



## TM-1020 Series Progressive Scan Shutter Cameras

Operation Manual





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## Warranty

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

## Certifications

### CE Compliance

The TM-1020 series cameras have been certified to conform to the requirements of Council Directive 89/336/EC for electromagnetic compatibility and to comply with the following European Standards:

Immunity: EN50082-2/1995

Emissions: EN55011/EN61326-1, Class A

All JAI, Inc. products bearing the CE mark have been declared to be in conformance with the applicable EEC Council Directives. However, certain factory-installed options or customer-requested modifications may compromise electromagnetic compatibility and prohibit use of the CE mark. Please note that the use of interconnect cables that are not properly grounded and shielded may affect CE compliance.

Contact JAI, Inc. Applications Engineering Department for further information regarding CE compliance.

### FCC

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

## WARNING

**Changes or modifications to this unit not expressly approved by the party responsible for FCC compliance could void the user's authority to operate the equipment.**

TM-1020 Series Operation Manual

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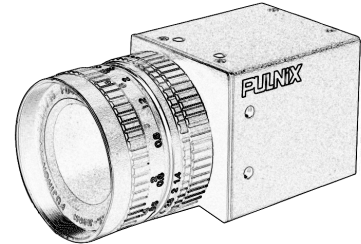
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# TM-1020 Series Progressive Scan Shutter Cameras

## Operation Manual

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## 1 Introduction

### 1.1 Product Description

The JAI, Inc. TM-1020 series<sup>1</sup> consists of high-resolution, high-speed monochrome progressive scan CCD cameras. The interline-type CCD permits full vertical and horizontal resolution of very high speed shutter images and applications. The electronic shutter, which has speeds to 1/16,000 sec., can be reset asynchronously by external pulse control. The base model's frame rate is 15 fps. A square imager format with uniform square pixels provides superior image definition in any orientation. On-chip micro lenses provide increased sensitivity.

The TM-1020 series has a full dynamic range control function, which can be set at externally selectable look-up table (LUT) knee slopes to convert 10-bit input to 8-bit output, thereby optimizing the CCD's full dynamic range in the normal output signal range. The camera has an 8-bit, RS-422 or RS-644 digital signal output for interfacing with external image-processing systems. All the key functions are externally controlled via RS-232C. The CL models have a Camera Link output.

Applications for the TM-1020 series include machine vision, medical imaging, intelligent transportation systems, high-definition graphics, on-line inspection, gauging, character reading, archiving, and high-security surveillance.

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1. Unless specifically mentioned, all information in this manual is relevant to all released cameras in the TM-1020 series, including TM-1020-15, RM-1020-15, TM-1020A and all variations, Camera Link versions (CL), FW version, and the TM-1020-30 and CL.

## 1.2 Features

- **Miniature size and light weight**

The printed circuit boards in the TM-1020 series have been arranged based on a new design philosophy. This creates modular electronics for the camera, giving it flexibility. In addition, the use of miniature solid-state components results in a compact, lightweight camera that is 44mm x 44mm x 64mm in dimensions, and weighs only 149 grams.

- **Imager**

The TM-1020 series uses a progressive-scan interline transfer CCD that has the following features:

- Resolution of 1008 x 1018 active pixels for excellent image quality.
- 9.0 x 9.0  $\mu\text{m}$  square pixels for precise dimensional measurement.
- High-speed electronic shutter capability for high dynamic resolution of moving objects and electronic iris control that eliminates the need for a mechanical shutter.
- Progressive-scan CCD eliminates interlace deterioration of image and increases ease of computer interface.
- High sensitivity and low noise at fast scanning. The 1" CCD has an excellent S/N ratio that is greater than 50dB.
- The CCD has a built-in microlens for increased quantum efficiency.

- **Electronic shutter**

The TM-1020 series has a substrate drain-type shutter mechanism which provides superb pictures at various speeds without smearing. A built-in manual shutter speed control selects the electronic shutter rate of 1/60 (non-async mode only), 1/125, 1/250, 1/500, 1/1,000, 1/2,000, 1/4,000, 1/8,000, or 1/16,000 second.

With VINIT high (5V), the CCD keeps discharging. With a negative pulse to VINIT, the camera resets and purges the charge momentarily. Then it starts integrating for the period of shutter control set by either an external pulse width or internal shutter control. Progressive scanning permits a full 1000 lines of vertical resolution, as compared to a conventional CCD camera which captures only half the vertical lines per shutter.

- **Asynchronous reset**

The TM-1020 series captures async reset images and provides single-shot video output with single FDV. This makes it simpler for an ordinary frame grabber to capture the async reset images. The TM-1020 series's asynchronous reset is flexible and accepts external horizontal drive (HD) for phase locking. When the VINIT (5V) pulse is applied, it resets the camera's scanning and purging of the CCD.

The TM-1020A-15 has two modes to control the asynchronous reset and shutter speed:

- **External VINIT with pulse width.** The duration between pulse edges controls the shutter speed externally (No-delay shutter).
- **Internal shutter speed control.** The speed control varies from 1/125 to 1/16,000 sec. The video signal and FDV starts with internal V reset timing related to shutter speed.

The TM-1020-15 has three modes to control the asynchronous reset and shutter speed:

- **External VINIT with pulse width.** The duration between pulse edges controls the shutter speed externally.
- **Internal shutter speed with Fast mode.** The video signal has no delay from the reset timing. (shutter speed range is 1/2,000 to 1/16,000 sec.)



- **Internal shutter speed with Slow mode.** The speed control varies from 1/125 to 1/1,000 sec. The video signal starts with internal V reset timing related to shutter speed.

- **Output**

The TM-1020 series has an 8-bit RS-644 digital output for interfacing with external image-processing systems (TM-1020-15 is RS-422 only) with RS-644 digital output available as an option. Camera Link models are designated by the letters “CL” at the end of the camera name. Please contact your JAI, Inc. representative for details on these options and models. The analog output is 1.0 Vp-p composite video (75Ω) on all models.

- **Integration**

The TM-1020 series is capable of capturing high-resolution integration images. Its CCD imager can be exposed for longer than the normal scan timing of 1/15 sec. This integration feature provides extra sensitivity for applications in dark environments. The progressive scan imager permits a full frame of resolution in non-interlace format. Integration is achieved by pulling pin #11 of the 12-pin connector to low (GND) for the frames to be integrated.

- **Warranty**

The CCD solid-state image sensor allows the camera to maintain a superior performance level indefinitely while requiring virtually no maintenance. JAI, Inc. backs all of the TM-series cameras with a three-year warranty in the U.S., and a one-year warranty elsewhere.

**Warning: Unscrewing the camera cover or opening the camera in any way will void this warranty unless prior written approval is obtained from the factory.**

### 1.3 Functional Option

- RS-644 (LVDS/RS-422) output.

### 1.4 System Configuration

FIGURE 1. TM-1020 Series System Configuration

Figure 1 below presents a typical system configuration for the LVDS/RS-422 version.

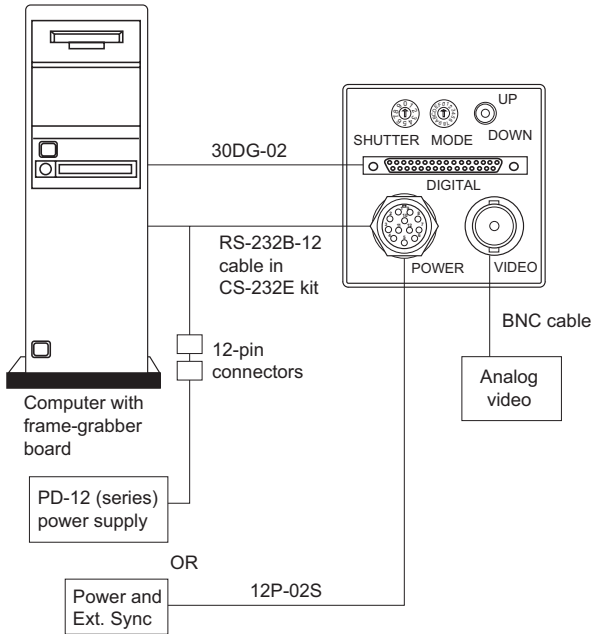
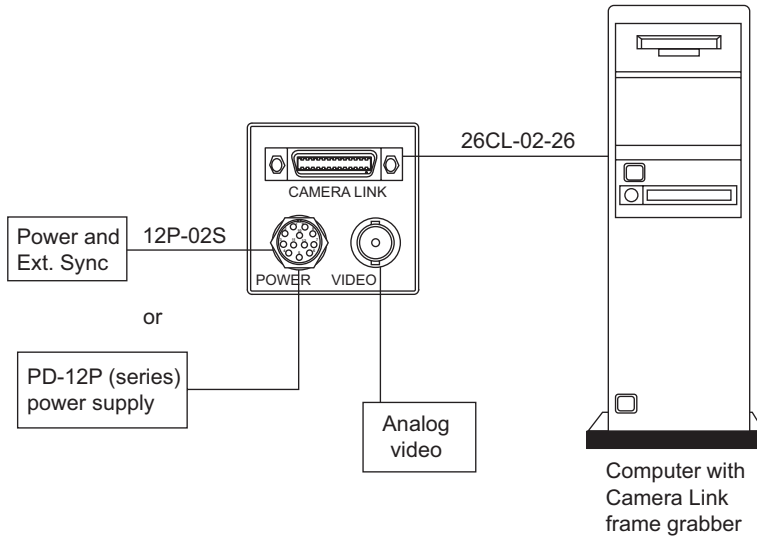


FIGURE 2. CL (Camera Link) System Configuration

Figure 2 below presents a typical system configuration for the Camera Link version.



## 2 Installation

The following instructions are provided to help you to set up your camera quickly and easily. We suggest that you read through these instructions before you unpack and set up your camera system.

### 2.1 Getting Started

#### 2.1.1 Unpacking Instructions

We recommend that you save the original packing cartons for the cameras and accessories in case you need to return or exchange an item.

We also recommend that you bench-test any equipment being sent to another location for field installation to assure that everything is fully operational as a system.

#### 2.1.2 Components List

Please begin by checking your order against the Components List shown below to assure that you have received everything as ordered, and that nothing has been overlooked in the packing materials. If any item is missing, please contact your JAI, Inc. representative immediately.

- TM-1020 series camera
- Camera-specific data sheet
- Camera-appropriate operation manual (if ordered)

#### 2.1.3 Accessories and Options

Following is a list of additional accessories and options that may be required for your application. Please check with your JAI, Inc. representative before you install your camera to determine what you might need.

- Digital output cable 30DG-02
- Serial Communication Kit CS-232E
- PD-12U series power supply
- 12P-02S power cable
- 26CL-02-26 Camera Link cable (for TM-1020 Camera Link models)

### 2.2 Camera Setup

#### 2.2.1 Heat Dissipation

The TM-1020 series camera from JAI, Inc., is a compact 1K by 1K camera. Since all the electronics have been packed in a compact package, the outer case of the camera gets hot due to heat dissipation.

For optimal performance, JAI, Inc. recommends using a cooling fan to set up a positive air flow around the camera and following the precautions below.

- Mount the camera on a large heat sink (camera bracket) made out of conductive material like aluminum.
- Make sure the flow of heat from the camera case to the bracket is not blocked by a non-conductive material like plastic.
- Make sure the camera has enough open space around it to facilitate the free flow of air.

Please contact JAI, Inc. at (800) 445-5444 or send an email to [imaging@jai.com](mailto:imaging@jai.com) if you have any questions.

## 2.2.2 Connector Pin Configurations

### 2.2.2 (a) 12-Pin Connector (LVDS/RS-422 version)

The TM-1020 series has a 12-pin Hirose connector for power input, serial communication, and signal integration. Pin #1 is Ground and Pin #2 is +12V DC. Other pins handle a number of input and output functions, as shown in Table 1 below.

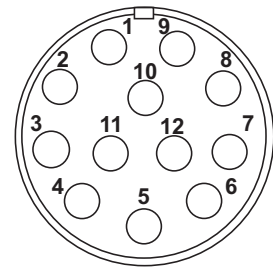


TABLE 1. 12-Pin Connector (LVDS/RS-422 version)

Pin	Description	Pin	Description
1	GND (power)	7	VD In
2	+12V DC	8	Strobe Out
3	GND (analog)	9	HD In
4	Video Out	10	RXD (RS-232)
5	GND (digital)	11	Integration Control
6	VINIT In	12	TXD (RS-232)

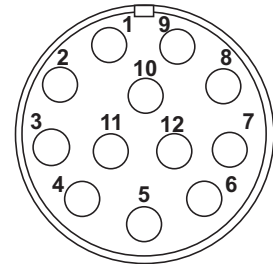


### 2.2.2 (b) 12-Pin Connector (Camera Link Version)

The CL versions have a 12-pin Hirose connector for power input and signal integration. Pin #1 is Ground and pin #12 is +12V DC. The pin-out table is shown below. For TM-1020-15CL, serial communication camera control is done via the Camera Link connector on the rear panel of the camera.

**TABLE 2. 12-Pin Connector (CL Version)**

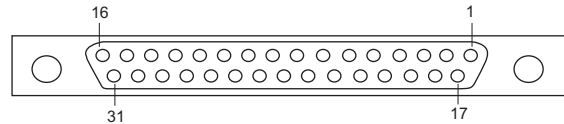
Pin	Description	Pin	Description
1	GND	7	VD in
2	+12V DC	8	Strobe out
3	GND (analog)	9	HD in
4	Video out	10	N/C
5	GND (digital)	11	Integration Control
6	VINIT in	12	N/C



### 2.2.2 (c) Digital Output Connector (LVDS/RS-422 only)

The LVDS/RS-422 version has a 31-pin AirBorn connector (MP211-031-113-4300) on the rear panel to output 8-bit, RS-644 video data. The TM-1020-15 is 8-bit, RS-422 video data. The connector pin-out is shown in the figure below.

**FIGURE 3. Rear Panel View of Digital Connector**

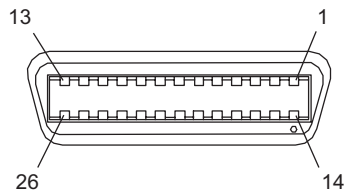


**TABLE 3. 31-Pin Connector (MP211-031-113-4300)<sup>1</sup>**

Pin#	Description	I/O	Pin #	Description	I/O
1	CLK+	Out	17	CLK-	Out
2	LDV+	Out	18	LDV-	Out
3	FDV+	Out	19	FDV-	Out
4	GND		20	VINIT [INTEG	In In]
5	EXT HD (TTL) [EXT CLK+	In In]	21	[EXT VD (TTL) [EXT CLK-	In In]
6	INTEG [HD+	In In]	22	N/C [HD-	In]
7	N/C [Vinit+/(VD+)	In	23	GND [Vinit-/(VD-)	In]
8	D0+	Out	24	D0-	Out
9	D1+	Out	25	D1-	Out
10	D2+	Out	26	D2-	Out
11	D3+	Out	27	D3-	Out
12	D4+	Out	28	D4-	Out
13	D5+	Out	29	D5-	Out
14	D6+	Out	30	D6-	Out
15	D7+	Out	31	D7-	Out
16	GND				

1. Note: CLK: data clock; LDV: Line Data Valid; FDV: Frame Data Valid; INTEG: Integration control; EXT CLK: External pixel clock; [ ]: Differential input option.

The CL version has a 26-pin connector on the rear panel to output Camera Link data. The connector pin-out is shown in Table 4 on page 9.



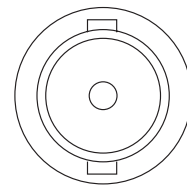
**TABLE 4. Connector and Pin-out Configurations**

Camera Link Connector					
Pin #	Description	I/O	Pin #	Description	I/O
1	GND		14	GND	(Shield)
2	Tx OUT 0-	Out	15	Tx OUT 0+	Out
3	Tx OUT 1-	Out	16	Tx OUT 1+	Out
4	Tx OUT 2-	Out	17	Tx OUT 2+	Out
5	Tx CLK OUT -	Out	18	Tx CLK OUT+	Out
6	Tx OUT 3-	Out	19	Tx OUT 3+	Out
7	SerTC+	In	20	SerTC-	In (LVDS/RS-422 or RS-232)
8	SerTFG-	Out	21	SerTFG+	Out
9	VINIT-	In	22	VINIT+	In
10	INTEG+	In	23	INTEG-	In
11	N/C		24	N/C	
12	N/C		25	N/C	
13	GND		26	GND	

*Note:* SerTC: Serial To Camera  
SerTFG: Serial to Frame Grabber

### 2.2.2 (d) Analog Output Connector

The TM-1020 series has a BNC connector on the rear panel to output analog video data. See Section 6.1, “Specifications,” on page 38 for additional information on analog video output.



**2.2.3 Shutter Speed Control Dial (LVDS/RS-422 version)**

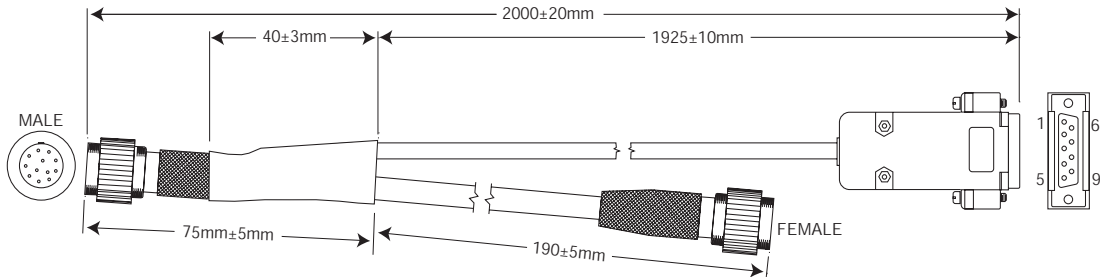
Shutter speed can be selected by switching the shutter dial to the appropriate setting (0 through 9). The factory default settings correspond to the shutter speeds as shown in Table 5 below.

**TABLE 5. Shutter Speed Control Dial**

	Manual	Async
0	no shutter	no shutter
1	1/60	1/16,000
2	1/125	1/8,000
3	1/250	1/4,000
4	1/500	1/2,000
5	1/1000	1/1,000
6	1/2,000	1/500
7	1/4,000	1/250
8	1/8,000	1/125
9	1/16,000	Ext. pulse-width control

**2.2.4 RS-232 Communication Cable (LVDS/RS-422 version)**

**FIGURE 4. Serial Communication Cable RS-232B-12**



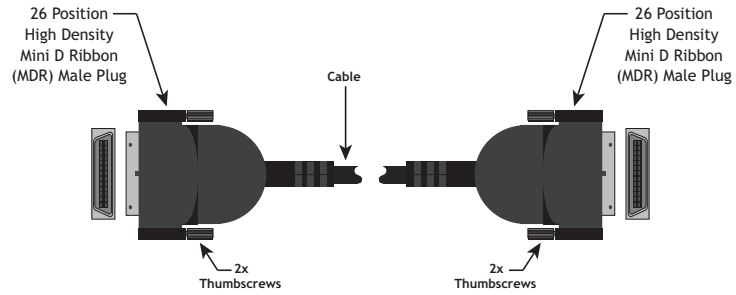
The RS-232 controller set CS-232E includes the RS-232B-12 interface cable, software disk, and a quick-start card. The TM-1020 (RS-422 and LVDS/RS-422 version) camera's built-in look-up table (LUT) can be controlled by an external RS-232 interface. The camera settings can be programmed or changed using the communication cable and software. Commands from the RS-232 interface will overwrite the rear panel switch settings of the camera. Please refer to the AccuPiXEL Series Camera-Control Software manual for details on the graphical user interface.



### 2.2.6 Camera Link Cable (CL Versions Only)

The Camera Link cable has a 26-pin connector on both ends. This is a straight-through cable and the pin-out configuration is shown in Table 4 on page 9. Contact JAI, Inc. for cable lengths other than 2 meters.

FIGURE 7. Camera Link Cable



**Note:** For CL versions, serial communication for camera control is done via the Camera Link connector on the rear panel of the camera.

## 2.2.7 Power Supplies and Power Cable Setup

### 2.2.7 (a) Power Supplies

The TM-1020 series camera requires 12V DC power that is obtained through the 12-pin connector located on the rear panel of the camera. JAI, Inc. recommends the following power supplies:

PD-12UU	100-240V AC/12V DC (No 12-pin connector)	1.2A universal voltage power supply, US Plug
PD-12UUP	PD-12UU with 12-pin connector	US plug
PD-12UE	PD-12UU (No 12-pin connector)	European plug
PD-12UEP	PD-12UU with 12-pin connector	European plug

For users providing power through the 12-pin connector, the PD-12P, PD-12UEP and PD-12UUP power supplies are available with the 12-pin mating connector already attached to the leads from the power supply. The PD-12UU and PD-12UE power supplies can be connected to the JAI, Inc. power cable via a terminal strip or directly.

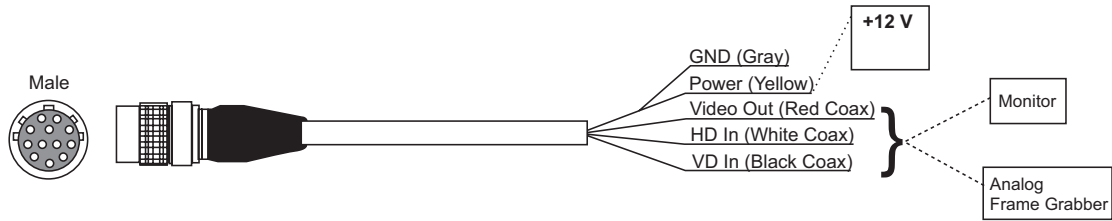
When wiring the PD-12UU and PD-12UE power supplies directly, please note the following:

- The lead ends must be twisted together and tin-soldered for strength and electrical continuity.
- Shrink tubing or a similar insulator should be used to prevent exposed leads from touching and shorting.
- The +12V lead is marked with a red stripe or white lettering; be sure not to reverse the leads.
- All connections must be properly insulated to prevent shorting.

### 2.2.7 (b) JAI, Inc. Power Cables

If you are using JAI, Inc. power cables such as the 12P-02S, please refer to the 12-pin connector pin-out diagram in “12-Pin Connector (LVDS/RS-422 version)” on page 6. The cable pin-out diagram is shown in Figure 8 below. The color-coded leads use Gray for Ground and Yellow for +12V.

FIGURE 8. 12P-02S Interface Cable (optional)



12P-02S Interface Cable					
Pin#	Lead Color	Function	Pin#	Lead Color	Function
1	Gray	GND	7	Black coax	VD Input
2	Yellow	+12V DC	8	White coax shield	Strobe out
3	Red coax shield	GND	9	White coax	HD Input
4	Red coax	Video Out	10	Brown	RXD (RS-232)
5	Orange coax shield	GND	11	Blue	Integration
6	Orange coax	VINIT IN	12	Black coax shield	TXD (RS-232)

**Note:** Make sure that the unused leads are not touching and that there is no possibility that exposed wires could cause the leads to short.

**2.2.7 (c) Building Your Own Power Cable**

Refer to the 12-pin connector pin-out in Section 2.2.2 (a on page 6. Connect the Ground lead to pin #1, and the +12V DC lead to pin #2 of the 12-pin connector. Power must be DC-regulated, and of sufficient current to properly power the camera.

**2.2.7 (d) Attaching the Power Cable to the Connector**

The 12-pin connector is keyed and will only fit in one orientation. Follow these directions to properly attach the power cable to the camera connector:

1. Rotate the connector while applying slight pressure until the keyways line up.
2. Press the connector into place until firmly seated.
3. Plug the power cord into the 100V AC socket. This will power the camera up.

**2.2.8 Attaching the Analog Video Output**

When connecting the TM-1020 series to an analog frame grabber or a monitor, use the BNC connector on the rear panel of the camera. The input of the monitor should be balanced for 75Ω termination. Standard RG-59 type coaxial cable should carry a full video signal for up to 500 feet. These monitors are specially modified to accept a 30Hz progressive scan image.

The multi-conductor cable 12P-02S from JAI, Inc. can be used to transmit analog video, power, sync. signals, and serial communication. The mini coaxial leads in JAI, Inc. multi-conductor cables are designed for short runs of no longer than 100 feet.





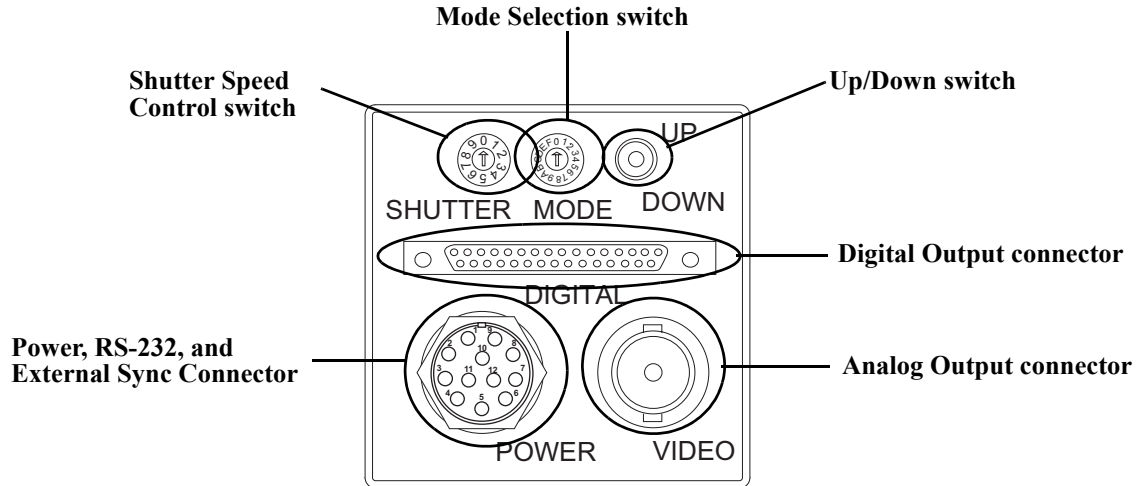
*Note: Make sure that no extraneous wires are visible which could cause a short.*

### **2.2.9 Attaching the Camera Lens**

The TM-1020 series camera accepts 1" or larger format size C-mount lenses. To attach the C-mount lens to the camera, carefully engage the threads and rotate the lens clockwise until it firmly seats on the mounting ring. Do not force the lens if it does not seat properly. Please note that some lenses with extremely long flangebacks may exceed the mounting depth of the camera.

## 3 Operation

### 3.1 Camera Rear Panel (LVDS/RS-422 Version)



#### 3.1.1 Up/Down Switch

The Mode Selection switch works in conjunction with the Up/Down switch. Refer to Table 6 above for information on the Up/Down switch.

#### 3.1.2 Digital Output Connector

Refer to Section 2.2.5 on page 11 for information on the digital output connector.

#### 3.1.3 Analog Output Connector

The LVDS-version cameras has a BNC connector on the rear panel to output analog video data.

#### 3.1.4 Power, RS-232, and External Sync Connector

Refer to Section 2.2.2 (a) on page 6 for information on the power, RS-232, and external sync connector.

#### 3.1.5 Shutter Speed Control Switch

Please refer to Section 2.2.3 on page 10 for information on the Shutter Speed Control dial. The factory default settings correspond to the shutter speeds as shown in Table 5 on page 10.

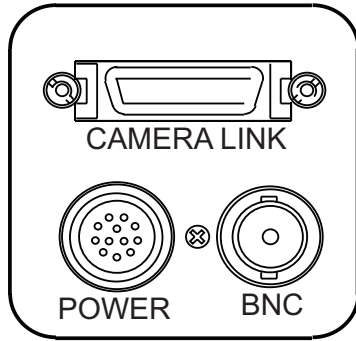
### 3.1.6 Mode Selection Switch

Various modes can be implemented with the rear panel Mode Selection switch. The Mode Selection switch works in conjunction with the Up/Down switch and RS-232 external control. Commands from the RS-232 interface will over-write the rear panel switch settings of the camera. The table below shows details on various modes.

**TABLE 6. Mode Selection Switch**

<b>Mode Selection Switch Position</b>	<b>Mode Information</b>	<b>Up/Down Switch</b>	<b>Functions</b>
0	Normal Mode	Display Mode (D)	
1	Set Gain	Up/Down	Change gain
2	Set Vtop (A/D)	Up/Down	Change A/D ref. top
3	Set Vbottom(A/D)	Up/Down	Change A/D ref. bottom
4	Gain Selection #1	Up: 9dB, Down: 12dB	Lower gain selection
5	Gain Selection #2	Up: 18dB, Down: 22dB	Higher gain selection
6	Linear LUT	Up: Linear, Down: LUT	Linear/LUT selection
7	Knee Selection	Up/Down (Scroll)	Scroll 10 different LUTs
8	Async Reset Mode	Up: Normal, Down: Async	Async and normal shutter
9	Factory default Recall	Up/Down: Recall	Factory setting
A	Power up Setting	Up: Recall, Down: Save	Power up page setting
B	User Page Storage #1	Up: Recall, Down: Save	User page storage setting
C	User Page Storage #2	Up: Recall, Down: Save	User page storage setting
D	Direct Shutter Control	Up/Down	Shutter speed increment by 1H
E	Scan Format2	Up: Optional, Down: Binning	Two-row binning selection
F	Scan Format1	Up: Normal, Down: Normal	Custom option scanning

### 3.2 Camera Rear Panel (CL Versions)



#### 3.2.1 Digital Output Connector

Refer to Section 2.2.6 on page 12 for information on digital output connectors.

#### 3.2.2 Analog Output Connector

The CL-version camera has a BNC connector on the rear panel to output analog video data.

#### 3.2.3 Power and External Sync Connector

Refer to Section 2.2.2 (b) on page 7 for information on the power and external sync. connectors.

### 3.3 Progressive Scanning

Standard TV-system scanning is 525 lines interlace scanning as specified in the RS-170 protocol. Every other horizontal line (odd lines and even lines) is scanned at a 60Hz rate per field, and the scanning is completed with two fields (one frame) at 30Hz rate. Because of the interlace scanning, the vertical resolution of CCD cameras is limited at 350 TV lines, regardless of the horizontal resolution. When electronic shutter is applied, the CCD can hold only one field of charge at each exposure. Therefore, the vertical resolution of the electronic-shutter camera is only 244 TV lines. The situation is the same for an HDTV-format camera, since it has interlaced scanning and the vertical resolution of the shuttered image is 500 lines.

The TM-1020 series uses a state-of-the-art progressive scanning interline transfer CCD which scans all lines sequentially from top to bottom at one frame rate. Like a non-interlace computer screen, it generates a stable, crisp image without alternating lines and provides full vertical TV resolution of 1000 lines (a normal TV monitor display may not be able to show 1000 lines due to monitor resolution of 30Hz scanning).

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

The TM-1020 series outputs the progressive-scanned image with an electronic shutter in two different formats:

1. Progressive-scanning digital and analog output

The CCD signal goes through A/D and D/A converters and through 10-bit in, 8-bit out look-up table (LUT).

The analog output is the same as 75 $\Omega$ , 1Vp-p format available from BNC and 12-pin connector. The digital output is available from 31-pin connector (RS-422 or RS-644) or Camera Link connector.

2. Double-speed scanning output (display output)

By selection, the two-row binning mode puts double-speed video for monitor display. It repeats twice from one frame of input video. Refer to Section 3.8 on page 27 for information on scan modes.

### 3.4 Electronic Shutter

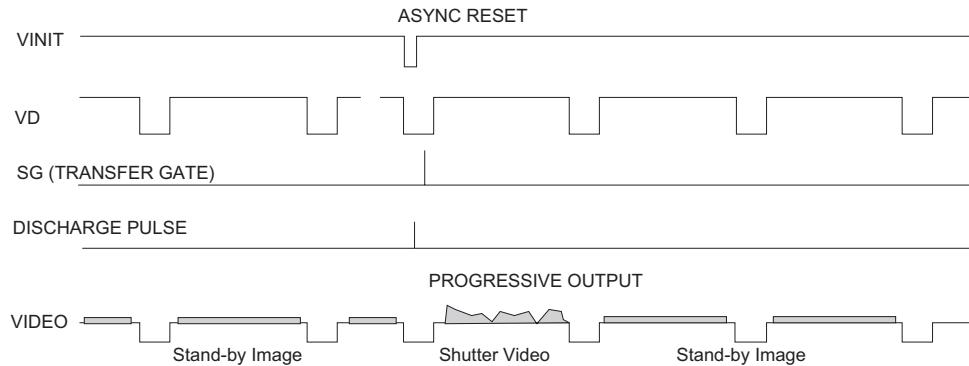
The TM-1020 series has a substrate drain-type shutter mechanism which provides a superb picture at various speeds without smearing. A built-in manual shutter speed control selects the electronic shutter rate of 1/60 (non-async mode only), 1/125, 1/250, 1/500, 1/1,000, 1/2,000, 1/4,000, 1/8,000, or 1/16,000 second.

With VINIT high (5V), the CCD keeps discharging. With a negative pulse to VINIT, the camera resets and purges the charge momentarily. Then it starts integrating for the period of shutter control set by either an external pulse width or internal shutter control. Progressive scanning permits a full 1000 lines of vertical resolution, as compared to a conventional CCD camera which captures only half the vertical lines per shutter.

### 3.5 Integration

The CCD imager of the TM-1020 series can be exposed for longer than the normal scan timing of 1/15 sec. This integration feature provides extra sensitivity for dark-environment applications. The progressive-scan imager permits a full frame of resolution in non-interlace format. Integration is achieved by controlling the #11 pin of the 12-pin connector to low (GND) or providing pulse-width control up to 1/15 frames. Please refer to Figure 2.2.2 on page 6 for pin-out information on the 12-pin connector.

### 3.6 Asynchronous Reset



The TM-1020 series's asynchronous reset is flexible and accepts external horizontal drive (HD) for phase locking. When the VINIT pulse is applied, it resets the camera's scanning and purging of the CCD. For asynchronous image capturing by frame grabbers, it outputs single FDV at async reset. For the TM-1020-15 and -15CL versions, there are three modes to control the asynchronous reset and shutter speed:

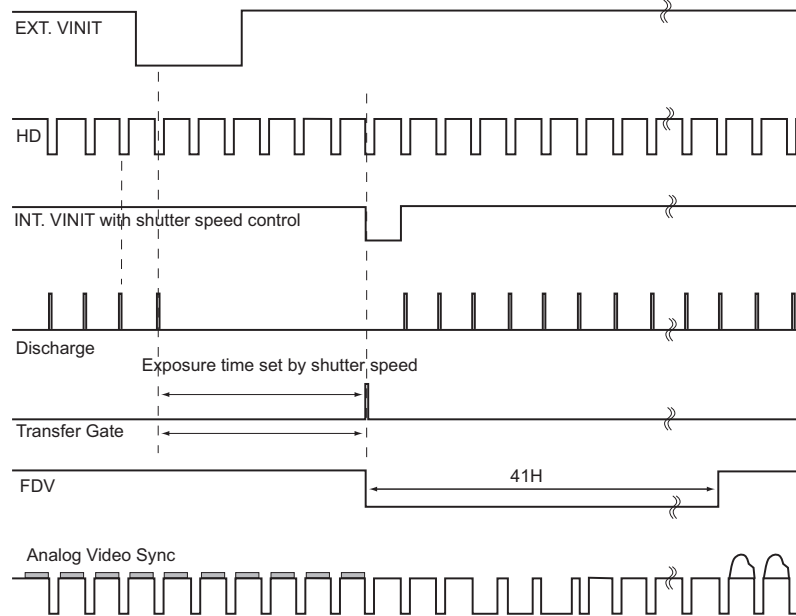
- Internal Shutter Speed with Fast Mode
- Internal Shutter Speed with Slow Mode
- External VINIT with Pulse Width

For the entire line of TM-1020 series cameras except the -15 and -15CL models, there are two modes to control the asynchronous reset and shutter speed:

- Internal Shutter Speed Control
- External VINIT with Pulse Width

### 3.6.1 Internal Shutter Speed Control (TM-1020 Series)

FIGURE 9. Internal Shutter Speed Control (TM-1020 Series)



The video signal starts with internal VINIT. The camera operates the reset and shutter in the same way as the external pulse width control mode. When the external VINIT pulse is applied, internal VINIT is latched to HD and the internal VINIT is delayed to set up the shutter speed period. The shutter speed is controlled by the dial switch from “1” to “8.” Video output timing starts right after the internal VINIT and single shots, FDV is output at the internal VINIT timing.

### 3.6.2 External VINIT With Pulse Width No-Delay Shutter and ROI (Read-Out Inhibit) (Except TM-1020-15 LVDS)

For multiple-camera applications such as 2D or 3D measurement and multi-angle inspection, simultaneous image capturing at an exact shutter timing for all cameras is critical requirement. The TM-1020 CL’s asynchronous pulse-width control mode provides no-delay shutter as standard. Regardless of the internal pulse timing, the camera discharges at the VINIT leading edge and transfers charges at the trailing edge of the pulse. Even though each camera runs with slightly different H and data clock timing, the image capturing is exactly simultaneous.

FIGURE 10. No-Delay Shutter

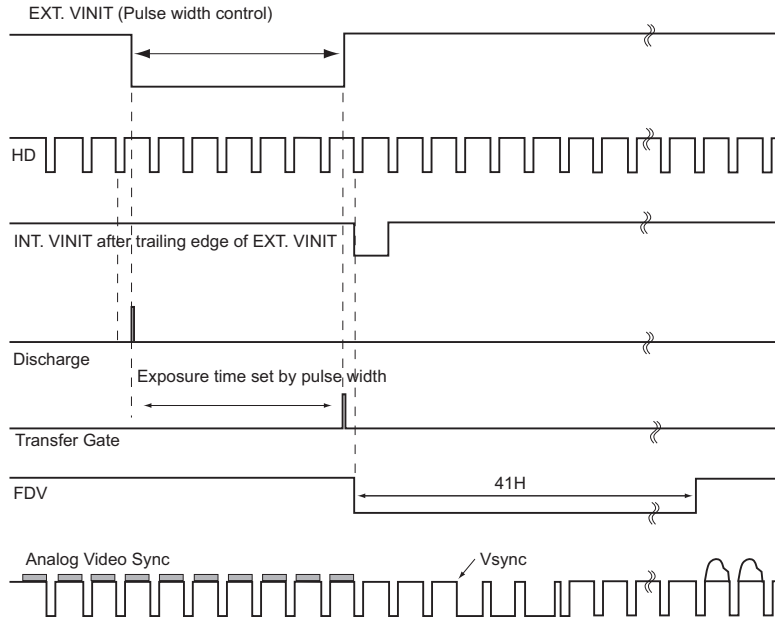
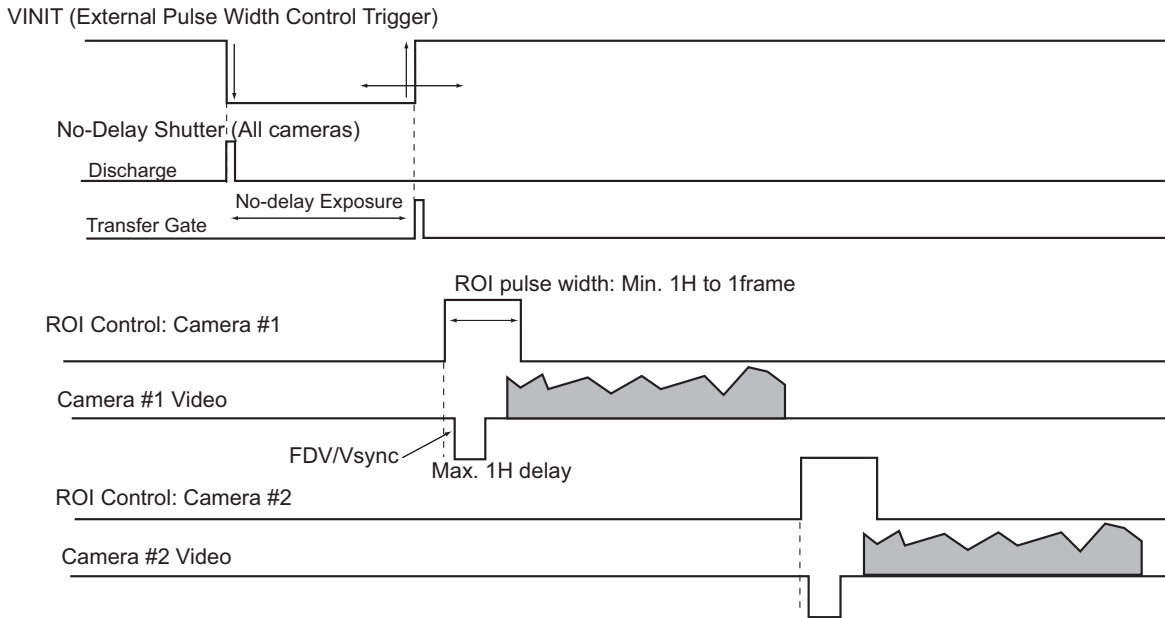


FIGURE 11. No-Delay Shutter and Read-Out Inhibit



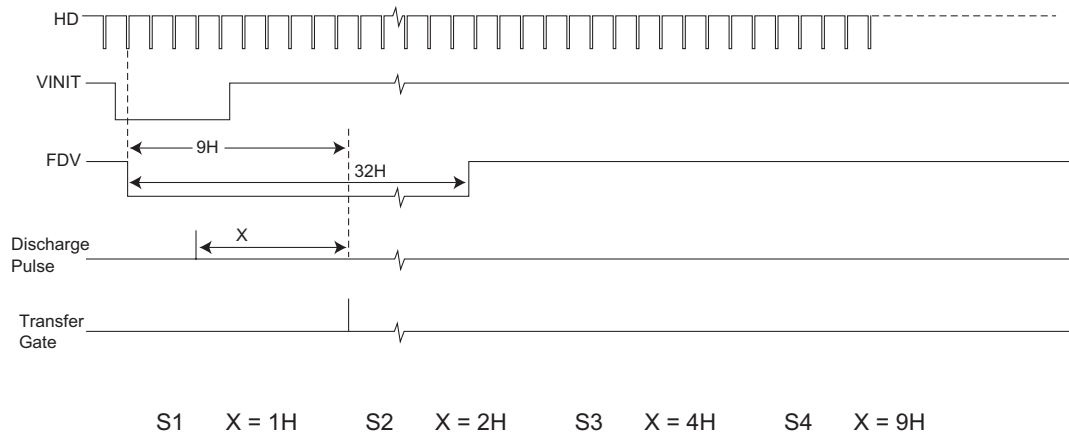
The TM-1020A series also has read-out-inhibit control (ROI) to control the vertical clock start (Async Shutter #9). When ROI is low, V-clock is stopped and the transferred charges remain in the vertical shift registers, which work like CCD memory. When the ROI is high, it clocks out the CCD data. This helps a single frame grabber process multiple images in pipeline processing (sequential process).



*Note: When the ROI function is not used, make sure that the INTEG/ROI inputs (#11 of 12-pin connector, #6 of the 31-pin connector, and #10 and #23 of the Camera Link connector) are kept open or logic high during Async. pulse width control mode.*

### 3.6.3 Internal Shutter Speed with Fast Mode (TM-1020-15 only)

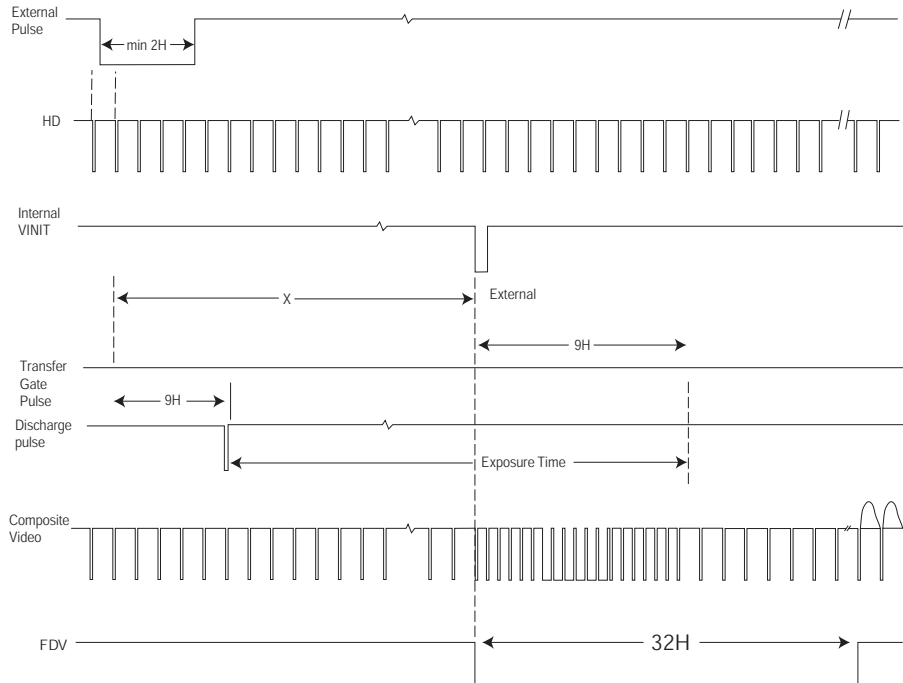
FIGURE 12. Internal Shutter Speed with Fast Mode (TM-1020-15 only)



The video signal has no delay from the reset timing. Shutter speed range is 1/2,400 to 1/31,000 sec. Select a dial switch setting from “1” to “4”. When the fast reset mode is selected, the camera resets with internal VINIT timing, which is latched to HD. Video output is also synchronized with internal VINIT timing without further delay. The shutter speed is controlled by the dial switch.

### 3.6.4 Internal Shutter Speed with Slow Mode (TM-1020-15 Only)

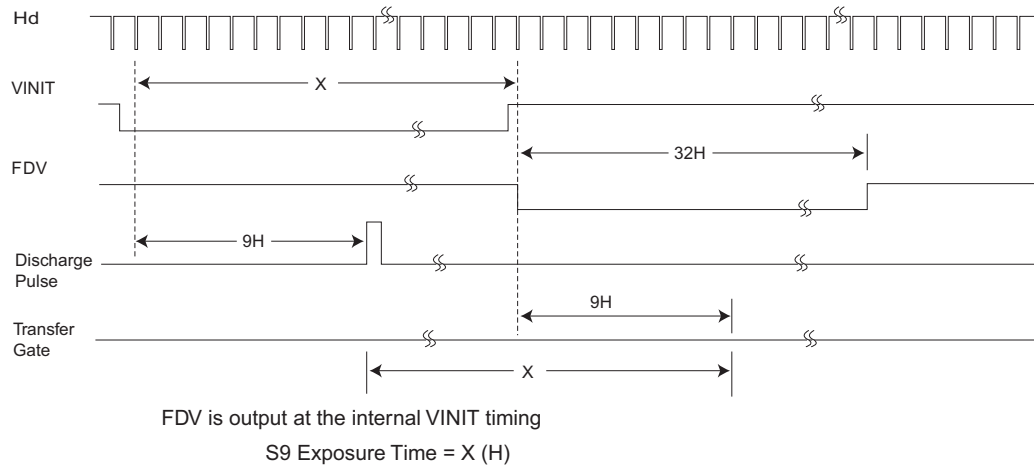
FIGURE 13. Internal Shutter Speed with Slow Mode (TM-1020-15 Only)



The speed control ranges from 1/120 to 1/950 sec. The video signal starts with internal VINIT. Select a dial switch setting from “1” to “4.” With the internal slow reset mode selected, the camera operates the reset and shutter in the same way as the external pulse width control mode. When the external VINIT pulse is applied, internal VINIT is latched to HD and the second internal VINIT signal is delayed to set up the shutter speed period. The shutter speed is controlled by the dial switch from “5” to “8.” Video output timing starts right after the internal VINIT. For the timing of the delayed internal reset, LPULSE output of the 51-pin connector can be used.

### 3.6.5 External VINIT with Pulse Width (TM-1020-15 Only)

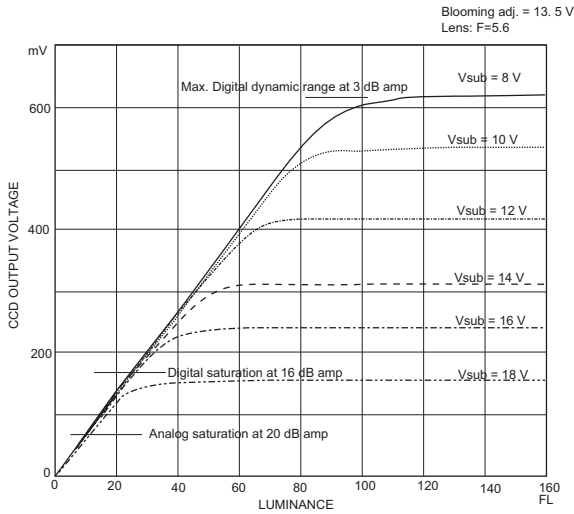
FIGURE 14. External VINIT with Pulse Width (TM-1020-15 Only)



The TM-1020 series can be reset with external reset pulse (VINIT). Set the dial switch to “9.” Apply a pulse-width control VINIT signal generated from an external event trigger to the camera. The internal reset pulse will be latched to HD and at the 9th HD timing from the external pulse leading edge (negative going edge). The CCD discharge pulse will be generated to clear the images. The internal VINIT will be generated at the following edge (positive going edge) of the external pulse, resetting the internal timing including the video sync. The shutter speed is the same as the external pulse width, but the integration delays 9H from the leading edge. For the immediate reset option, please contact JAI, Inc.

For the progressive format, one frame of video output will start from the rising edge of the pulse width control. When VINIT is kept high (5V), subsequent frames will contain black or invalid video until the next falling edge of Vinit triggers another frame.

### 3.7 Dynamic Range Control



The typical interline transfer CCD has fixed noise levels based on dark current (thermal or KT noise), pattern noise, and the operating clock speed. In general, the level of the 20 MHz pixel clock CCD at room temperature is around 20 to 50 electrons. The maximum capacity of CCD charges is limited by the well capacity at saturation. The range is limited by the structure and the pixel size.

The TM-1020 series uses a 1" CCD with  $9.0 \mu\text{m} \times 9.0 \mu\text{m}$  pixel and two-phase vertical shift register structure. The well capacity is 50,000 electrons. The theoretical dynamic range is  $50,000:30 = 1667:1$  (64 dB).

A typical CCD camera does not use the full dynamic range due to the nominal gain and the output specification such as RS-170. The typical CCD camera's gain is set at 16 to 22 dB and the RS-170 video level is 714 mV. Using 20 dB gain for the calculation, CCD output is limited to  $714/10 = 71.4 \text{ mV}$ . Since the CCD's saturation voltage is 400 mV to 500 mV, it uses less than 1/5 of the full dynamic range.

Machine vision and outdoor applications, cannot afford to miss image information behind the saturation, which is why the dynamic range adaptation is critical.

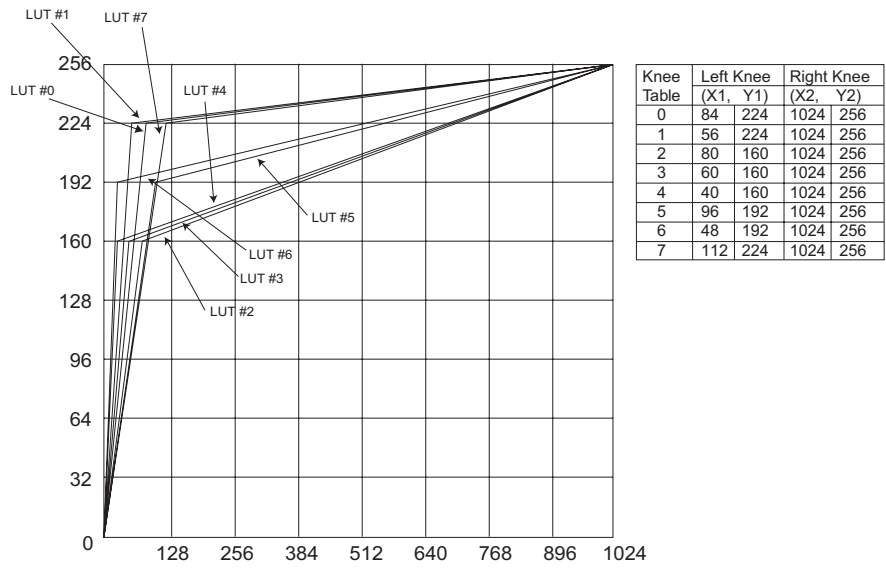
#### 3.7.1 Programmable Look-Up Table (LUT) and Knee Control

The TM-1020 series has a built-in LUT (look-up table) for dynamic range control.

At a specific gain setting, the offset (minimum level.... dark point) and A/D reference top voltage (maximum level... saturation point) are set to 10-bit A/D input so that the full dynamic range of the CCD is utilized at 10-bit references as the input and the LUT output is converted into 8-bit to adjust the gamma correction.

The look-up table has two knee points (variable gamma selection) that allow the 10-bit input to be segmented into three regions. The look-up table selection can be made either by variable knee curve or by direct input.

FIGURE 15. Look-Up Table

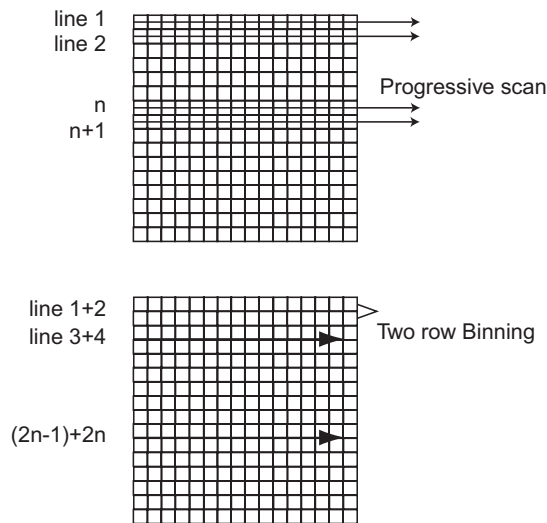


**Note:** The second knee point on the built-in LUT defaults to position (1024, 256). To reposition this point, click on it and drag it to a new location.

### 3.8 Scan Modes

The TM-1020 series supports the following scan modes:

FIGURE 16. Scan Modes



### 3.8.1 Full Progressive Scan

Normal scanning mode the TM-1020 series is for 1008 x 1018 pixels. The standard speed with single-channel output is 15 frame/sec at the pixel clock of 20 MHz. The progressive scan reads every line from top to bottom and, unique in an interlace-scan camera, all lines are obtained per image capturing with electronic shutter.

### 3.8.2 Two-Row Binning

This is a standard feature in the TM-1020 series. The camera scans two rows together and outputs 1008 (H) x 509 (V) pixels at 30 frames per second. Two-row binning is typically implemented to increase speed and to display real-time images on multi-sync monitors. When scan mode is changed from full progressive scan to two-row binning, then the camera settings will default to those in page 1 settings.

## 3.9 External Sync and Pixel Locking

The TM-1020 series accepts an external sync of standard HD and VD at TTL level for general locking to a system sync and clock. The external sync is not available in two-row binning and the frequency requirement is as follows:

15 Frame/Sec Models:

fHD = 15.734 KHz  $\pm$ 5%

fVD = 15.00 Hz  $\pm$  5%

(Internal Master clock = 40.00 MHz,  
Pixel clock = 20.00 MHz)

30 Frame/Sec Models:

fHD = 31.47 KHz  $\pm$ 5%

fVD = 30.00 Hz  $\pm$  5%

(Internal Master clock = 80.00 MHz,  
Pixel clock = 40.00 MHz)



### 3.10 Camera Timing Charts

Model: TM-1020-15

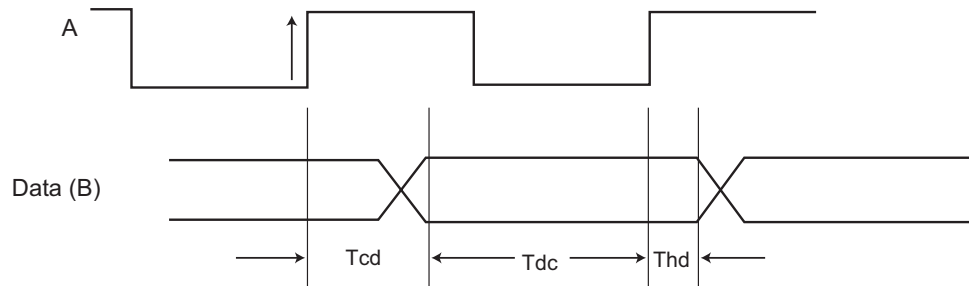
Operation Mode: 15 fps

Master Clock: 40.0 MHz, M= 25 nsec

Pixel Clock: 20.0 MHz, P= 50 nsec

#### 1. Pixel Clock and Digital Data

Pixel Clock

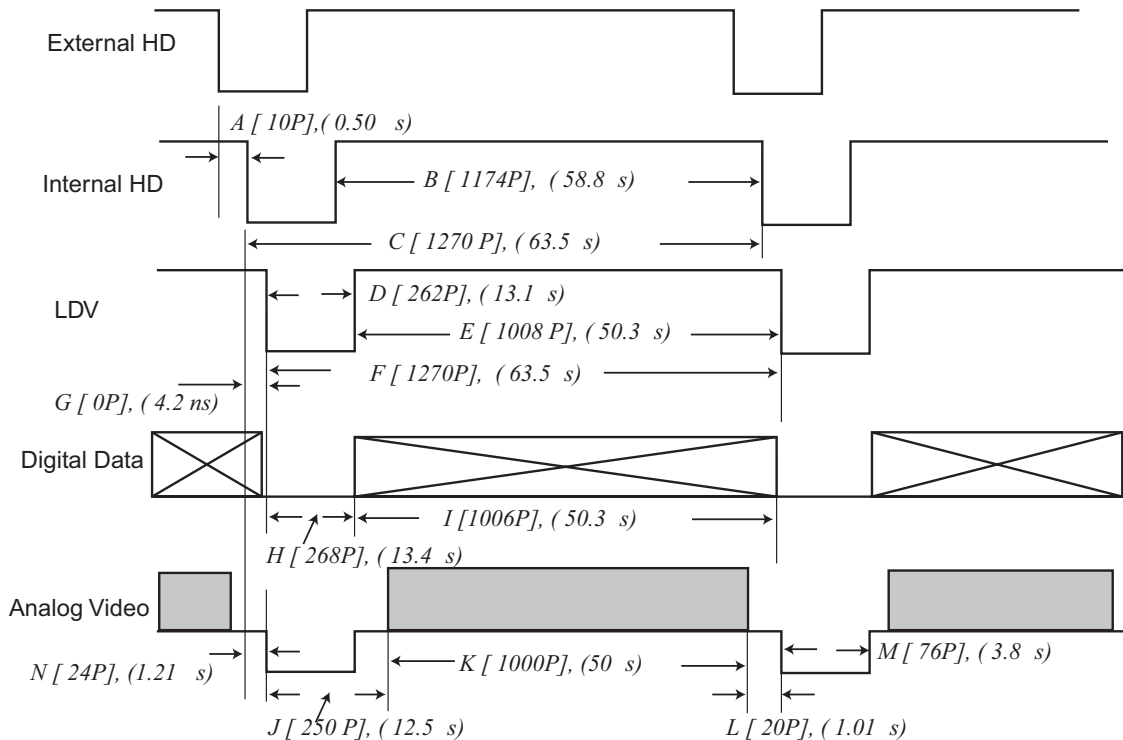


Tcd: Clock to Data Ready  
 Tdc: Data Ready to Next Clock  
 Thd: Data Hold Time

Tcd = 19.00 nsec, Tdc = 31.00 nsec, Thd = 11.00 nsec.

#### 2. Horizontal Signals

fHD = [ 15.75 KHz]  
 tHD = [ 63.50 sec]



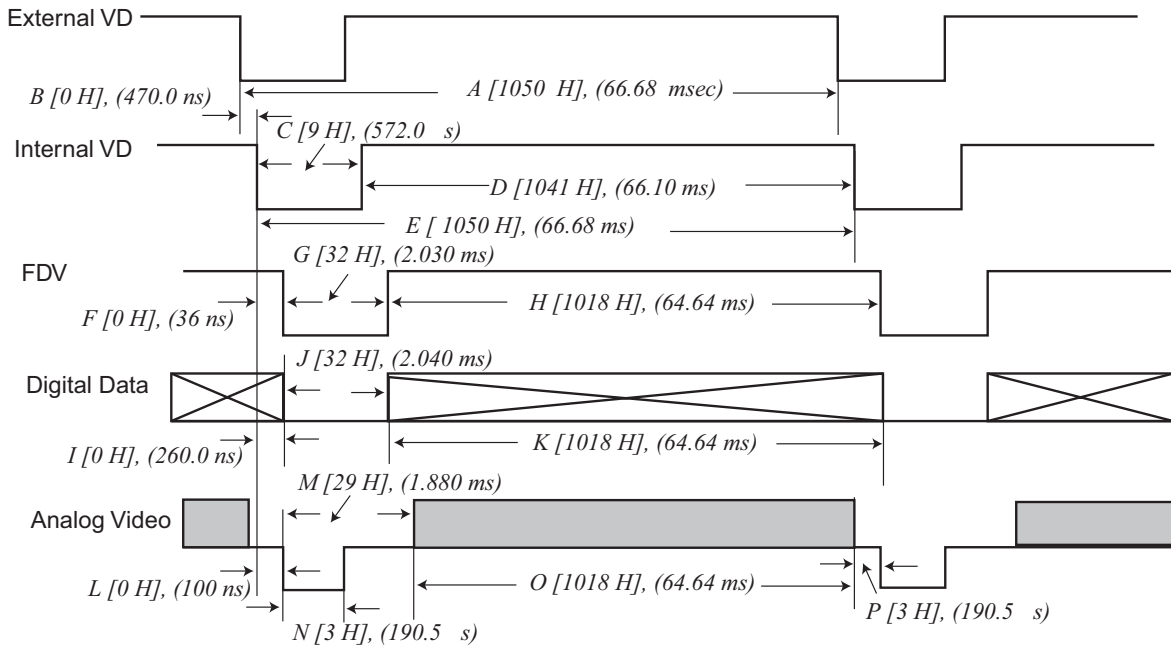
Model: TM-1020

Operation Mode: 15 Frames/Second

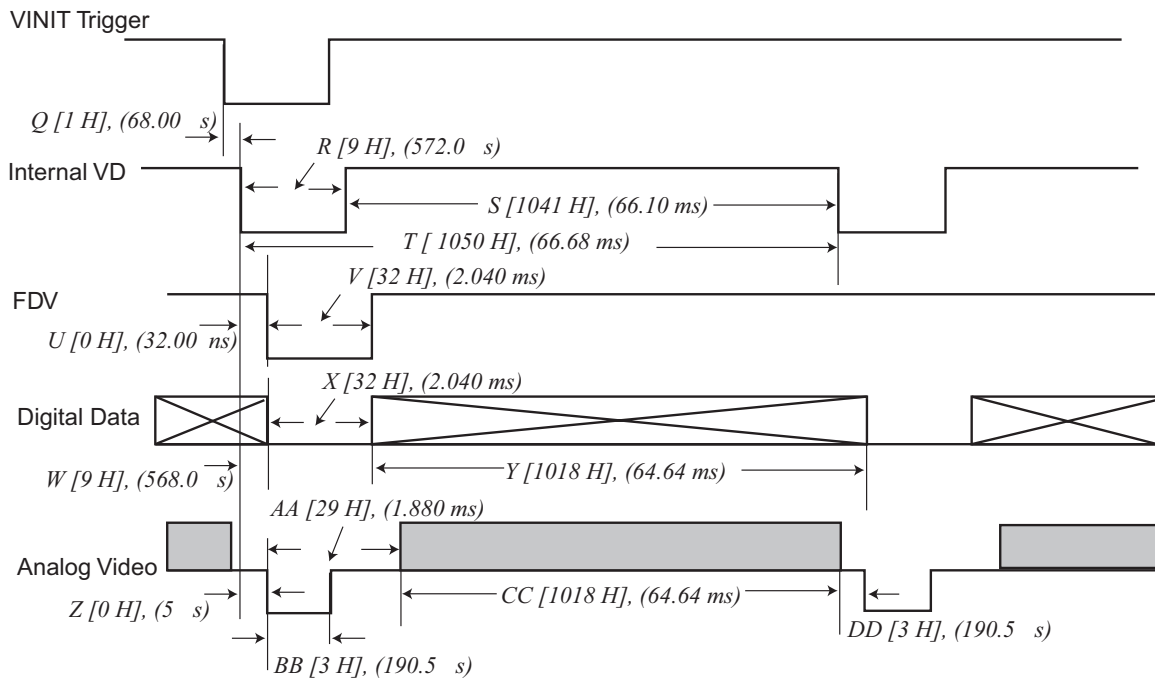
Master Clock: 40 MHz, M= 25 nsec  
 Pixel Clock: 20 MHz, P = 50 nsec

Horizontal Frequency: 15.748 KHz  
 1H = 63.50 sec

### 3. External Reset Timing



### 4. Async Reset Timing





Model: TM-1020-30

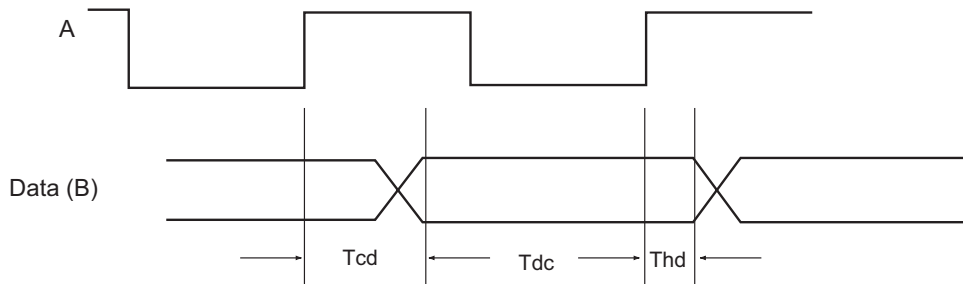
Operation Mode: 30 fps

Master Clock: 80.0 MHz, M= 12.5 nsec

Pixel Clock: 40.0 MHz, P= 25 nsec

1. Pixel Clock and Digital Data

Pixel Clock

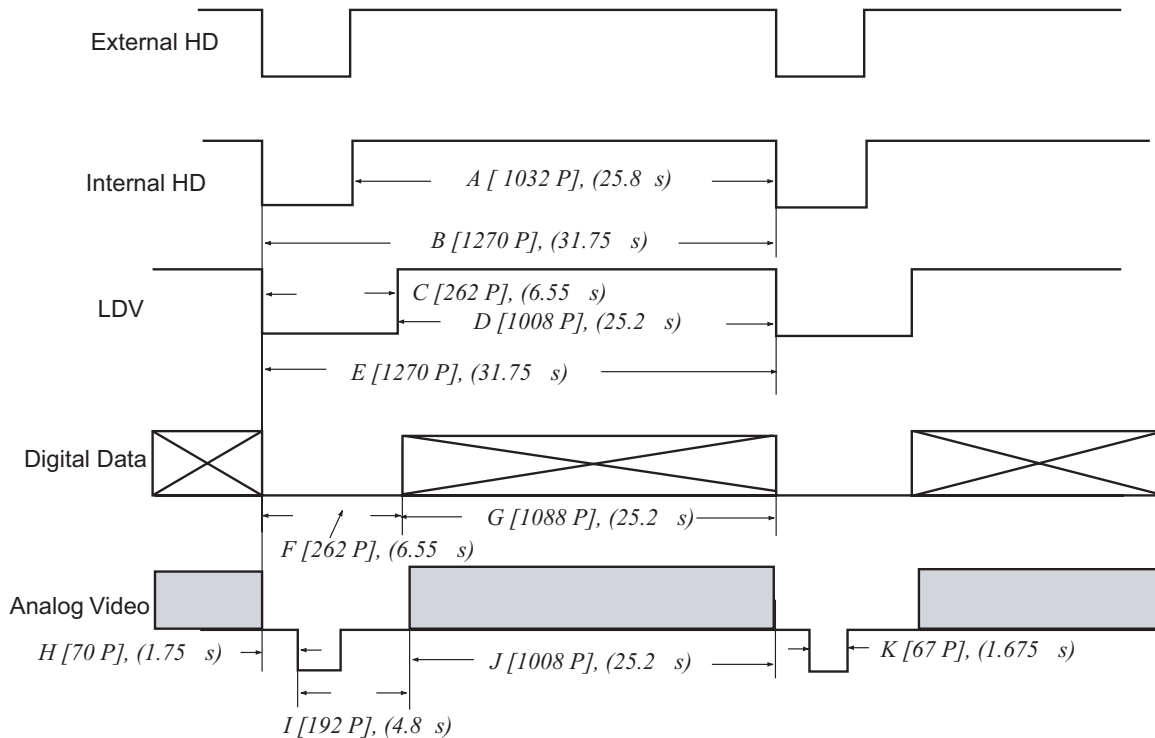


Tcd: Clock to Data Ready  
 Tdc: Data Ready to Next Clock  
 Thd: Data Hold Time

Tcd = 9.0 nsec, Tdc = 16.0 nsec, Thd = 6.00 nsec.

2. Horizontal Signals

fHD = [ 31.50 KHz]  
 tHD = [ 31.75 sec]



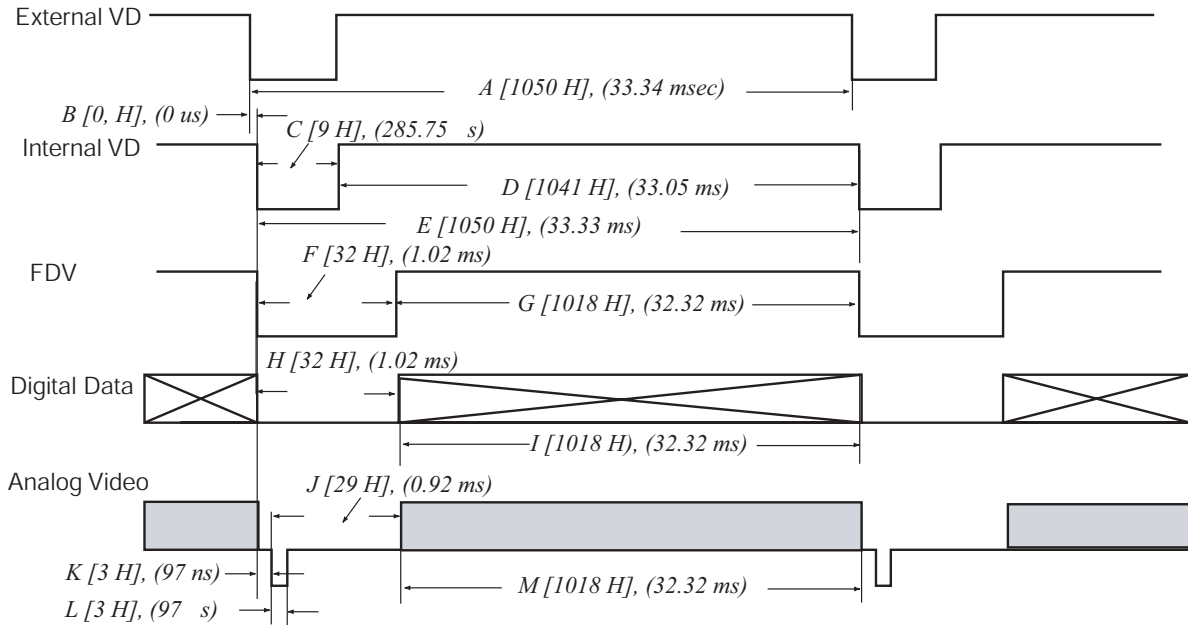
Model: TM-1020-30

Operation Mode: 30 Frames/Second

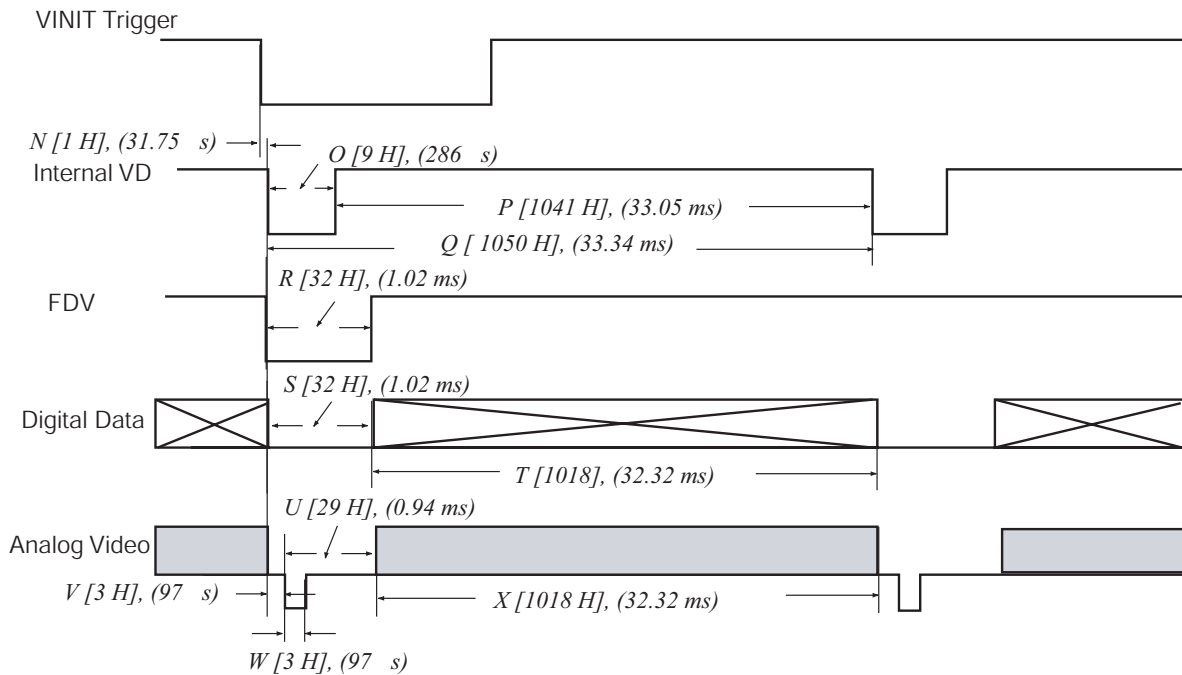
Master Clock: 80 MHz, M= 12.5 nsec  
 Pixel Clock: 40 MHz, P = 25 nsec

Horizontal Frequency: 31.50 KHz  
 1H = 31.75 sec

3. External Reset Timing



4. Async Shutter 0 Reset Timing



### 3.11 Serial Communication Kit

- **LVDS/RS-422 Version** The LVDS/RS-422 version's functions can be controlled by a PC via RS-232C communication using the CS-232E serial communication kit. This kit consists of the RS-232B-12 cable, software disk, and quick-start card. The software disk contains setup files for the graphical user interface (GUI) program. Please refer to the AccuPiXEL Series Camera-Control Software manual for information on the GUI.
- **Camera Link** The Camera Link version's control software is also included in the AccuPiXEL Camera Control software.

## 4 LVDS-Version Camera RS-232 Commands

The LVDS-version camera can be controlled via RS-232 commands. The Start character is always “.” and the end character is always “CR” (return). For example, to set Asynchronous Pulse Width Mode, send the command :SA9”CR” to the camera. The following table contains RS-232 commands that can be used to control the camera.

**TABLE 7. RS-232 Command List**

	<b>First Character</b>	<b>Second Character</b>	<b>Third Character</b>	<b>Response</b>	<b>Functions</b>
<b>1</b>	“S” (shutter)	“M” (Manual)	“0” - “9” Mode	ACK	Manual Shutter Mode
		“A” (ASYNC)	“0” - “8” Mode	ACK	Async Shutter Mode
			“9” (Pulse Width Mode)	ACK	Async Pulse Width Mode
<b>2</b>	“G” (Gain)	“M”	“00” - “FF”	ACK	Gain Control
<b>3</b>	“V” (A/D Vref)	“T” (Top)	“00” - “FF”	ACK	Vtop reference setting
		“B” (Bottom)	“00” - “FF”	ACK	Vbtm reference setting
<b>4</b>	“W” (Write)	“P” (Page)	“0” - “6”	ACK	Write current setting to Page EEPROM
		“U” (User)	“A” - “D”	ACK	Write current setting to User EEPROM
		“S” (System)	“A” - “D”	ACK	Write current setting to System EEPROM
<b>5</b>	“L”	“P” (Page)	“0” - “6”	ACK	Restore setting from Page EEPROM
		“U” (User)	“A” - “D”	ACK	Restore setting from User EEPROM
		“S” (System)	“A” - “D”	ACK	Restore setting from System EEPROM
		“N” (kNee)	“0” - “9”	ACK	Load Preset Knee Table
<b>6</b>	“R” (Report)	“P” (Page)	“0” - “6”	ACK	ACK + “P” + (“9” - “F”) + 16 bytes
		“U” (User)	“A” - “D”	ACK	ACK + “U” + (“A” - “D”) + 6 bytes
		“S” (System)	“A” - “D”	ACK	ACK + “S” + (“A” - “D”) + (6 bytes)
		“R” (Current)		ACK	ACK + “RR” + 16 bytes
		“X” (Execute)		ACK	Set Camera with loaded data
		“D” (Date)		info	Report CPU program version



	First Character	Second Character	Third Character	Response	Functions
7	"T" (Table)	"N" (kNee)	X1 + Y1 + X2 + Y2	ACK	(X1, Y1) coordinate for knee 1
			X1, Y1, X2, Y2: "00 - FF"		(X2, Y2) coordinate for knee 2
		"M" (Gamma)		ACK	
		"L" (Linear)		ACK	
		"C" (Switch A, B Table)	"0" or "1"	ACK	
8	"N"	"0" (Normal)		ACK	Normal Scan Formal
		"1" (Binning)		ACK	Double Speed Binning

*Note: One byte of data consists of two ASCII codes. For example, 0x3A is "3" (0x33). "A" (0x41) x <ACK> is 0x06. <NAK> is 0x15.*

*This command's basic protocol is the same for Camera Link model cameras.*

## 5 Troubleshooting

### 5.1 Problems and Solutions

Following are troubleshooting tips for common problems. In general, problems can easily be solved by following these instructions. If the following remedies fail to offer a solution to your problems, please contact a JAI, Inc. representative.

#### 5.1.1 Symptom: No Video

Remedies: Check that the following are properly connected and operational.

- Power supplies
- Power cables
- Main power source
- Shutter control
- Async mode
- Lens
- Digital output cable
- Analog video cable

#### 5.1.2 Symptom: Dark Video

Remedies: Check that the following are properly connected and operational.

- Shutter selection
- Iris opening on the lens

#### 5.1.3 Symptom: Non-synchronized Video

Remedies: Check that the following are properly connected and operational.

- Proper mode output
- Frame grabber software camera selection



## 5.2 Information and Support Resources

For further information and support:

Phone: (408) 383-0300  
(800) 445-5444  
Fax: (408) 383-0301  
E-mail: [imaging@jai.com](mailto:imaging@jai.com)  
Mail: JAI, Inc.  
Sales Department  
625 River Oaks Parkway  
San Jose, CA 95134  
ATTN: Video Applications  
Web Site: [www.jai.com](http://www.jai.com)

## 6 Appendix

### 6.1 Specifications

TABLE 8. TM-1020 Series Camera Specifications Table

Feature	TM-1020-15 TM-1020-15CL TM-1020A-15	TM-1020-30 TM-1020-30CL
<b>Imager</b>	1" (9.1mm x 9.2mm) progressive scan interline transfer CCD	
<b>Pixels</b>	1024 (H) x 1024 (V), 1008 x 1018 active	
<b>Cell size</b>	9.0 $\mu$ m x 9.0 $\mu$ m	
<b>Scanning</b>	1050 lines at 15Hz; 1024 x 512 lines at 30Hz (two-row binning)	1050 lines at 30Hz Partial scan: 500L at 58Hz : 250L at 102Hz
<b>Sync</b>	Internal/external auto switch HD/VD, 4.0 Vp-p impedance 4.7K $\Omega$ VD=15Hz $\pm$ 5%, non-interlace HD=15.734kHz $\pm$ 5%	Internal/external auto switch HD/VD, 4.0 Vp-p impedance 4.7K $\Omega$ VD=30Hz $\pm$ 5%, non-interlace HD=31.47kHz $\pm$ 5%
<b>Data clock output</b>	20.000 MHz	40.000 MHz
<b>Resolution</b>	Digital: 1008 (H) x 1018 (V), (Analog: over 700 TV lines (H) x 800 TV lines (V))	
<b>S/N ratio</b>	50dB min. (AGC: off)	
<b>Min. illumination</b>	1.0 lux with factory defaults: f=1.4 without IR cut filter (no shutter) Sensitivity: 12 $\mu$ V/ e-	
<b>Video output</b>	Analog: 1.0 Vp-p composite video, 75 $\Omega$ Digital output: 8-bit RS-644 (TM-1020-15: 12S-RS-422) Camera Link (CL models only)	Analog: 1.0 Vp-p composite video, 75 $\Omega$ Digital output: 8-bit RS-644 Camera Link (CL model only)
<b>AGC</b>	Not available	
<b>Gamma</b>	Programmable LUT (1.0 std.)	
<b>Lens mount</b>	C-mount (use 1" format lenses)	
<b>Power requirement</b>	12V DC, 500mA (current measured at 25 $^{\circ}$ )	
<b>Operating temp.</b>	-10 $^{\circ}$ C to 45 $^{\circ}$ C*	
<b>Random vibration</b>	7 Grms (10Hz to 2000Hz)	
<b>Shock</b>	70G, 10-11msec	
<b>Size (W x H x L)</b>	44mm x 44mm 64mm (1.75" x 1.75" x 2.50")	
<b>Weight</b>	Std. version: 133 grams, 4.7 oz. (without tripod) CL version: 137 grams, 4.8 oz. (without tripod) tripod weight: 13.8 grams 0.5 oz.	
<b>Power cable</b>	12P-02S (optional)	



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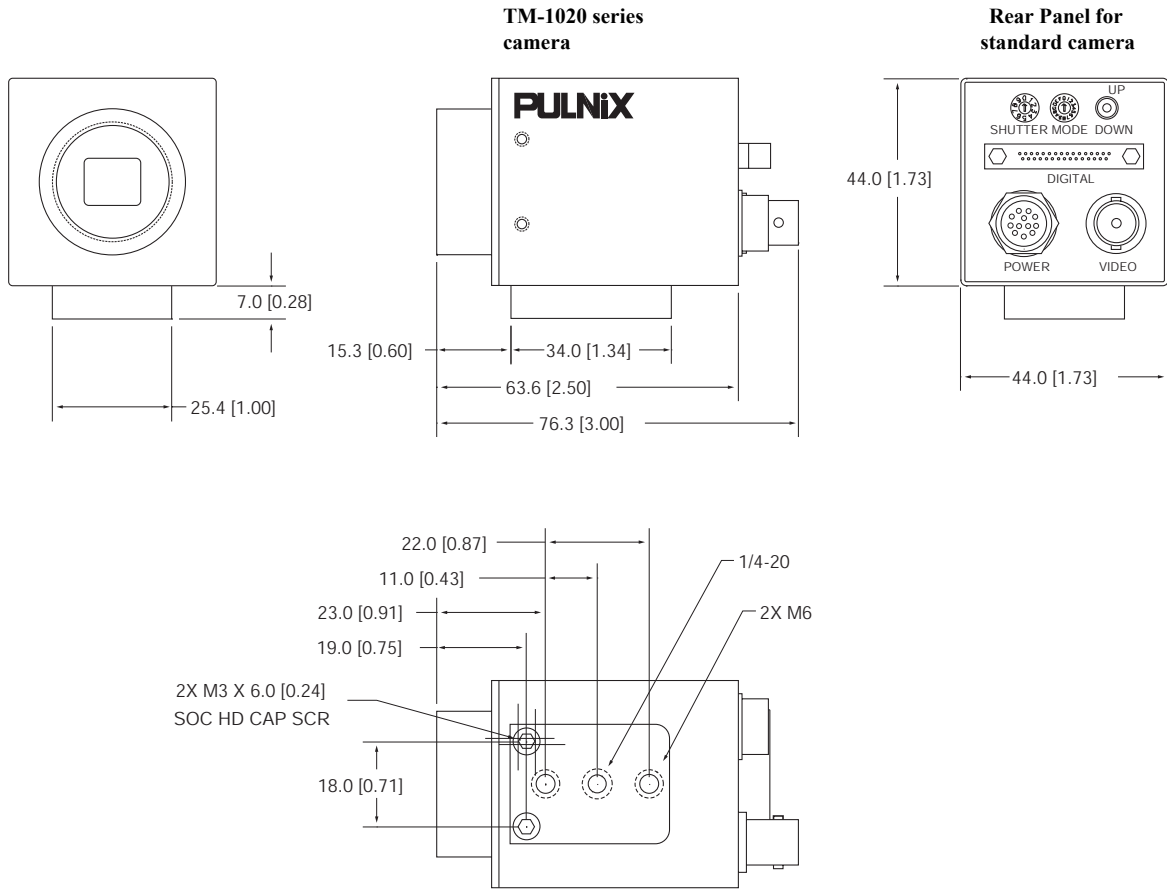
**TM-1020 Series Progressive Scan Shutter Cameras**

<b>Feature</b>	<b>TM-1020-15 TM-1020-15CL TM-1020A-15</b>	<b>TM-1020-30 TM-1020-30CL</b>
<b>Power supply</b>	PD-12UUP (includes power connector)	
<b>Functional options</b>	RS-644 (LVDS/RS-422) output.	
<b>I/O</b>	26CL-02-26 digital output cable (CL models)	

\*. Refer to Section 2.2.2 on page 6 for information on camera heat dissipation. Image quality will degrade with increasing temperature.

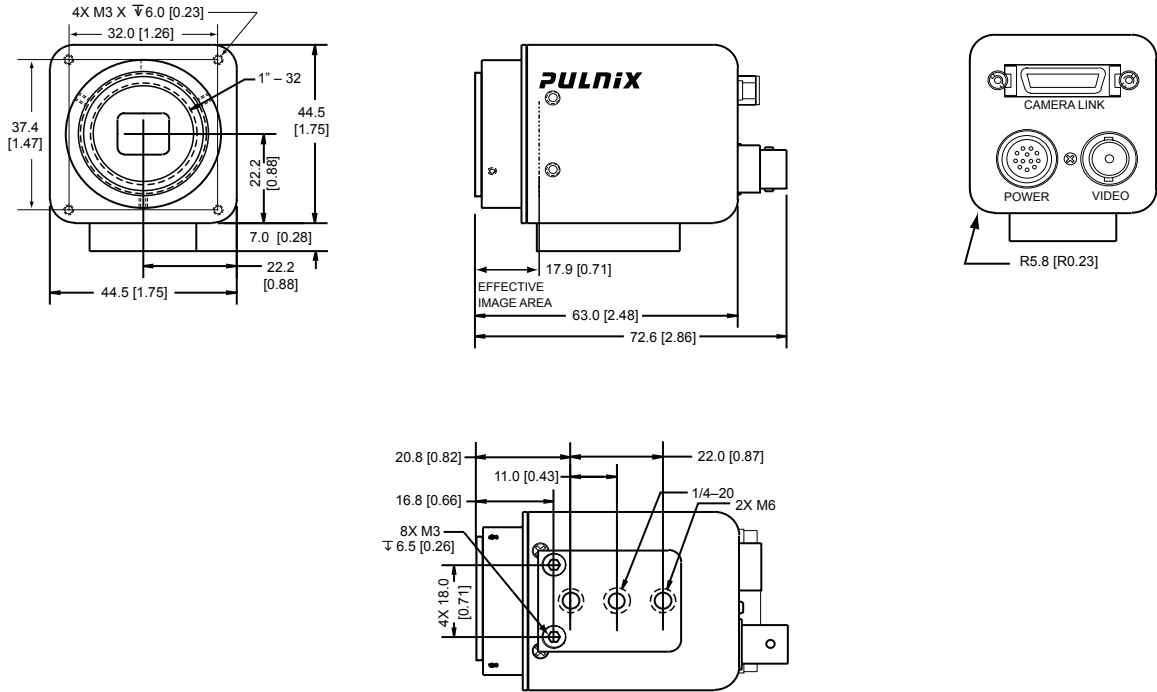
### 6.1.1 TM-1020 Series Physical Dimensions

FIGURE 17. Physical Dimensions



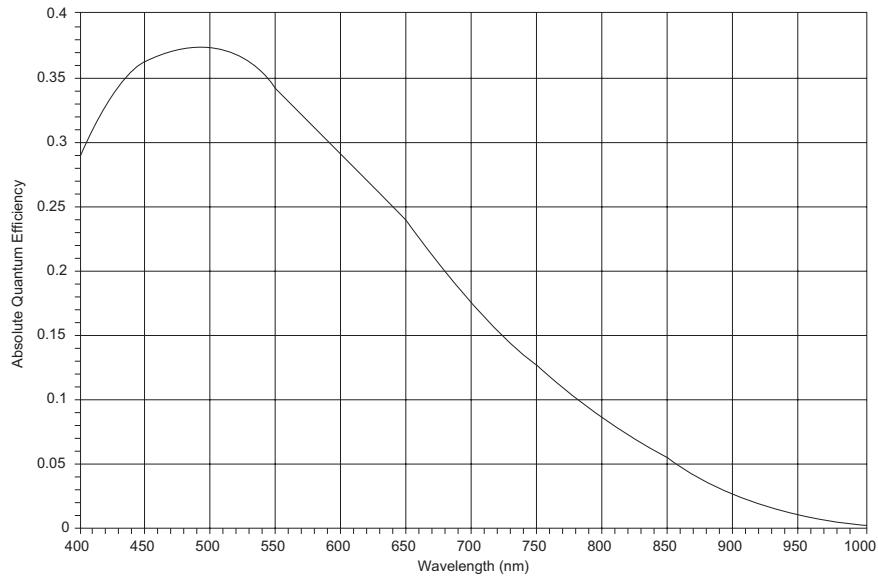
### 6.1.2 TM-1020 CL Series Physical Dimensions

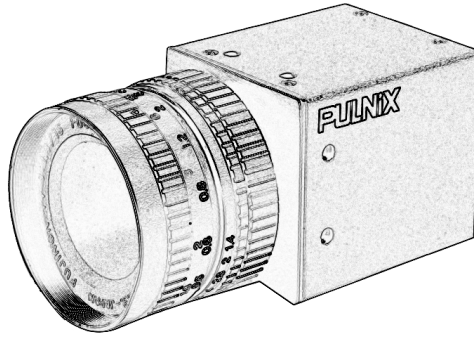
FIGURE 18. CL Version Physical Dimensions



### 6.1.3 Spectral Response

FIGURE 19. Spectral Response





*See the possibilities*

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