

COHU, INC. Electronics Division Technical Reference Manual

6600-1000 Analog Output Progressive Scan Camera

Technical Manual 6X-987

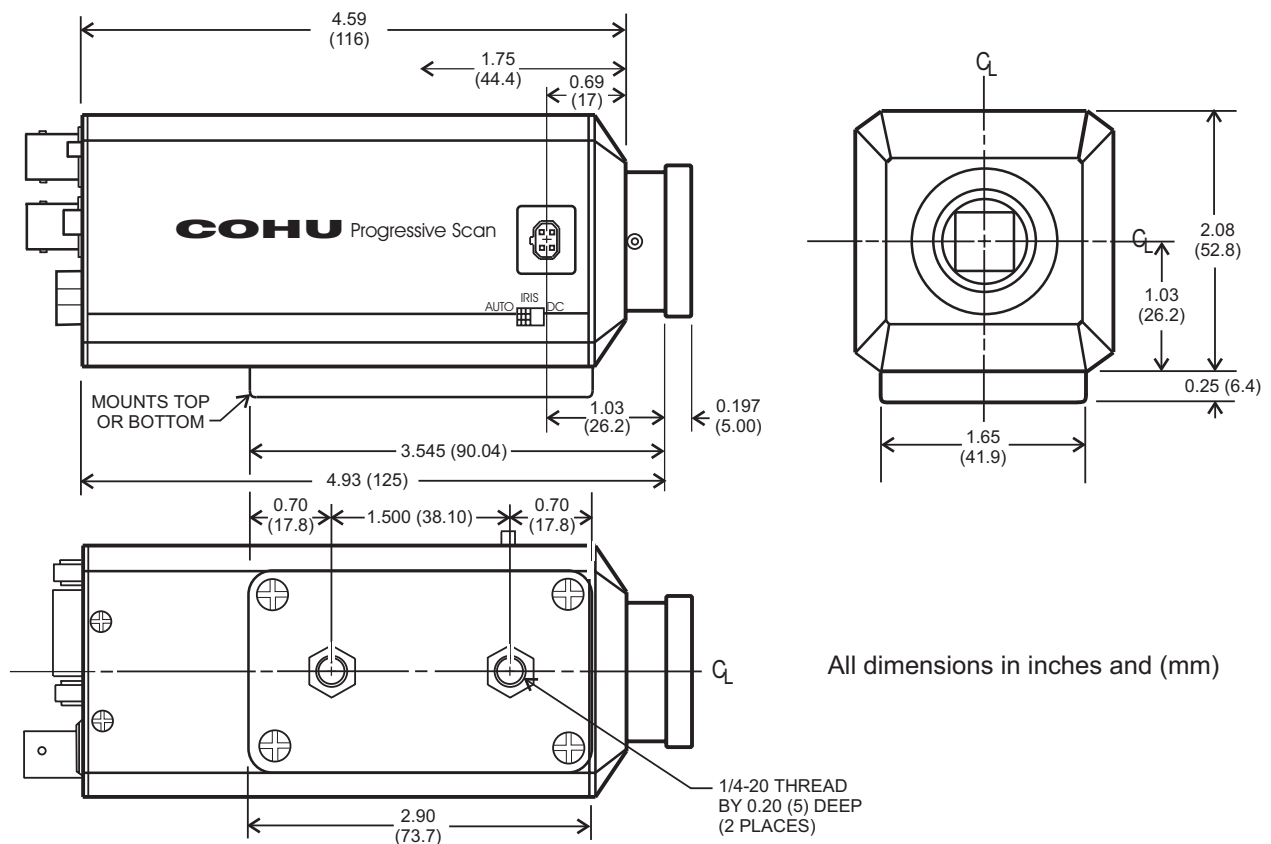


Fig. 1. Dimensions

October 22, 1998

TABLE OF CONTENTS		
SECTION		PAGE
1.0	Electrical Characteristics	5
2.0	Mechanical Characteristics	5
3.0	Equipment Supplied	8
4.0	Equipment Required but not Supplied	9
5.0	Interface Connectors	9
6.0	Power Input Connector	9
7.0	Video Output Connectors	9
8.0	Lens Connector	9
9.0	Auxiliary Connector	9
10.0	External Gain Control Input	11
11.0	Internal Switch Selections	11
12.0	Internal Control Potentiometers	15
13.0	Operating Modes	15
LIST OF ILLUSTRATIONS		
FIG.		PAGE
1	Dimensions	1
2	Spectral Response Curve	5
3	Modulation Transfer Function (MTF) Curve	5
4	Model 6600-1000 Functional Diagram	6
5	Power Connector	8
6	Progressive Scan and Interlaced Format	8
7	Lens Connector Pin Functions	9
8	Auxiliary Connector Pin Layout	9
9	External Gain Control	11
10	Main Board Side A	13
11	Channel B Board	13
12	Sensor Board Adjustment	17
<i>Continued to page 3 for timing waveform illustrations</i>		

List of Illustrations (Continued)		
(Timing Waveforms)		
FIG.		PAGE
	CONTINUOUS OPERATION	
WF-1	Frame Timing, 60 fps	18
WF-2	Frame Timing, 30 fps	18
	ASYNCHRONOUS RESET OPERATION	
WF-3	Trigger and Video Timing	19
	INTEGRATION OPERATION	
WF-4	Programmed Integration	20
WF-5	External Integration	20
	GENLOCK OPERATION	
WF-6	Vertical Trigger, Odd Field	21
WF-7	Vertical Trigger, Even Field	21
WF-8	Horizontal Trigger	21
	DIRECT RESET	
WF-9	Vertical Trigger Control, Vertical and Horizontal Mode	22
WF-10	Horizontal Trigger, Horizontal Mode	22
WF-11	Video Timing	23
WF-12	Field Steering	24
<i>Note: The waveform portion of the list of illustrations is formatted to emphasize the relationship of the waveforms to the basic sync functions of the camera.</i>		

LIST OF TABLES		
TABLE		PAGE
1	Model 6600-1000 Specifications	4
2	Auxiliary Connector Pin Identification	7
3	Camera Interface Connectors	8
4	Internal Switch Selections	10
5	Camera Adjustment List	12
6	Camera Modes	14
7	Model 6600-1000 Sync Modes and Control Configurations	16
8	Shutter/Integration Mode Settings	17

Table 1. Model 6600-1000 Specifications

Imager	Monochrome, 1/2-inch format, interline transfer format square pixel CCD array
Format	Progressive Scan 1 Vp-p at either 60 frames per second (fps) (dual channel RS-170(A) interlaced with opposite fields on each channel) or 30 fps (single channel, single field). Each channel output through a BNC connector.
Pixel Array	659 (H) by 494 (V)
Cell Size	9.9 μm
Sync	Internal crystal, genlock, asynchronous reset, direct H&V reset
Sensitivity	4 lux with full video, no AGC; 0.15 lux with 80% video, AGC on
Gain	AGC or manual up to 28 dB. Manual is rear panel adjustable
S/N Ratio	56 dB (gain 0 dB, gamma 1, 6 MHz filter)
Integration	1/60 s to 1/10,000 s high speed shutter in 8 steps 2 fields to 16 fields low speed shutter in 8 steps Internal switch selectable or via rear panel connector
Lens Mount	CS with 5 mm extender provided for C-mount lenses
Lens Drive	Auto iris or dc iris, switch selectable on side panel of camera
Weight	320 grams, less lens
Power	12 V dc, 5 W
Mounting	1/4-20 female threads top and bottom of housing in line with optical axis
Humidity	Up to 95% relative, noncondensing
Vibration	Per MIL-STD-810E, Method 514.4, Categories 1, 8, and 10 (less lens)
Reliability	MTBF: 20,000 hours (less lens)
Shock	No damage to 30 g's, 11 ms duration (less lens)
Altitude	Sea level to 3,000 meters / 10,000 feet (508 mm / 20 inch Hg)
Ambient Temperature Operating: Storage:	-20 °C to +70 °C (-4 °F to +158 °F) -30 °C to +80 °C (-22 °F to +176 °F)
<i>Note: See figure 2 for the sensor response curve and figure 3 for the camera modulation transfer curve</i>	

1.0 ELECTRICAL CHARACTERISTICS

The 6600 is an interline transfer progressive scan camera with video output in analog format.

It can operate at either 60 frames per second (fps) or 30 fps. At 60 fps video is output through two channels, each containing the opposite field of an interlaced — RS-170(A) — frame. At 30 fps video is output through a single channel formatted as a single frame of sequential lines.

Each video channel is output through a BNC connector at 1 Vp-p with RS-170(A) sync.

Note: In 60 fps (continuous modes) each channel alternates transmission of odd and even fields just as with RS-170(A). This allows two low-cost single channel frame grabbers to capture at a combined rate of 60 fps.

A 15-pin auxiliary connector on the rear panel provides multiple control inputs for various functions. This includes shutter/integration selections, sync modes, asynchronous reset triggering, H & V triggering input, and other functions. See table 2.

Switches and potentiometers on the internal circuit boards also provide selection of control functions including sync modes, shuttering, gamma and setup.

A side panel lens connector and switch provide for use of either an auto iris or dc iris lens if required in lieu of a mechanical lens.

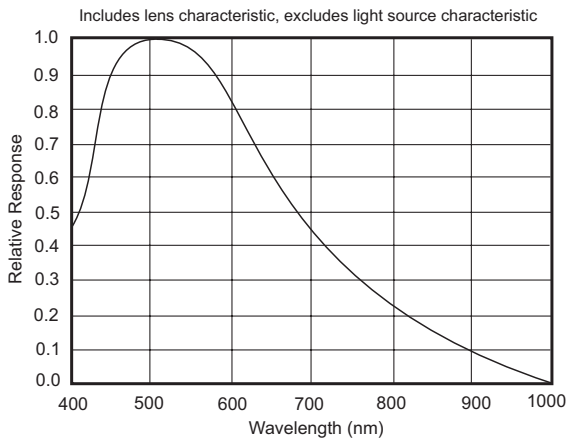


Figure 2. Sensor Response Curve

2.0 MECHANICAL CHARACTERISTICS

Figure 1 illustrates dimensions of the camera. The camera chassis consists of a full width U-shaped bottom rail to which attaches a vertically mounted front casting and rear plate. Four screws secure these chassis parts together, two at front and two at rear.

The casting is threaded to accept a CS-mount lens from the front. The sensor board mounts to the back side of the casting with a screw at each corner.

The rear panel mounts two BNC connectors, a D-15 connector, and a 3-pin power connector. The upper right corner has an access hole for the manual gain control potentiometer.

The main board mounts inside the bottom rail on four standoffs. This board positions the lens iris selection switch, auxiliary connector, and power input connector for access from outside the camera when the cover is installed.

The channel-B board mounts about 1.3 inch (33 mm) above the main board. It mounts at the corners to three standoffs and a bracket. The rear of this board has a gain control potentiometer mounted so that it is accessible through an adjustment hole in the camera rear panel.

The cover is shaped like a flat bottomed U and open at the two ends. It slides down over the chassis from the top. Four screw holes on top of the cover (2 front, 2 rear) provide for securing it to the front casting and rear plate.

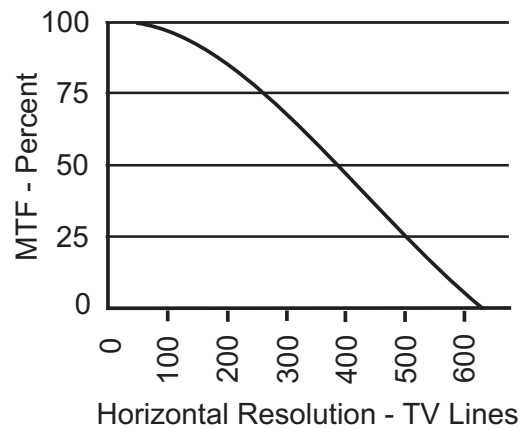


Figure 3. Modulation Transfer Function (MTF) Curve

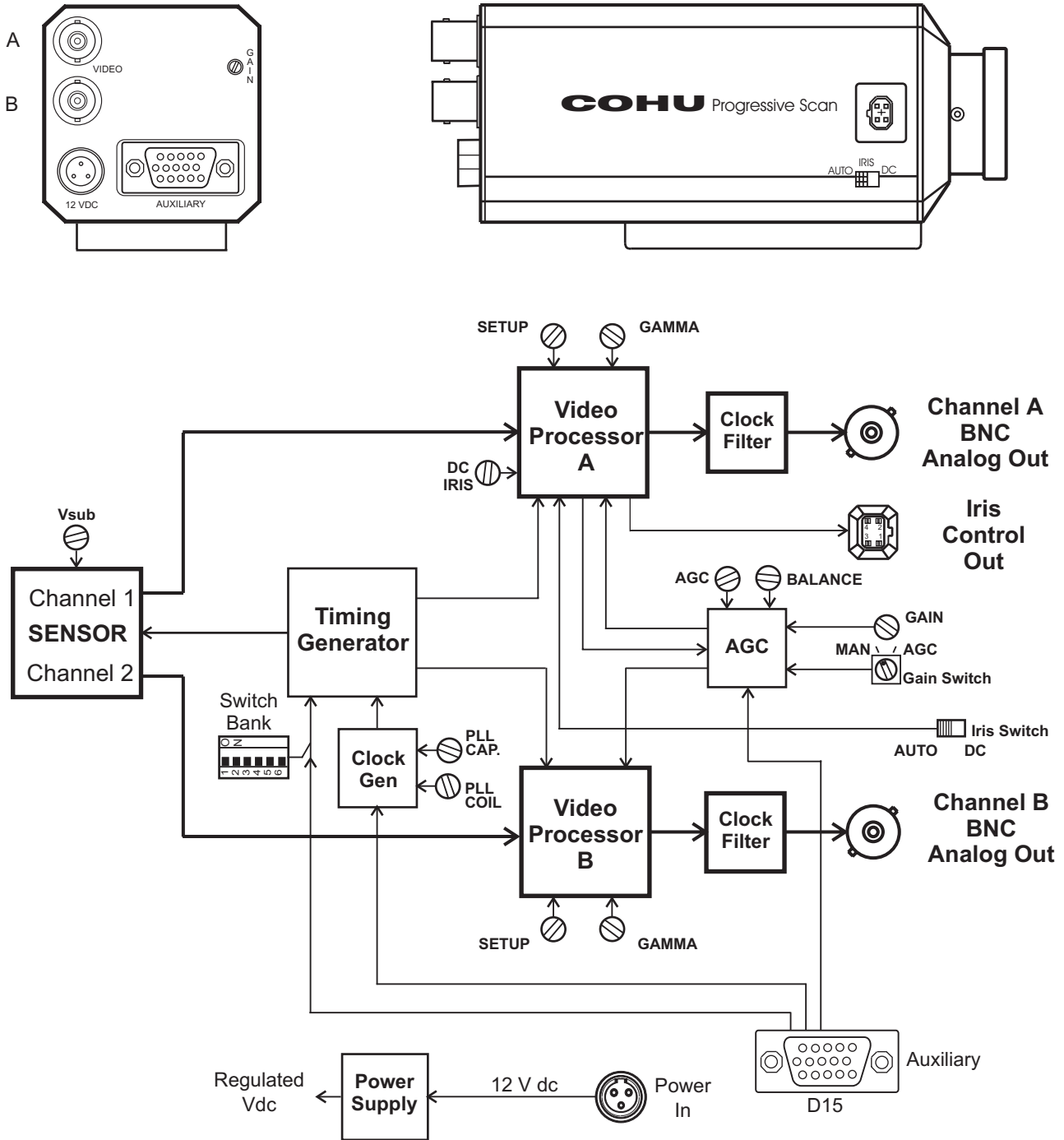


Figure 4. Model 6600-1000 Functional Diagram

Table 2. Auxiliary Connector Pin Identification

Pin No.	Signal Name	Input / Output	Level	Description
1	EDI 0	Input	TTL	Shutter/integration control. Refer to mode and control configuration table for selections
2	EDI 1			
3	EDI 2			
4	SMD 1	Input	TTL	Shutter/integration control. Refer to mode and control configuration table for selections
5	SMD 2			
6	EXT	Input	TTL	Sync mode. External sync (TTL high) locks to vertical trigger (VT) or to horizontal trigger (HT). Internal sync (TTL low) provides a crystal reference.
7	$\overline{\text{HTSG}}$	Input	TTL	Integrate enable. Allows external control of integration period (modes 5, 12, & 19). Integrate when low. Outputs a single image on the next vertical interval following HTSG going high.
8	REMGAIN	Input	Analog	Remote gain. External control of manual gain with voltage or resistance. Maximum gain = 0 V or 2.4 kilohm. Min gain = 4.6 V or 46 kilohm. Impedance is 5 to 10k, depending on setting of internal gain potentiometer.
9	RDM	Input	TTL	Trigger mode. Normal (TTL low) is continuous operation; Asynchronous reset, Donpisha (TTL high) provides snap shot operation.
10	RM	Input	TTL	Video mode. Progressive scan (TTL low) provides 30 fps through single channel. Interlaced (TTL high) provides 60 fps through dual channels.
11	$\overline{\text{WEN}}$	Output	TTL	Write enable pulse. Goes low at the start of a video frame.
12	ARESET	Input	TTL	Asynchronous reset. Triggers Donpisha reset on negative-going edge.
13	VT	Input	1.5-5Vp-p ac coupled (TTL ok)	Vertical Trigger. Used for external sync modes. Triggers on negative-going edge. Neg pulse is 126 μs minimum (2H period).
14	GNDD	Output	—	Digital ground
15	HT	Input	1.5-5Vp-p ac coupled (TTL ok)	Horizontal trigger. Used for external sync modes. Triggers on negative-going edge. Negative pulse is 0.3 μs minimum.

Before disassembling make note of any spacing or lock washers on the standoffs. These may be used during assembly to prevent components from shorting to the chassis or other components.

Field disassembly is typically limited to removing the cover to make any required adjustments or changes to switches.

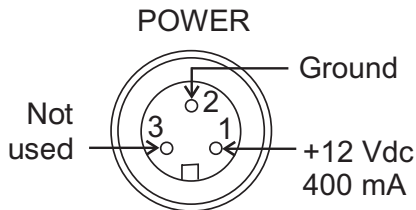
Table 3. Camera Interface Connectors

REF DESIG	CONNECTOR NAME	CAMERA CONNECTOR		MATING CABLE CONNECTOR	
		Cohu P/N	Mfg P/N	Cohu P/N	Mfg P/N
J1	D-15 Auxiliary	1310437-015	Amp 749768-1	1310445-015	Amphenol 17HD-015S-AA000
J43	BNC Analog Video	1310242-001	Amp 227754-1	Standard BNC Plug	Standard BNC Plug
J44	BNC Analog Video	1310242-001	Amp 227754-1	Standard BNC Plug	Standard BNC Plug
J45	Power	1310356-003	Switchcraft TB3M	1310356-103	Switchcraft TA3F
J51	Lens	1310418-004	Chuomusen D4-151N-100	1310419-004	Chuomusen E4-191J-100

3.0 EQUIPMENT SUPPLIED

The following list is for a camera ordered in its most basic form. A lens and power supply can be ordered with the camera if desired.

1. Camera
2. CS-mount (pn 8359208-001)
3. Setscrew, CS Mount, 4-40 x 5/16, nylon tipped (pn 2010258-005)
4. CS TO C-mount 5 mm extender (pn 2010695-001)
5. Power Connector for cable
6. Lens connector for cable
7. Auxiliary connector for cable
8. Installation and operation manual (No. 6X-987)



Mating view of pins looking at rear panel of camera

Fig. 5. Power Connector

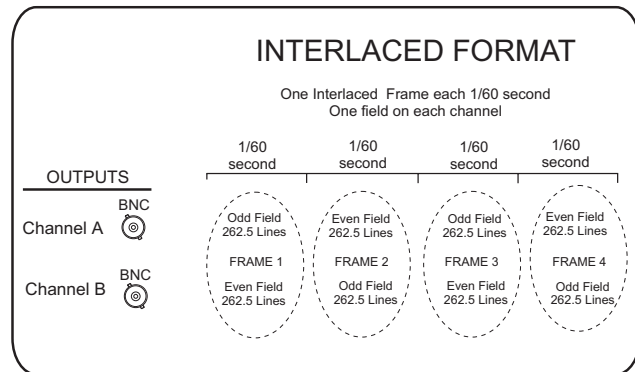
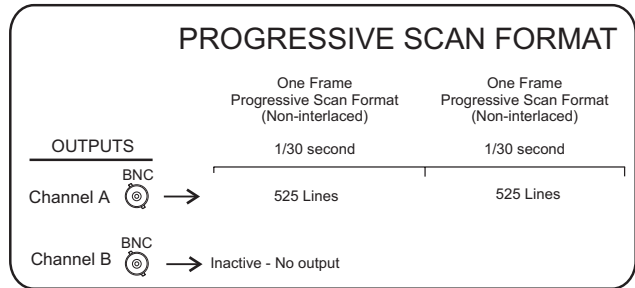


Figure 6. Progressive Scan and Interlaced Format

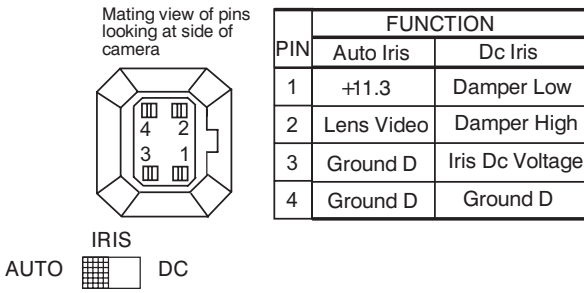


Figure 7. Lens Connector Pin Functions

4.0 EQUIPMENT REQUIRED BUT NOT SUPPLIED

The intended use largely determines what equipment is required to make use of the camera. The following list offers typical supporting items required to make full use of the camera. Items 1 and 2 are usually ordered with the camera.

1. Power supply, 12 V dc, 400 mA
2. Lens, manual, auto iris or dc iris with a CS or C-mount
3. Frame grabber, analog input, 1 - or 2-channel
4. External sync source with H and V trigger outputs
5. Auxiliary input control
6. 75 Ohm coaxial cables

5.0 INTERFACE CONNECTORS

Table 3 lists each of the interface connectors on the camera and the mating connector for the cable. This table includes part numbers for these connectors.

6.0 POWER INPUT CONNECTOR

Power is applied to the camera through a three pin connector. Pin 1 is a 12 V dc input, pin 2 is ground. This connector is shown in figure 5.

7.0 VIDEO OUTPUT CONNECTORS

Video output is available at the two BNC connectors on the rear panel of the camera (figure

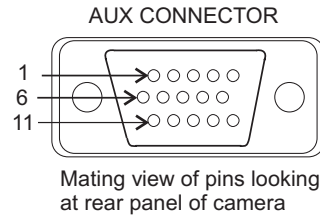


Figure 8. Auxiliary Connector Pin Layout

4). The top connector is the A-channel. The lower BNC connector is B-channel video.

Progressive scan (single channel) mode video appears at the top, A-channel, connector. No output appears at the B-channel connector when in this mode. See top portion of figure 6.

When the camera is in the interlaced scan mode, video appears at both the top and bottom BNC connectors. When the top connector provides odd/even fields the bottom connector simultaneously provides even/odd fields. A standard monitor can be connected to either connector for viewing the scene. See the bottom portion of figure 6.

To provide a frame of video in 1/60 of a second, both BNC connectors must be connected to a two-channel frame grabber system that can combine the two fields.

8.0 LENS CONNECTOR

See figure 7. This connector can be used with either auto iris lenses or dc iris lenses. The related switch below this connector selects the desired use for this connector. The Iris Connection table lists pin functions of this connector for both switch selections.

9.0 AUXILIARY CONNECTOR

Note: TTL low = 0 to 1.5 volt

TTL high = 3 to 5 volts

Of the 15 pins on this connector 12 are inputs operating at TTL levels. Pin 8 is an analog gain control input, pin 12 is a TTL output, and pin 14 is ground. Figure 8 identifies pin numbers. Table 2 lists pin functions.

Table 4. Internal Switch Selections

REF DESIG	SIGNAL NAME	FUNCTION NAME	FUNCTION
MAIN BOARD			
S1-1	RM	1/30 or 1/60	Selects frame rate between [On] 1/30 (non-interlaced) and [Off] 1/60 (interlaced)
S1-2	RDM	Normal or asynch reset	Selects either normal or asynchronous reset. Asynchronous reset is triggered with pin 12 of the auxiliary connector. On is normal operation. Off is asynchronous reset.
S1-3	REVH	V or HV reset	Selects either vertical or horizontal & vertical direct reset; activates pin 13 (V. trigger) or pins 13 and 15 (H. trigger) on the auxiliary connector. On is V reset. Off is HV reset.
S1-4	REND	Normal or direct reset	Selects either normal or direct reset mode. Direct reset allows direct control of the camera vertical and horizontal triggers. On is normal reset. Off is direct reset.
S1-5	EXT	Internal or external sync	Selects internal or external sync source. On is internal sync. Off is external sync.
S1-6	—	—	Not used
S2-1	EDI0	Shutter control	Selects either normal operation, shuttering speeds, or number of frames of integration. See tables 7 and 8 for a list of various shuttering/integration selections
S2-2	EDI1		
S2-3	EDI2		
S2-4	SMD1		
S2-5	SMD2		
S2-6	—	—	Not used; see Note at bottom of table
S3	—	Auto/dc Iris (Side panel)	Selects between auto iris control or dc iris control at the side panel connector for the lens interface cable. Auto is to rear.
S4	—	AGC On or Manual	Selects whether camera has automatic gain control (agc) operation (cw) or manual gain (ccw)
<p><i>Note: Early versions of the 6612-1000 required switch S2-6 to remain open at all times.</i></p>			

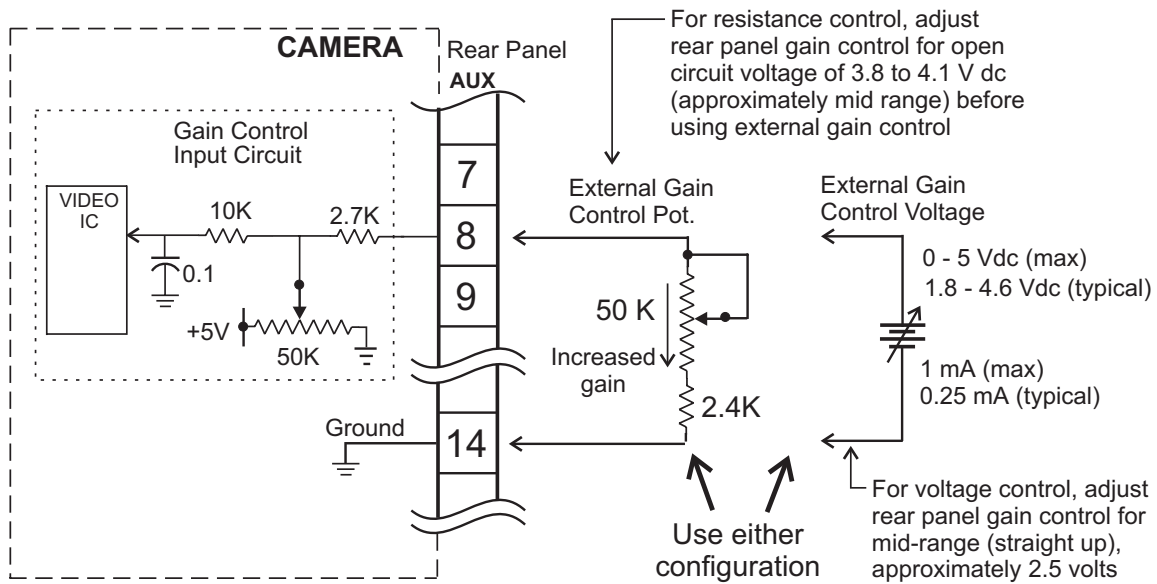


Fig. 9. External Gain Control

Pins 1 to 5 select shutter speeds or frames of integration. Tables 7 and 8 list the selection choices for these pins. These five lines are connected to internal DIP switches.

Pins 6, 9, and 10 select control functions. These lines are also connected to internal DIP switches. The Sync Function Selections (table 7) lists the possible sync modes. Pin 10 when low selects progressive scan (1/30) or when high interlaced scan (1/60). Pin 6 when low selects the camera internal sync as the reference; when this pin is high it activates the external sync inputs. Pin 9 when low selects normal (continuous) mode; when high, pin 12 is activated so that an asynchronous reset pulse may be applied.

HTSG (pin 7) initiates integration when pulled low in the integration mode. Integration continues until the input again goes high. Integration time is limited only by the amount of unacceptable star-pattern artifacts present in the video.

HT and VT (pins 13 and 15) are the horizontal trigger and vertical trigger inputs. Figures WF6 through WF12 show the required pulse characteristics for H and V. These inputs are active only in the external sync modes.

Note: Two additional sync mode selections (REXH and REND) that are not brought out to pins on the aux connector are available at the internal DIP switch. These modes are shown in table 7, which lists all available sync modes.

10.0 EXTERNAL GAIN CONTROL INPUT

Manual control of gain from an external source requires connection of either a voltage source or a potentiometer to pin 8 of the auxiliary connector. Figure 9 illustrates this connection.

The rear panel manual GAIN control must be set midrange for this external control to have full range.

11.0 INTERNAL SWITCH SELECTIONS

Several functions can be controlled by DIP switch selections inside the camera on the main board (fig. 10). Table 4 lists these switches.

DIP switch S1 controls sync functions and S2 controls shutter/integration timing selections.

Table 6 provides a brief description of the camera operating modes.

Table 5. Camera Adjustment List

REF DESIG	LOCATION	NAME	SETTING
Potentiometers, Capacitors, and Coils			
R58	Channel B board (top)	Gain set	ccw is minimum gain (& min noise); cw is max gain
R18	Channel B board (top)	Gain balance	Factory set; adjust to balance channels A & B if required
R22	Main board	AGC level	Factory set
R31	Main board	Channel A setup (black level)	7.5 IRE
R25	Channel B board (top)	Channel B setup (black level)	7.5 IRE
R12	Main board	Channel A gamma	ccw = 1 (min); cw = 0.45 (max)
R12	Channel B board (top)	Channel B gamma	ccw = 1 (min); cw = 0.45 (max)
R89	Main board	DC iris level set	Factory set
L4	Main board	PLL tuning	Factory set
C91	Main board	PLL tuning	Factory set
R5	Sensor Board	Vsub	Factory Set
Adjustable Mode Switches			
S4	Main bd	Manual/agc select.	ccw = manual gain (set with R58 on channel B board; cw = agc
S3	Main bd	Auto iris / dc iris select	set towards camera front = dc iris; set towards camera rear = auto iris
S2-6	Main bd	—	not used; open on early versions of camera
S1-6	Main bd	—	not used
<p><i>Note: The main board is at the bottom; the channel B board is at the top.</i> <i>bd=circuit board, S=switch, R=variable resistor, L=variable coil, C=variable capacitor</i></p>			

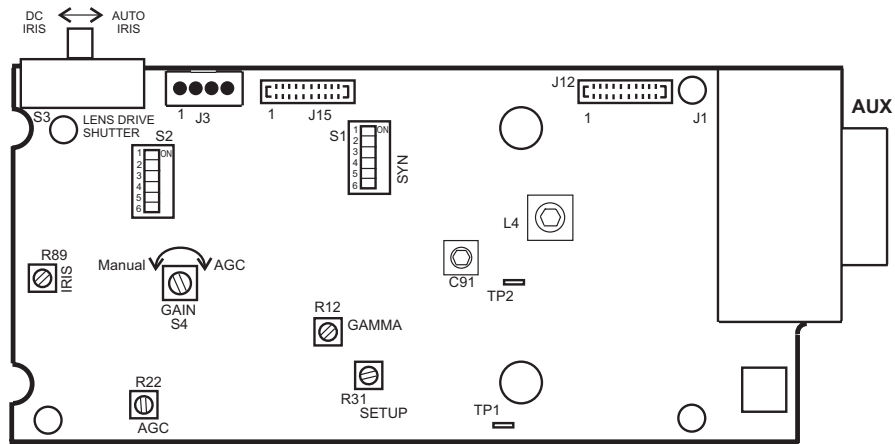
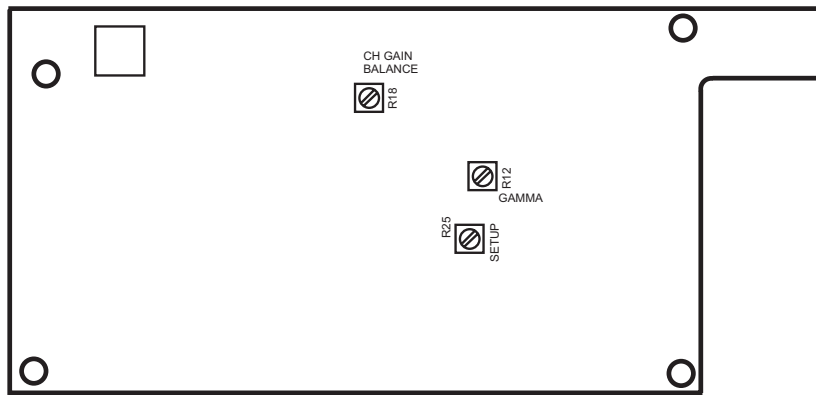
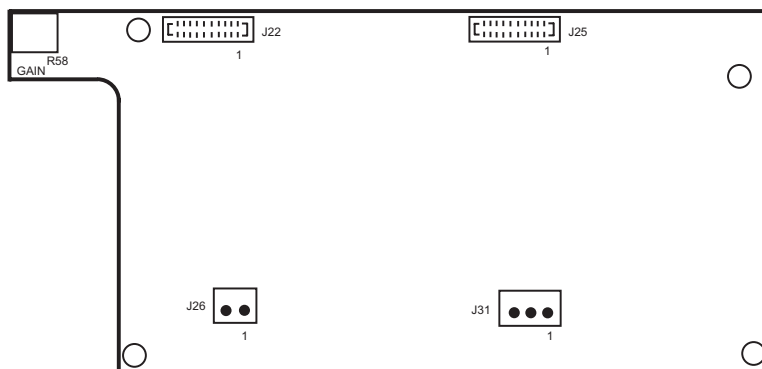


Figure 10. Main Board Side A



Side A



Side B

Figure 11 Channel B Board

Table 6. Camera Modes

OPERATING MODES	
Continuous - Internal Clock	Continuous (free running) operation using internal crystal. Supports all shutter/integration modes. Operates in single or dual channel modes.
Continuous - Genlock	Continuous operation using internal PLL locked to horizontal sync. Supports all shutter/integration modes. Only operates in dual channel mode.
Asynch Reset (Donpisha)	Snap-shot operation. Outputs a single frame on negative edge of ARESET (auxiliary connector). Operates in single or dual channel modes. In dual channel mode the A-channel always outputs the odd field and the B-channel the even field. Supports all shutter modes. Does not output a vertical sync pulse in the video frame. WEN output on the auxiliary connector identifies the beginning of a video frame.
Direct Reset - Vertical	<p>Snap-shot operation. Outputs a single frame on negative edge of VT (vertical trigger) on the auxiliary connector. Operates in single or dual-channel modes. Does not support internal shutter or integration.</p> <p>Shuttering is controlled externally by clearing the sensor with one VT then transferring the accumulated charge (the picture) with a second VT. The time between the two VT pulses is the shutter interval. The shutter interval must be greater than a frame interval to capture a full frame.</p> <p>Partial scanning at up to twice the frame rate is possible, but a portion of the image will be corrupted. At twice the frame rate the whole image is corrupted. Partial scanning at faster rates is possible by masking portions of the sensor. Consult Cohu Applications Engineers or Field Representatives for details if desired.</p> <p>HT (horizontal trigger) may be used to steer a field output direction in dual channel mode. If no HT is provided, field direction is arbitrary.</p>
Direct Reset Horizontal / Vertical	Snap-shot operation. Outputs a single line for each negative edge of HT. Operates in single or dual channel modes. Does not support internal shutter / integration. VT and HT control shutter and field direction the same as in Direct Reset - Vertical mode.
OUTPUT MODES	
Single Channel	30 frames a second output from channel A.
Dual Channel	60 frames per second output through both channels A and B. Each channel outputs an interlaced field (every other line of a frame) at a rate of 60 fields per second. Each channel simultaneously outputs the opposite field (one field with odd lines, the other with even lines) for a combined rate of 60 frames per second. During continuous operation, each channel continuously alternates between odd and even fields.
SHUTTER / INTEGRATION MODES	
No Shutter	Sensor integrates over the full vertical interval (1/30 second in single channel mode and 1/60 second in dual channel mode).
Flickerless	For use with fluorescent lighting. A 1/100 second shutter guarantees exposure only to one fluorescent light cycle where 50 Hz power is used.
Programmable Shutter	8 settings ranging from 1/60 to 1/10,000 second. Note: flickerless is the 9th programmable selection
Programmable Integration	8 settings ranging from 2 fields to 16 fields.
External Integration	Integrate for the duration of $\overline{\text{HTSG}}$ (on the auxiliary connector).

Table 7 lists all the switch and auxiliary (Aux) connector signals required to control the camera. Note that two control signals (REXH and REND) are only accessible with internal switches and are not available on the aux connector

Any sync function controlled through the Aux connector must have its respective internal switch in the open position..

Table 8 lists the various shuttering and integration selections and gives the corresponding switch select position and auxiliary control input low/high state. If any of the internal switches is set to On (pulling a low state) the external control input on the auxiliary connector cannot then force that input high. Conversely, any external control line on the auxiliary connector pulled low overrides any internal switch set to high.

12.0 INTERNAL CONTROL POTENTIOMETERS

Table 5 lists all the adjustments on the three boards. Several of these may require field adjustment due to installation or operational considerations. Most of the controls require test bench setups and detailed step-by-step instructions and should not be changed.

On the main board (fig. 10) are potentiometers for setting A-channel gamma (R12) and setup (R31) level. Setup should be left at the industry standard 7.5 IRE units unless some special application mandates a different setting. An oscilloscope or waveform monitor is required to adjust setup to a known level when the lens is capped.

On the channel-B board (fig. 11) are four potentiometers. Gamma for the B-channel video is controlled by R12 (not to be confused with the R12 gamma on the main board). Setup level for the B-channel video is controlled by R25.

On the opposite side of the board from these two pots is R58, a gain control accessible from the rear panel of the camera. This pot controls gain for both channels when the camera is in manual gain mode.

Channel B has a balance potentiometer associated with it (R18). In the interlaced mode it provides equal video level for the odd and even fields.

13.0 OPERATING MODES

See table 6 for a summary of operating modes. See tables 7 and 8 for mode switch and control settings.

TABLE 7. NOTES

<p><i>NOTES:</i></p> <p><i>Mode select signals are controlled either through the rear panel Aux connector (J1) or internal switches S1 and S2.</i></p> <p><i>Signals with associated connector pins (J1-n) and switches (S1-n or S2-n) are shown in table 8.</i></p> <p><i>When using the aux connector inputs, all associated switches must be in the open position</i></p> <p><i>Mode 1 is the default mode as shipped</i></p>
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Table 7. Model 6600-1000 Sync Modes and Control Configurations

Mode No.	MODE SELECT SIGNALS													CONTROL SIGNALS			
	RM Interface or Prog-Scan	RDM Norm/ Async Trigger	REVH V or HV Direct Reset	REND Normal/ Direct Ext Rst	EXT Internal/ External Sync	EDIO Shutter Speed	EDI1 Shutter Speed	EDI2 Shutter Speed	SMD1 Shutter Mode	SMD2 Shutter Mode	ARESET Async Reset	HTSG Integrate Enable	VT Vertical Trigger	HT Horiz Trigger			
	J1-10 S1-1	J1-9 S1-2	— S1-3	— S1-4	J1-6 S1-5	J1-1 S2-1	J1-2 S2-2	J1-3 S2-3	J1-4 S2-4	J1-5 S2-5	J1-12	J1-7	J-13	J-15			
	Internal Sync (Crystal Operation)																
	Dual Channel Operation (Interlaced)																
	Continuous - Internal Clock (Normal Trig)																
1	(Default) No Shutter																
2	Flickerless Shutter (1/100 sec)																
3	Programmable Shutter																
4	Programmable Integration (Fixed Intervals)																
5	External Integration (HTSG)																
	Async Reset - Dompisha (Single Shot) (No V Sync)																
6	Flickerless Shutter (1/100 sec)																
7	Programmable Shutter																
	Single Channel Operation (Prog Scan) (Ch A Only)																
	Continuous - Internal Clock (Normal Trig)																
8	No Shutter																
9	Flickerless Shutter (1/100 sec)																
10	Programmable Shutter																
11	Programmable Integration (Fixed Intervals)																
12	External Integration (HTSG)																
	Async Reset - Dompisha (Single Shot) (No V Sync)																
13	Flickerless Shutter (1/100 sec)																
14	Programmable Shutter																
	External Sync (using VT & HT)																
	Dual Channel Operation (Interlaced)																
	Continuous - Genlock (PLL locked to HT)																
15	No Shutter																
16	Flickerless Shutter (1/100 sec)																
17	Programmable Shutter																
18	Programmable Integration (Fixed Intervals)																
19	External Integration (HTSG)																
	Direct Reset - V or HV (Single Shot)																
20	Vertical (1 frame / V sync) (see note 1)																
21	Horiz / Vert (1 line per H sync)																
	Single Channel Operation (Prog Scan) (Ch A Only)																
	Direct Reset - V or HV (Single Shot)																
22	Vertical (1 frame / V sync)																
23	Horiz / Vert (1 line per H sync)																

Note 1: HT may be used to steer output field direction. Otherwise field direction is arbitrary

Table 8. Shutter/Integration Mode Settings

FUNCTION	Shutter / Integration Control Signals (Aux Pins / Switches)			
	EDIO (S2-1)	EDI1 (S2-2)	EDI2 (S2-3)	Shutter Speed
Shuttering	low / on	low / on	low / on	1/10,000 s
	high / off	low / on	low / on	1/4,000 s
	low / on	high / off	low / on	1/2,000 s
	high / off	high / off	low / on	1/1,000 s
	low / on	low / on	high / off	1/500 s
	high / off	low / on	high / off	1/250 s
	low / on	high / off	high / off	1/125 s
	high / off	high / off	high / off	1/60 s
Integration	low / on	low / on	low / on	16 fields (8/30 s)
	high / off	low / on	low / on	14 fields (7/30 s)
	low / on	high / off	low / on	12 fields (6/30 s)
	high / off	high / off	low / on	10 fields (5/30 s)
	low / on	low / on	high / off	8 fields (4/30 s)
	high / off	low / on	high / off	6 fields (3/30 s)
	low / on	high / off	high / off	4 fields (2/30 s)
	high / off	high / off	high / off	2 fields (1/30 s)

Note: S2 is on the main board

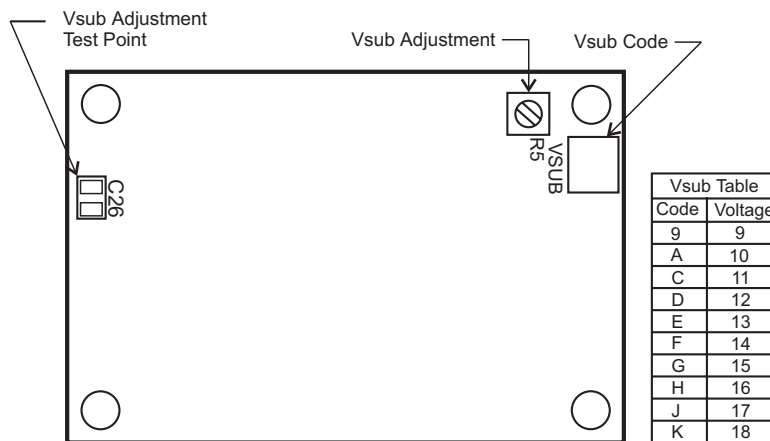


Figure 12. Sensor Board Adjustment

CONTINUOUS OPERATION

Dual Channel - Interlaced Mode

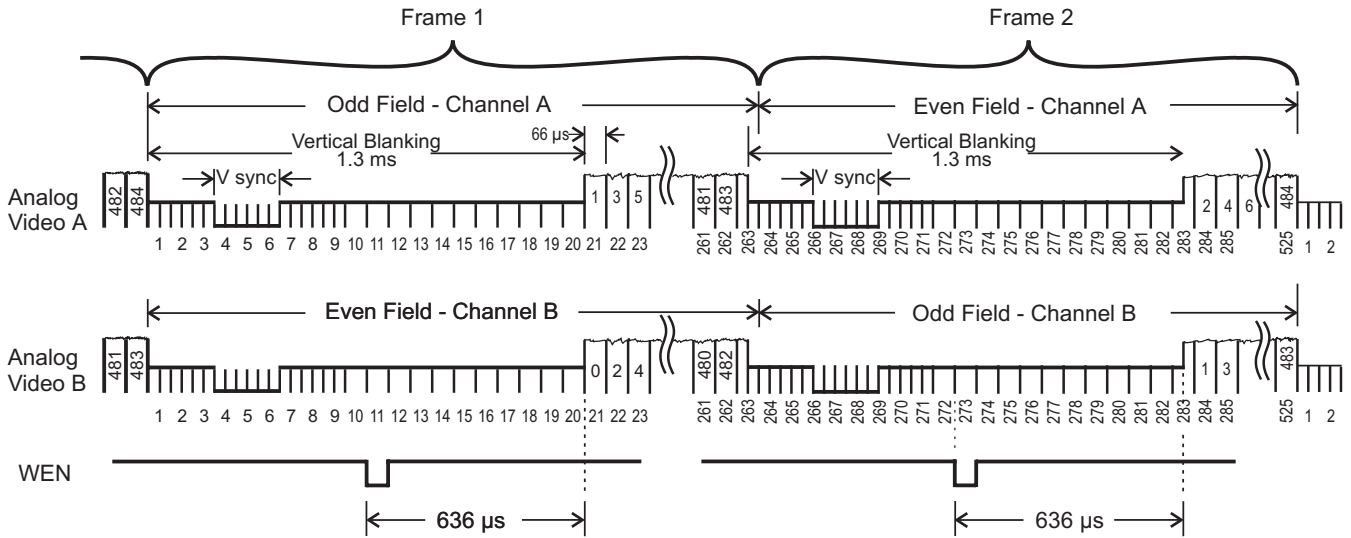


Figure WF1. Timing Diagram, Continuous Operation, Frame Timing, 60 fps

Single Channel - Progressive Scan Mode

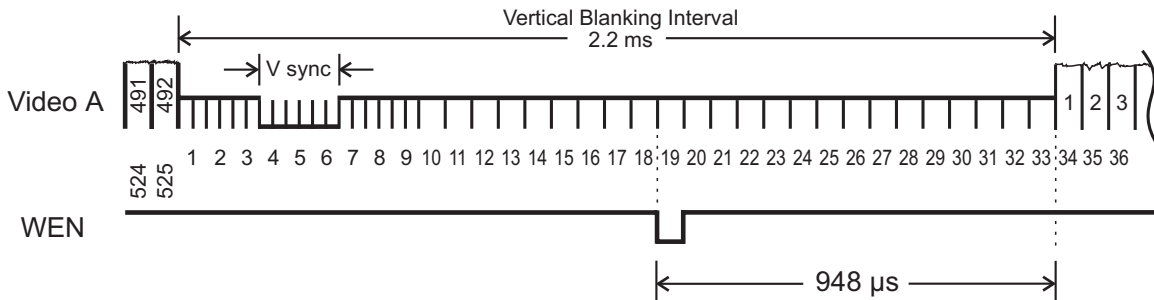
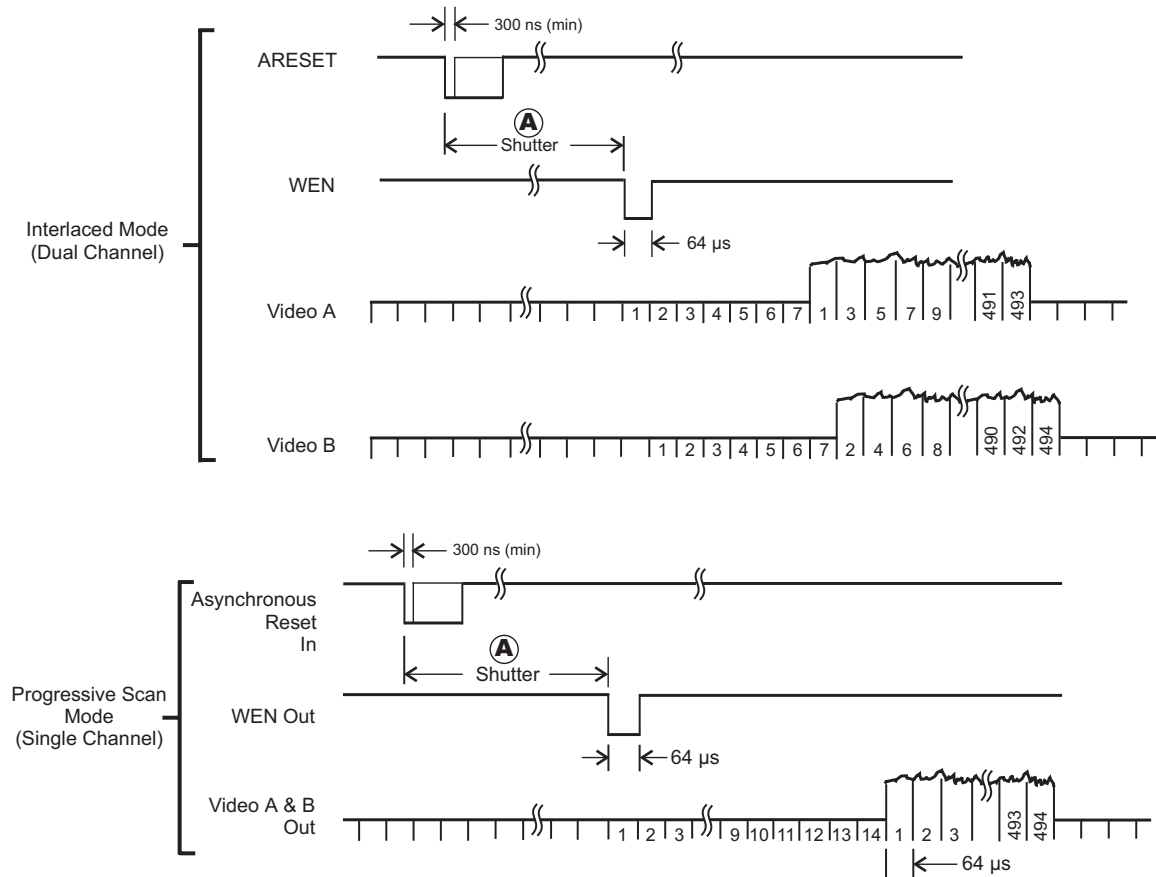


Figure WF2. Timing Diagram, Continuous Operation, Frame Timing, 30 fps

ASYNCHRONOUS RESET OPERATION



NOTE: In dual channel mode channel A always has the odd field and channel B always has the even field

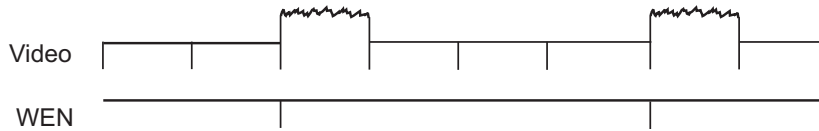
Ⓐ SHUTTER TIMINGS

Shutter Speed	Time
1/10,000	0.1 ms (100 μs)
1/4,000	0.250 ms (250 μs)
1/2000	0.500 ms (500 μs)
1/1000	1 ms
1/500	2 ms
1/250	4 ms
1/125	8 ms
1/60	16.67 ms

Figure WF3. Asynchronous Reset (Donpisha) Trigger Timing, 60 & 30 fps

INTEGRATION OPERATION

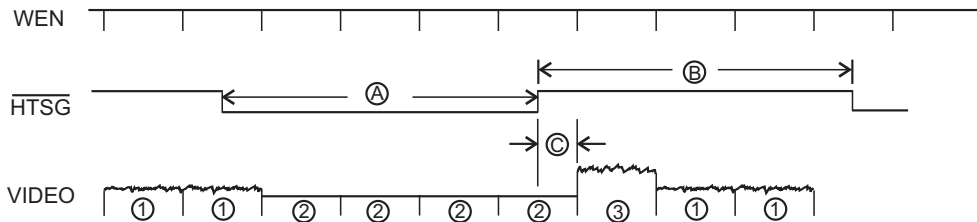
Programmed Integration (Modes 4, 11, & 18)



NOTE: WEN timing is the same as for normal video

Figure WF4. Timing Diagram, Integration, Programmed Integration

External Integration (Modes 5, 12, & 19)



Waveform	Dual Channel Mode	Single Channel Mode
Ⓐ HTSG (Active - Low)	17 ms, min	34 ms, min
Ⓑ HTSG (Off - High)	17 ms, min	34 ms, min
Ⓒ HTSG → Video Delay	0 - 17 ms	0 - 34 ms

NOTES:

1. In dual channel mode, field selection is arbitrary. Use the sync timing of channel A to determine field/channel orientation
2. Frame type ① should be ignored. It contains normal continuous video (no shutter mode)
3. Frame type ② should be ignored. It contains sync with no video
4. Frame type ③ is the integrated video frame. It begins at the vertical interval following the rise of HTSG

Figure WF5. Timing Diagram, Integration, External Integration

GENLOCK OPERATION

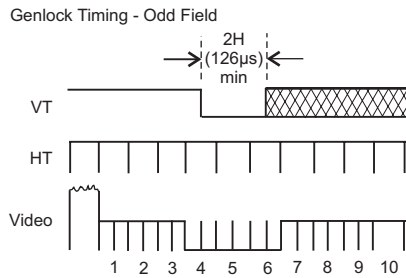


Figure WF6. Timing Diagram, Genlock, Odd Field

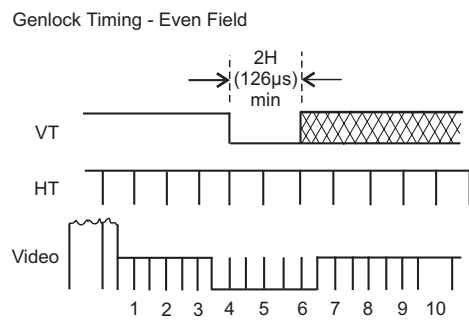


Figure WF7. Timing Diagram, Genlock, Even Field

Horizontal Sync

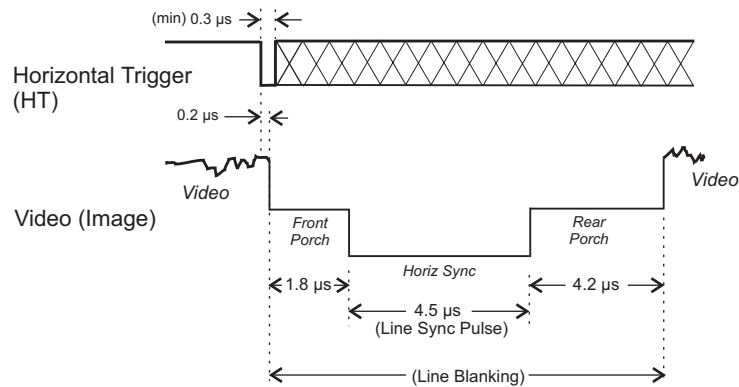


Figure WF8. Timing Diagram, External Sync, Genlock and Direct Reset - Trigger Timing (Analog - Horizontal Sync Timing)

DIRECT RESET OPERATION

Direct Reset - Vertical & Horizontal Modes

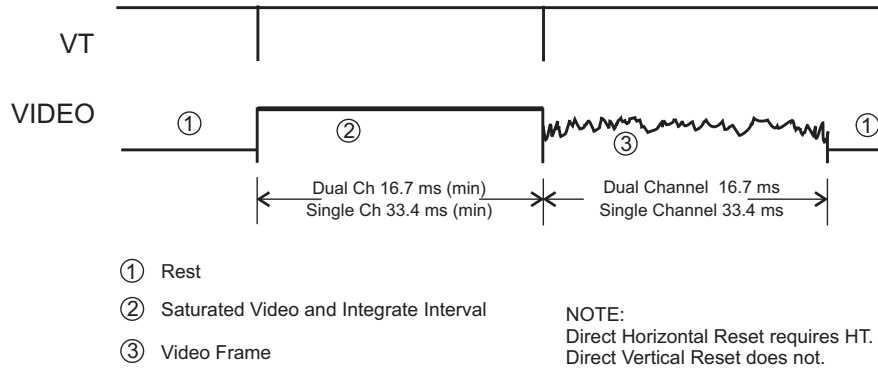


Figure WF9. Timing Diagram, Direct Reset - Vertical Trigger Control - Vertical and Horizontal Modes

Direct Reset - Horizontal Mode

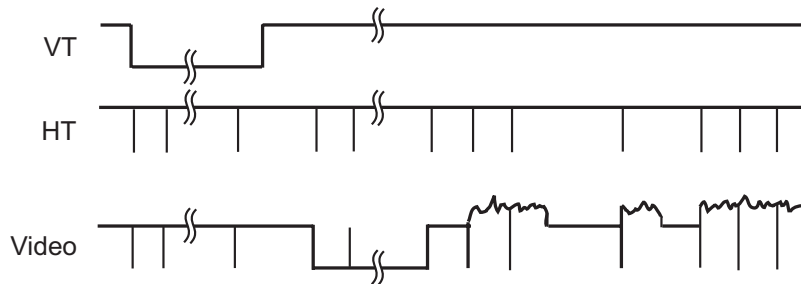
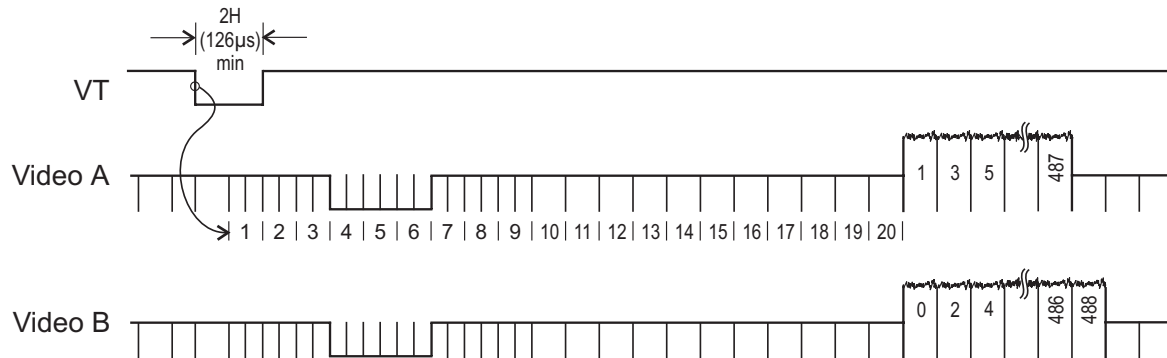


Figure WF10. Timing Diagram, Direct Reset - Vertical and Horizontal Trigger Control - Horizontal Mode

DIRECT RESET OPERATION (CONTINUED)

Direct Reset to Odd Field



Direct Reset to Even Field

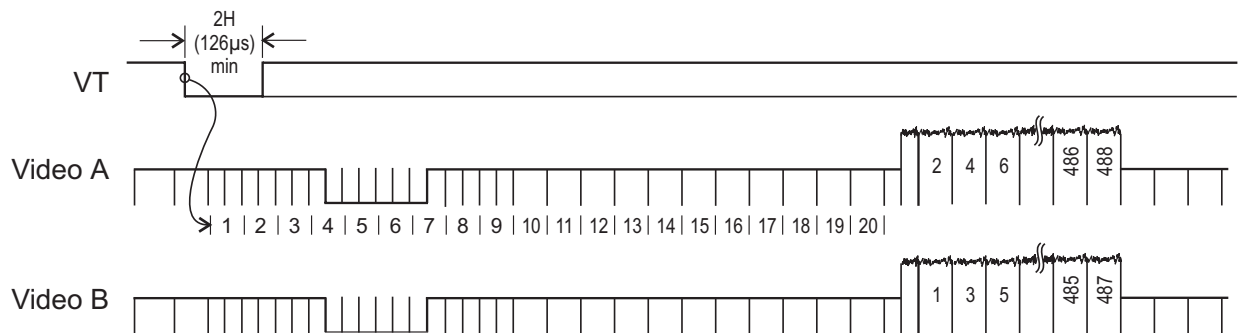
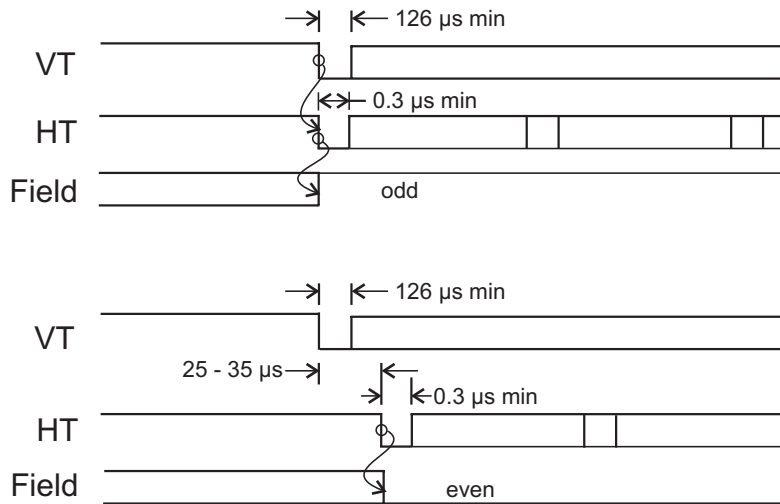


Figure WF11. Timing Diagram, Direct Reset - Vertical and Horizontal Video Timing

DIRECT RESET OPERATION (CONTINUED)

Field Steering - 60 fps - Direct Reset



Field steering is accomplished by triggering HT in phase with VT.

If HT goes low with VT, the camera is steered to an odd field (Channel A).

HT and VT can be tied together to steer to an odd field.

To steer to an even field, HT must go low between 25 and 35 μs after VT goes low

If no HT is applied, field direction will be arbitrary.

**Figure WF12. Timing Diagram, Direct Reset,
Vertical and Horizontal Field Steering**