TM-6740CL Series Progressive Scan Shutter Cameras

Operation Manual

69-1209
Rev. A

PULNiX®
Imaging Products

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Warranty

All of our solid-state cameras sold in North America have a full three-year warranty. Those sold elsewhere have a full one-year warranty. If any such product proves defective during the warranty period, JAI PULNiX, 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-6740CL series of cameras has 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: EN50082-2/1997
Emissions: CISPR22: 1997/EN55011: 1998 Class B

All PULNiX 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 affect CE compliance. Please note that the use of interconnect cables that are not properly grounded and shielded may affect CE compliance.

Contact PULNiX 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 may 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-6740CL Series Operation Manual
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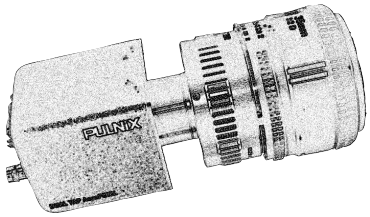


1 Introduction

1.1 Product Description

The PULNiX TM-6740 series consists of dual-tap output, high-speed progressive scan CCD cameras.[1] 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 1/64,000 sec., can be reset asynchronously by external pulse control. The frame rate for a full image is 200 fps, with partial scan mode of up to 3200 fps. A 4:3 ratio imager format with uniform square pixels provides superior image definition in any orientation. On-chip micro lenses provide increased sensitivity.

The TM-6740 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. As a dual-tap outputs camera, the TM-6740 has dual-channel auto-black level balancing[2] and semi-auto-gain balancing functions. The camera has a dual-tap, 10-bit/8-bit Camera Link output (see Figure 1, "CL (Camera Link) System Configuration," on page 3). All the key functions are controlled via a Camera Link serial communication interface.

Applications for the TM-6740 include machine vision, medical imaging, intelligent transportation systems, high-definition graphics, on-line inspection, gauging, character reading, archiving, and high-security surveillance.

1. The TM-6740 series consists of TM-6740CL, TMC-6740CL (Camera Link), TM-6740GE, and TMC-6740GE (gigabit ethernet). Unless otherwise noted, all information contained in this manual is relevant to all models.
2. Due to the CCD's structure, auto-black level balancing works with full-image scan modes and vertical partial scan modes. Auto-black level balancing does not work with horizontal partial scan modes.

1.2 Features

- **Miniaturized and lightweight**

  The printed circuit boards in the TM-6740 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 50.8mm x 50.8mm x 81.5mm in dimensions, and weighs only 155 grams.

- **Imager**

  The TM-6740 uses a dual-tap progressive-scan interline transfer CCD that has the following features:

  - Resolution of 640 x 480 active pixels for excellent image quality.
  - 7.4 x 7.4 µm square pixels for precise dimensional measurement.
  - High-speed electronic shutter capability for high dynamic resolution of moving objects 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 CCD has an excellent S/N ratio at the default setting that is greater than 48dB.
  - The CCD has a built-in microlens for increased quantum efficiency.

- **Electronic shutter**

  The TM-6740 has a substrate drain-type shutter mechanism which provides superb pictures at various speeds without smearing. For more information, please see Section 3.3, “Electronic Shutter,” on page 13.

- **Asynchronous reset**

  The TM-6740 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-6740CL’s asynchronous reset is flexible and accepts external horizontal drive (HD) for phase locking. When the VINIT (5V) pulse is applied to CC1, it resets the camera's scanning and purging of the CCD.

  The TM-6740 has three modes to control the asynchronous reset and shutter speed:

  - **Async, no shutter.** The video signal and FDV are reset by external VINIT.
  - **Internal shutter speed control**. The speed control varies from 1/250 to 1/64,000 sec. The video signal and FDV starts with internal V reset timing related to shutter speed.
  - **External VINIT with pulse width**. The duration between pulse edges controls the shutter speed externally.

- **Output**

  The TM-6740 has a dual tap 10-bit/8-bit Camera Link output. The analog output is 714 mVp-p composite video (75 ohms) on all models.

- **Dual-Channel Auto Black Level Balancing and Semi-Auto Gain Balancing**

  The TM-6740, as a dual-tap output camera, has auto black level balancing and semi-auto gain balancing functions.

- **Integration**

  The TM-6740 is capable of capturing high-resolution integration images. Its CCD imager can be exposed for longer than the normal scan timing of 1/200 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 applying INTEG signal to CC2 control of Camera Link or by feeding VINIT pulse width control up to 1 sec of the pulse width in async pulse width control mode for the frames to be integrated.

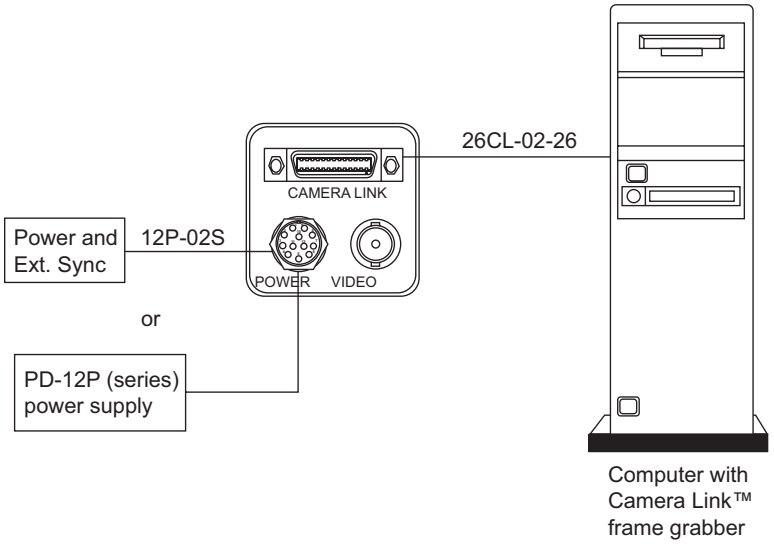
- **Warranty**

  Please contact your factory representative for details about the warranty.

1.3 System Configuration

FIGURE 1. CL (Camera Link) System Configuration

Figure 1 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 PULNiX representative immediately.

- TM-6740 camera
- Camera-specific data sheet
- Camera-appropriate operation manual (if ordered)
- Dual-tap AccuPiXEL camera-control software

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 PULNiX representative before you install your camera to determine what you might need.

- PD-12U series power supply
- 12P-02S power cable
- 26CL-02-26 Camera Link cable

2.2 Camera Setup

2.2.1 Heat Dissipation

The TM-6740 is a compact 640 by 480 camera. Since all the electronics have been packed in a compact package, the outer case of the camera can become hot due to heat dissipation. For optimal performance, PULNiX 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 heat-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 PULNiX, Inc. at (800) 445-5444 or send an E-mail to imaging@jaipulnix.com if you have any questions.

2.2.2 Connector Pin Configurations

2.2.2 (a) 12-Pin Connector

The TM-6740 has a 12-pin Hirose connector for power input and signal integration. Pin #1 is Ground and pin #2 is +12V DC. The pin-out table is shown below.

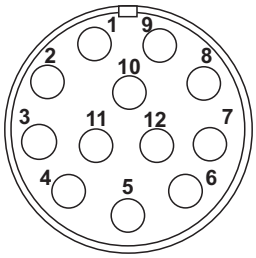


TABLE 1. 12-Pin Connector

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

*. Option 25-2 TTL inputs on 12-pin

2.2.2 (b) Digital I/O Connector

The TM-6740 has a 26-pin connector on the rear panel to output Camera Link data. The connector pin-out is shown in Table on page 6.

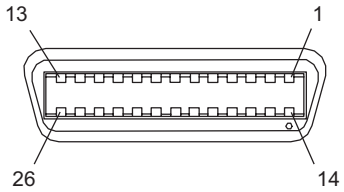


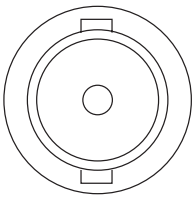
TABLE 2. Connector and Pin-Out Configurations

Camera Link Connector					
Pin #	**Description**	**I/O**	**Pin #**	**Description**	**I/O**
1	GND		14	GND	
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/RXD+	20	SerTC-	In/RXD-
8	SerTFG-	Out/TXD-	21	SerTFG+	Out/TXD+
9	CC1-	In/VINIT-	22	CC1+	In/VINIT+
10	CC2+	In/INTEG+	23	CC2-	In/INTEG-
11	CC3-	In/EX_HD-	24	CC3+	EX_HD+
12	CC4+	In/EX_VD+	25	CC4-	EX_VD-
13	GND		26	GND	

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

2.2.2 (c) Analog Output Connector

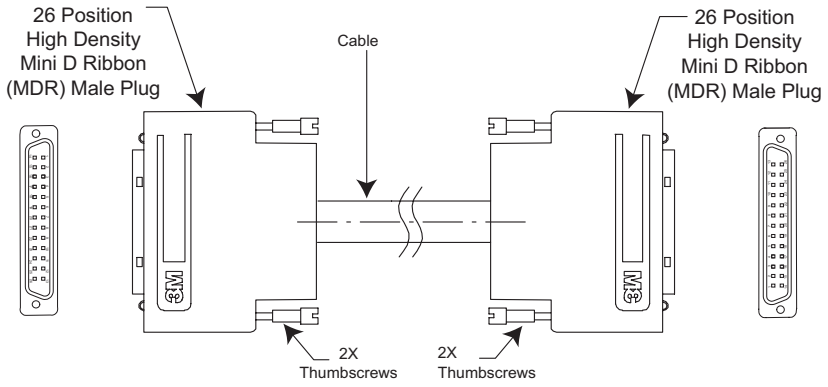
The TM-6740 has a BNC connector on the rear panel to output analog video signal (80 MHz).



2.2.3 Camera Link Cable

The 26CL-02-26 cable assembly has been standardized as the Camera Link cable. This cable has a 26-pin connector on both ends. This is a straight-through cable and the pin-out configuration is shown in Table on page 6. Contact PULNiX for cable lengths other than 2 meters.

FIGURE 2. 3M 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.*

2.2.4 Power Supplies and Power Cable Setup

2.2.4 (a) Power Supplies

The TM-6740 camera requires 12V DC power that is obtained through the 12-pin connector located on the rear panel of the camera. PULNiX recommends the following power supplies:

PD-12UU	100-240V AC/12V DC	1.2A universal voltage power supply, US Plug
PD-12UUP	PD-12UU with12-pin connector	US plug
PD-12UE	PD-12UU	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 PULNiX power cable via a terminal strip or directly.

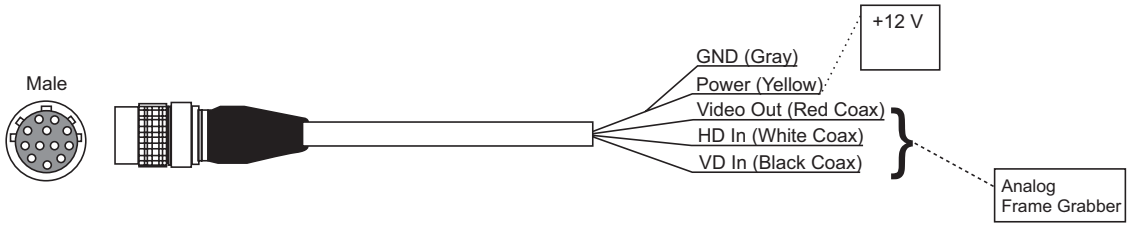
When wiring the PD-12UU and PD-12UE power supplies directly, please note the following:

- 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.

2.2.4 (b) PULNiX Power Cables

If you are using PULNiX power cables such as the 12P-02S, please refer to the 12-pin connector pin-out diagram below. The cable pin-out diagram is shown in Figure 3 below. The color-coded leads use Gray for Ground and Yellow for +12V.

FIGURE 3. 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 Output
3	Red coax shield	AGND	9	White coax	HD Input*
4	Red coax	Video Out	10	Brown	N/C
5	Orange coax shield	DGND	11	Blue	Integration*
6	Orange coax	VINIT Input*	12	Black coax shield	N/C

*. Optional OP25-2 TTL inputs on 12-pin connector

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.*

2.2.4 (c) Building Your Own Power Cable

Refer to the 12-pin connector pin-out in Figure 3 on page 8. 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.

2.2.4 (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.

2.2.5 Attaching the Analog Video Output

When connecting the TM-6740 to an analog frame grabber, use the BNC connector on the rear panel of the camera. The input of the monitor should be balanced for 75 ohms termination.

The multi-conductor cable 12P-02S from PULNiX can be used to transmit analog video, power, sync. signals, and serial communication. The mini coaxial leads in PULNiX multi-conductor cables are designed for short runs of no longer than 10 feet.

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

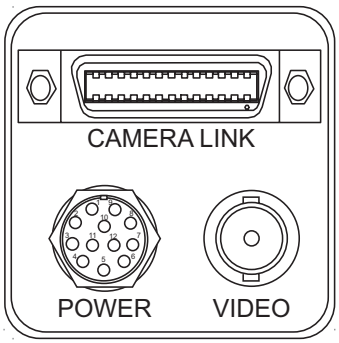
2.2.6 Attaching the Camera Lens

The TM-6740 camera accepts 1/3" or larger format size C-mount lenses. To attach the C-mount lens[3] 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. C-mount to F-mount and C-mount to K-mount adapters are available for larger format lenses (35mm). Check with local photography dealers for these lens adapters.

3 Operation

3.1 Camera Rear Panel



3.1.1 Digital I/O Connector (Camera Link)

Refer to Section 2.2.3 on page 6 for information on digital output connectors.

3.1.2 Analog Output Connector

The camera has a BNC connector on the rear panel to output analog video signal.

3.1.3 Power and External Sync Connector

Refer to Section 2.2.2 (b on page 6 for information on the power and external sync. connectors.

3.2 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. This means that 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-6740 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 480 lines. Due to the TM-6740CL's extremely high frame rate, however, it will not synchronize to most monitors.

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-6740 outputs the progressive-scanned image with an electronic shutter in thirty-six different formats. See Table 3 on page 12 for more information.

1. Progressive-scanning digital and analog output

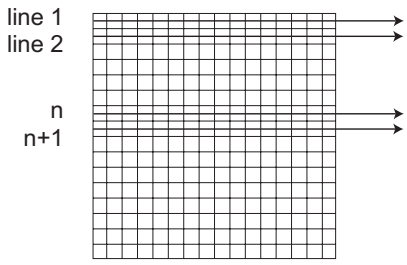
The CCD signal goes through A/D converters 10-bit in, 10-bit/8-bit out. The digital output is available via the Camera Link connector.

The analog output is the same as 75 ohms, 714mV format available from BNC and 12-pin connector.

2. Full Progressive Scan

Normal scanning mode the TM-6740 is for 640 x 480 pixels. The standard speed with dual-channel output is 200 frame/sec at the pixel clock of 40 MHz. The progressive scan reads every line from top to bottom and all lines are exposed with a single electronic shutter.

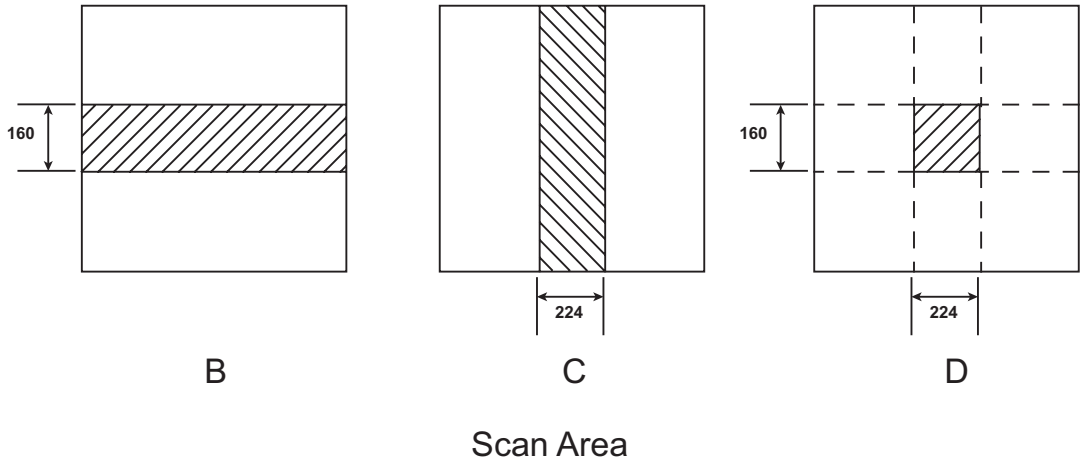
FIGURE 4. Full Progressive Scan Mode (A)



3. Partial Scan Mode

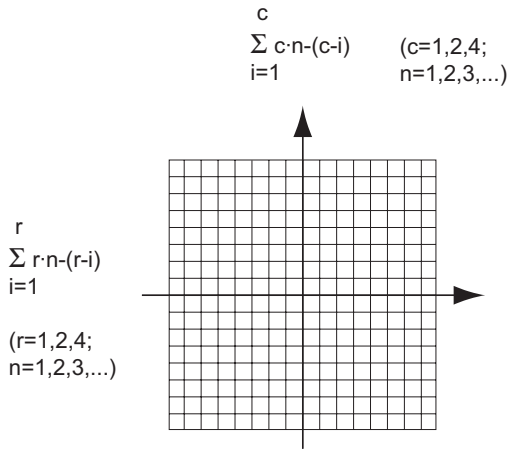
By selection, the camera has three partial scan modes: centered 160 lines, centered 224 columns, and centered 224 x 160 area. In partial scan mode at 1000 lines, partial scan's frame rate is 28fps. 500 lines is 50 fps, 250 lines is 80 fps.

FIGURE 5. Partial Scan Mode (B, C, and D)



4. Binning Mode

The TM-6740 series has horizontal and vertical binning. By selection, the camera has 1x2, 1x4, 2x1, 2x2, 2x4, 4x1, 4x2, and 4x4 binning.



Binning

TABLE 3. TM-6740 Scan Mode

Scan Mode		Active Pixels	Vertical Frequency (Hz)	Horizontal Frequency (KHz)	Output Clock	
Binning	Scan Area				Digital (MHz)	Analog (MHz)
No binning	A	640x480	200	100	40	80
	B	640x160	540	100		
	C	224x480	500	250		
	D	224x160	1250	250		
1x2	A	640x240	400	100		
	B	640x80	1000	100		
	C	224x240	1000	250		
	D	224x80	2315	250		
1x4	A	640x120	712	100		
	B	640x40	1596	100		
	C	224x120	1602	250		
	D	224x40	3205	250		

TABLE 3. TM-6740 Scan Mode (Continued)

Scan Mode		Active Pixels	Vertical Frequency (Hz)	Horizontal Frequency (KHz)	Output Clock	
Binning	Scan Area				Digital (MHz)	Analog (MHz)
2x1	A	320x480	200	100	20	40
	B	320x160	540	100		
	C	112x480	500	250		
	D	112x160	1250	250		
2x2	A	320x240	400	100		
	B	320x80	1000	100		
	C	112x240	1000	250		
	D	112x80	2315	250		
2x4	A	320x120	712	100		
	B	320x40	1596	100		
	C	112x120	1602	250		
	D	112x40	3205	250		
4x1	A	160x480	200	92.59	10	20
	B	160x160	540	92.59		
	C	56x480	500	208.33		
	D	56x160	1250	208.33		
4x2	A	160x240	400	92.59		
	B	160x80	1000	92.59		
	C	56x240	1000	208.33		
	D	56x80	2315	208.33		
4x4	A	160x120	712	92.59		
	B	160x40	1596	92.59		
	C	56x120	1602	208.33		
	D	56x40	3205	208.33		

3.3 Electronic Shutter

The TM-6740 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 1/250 (non-async mode only), 1/500, 1/1,000, 1/2,000, 1/4,000, 1/8,000, 1/16,000, 1/32,000, or 1/64,000 second.

With VINIT high (CC1), the CCD keeps discharging. With an active low 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 480 lines of vertical resolution, as compared to a conventional CCD camera which captures only half the vertical lines per shutter.

3.4 Integration

The CCD imager of the TM-6740 can be exposed for longer than the normal scan timing of 1/200 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 CC2 Camera Control line through the Camera Link cable to low (GND) or providing pulse-width control up to 1 sec. Please refer to Table 2 on page 6 for pin-out information on the 12-pin connector.

3.5 External Sync and Pixel Locking

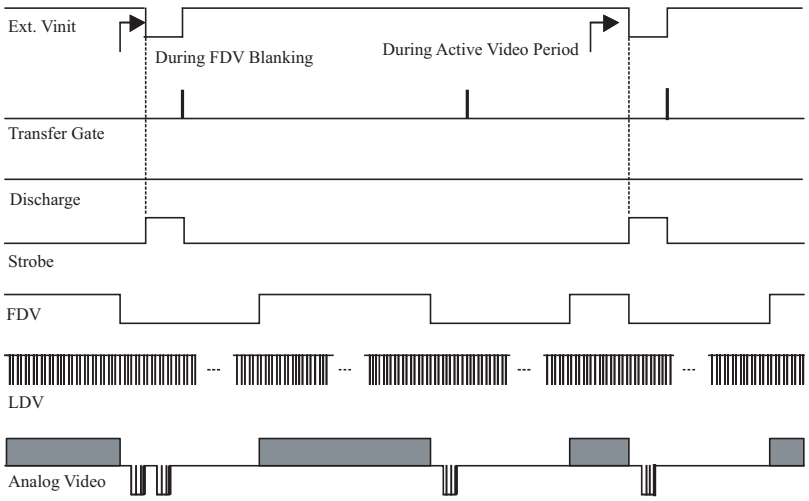
The TM-6740 accepts an external sync of standard HD and VD on CC3 and CC4 of the Camera Link connector for general locking to an external source.The frequency requirement is shown in Table 3 on page 12. The tolerance is ±2% horizontal frequency.

3.6 Asynchronous Reset

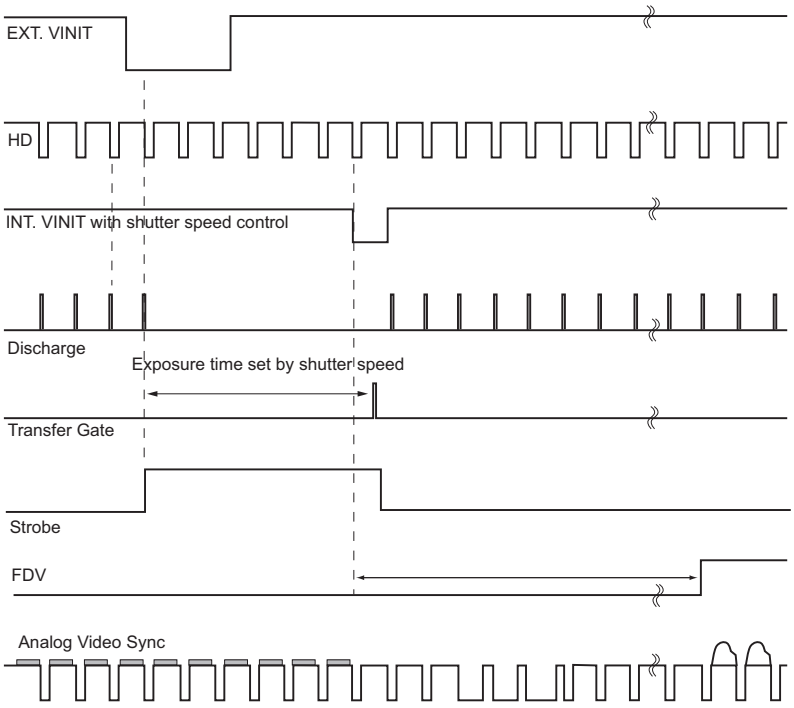
The TM-6740 camera includes three modes to control the asynchronous reset and shutter speed:

- Async No Shutter
- Internal Shutter Speed Control
- External VINIT with Pulse Width (No-Delay Shutter) and ROI

3.6.1 Async No Shutter



3.6.2 Internal Shutter Speed Control

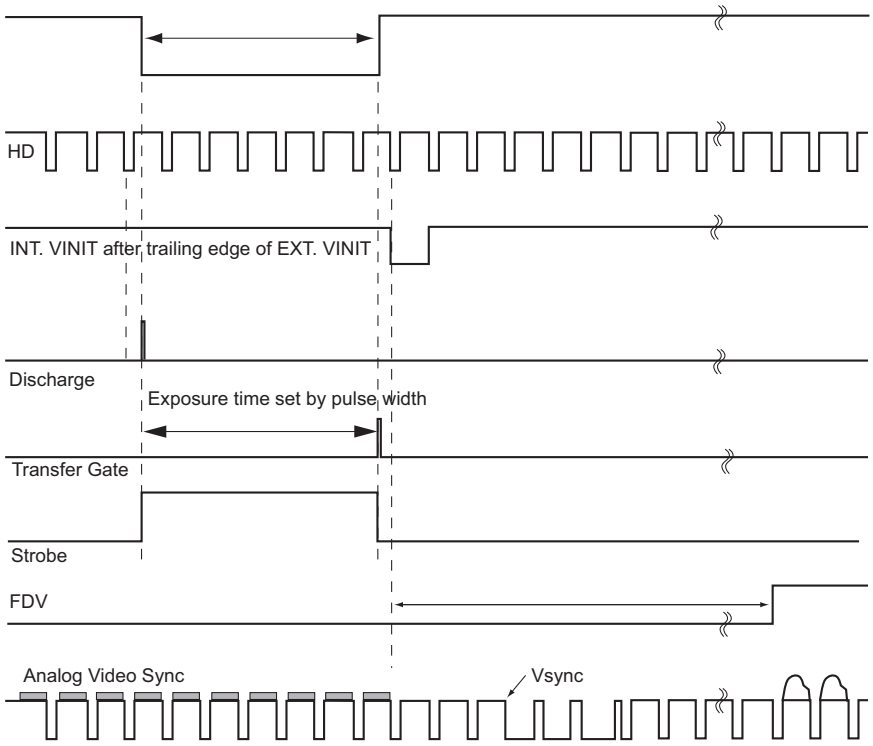


The video signal starts with internal VINIT. The camera operates the reset and shutter in the same way as the external pulse width control mode. When the external VINIT pulse is applied, internal VINIT is latched to HD and the internal VINIT is delayed to set up the shutter speed period. The shutter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

3.6.3 External VINIT With Pulse Width (No-Delay Shutter) and ROI (Read-out Inhibit)

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 a critical requirement. The TM-6740'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.

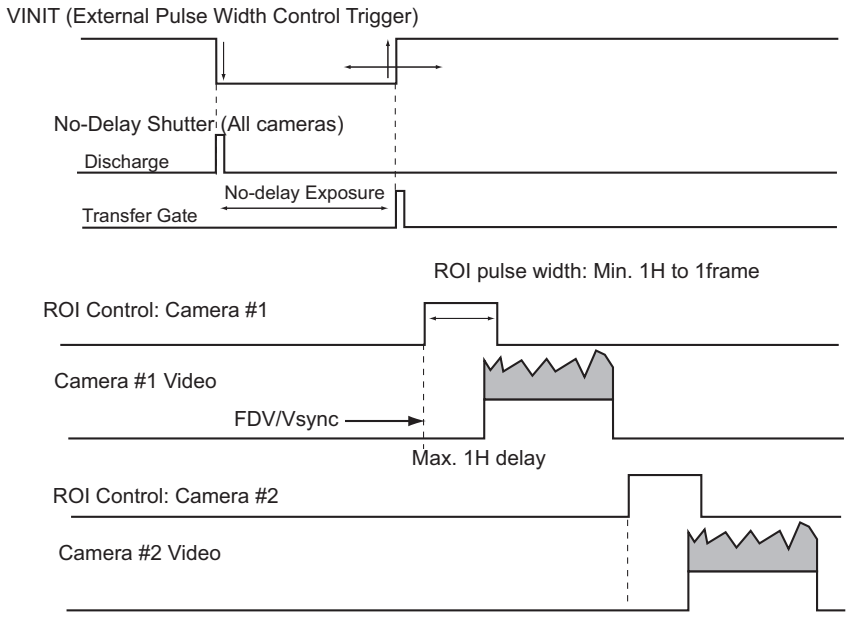
FIGURE 6. No-Delay Shutter



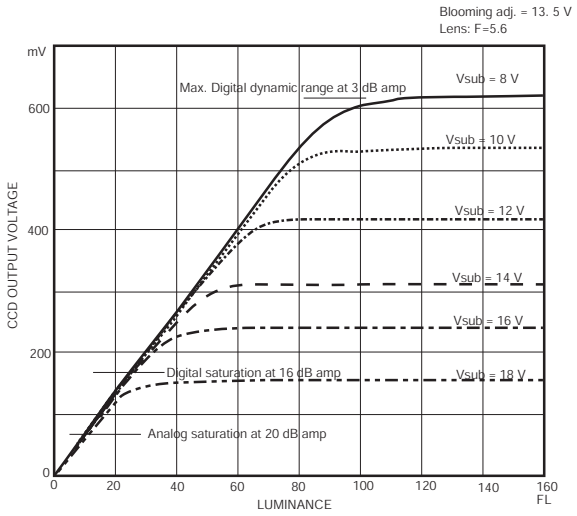
The TM-6740 camera also has read-out-inhibit control (ROI) to control the vertical clock start (Async Shutter #9). When ROI is low, V-clock is stopped and the transferred charges remain in the vertical shift registers, which work like CCD memory. When the ROI is high, it clocks out the CCD data. This 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 CC2 input is kept logic high during Async. pulse width control mode.

FIGURE 7. Read-Out Inhibit



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-6740 uses a CCD with 7.4 µm x 7.4 µm pixel and two-phase vertical shift register structure. The well capacity is 20,000 electrons. The theoretical dynamic range is 20,000:30 = 666:1 (56 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 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-6740 has a built-in LUT (look-up table) for dynamic range control.

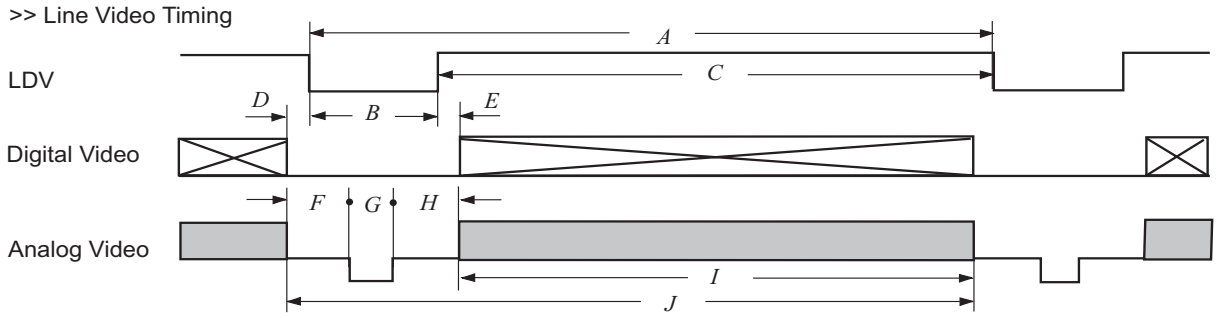
At a specific gain setting, the offset (minimum level.... dark point) and A/D reference top voltage (maximum level... saturation point) are set to 10-bit A/D input so that the full dynamic range of the CCD is utilized at 10-bit references as the input and the LUT output is converted into 8-bit to adjust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

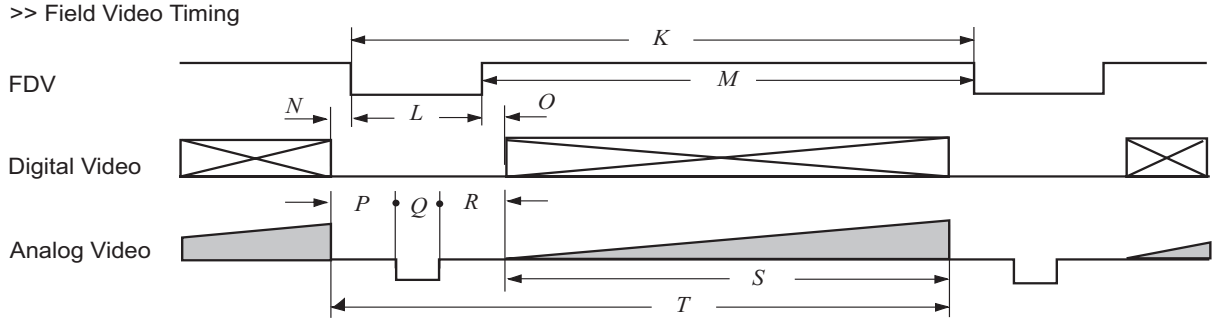
3.8 Camera Timing Charts

1. Video Output

>> Line Video Timing

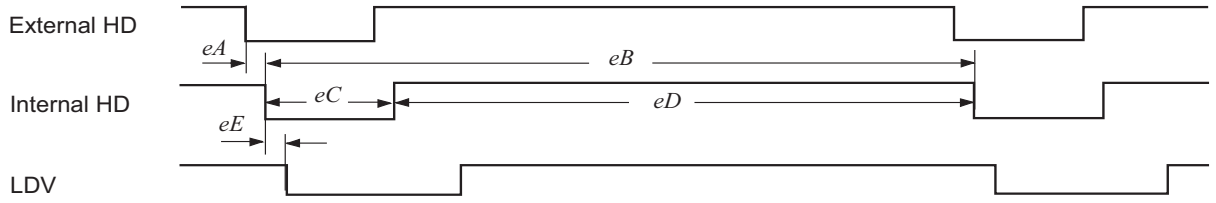


>> Field Video Timing

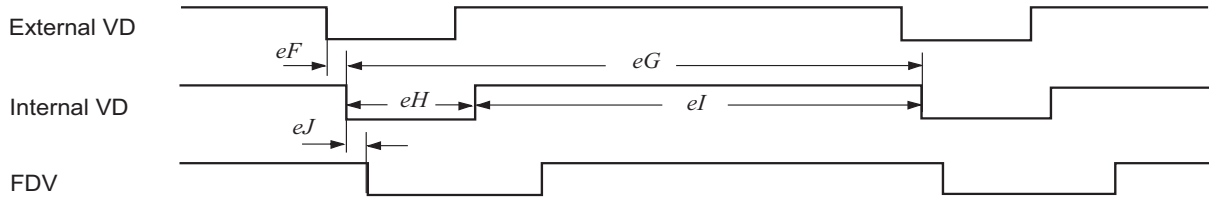


2. External HD Locking & Exteranl VD Reset

>> External HD Locking

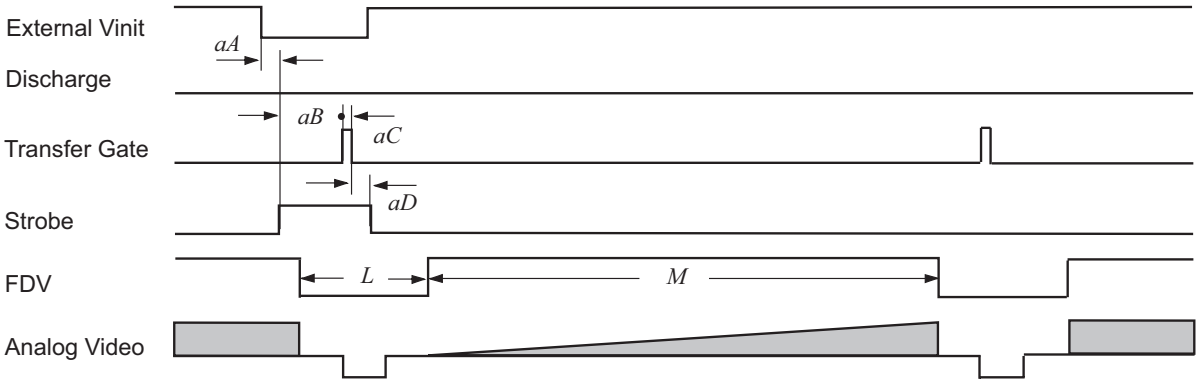


>> External VD Reset

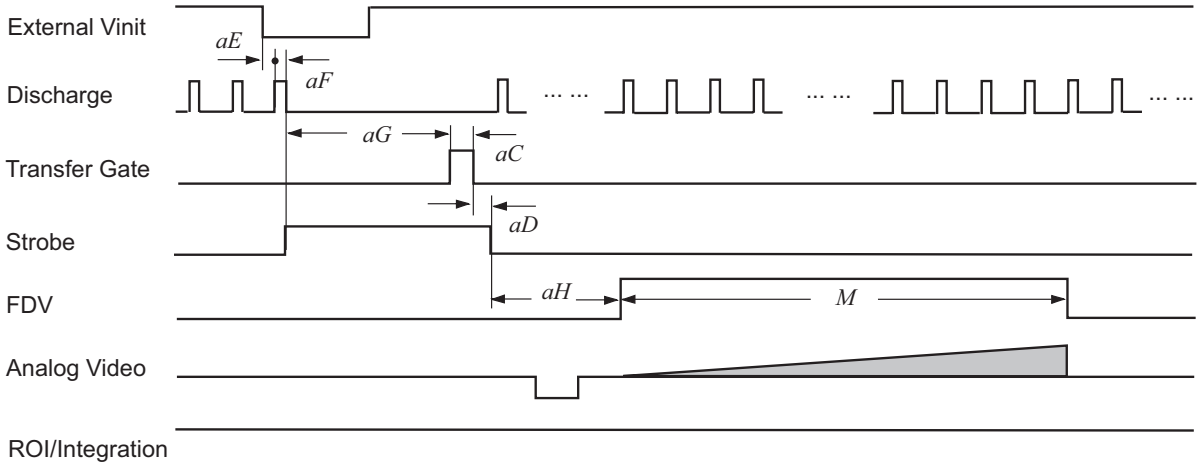


3. Async Reset

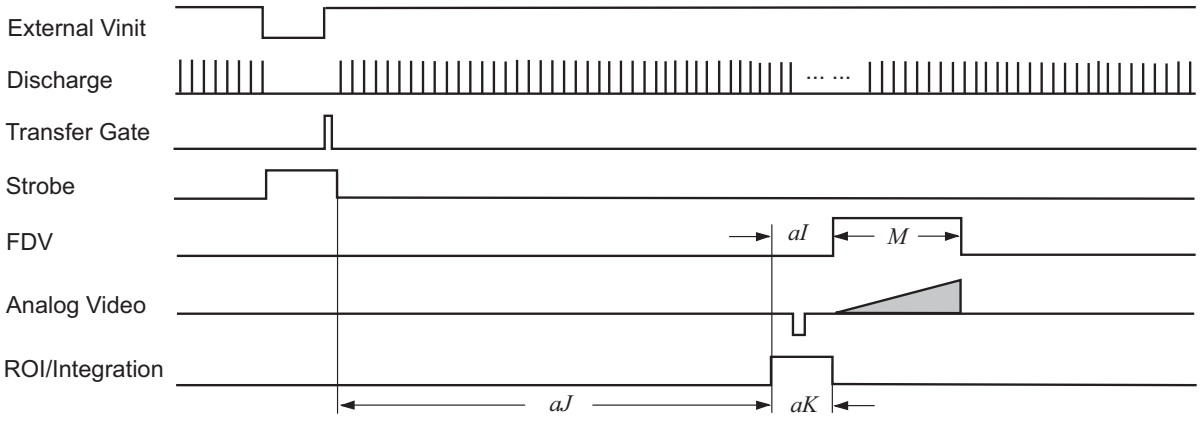
>> Async No Shutter (async shutter 0)



>> Async Normal Shutter (async shutter 1-8) & Async No-delay Shutter (async shutter 9)



>> Read-Out Inhibit (ROI, async shutter 9)



4. Video Output Order

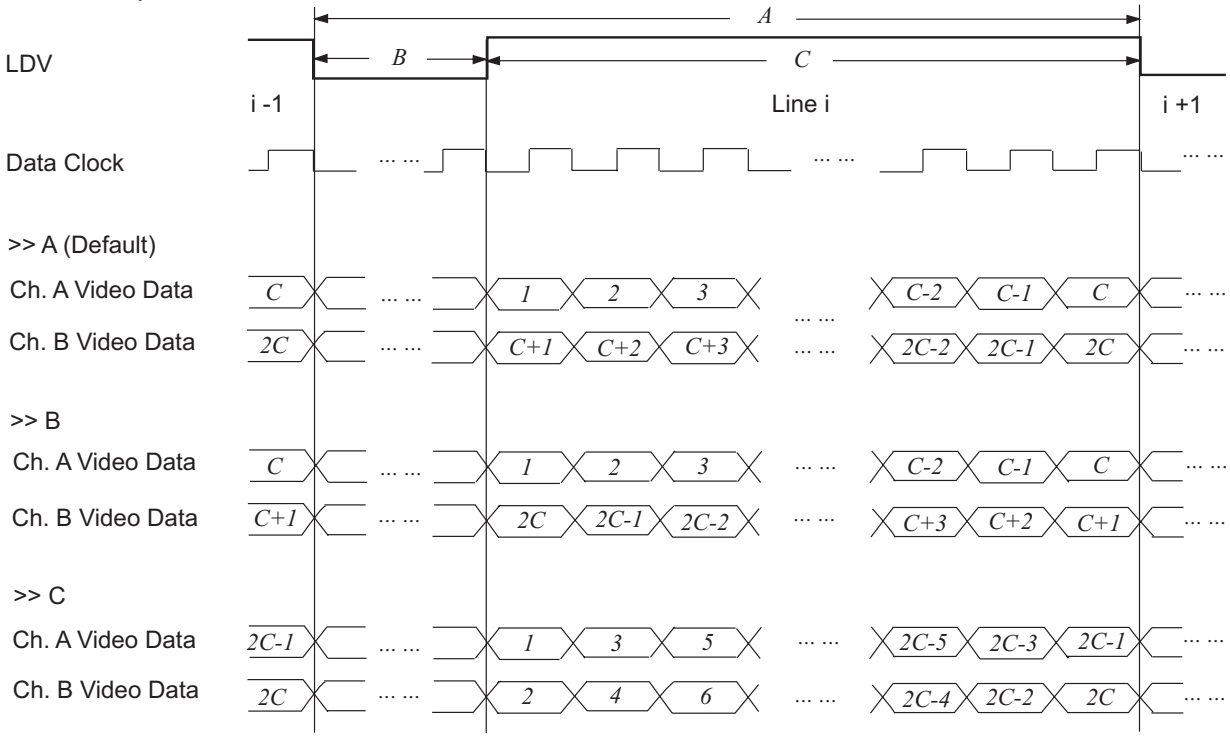


TABLE 4. Video Output (A to J)

Scan Mode		Output		Horizontal (Pixels)							
				Digital			Analog				
Binning	Scan Area	Digital	Analog	A	B	C	F*	G	H	I	J
No binning	A	40Mhz 25ns	80Mhz 12.5ns	400	80	320	58	16	86	640	800
	B			400	80	320				640	800
	C			160	48	112				224	320
	D			160	48	112				224	320
1x2	A			400	80	320				640	800
	B			400	80	320				640	800
	C			160	48	112				224	320
	D			160	48	112				224	320
1x4	A			432	112	320				640	864
	B			432	112	320				640	864
	C			192	80	112				224	384
	D			192	80	112				224	384

TABLE 4. Video Output (A to J) (Continued)

Scan Mode		Output		Horizontal (Pixels)							
Binning	Scan Area	Digital	Analog	Digital			Analog				
				A	B	C	F*	G	H	I	J
2x1	A	20MHz 50ns	40MHz 25ns	200	40	160	20	8	52	320	400
	B			200	40	160	20		52	320	400
	C			80	24	56	22		50	112	160
	D			80	24	56	22		50	112	160
2x2	A			200	40	180	20		52	320	400
	B			200	40	180	20		52	320	400
	C			80	24	56	22		50	112	160
	D			80	24	56	22		50	112	160
2x4	A			216	56	160	20		52	320	432
	B			216	56	160	20		52	320	432
	C			96	40	56	22		50	112	192
	D			96	40	56	22		50	112	192
4x1	A	10MHz 100ns	20MHz 50ns	100	20	80	10	4	26	160	200
	B			100	20	80				160	200
	C			40	12	28				56	80
	D			40	12	28				56	80
4x2	A			100	20	80				160	200
	B			100	20	80				160	200
	C			40	12	28				56	80
	D			40	12	28				56	80
4x4	A			108	28	80				160	216
	B			108	28	80				160	216
	C			48	20	28				56	96
	D			48	20	28				56	96

*. D, E=0 pixels.

TABLE 5. Video Output (K to T)

Scan Mode		Output		Vertical (Pixels)						
Binning	Scan Area	Digital	Analog	Digital			Analog			
				K	L	M*	P†	R	S	T
No binning	A	40Mhz 25ns	80Mhz 12.5ns	500	20	480	3	14	480	500
	B			185	25	160	9	13	160	185
	C			500	20	480	3	14	480	500
	D			200	40	160	9	28	160	200
1x2	A			250	10	240	3	4	240	250
	B			100	20	80	6	11	80	100
	C			250	10	240	3	4	240	250
	D			108	28	80	4	21	80	108
1x4	A			130	10	120	3	4	120	130
	B			58	18	40	5	10	40	58
	C			130	10	120	3	4	120	130
	D			65	25	40	4	18	40	65
2x1	A	20MHz 50ns	40MHz 25ns	500	20	480	3	14	480	500
	B			185	25	160	9	13	160	185
	C			500	20	480	3	14	480	500
	D			200	40	160	9	28	160	200
2x2	A			250	10	240	3	4	240	250
	B			100	20	80	6	11	80	100
	C			250	10	240	3	4	240	250
	D			108	28	80	4	21	80	108
2x4	A			130	10	120	3	4	120	130
	B			58	18	40	5	10	40	58
	C			130	10	120	3	4	120	130
	D			65	25	40	4	18	40	65

TABLE 5. Video Output (K to T) (Continued)

Scan Mode		Output		Vertical (Pixels)						
				Digital			Analog			
Binning	Scan Area	Digital	Analog	K	L	M*	P†	R	S	T
4x1	A	10MHz 100ns	20MHz 50ns	500	20	480	3	14	480	500
	B			185	25	160	9	13	160	185
	C			500	20	480	3	14	480	500
	D			200	40	160	9	28	160	200
4x2	A			250	10	240	3	4	240	250
	B			100	20	80	6	11	80	100
	C			250	10	240	3	4	240	250
	D			108	28	80	4	21	80	108
4x4	A			130	10	120	3	4	120	130
	B			58	18	40	5	10	40	58
	C			130	10	120	3	4	120	130
	D			65	25	40	4	18	40	65

*. N, O=0 pixels.

†. Q=3 lines.

TABLE 6. External HD Locking and External VD Reset (eA to eE)

Scan Mode		Pixel Clock	Horizontal		External HD Locking Timing (Pixels)				
Binning	Scan Area		Freq. (kHz)	Time (μsec)	eA	eB	eC	eD	eE
No binning	A	40Mhz 25ns	100	10	<20ns	400	32	368	13
	B		100	10		400		368	
	C		250	4		160		128	
	D		250	4		160		128	
1x2	A		100	10		400		368	
	B		100	10		400		368	
	C		250	4		160		128	
	D		250	4		160		128	
1x4	A		92.6	10.8		432		400	
	B		92.6	10.8		432		400	
	C		208.3	4.8		192		160	
	D		208.3	4.8		192		160	

TABLE 6. External HD Locking and External VD Reset (eA to eE) (Continued)

Scan Mode		Pixel Clock	Horizontal		External HD Locking Timing (Pixels)				
Binning	Scan Area		Freq. (kHz)	Time (μsec)	eA	eB	eC	eD	eE
2x1	A	20MHz 50ns	100	10	<20ns	200	16	184	12
	B		100	10		200		184	12
	C		250	4		80		64	11
	D		250	4		80		64	11
2x2	A		100	10		200		184	12
	B		100	10		200		184	12
	C		250	4		80		64	11
	D		250	4		80		64	11
2x4	A		92.6	10.8		216		200	12
	B		92.6	10.8		216		200	12
	C		208.3	4.8		96		80	11
	D		208.3	4.8		96		80	11
4x1	A	10MHz 100ns	100	10	<20ns	100	16	84	15
	B		100	10		100		84	
	C		250	4		40		24	
	D		250	4		40		24	
4x2	A		100	10		100		84	
	B		100	10		100		84	
	C		250	4		40		24	
	D		250	4		40		24	
4x4	A		92.6	10.8		108		92	
	B		92.6	10.8		108		92	
	C		208.3	4.8		48		32	
	D		208.3	4.8		48		32	

TABLE 7. External HD Locking (eF to eJ)

Scan Mode		Pixel Clock	Vertical		Vertical VD Reset Timing (Lines)				
Binning	**Scan Area**		**Freq. (kHz)**	**Time (μsec)**	**eF**	**eG**	**eH**	**eI**	**eJ**
No binning	A	40Mhz 25ns	200	5000	<2	500	9	491	1
	B		540	1850		185		176	-5
	C		500	2000		500		491	1
	D		1250	800		200		191	-5
1x2	A		400	2500		250		241	1
	B		1000	1000		100		91	-2
	C		1000	1000		250		241	1
	D		2315	432		108		99	0
1x4	A		712	1404		130		121	1
	B		1596	626.4		58		49	-1
	C		1602	624		130		121	1
	D		3205	312		65		56	0
2x1	A	20MHz 50ns	200	5000	<20ns	500	9	491	1
	B		540	1850		185		176	-5
	C		500	2000		500		491	1
	D		1250	800		200		191	-5
2x2	A		400	2500		250		241	1
	B		1000	1000		100		91	-2
	C		1000	1000		250		241	1
	D		2315	432		108		99	0
2x4	A		712	1404		130		121	1
	B		1596	626.4		58		49	-1
	C		1602	624		130		121	1
	D		3205	312		65		56	0

TABLE 7. External HD Locking (eF to eJ) (Continued)

Scan Mode		Pixel Clock	Vertical		Vertical VD Reset Timing (Lines)				
Binning	Scan Area		Freq. (kHz)	Time (µsec)	eF	eG	eH	eI	eJ
4x1	A	10MHz 100ns	200	10	<20ns	500	9	491	1
	B		540	10		185		176	-5
	C		500	4		500		491	1
	D		1250	4		200		191	-5
4x2	A		400	10		250		241	1
	B		1000	10		100		91	-2
	C		1000	4		250		241	1
	D		2315	4		108		99	0
4x4	A		712	10.8		130		121	1
	B		1596	10.8		58		49	-1
	C		1602	4.8		130		121	1
	D		3205	4.8		65		56	0

TABLE 8. Async Reset

Scan Mode		Async Reset Timing								
Binning	Scan Area	aA (lines)	aB (µsec)	aC (µsec)	aD (µsec)	aE	aG (lines)	aH (lines)		aI (lines)*
								s1-8†	s9‡	
No binning	A	>1 & <2	43.2	4.8	1.9	s1-8: >1 line	s1=1 s2=2 s3=5 s4=12 s5=24 s6=49 s7=99 s8=199 s9=PW	20	>aH (s8) & < aH (s8) + 1	>aH (s8) +1 & < aH(s8) + 2
	B		43.2	4.8	1.9			19		
	C		16.0	4.0	3.8			18		
	D		16.0	4.0	3.8			32		
1x2	A		43.2	4.8	1.9			10		
	B		43.2	4.8	1.9			17		
	C		16.0	4.0	3.8			8		
	D		16.0	4.0	3.8			25		
1x4	A		46.4	4.8	2.7			10		
	B		46.4	4.8	2.7			16		
	C		19.2	4.0	4.6			8		
	D		19.2	4.0	4.6			22		

TABLE 8. Async Reset (Continued)

Scan Mode		Async Reset Timing								
Binning	Scan Area	aA (lines)	aB (μsec)	aC (μsec)	aD (μsec)	aE	aG (lines)	aH (lines)		aI (lines)*
								s1-8†	s9‡	
2x1	A	>1 & <2	43.2	4.8	1.9	s1-8: >1 line	s1=1 s2=2 s3=5 s4=12 s5=24 s6=49 s7=99 s8=199 s9=PW	20	>aH (s8) & < aH (s8) + 1	>aH (s8) +1 & < aH(s8) + 2
	B		43.2	4.8	1.9			19		
	C		16.0	4.0	3.8			18		
	D		16.0	4.0	3.8			32		
2x2	A		43.2	4.8	1.9			10		
	B		43.2	4.8	1.9			17		
	C		16.0	4.0	3.8			8		
	D		16.0	4.0	3.8			25		
2x4	A		46.4	4.8	2.7			10		
	B		46.4	4.8	2.7			16		
	C		19.2	4.0	4.6			8		
	D		19.2	4.0	4.6			22		
4x1	A	>1 & <2	43.2	4.8	1.9	s1-8: >1 line	s1=1 s2=2 s3=5 s4=12 s5=24 s6=49 s7=99 s8=199 s9=PW	20	>aH (s8) & < aH (s8) + 1	>aH (s8) + 1 & < aH(s8) + 2
	B		43.2	4.8	1.9			19		
	C		16.0	4.0	3.8			18		
	D		16.0	4.0	3.8			32		
4x2	A		43.2	4.8	1.9			10		
	B		43.2	4.8	1.9			17		
	C		16.0	4.0	3.8			8		
	D		16.0	4.0	3.8			25		
4x4	A		46.4	4.8	2.7			10		
	B		46.4	4.8	2.7			16		
	C		19.2	4.0	4.6			8		
	D		19.2	4.0	4.6			22		

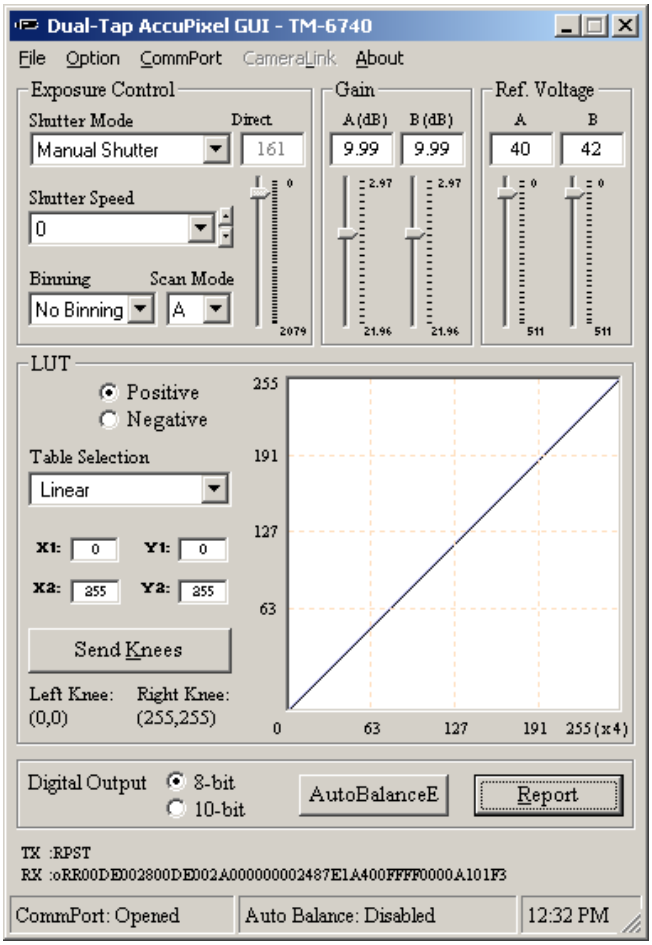
*. aJ < 1 sec (recommended value)
aK = > 1 line

†. s1-9 means async shutter 1-9.
PW means pulse width of external vinit.

‡. aE = s1-8 < 1 line. s9 <125 nsec.
aF = 500 nsec.

3.8.1 Serial Communication Kit

The Camera Link version's control software is included in the AccuPiXEL Camera Control software. For a detailed description of the software's operation, please see the AccuPiXEL software manual.



4 TM-6740 Command List

The Start character is always ":" and the End character is always "cr" (return). For example, to set Asynchronous Pulse Width Mode, send the command "ASH=9<cr>" to the camera. The following table contains commands that can be used to control the camera.

TABLE 9. TM-6740 Command List

Command Parameters	End of Command	Ack Response	Description	
Camera Control				
:VRA=	DDD	<cr>	:o<cr>	Set reference voltage for ch A (DDD = 000 - 1FF)
:VRB=	DDD	<cr>	:o<cr>	Set reference voltage for ch B (DDD = 000 - 1FF)
:MGA=	DDD	<cr>	:o<cr>	Set CDS gain for ch A (DDD = 042 - 1E8)
:MGB=	DDD	<cr>	:o<cr>	Set CDS gain for ch B (DDD = 042 - 1E8)
:VRA?		<cr>	:oVA[DDD]<cr>	Enquire reference voltage for ch A
:VRB?		<cr>	:oVB[DDD]<cr>	Enquire reference voltage for ch B
:MGA?		<cr>	:oGA[DDD]<cr>	Enquire CDS gain for ch A
:MGB?		<cr>	:oGB[DDD]<cr>	Enquire CDS gain for ch B
Test Pattern & Auto Balancing & Data Output Order				
:TPTN	N	<cr>	:o<cr>	Enable/Disable Test Pattern (N=1 Enable, N=0 Disable)
:EABL		<cr>	:o<cr>	Enable auto gain balance
:DABL		<cr>	:o<cr>	Disable auto gain balance
:ABL?		<cr>	:oAB[N]<cr>	Check if auto gain balance is enable (N=1 Enable, N=0 Disable)
:VDO	S	<cr>	:o<cr>	Video Data Output Order (s=A, B, C)
:DDP=	N	<cr>	:o<cr>	Set output data depth (N=0 8 bit, N=1 10 bit)
Shutter Control				
:MSH=	S	<cr>	:o<cr>	Set Manual Shutter (S= 0 - 9)
:DSH=	DDD	<cr>	:o<cr>	Set Direct Shutter (DDD=000 - XXX*)
:ASH=	S	<cr>	:o<cr>	Set Async Shutter (S= 0 - 9)
:SHR?		<cr>	:o[shtr]<cr>	Enquire current shutter mode and number

TABLE 9. TM-6740 Command List (Continued)

Command Parameters	End of Command	Ack Response	Description	
Lookup Table				
:GM45		<cr>	:o<cr>	Set gamma (.45) table
:LINR		<cr>	:o<cr>	Set linear table
:KNEE=	X1Y1X2Y2	<cr>	:o<cr>	Set knees (X1,Y1,X2,Y2 = 00 - FF)
:SLUT	N	<cr>	:o<cr>	Set positive knee or negative knee (0=positive, 1=negative)
:LUT?		<cr>	:o[lut]<cr>	Enquire current LUT setting
Memory Pages				
:WRPG	N	<cr>	:o<cr>	Write Page N (N = 0 - 6; Page 0 is factory setting and not allowed to change by customer)
:LDPG	N	<cr>	:o[settings]<cr>	Load Page N (N = 0 - 6)
:RDPG	N	<cr>	:o[settings]<cr>	Read (Report) Page N (N = 0 - 6)
:RPST		<cr>	:o[settings]<cr>	Report Current Overall Settings
Scan Mode				
:SMD	M	<cr>	:o<cr>	Set Mode (M = A,B,C,D)
:SMD?		<cr>	:oMD[mode]<cr>	Enquire current scan mode
:SMB=	N	<cr>	:o<cr>	Set Binning Mode (N=0~8)
Miscellaneous				
:CAM?		<cr>	[CamMode]	Enquire Camera Model
:VER?		<cr>	[version]	Enquire current version of firmware

*. Maximum size is equal to the maximum line number of each scan mode.

Note: If a command is not accepted for any reason, the camera will return a Nack response ":e<cr>".

Report Command : RPST<cr>

TS Return : 0 RR + "24 bytes" + <cr>

TABLE 10. 18 Bytes Status Report

Byte 1, 2	MGA		Channel A Gain Control (H'042 - H'1E8)
Byte 3, 4	VRA		Channel A Offset Voltage (H'000 - H'1FF)
Byte 5, 6	MGB		Channel B Gain Control (H'042 - H'1E8)
Byte 7, 8	VRB		Channel B Offset Voltage (H'000 - H'1FF)
Byte 9	Function Flag 0		
	Bit 7	output pixel order 1	"00"=<-- "10"=<-- "01"=<--
	Bit 6	output pixel order 0	
	Bit 5 Bit 4	ScanMode5 ScanMode4	"00" = horizontal no binning "10" = horizontal binning by 2 "01" = horizontal binning by 4
	Bit 3 Bit 2	ScanMode3 ScanMode2	"00" = vertical no binning "01" = vertical binning by 2 "10" = vertical binning by 4
	Bit 1 Bit 0	ScanMode1 ScanMode0	"00" = Scan area A "01"=Scan area B "10"=Scan area C "11"=Scan area D
Byte 10	Function Flag 1		
	Bit 7	ShutterMode2	"000"=Manual Shutter "001"=Async Shutter "010"=Direct Shutter
	Bit 6	ShutterMode1	
	Bit 5	ShutterMode0	
	Bit 4	Output Data Depth 0=8 bit	0=8bit; 1=10bit
	Bit 3	ShutterSpeed3	"0000" - "1001" Shutter Speed 0 - 9
	Bit 2	ShutterSpeed2	
	Bit 1	ShutterSpeed1	
	Bit 0	ShutterSpeed0	
Byte 11	Function Flag 2		
	Bit 7	LUTSIGN	0=Positive LUT; 1=Negative LUT
	Bit 6		
	Bit 5		
	Bit 4		
	Bit 3		
	Bit 2	LUTTABLE2	"000"=Linear LUT "001"=Gamma.45 LUT "010"=Two Knee Table
	Bit 1	LUTTABLE1	
	Bit 0	LUTTABLE0	
Byte 12	Function Flag 3		

TABLE 10. 18 Bytes Status Report (Continued)

	Bit 7	TESTPATTERN	0=Disable TP; 1=Enable TP
	Bit 6	PASSWORD	0=Disable PW; 1=Enable PW
	Bit 5		
	Bit 4		
	Bit 3		
	Bit 2		
	Bit 1		
	Bit 0	AUTOBALANCING	0=Disable AB; 1=Enable AB
Byte 13	X1		(X1, Y1) Coordinate for Knee 1 (X1, Y1 = H'00 - H'FF)
Byte 14	Y1		
Byte 15	X2		(X2, Y2) Coordinate for Knee 1 (X2, Y2 = H'00 - H'FF)
Byte 16	Y2		
Byte 17	Reserved		
Byte 18	Reserved		
Byte 19	Reserved		
Byte 20	Reserved		
Byte 21, 22	Direct Shutter		H'000 - H'819
Byte 23, 24	Reserved	Total line number	H'040 - H'1F3

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 PULNiX 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) 747-0300
	(800) 445-5444
Fax:	(408) 747-0660
E-mail:	imaging@jaipulnix.com
Mail:	JAI PULNiX, Inc.
	Sales Department
	1330 Orleans Drive
	Sunnyvale, CA 94089
	ATTN: Video Applications
Web Site:	www.jaipulnix.com

6 Appendix

6.1 Specifications

TABLE 11. TM-6740 Camera Specifications Table

Feature	TM-6740CL
Imager	1/3" progressive scan interline transfer CCD
Active Area	5.87mm x 4.71mm
Active Pixels	640 (H) x 480 (V)
Cell Size	7.4µm x 7.4µm
Display Mode (Active Pixels)	640 (H) x 480 (V) @ 200 Hz (full image) 640 (H) x 160 (V) @ 540Hz (partial scan) 224 (H) x 480 (V) @ 500Hz (partial scan) 224 (H) x 160 (V) @ 1250Hz (partial scan) (1x2, 1x4, 2x1, 2x2, 2x4, 4x1, 4x2, 4x4 binning)
Sync	Internal/External auto switch HD/VD, 4.0 Vp-p impedance 4.7 K ohms VD=frame rates±2%, non-interlace HD=horizontal frequency ±2%
Data Clock Output	40.00 MHz
Resolution	Digital:640 (H) x 480 (V), (Analog: over 480 TV lines (H) x 480 TV lines (V))
S/N Ratio	50dB min.
Min. Illumination	1.0 lux, f=1.4 (no shutter) @ 200 fps Sensitivity: 31µV/e-
Video Output	Analog: 714 mV, 75 ohms, (750 mV white clip) Digital output: 8-bit x 2 / 10-bit x 2 Camera Link
Gamma	Programmable LUT (1.0 std.)
Lens Mount	C-mount (use >1/3" format lenses or larger)
Power Requirement	12V DC, ± 10%, 440mA (maximum current at 25°)
Operating Temp.	-10°C to 45°C*
Vibration	7 Grms (10Hz to 2000Hz) Random
Shock	70G
Size (W x H x L)	50.8mm x 50.8mm x 85.1mm
Weight	162 grams, 5.7 oz (without tripod)

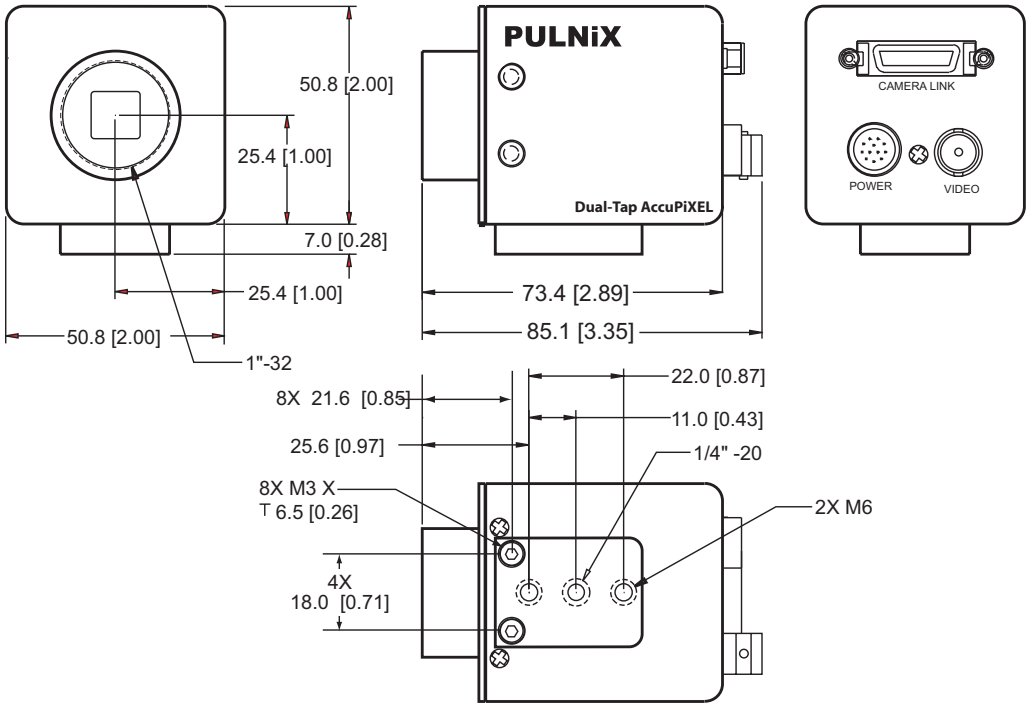
TABLE 11. TM-6740 Camera Specifications Table

Feature	TM-6740CL
Optional Functions	OP 3-1, internal IR filter; OP 3-2, optical filter removal; OP 25-2, TTL signals on 12-pin connector; OP 21, glassless CCD imager; OP 21-UV, UV glassless CCD imager
Optional Accessories **I/O CL cable** **Power Cable** **Power Supply**	 26CL-02-26 (2m), 26CL-05-26 (5m) 12P-02S PD-12UUP series (includes power connector)

*. Refer to Section 2.2.1 on page 4 for information on camera heat dissipation. Image quality will degrade with increasing temperature.

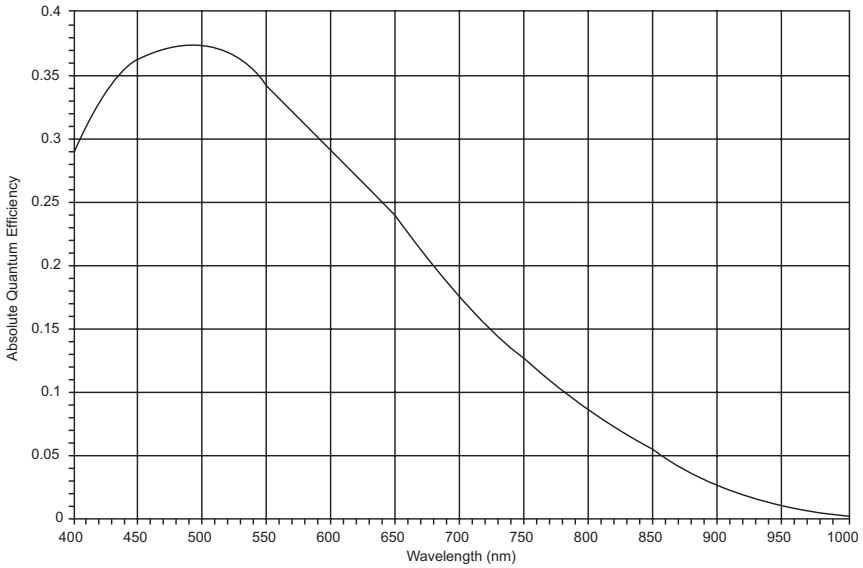
6.1.1 TM-6740 Physical Dimensions

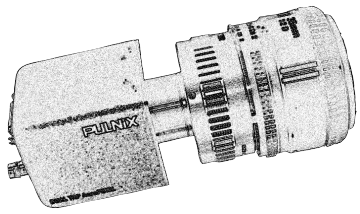
FIGURE 8. Physical Dimensions



6.1.2 Spectral Response

FIGURE 9. Spectral Response





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69-1209
Rev. A