings.				
AS	AGC switch	AS=[Param.]<CR><LF>	0 = OFF (Manual) 1 = ON (Auto)	
GA	Master gain level	GA=[Param.]<CR><LF>	0 - 700	Available when AS=0.
RG	Red gain level	RG=[Param.]<CR><LF>	0 - 255	Available when WB=0.
BG	Blue gain level	BG=[Param.]<CR><LF>	0 - 255	Available when WB=0.
AG	AGC level	AG=[Param.]<CR><LF>	0 - 255	Available when AS=1.
WB	White balance	WB=[Param.]<CR><LF>	0 = Manual 2 = 4600K 1 = Auto 3 = 5600K	Sets manual gain values (RG, BG) when changed to 0 from other selections.
AW	Auto white balan.	AW=[Param.]<CR><LF>	0 = One push auto white balance	Available when WB=1.
SU	Master setup level	SU=[Param.]<CR><LF>	33 - 223	default = 128
RS	Red setup level	RS=[Param.]<CR><LF>	96 - 160	default = 128
BS	Blue setup level	BS=[Param.]<CR><LF>	96 - 160	default = 128
WC	White clip level	WC=[Param.]<CR><LF>	0 - 1023	
GS	Gamma select	GS=[Param.]<CR><LF>	0 = 1, 1 = 0.45, 2 = 0.6	
D - saving and loading data in EEPROM				
LD	Load settings from camera EEPROM	LD=[Param.]<CR><LF>	0 = FACTORY DATA 1 = USER DATA	Latest used DATA AREA becomes default at next power up.
SA	Save settings to camera EEPROM	SA=[Param.]<CR><LF>	1 = USER DATA AREA	
			0 = FACTORY DATA AREA	Not disclosed for user.
EA	EEPROM Current Area No. Request	EA?<CR><LF>	0 = FACTORY DATA 1 = USER DATA	Return latest used area

!! Do not try to use commands not shown in this list.

8. Camera Control Tool for CV-M77

The Camera Control Tool for Windows 98/NT/2000 can be downloaded from www.jai.com. The control tool contents a camera control program and tools for making your own program. For the integrator and experienced user, the Camera Control Tool is much more than a program with a window interface. It also provides an easy and efficient ActiveX interface built for MS Windows 98, ME, NT and 2000. The OCX interface has the ability to connect to the camera using the serial interface of the PC by reading and writing properties for the camera. This integration requires simple programming skills within Visual Basic, Visual C++ or similar languages in a Microsoft Windows environment.

8.1. Control Tool Windows

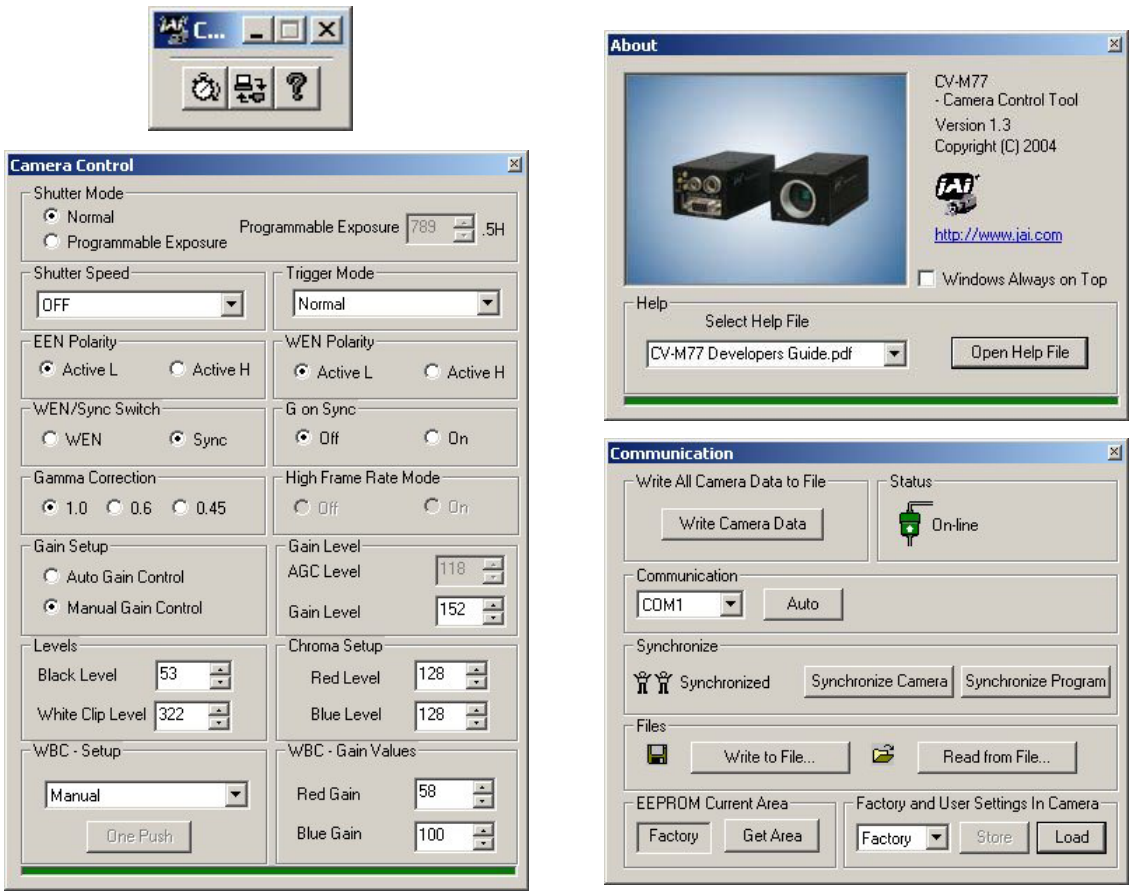
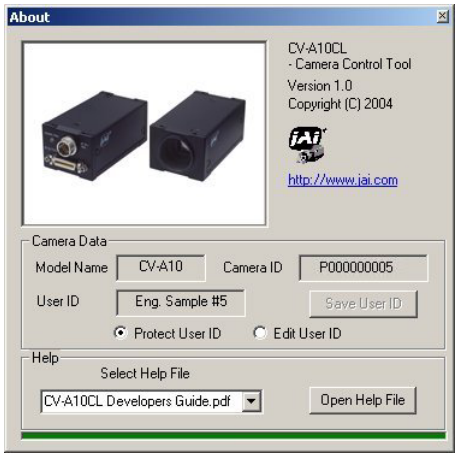


Fig. 27. Camera Control Tool windows

8.2. Camera Control Tool Interface

The Camera Control Tool Software is based on a main Tool Bar and a number of associated Tool Windows. Each button in the Tool Bar pops up a separate Tool Window when pressed. The layout of the program can be adjusted by arranging the windows the way it is preferred. The program will store this information and recreate this layout, when the program is restarted.
All Camera Control Tools have a Communication Window and an About Window. The other window(s) contains camera control commands.

The About window



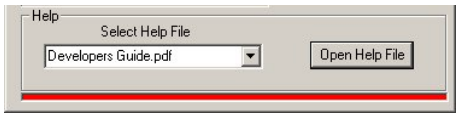
The about window contains a picture of the camera and information about the version of the program, Internet connection to JAI A/S and access to the help documents.
The List box that contains the help documents will list all files, which have the extension .pdf and that are found in the program (default) folder

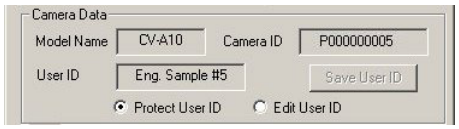
C:\Program Files\JAI A-S\'Control Tool Name'

It is possible to download updated operation manuals from the jai website:

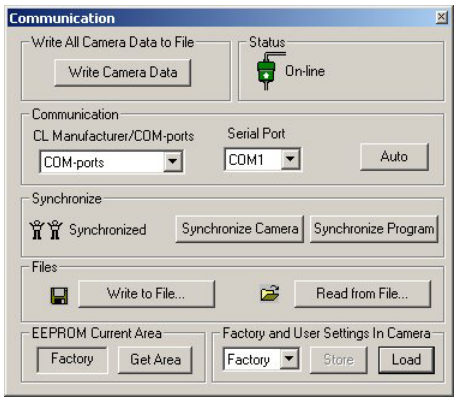
http://www.jai.com/camera/manuals.asp/sprog=uk

An updated manual can be saved in the folder address mentioned above and it will automatically be included in the list of help files.
For newer camera models the About Window also shows Model Name, camera ID and User ID. It is possible to edit and save free text in User ID.
At the bottom of the windows (all windows but the Communication Window is a coloured bar. The bar is green when the Camera Control Tool is connected to a camera and the camera is turned on.
The bar is red when the Camera Control Tool is not connected to a camera or when the camera is turned off.

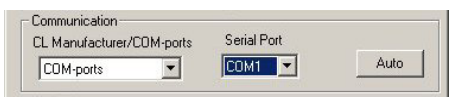




The Communication Window



The Communication Window is used to connect the Camera Control Tool with the JAI camera. Depending of camera there are 2 possible ways to communicate with a JAI camera.
RS-232:
Select the communication port, where the serial cable is connected from the list box in the 'Communication Port' field, or click the 'Auto' button to search for a camera on communication port 1 to 16. The camera control program automatically sends a camera request on every communication port. The user is prompted to use a communication port if a camera answers the request.
RS-232 and Camera Link:
The Communication Window looks a bit different when it is possible to communicate with the camera using Camera Link and RS-232 com port. The Communication area contains 2 list boxes now.

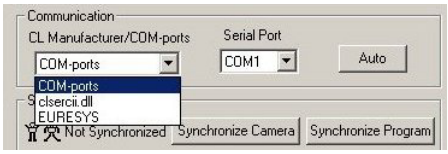


RS-232 communication:

1. Select 'COM-ports' from the 'CL Manufacturer/COM-ports' list Box.
2. Select the communication port, where the serial cable is connected to the camera from the 'Serial Port' list box or click the 'Auto' button to search for a camera on communication port 1 to 16.

The Serial Port list box and the Auto search button are only active when COM-ports is selected.

Camera Link communication:
The 'CL Manufacturer/COM-ports' list box also contains DLL file names (or frame grabber names) for all Camera Link frame grabbers that are installed in the pc. This is done by using a DLL file called "clserial.dll" to upload all frame grabber DLLs that are found in the pc.
Just select the option for the frame grabber that is installed in the pc.



Auto search
Click the auto button to search for a camera on communication port 1 to 16. The camera control program automatically sends camera request on every communication port. The user is prompted to use a communication port if a camera answers the request.
This button is only used for RS-232 communication.

Off/On-line mode
The Camera Control Tool Application can run Offline (without a camera attached) and all functions are fully functional in offline mode.
Off line mode is indicated in The Communication Window, where a status field with graphic and text indicates the on/off-line status.
Changing the selected communication port (from the communication window) changes the online/off-line status. If a camera is found on the selected communication port the application runs online otherwise offline.

Changing the settings in the application will automatically update the camera settings when the application is online.
If the application looses connection with the camera it will automatically go to offline mode and it is indicated in the communication window.

Synchronize program and camera
The Camera Control software has the ability to synchronize either the camera or the program. Click Synchronize camera to write all settings from the program to the camera or click the Synchronize program to load all settings from the camera to the program.

Files
When clicking the Write to File or Read from File button, the user is prompted for a file using a standard file dialog. New files are created if they do not already exist.
Files for camera settings have the extension cam. Information about the communication port is not stored in the files. All settings are automatically sent to the camera when a file has been loaded (if the camera is online).

Factory and User Settings

Use the Store button to store the current camera settings into the user settings area in EEPROM. Current camera settings are not saved when the camera is turned off. To save current camera settings you have to save them on the available user areas.
Use the Load button to restore previously saved camera settings from either the Factory or the User EEPROM area.

Write All Camera Data to File.
Click the "Write Camera Data" button to save all camera settings into a text file. The information that can be saved is:
Model Name, Camera ID, User ID, Firmware Version, Current Settings, Factory Settings and the available User Areas.
The file is formatted as shown in the picture below:

cameradata.txt - Notepad

File Edit Format View Help

Model Name	,CV-A10				
Camera ID	,P000000005				
User ID	,Eng. Sample #1				
Firmware Version	,102				
	,Current Settings	,Factory Settings	,User Area 1	,User Area 2	,User Area 3
Shutter Mode	,Auto Shutter	,Shutter Speed	,Shutter Speed	,Programmable Exposure	,Auto Shutter
Shutter Speed	,1/25000	,OFF	,1/100	,1/120	,1/25000
Programmable Exposure	,3	,628	,628	,2	,3
Trigger Mode	,Continuous	,Continuous	,Continuous	,Sensor Gate Control	,Continuous
Smearless	,off	,off	,off	,On	,off
LVAL Accumulation	,Async	,Sync	,Async	,Sync	,Async
Trigger Input	,CameraLink	,CameraLink	,Hirose12pin	,Hirose12pin	,CameraLink
Trigger Polarity	,Active High	,Active Low	,Active Low	,Active High	,Active High
Partial Scan Mode	,1/8 Partial	,Full Frame	,Full Frame	,1/4 Partial	,1/8 Partial
Vertical Binning	,1/3 Binning	,OFF	,OFF	,1/2 Binning	,1/3 Binning
Horizontal Binning	,1/3 Binning	,OFF	,OFF	,1/2 Binning	,1/3 Binning
Output Bit Allocation	,8bit	,10bit	,8bit	,8bit	,8bit
AGC Select	,On	,Off	,Off	,Off	,On
AGC Level	,3	,512	,512	,2	,3
Manual Gain Level	,3	,0	,0	,2	,3
Black Level	,3	,216	,2	,2	,3
Gamma	,0.45	,1.0	,0.45	,1.0	,0.45

EEPROM Current Area.
Click the 'Get Area' button to read the power up settings area number.

7.3.3. Using the Camera Control Tool

Here is some practical information about the Camera Control Tool:

1. The Camera Control Tool bar is always on top of other windows.
2. When you minimize the Camera Control Tool bar all open windows will close.
3. It is possible to work with the Camera Control Tool when the camera is online and when the camera is offline.
4. The newer JAI cameras always start up with the last used user area (but for some old models it will start up with the last saved user area.)
5. The Camera Control Tool saves the last used settings (not the user area), which don't have to be the same as for the last saved user area.
6. The setup file 'CameraName.ini' stores all information about camera settings. When the program is started the last settings for the program are loaded from the file 'CameraName.ini'
7. When you turn on the camera and the Camera Control Tool, it is possible that the Camera Control Tool does not show the actual camera settings (see 4. and 5.).
    a. To obtain the camera settings click "Synchronize Program".
    b. To send the settings that are saved in the Camera Control Tool (last used settings) to the camera click "Synchronize Camera".
    c. To see which area the camera has started up in click "Get Area".

9. External Appearance and Dimension

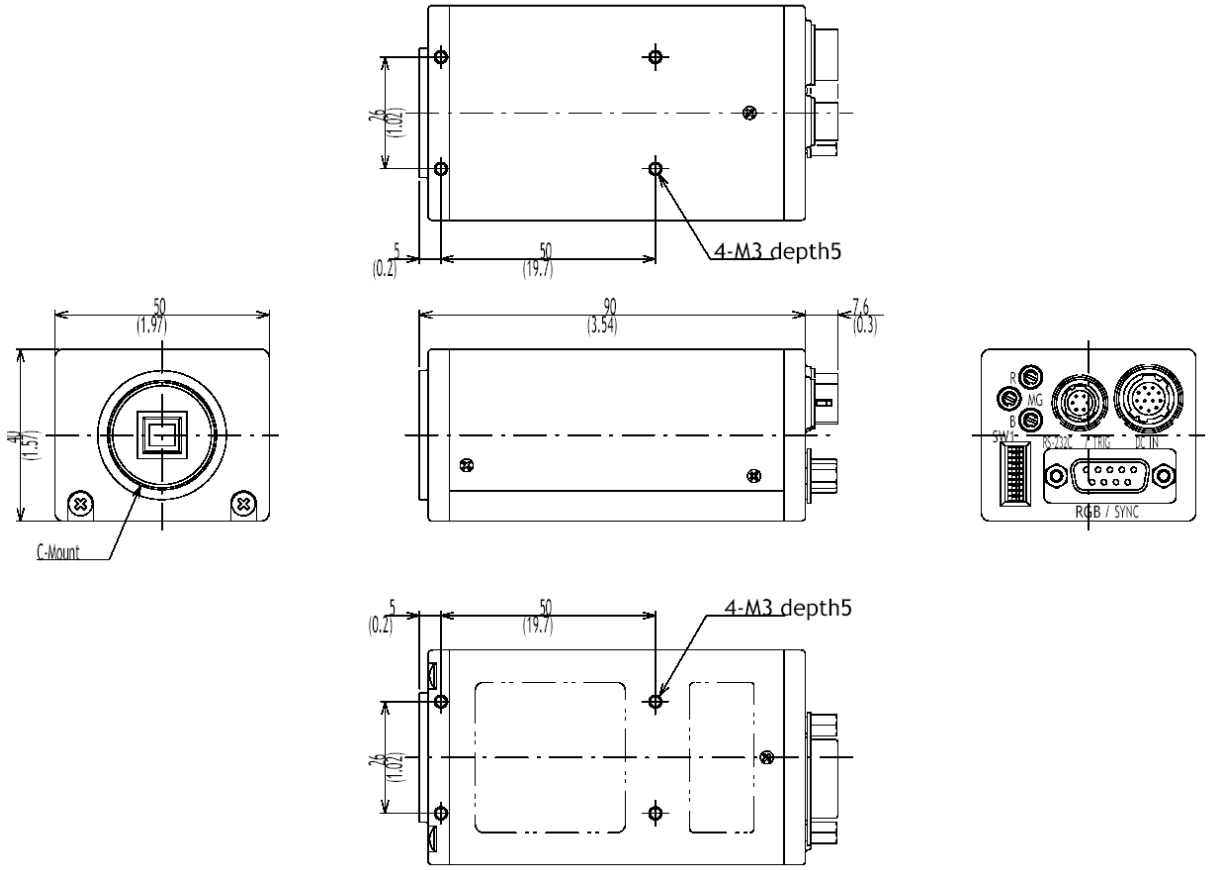


Fig. 28. Outlines

10 Specifications

10.1. Specification table

Specifications	CV-M77
Scanning system	Progressive 792 lines 24.8 frames/sec.
Pixel clock	25.000 MHz
Line frequency	19.685 kHz (1270 pixel clock/line)
Frame rate	24.8 frames/sec. (792 lines/frame). Normal 74 frames/sec. (264 lines/frame). High frame rate
CCD sensor	1/3" RGB primary color IT CCD. Type Sony ICX-204AK
Sensing area	4.8 (h) x 3.6 (v) mm
Effective pixels	1034 (h) x 779 (v)
Pixels in video output	1028 (h) x 770 (v). 25 fps. Continuous mode 1016 (h) x 770 (v). Triggered modes 1028 (h) x 242 (v). Continuous high frame rate 1016 (h) x 242 (v). Triggered high frame rate
Cell size	4.65 (h) x 4.65 (v) μm
Sensitivity on sensor	1.5 Lux (Max. gain, 50% video)
S/N ratio	>50 dB
Video output	RGB video signal, 0.7 Vpp, 75 Ω Composite sync. on G, 0.3 Vpp (selectable)
Gamma	1.0 – 0.6 – 0.45
Gain Gain range	Manual – Automatic -3 to +15 dB
Synchronization	Int. X-tal. Ext. HD/VD or random trigger
HD sync. input/output	4 V ±2 V, 75 Ω
Trigger input	4 V ±2 V, 75 Ω
WEN output (write enable)	4 V ±2 V, 75 Ω
EEN output (exposure enable)	4 V ±2 V, 75 Ω
Pixel clock output	4 V ±2 V, 75 Ω
Composite sync. output	4 V ±2 V, 75 Ω
Trigger modes	Continuous, Edge pre-select, Pulse width control (HD non-reset)
Trigger input. (Edge pre-select)	>1 H
Shutter	1/25, 1/50, 1/125, 1/250, 1/500, 1/750, 1/1000, 1/1500, 1/2000, 1/3000, 1/4000, 1/10,000 second
Programmable exposure	1.5 H to 791 H
Pulse width control	1.5 H to 2000 H
Long time exposure	2 frames to ∞
Frame-delay readout	1 H to 2000 H Time from trigger input to ext. VD input. For Edge pre-select and Pulse width control
Functions controlled by DIP switch on rear	Shutter speed, Trigger mode, Readout mode, Gamma, Gain, Control
Functions controlled by internal DIP switches	VD input/output, HD input/output HD, VD and Trigger 75 Ω termination on/off WEN polarity, Sync. on G, White balance
Functions controlled by RS 232C	Shutter speed, Trigger mode, Readout mode, WEN polarity, Sync on G, Programmable exposure, Gain levels, White clip, Setup, Gamma, White balance
Communication Baud rate	9600 bps
Operating temperature	-5°C to +45°C
Humidity	20 - 80% non-condensing
Storage temp./humidity	-25°C to +60°C / 20% - 80 %
Power	12V DC ± 10%, 5.5 W
Lens mount	C-mount
Dimensions	40 x 50 x 90 mm (H x W x D)
Weight	270 g

***Note**: Above specifications are subject to change without notice.*

10.2. Spectral sensitivity

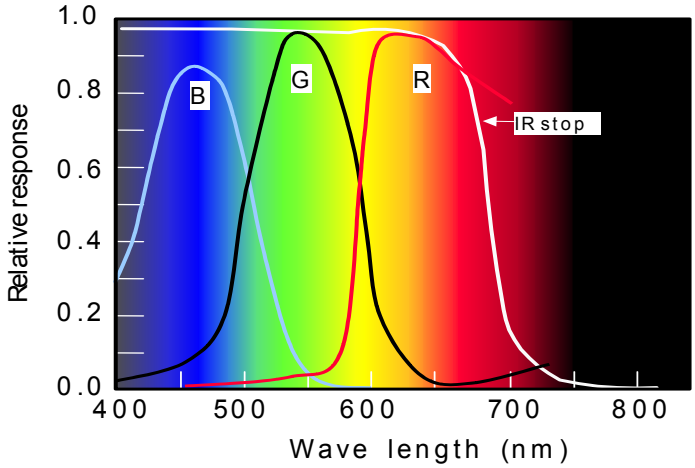


Fig. 29. Spectral sensitivity

11. Appendix

11.1. Precautions

Personnel not trained in dealing with similar electronic devices should not service this camera.
The camera contains components sensitive to electrostatic discharge. The handling of these devices should follow the requirements of electrostatic sensitive components.
Do not attempt to disassemble this camera.
Do not expose this camera to rain or moisture.
Do not face this camera towards the sun, extreme bright light or light reflecting objects.
When this camera is not in use, put the supplied lens cap on the lens mount.
Handle this camera with the maximum care.
Operate this camera only from the type of power source indicated on the camera.
Power off the camera during any modification such as changes of jumper and switch setting.

11.2. Typical Sensor Characteristics

The following effects may be observed on the video monitor screen. They do not indicate any fault of the camera, but do associate with typical sensor characteristics.

V. Aliasing
When the CCD camera captures stripes, straight lines or similar sharp patterns, jagged image on the monitor may appear.

Blemishes
Some pixel defects can occur, but this does not have en effect on the practical operation.

Patterned Noise
When the sensor captures a dark object at high temperature or is used for long time integration, fixed pattern noise may appear on the video monitor screen.

11.3. References

1. This manual and datasheet for CV-M77 can be downloaded from www.jai.com
2. Camera control software can be downloaded from www.jai.com
3. Specifications for the CCD sensor ICX-204AK can be found on www.jai.com

12. Users Record

Camera type: **CV-M77**

Revision: **(Revision B)**

Serial No. **……..**

Firmware version. **……..**

For camera revision history, please contact your local JAI distributor.

Users Mode Settings.

Users Modifications.

DECLARATION OF CONFORMITY
AS DEFINED BY THE COUNCIL DIRECTIVE
89/336/EEC
EMC (ELECTROMAGNETIC COMPABILITY)
WE HEREWITH DECLARE THAT THIS PRODUCT
COMPLIES WITH THE FOLOWING PROVISIONS APPLYING TO IT.
EN-50081-1
EN-50082-1

JAI A-S, Denmark
Phone +45 4457 8888
Fax +45 4491 8880
www.jai.com

JAI UK Ltd, England
Phone +44 1895 821 481
Fax +44 1895 824 433
www.jai.com

JAI Corporation, Japan
Phone +81 45 440 0154
Fax +81 45 440 0166
www.jai-corp.co.jp

JAI PULNiX Inc, USA
Phone (Toll-Free) +1 800 445 5444
Phone +1 408 747 0300
www.jai.com

THE MECHADEMIC COMPANY