

# TM-1020-15 Progressive Scan High-Resolution Shutter Camera

**PULNiX**  
Imaging Products



## General Description

The TM-1020-15 is a miniature, high-resolution monochrome progressive scan CCD camera. The imager resolution is 1024 x 1024 pixels and the frame rate is 15 frames per second. The interline transfer CCD permits full vertical and horizontal resolution of high speed shutter images. The electronic shutter has speed up to 1/16,000 sec. and can be reset asynchronously by external pulse control. The square imager format with uniform square pixels provides superior image definition in any orientation.

The TM-1020-15 has a patent-pending, PULNiX exclusive, built-in look-up-table (LUT). This full dynamic range-control function can be set at externally selectable knee slopes to optimize the CCD's full dynamic range in the normal output signal range. The camera has both analog and digital (RS-422) output for interfacing with frame grabbers.

All camera control functions are externally controlled via a user-friendly RS-232C graphical interface provided by PULNiX. The TM-1020-15 has a pixel clock locking phase lock loop (PLL) for multi-camera operation which requires exact data and clock phases from each camera (optional).\*

Applications for the TM-1020-15 include machine vision, medical imaging, intelligent transportation systems, high-definition graphics, gauging, character recognition, documents archiving, and surveillance.

## Integration

The CCD imager of the TM-1020-15 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 pin #11 of the 12-pin connector to low (GND).

## Asynchronous Reset

The TM-1020-15'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. There are three modes to control the asynchronous reset and shutter speed:

- ① External VINIT with pulse width. The duration between pulse edges controls the shutter speed externally.
- ② 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.)
- ③ 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.

## Product Summary

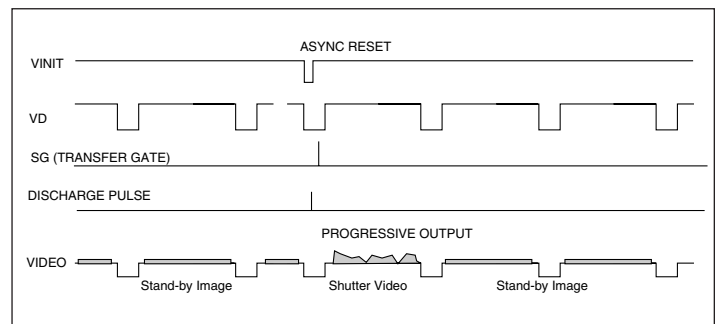
- High resolution, high-speed 1" progressive scan 1024(H) x 1024(V) interline transfer CCD imager
- Miniature 44x64x44 mm housing with high-rel connector
- Digital RS-422 output and analog output
- 15 frames per second
- Maximum dynamic range control with exclusive, patent-pending built-in look-up table (Gamma, knee, user parameters)
- Full frame integration, two-row binning (1024x512) pixels at 30fps
- Full-frame shutter to 1/16,000 sec.
- Asynchronous reset with external shutter control
- RS-232 external control
- Pixel clock locking for precision multiplexing of cameras (optional)\*

## Electronic Shutter

The TM-1020-15 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.

The CCD discharges at a high VINIT of 5V DC. With a negative pulse to VINIT, the camera resets and purges the charge momentarily. Then it starts integrating for the period of preset shutter control time 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.



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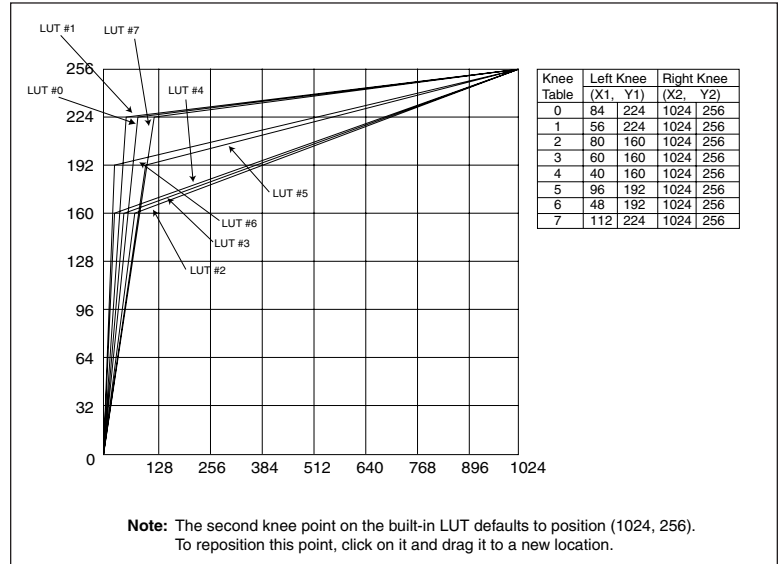
## Dynamic Range Control

Typical interline transfer CCDs have fixed noise levels based on dark current (thermal or KT noise), pattern noise, and operating clock speed. Typically for a 1k x 1k CCD operating at 20MHz pixel clock, the noise level is around 30 electrons. The maximum capacity of the CCD charges is limited by the well capacity at saturation. The range is limited by the structure and the pixel size.

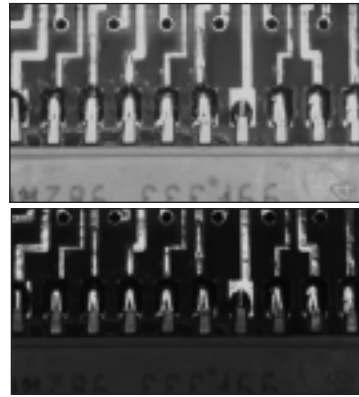
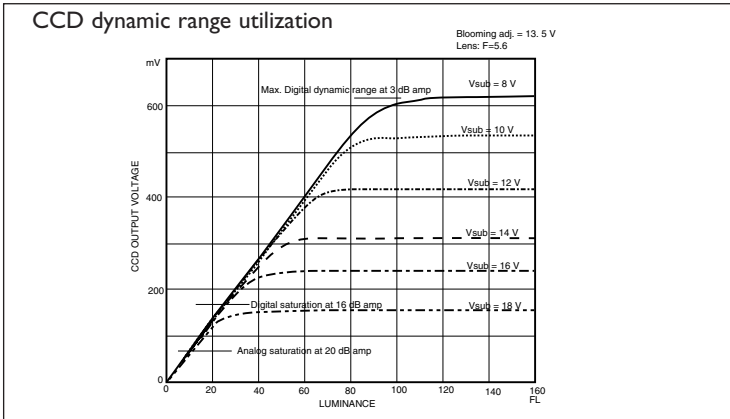
The TM-1020-15 uses a 1" CCD with 9.0 μm x 9.0 μm pixel and two-phase vertical shift register structure. The well capacity is 50,000 electrons. The theoretical dynamic range is 50,000:30 = 1667:1 (64 dB).

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 has its gain 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.

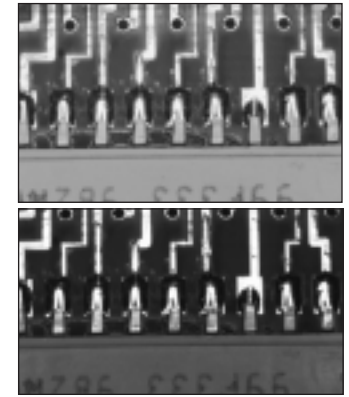
Machine vision and outdoor applications cannot afford to miss image information behind the saturation, which is why the dynamic range adaptation is critical.



resulting in all lines being obtained per captured image frame with electronic shutter.



Linear image: When PCB surface is visible, metal trace is saturated. If the metal surface appears, then the plastic surface is too dark.



Knee-controlled image: The upper is LUT#6, the lower is #7. Both show the full dynamic range with different effects.

## Programmable LUT and Knee Control (patent pending)

The TM-1020-15 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 full dynamic range of 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 to be segmented into three regions. The look-up table selection can be made either by variable knee curve or by direct input.

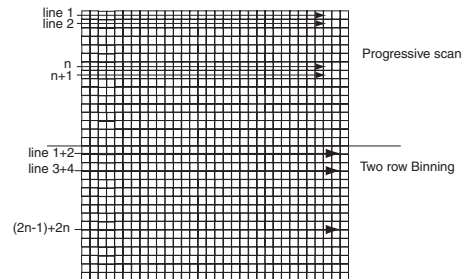
## Scan Mode

### Full Progressive Scan

Normal scanning mode for the TM-1020-15 is 1024 x 1024 pixels. The standard speed with single-channel output is 15 frame/sec at the pixel clock of 20 MHz. Unlike an interlace scan camera, the TM-1020-15 reads every line from top to bottom,

## Two-Row Binning

This is a standard feature in the TM-1020-15. The camera scans two rows together and outputs 1024 (H) x 512 (V) pixels at 30 frames per second. Two-row binning is typically implemented to increase speed.



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## External Sync

The TM-1020-15 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 only available for 15-frame mode and the frequency requirement is as follows:

$$f_{HD} = 15.734 \text{ KHz} \pm 5\%$$

$$f_{VD} = 15.00 \text{ Hz} \pm 5\%$$

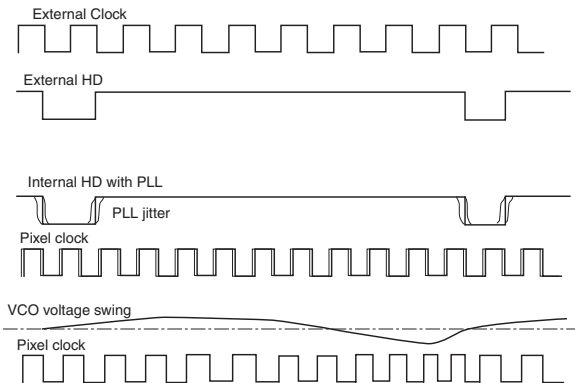
(Internal Master clock = 40.00 MHz,  
Pixel clock = 20.00 MHz)

Please contact PULNiX for TM-1020-15 timing charts.

## Pixel Clock Locking\*

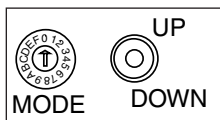
For multiple-camera applications such as 2D or 3D measurement, a parallel digital data input capability is important. The high resolution and precision measurement requires that camera data be consistent and free from phase lock loop (PLL) jitter. This is especially important for digital output multiplexing.

The TM-1020-15 has an optional capability for pixel clock locking. It takes RS-422 (differential) external clock and H and V reset sync (TTL or RS-422). By doing this, each camera's digital data is in-phase with the pixel clock (data clock) for multiplexing or parallel input to a frame grabber.



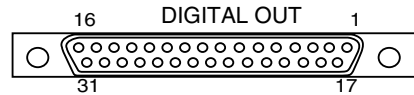
## Mode Switches

Various modes can be implemented with the rear panel-mode selection switch and Up/Down switch as well as RS-232 external control. When RS-232 is connected, the command over-rites the rear panel switch settings.



## Connector and Pin Configurations

### Digital Output Connector

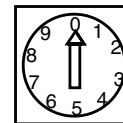
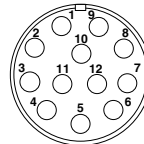


31-Pin connector (MP211-031-113-4300)					
Pin#	Description	I/O	Pin#	Description	I/O
1	CLK+	Out	17	CLK-	Out
2	LDV+	Out	18	LDV-	Out
3	FDV+	Out	19	FDV-	Out
4	GND		20	VINIT	In
				[INTEG	In]
5	EXT HD (TTL) in		21	EXT VD (TTL)	
	[EXT CLK+ In]			[EXT CLK-	In]
6	INTEG	In	22	N/C	
	[HD+ In]			[HD-	In]
7	N/C		23	GND	
	[Vinit+/(VD+) In]			[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				

**Note:** CLK: data clock, LDV: Line data valid, FDV: Frame data valid, INTEG: Integration control, EXT CLK: external pixel clock, [ ]: Differential input option

### 12-Pin Connector

1	GND (power)	7	VD in
2	+12V	8	Strobe+ out
3	GND (analog)	9	HD in
4	Video out	10	RXD(RS232)
5	GND (digital)	11	Int. cont
6	VINIT in	12	TXD(RS232)



### Shutter Control Switch

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	1/1,000	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

### Mode Switch

### Up/Down Switch

### Functions

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	Back to linear table
7	Knee Selection	Up / Down (Scroll)	Scroll 10 different LUTs
8	Async Reset Mode	Up: Normal, Dwn: Async	Async and normal shutter
9	Factory Default Recall	Up / Down: Recall	Factory setting
A	Power up Setting	Up: Recall, Dwn: Save	Power up page setting
B	User Page Storage#1	Up: Recall, Dwn: Save	User page storage setting
C	User Page Storage#2	Up: Recall, Dwn: Save	User page storage setting
D	Direct Shutter Control	Up / Down	Shutter speed increment by 1H
E	Scan Format2	Up: Optional, Dwn: Binning	Two-row binning selection
F	Scan Format1	Up: Normal, Dwn: Optional	Custom option scanning

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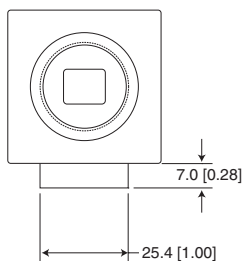
## Product Specifications

<b>Imager</b>	1" (9.1mm x 9.2mm) progressive scan interline transfer CCD
<b>Pixel</b>	1024 (H) x 1024 (V)
<b>Cell size</b>	9.0 $\mu\text{m}$ x 9.0 $\mu\text{m}$
<b>Scanning</b>	1050 lines; 15 Hz; 1024 x 512 lines, 30Hz (two-row binning)
<b>Sync</b>	Internal/external auto switch HD/VD, 4.0 Vp-p impedance 4.7K $\Omega$ VD=15 Hz $\pm$ 5%, non-interlace, HD=15.734kHz $\pm$ 5%
<b>Data clock output</b>	20.000 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, f=1.4 without IR cut filter (no shutter) Sensitivity: 12 $\mu\text{V}/\text{e}^-$
<b>Video output</b>	Analog: 1.0 Vp-p composite video, 75 $\Omega$ Digital output: 8-bit RS-422
<b>AGC</b>	OFF
<b>Gamma</b>	Programmable LUT(1.0 std.)
<b>Lens mount</b>	C-mount (use 1" format lenses)
<b>Power req.</b>	12V DC, 500 mA (current measured at 25 $^{\circ}$ )
<b>Operating temp.</b>	-10 $^{\circ}\text{C}$ to 45 $^{\circ}\text{C}$ **
<b>Vibration</b>	7Grms (10 Hz to 2000 Hz) Random
<b>Shock</b>	70G
<b>Size (W x H x L)</b>	44mm x 44mm x 64mm (1.73" x 1.73" x 2.51")
<b>Weight</b>	149 grams, 6.1 oz
<b>Power cable</b>	12P-02S (optional)
<b>Power supply</b>	PD-12UUP series (includes power connector)
<b>Functional options</b>	RS-644 output, adjustable back-focus front end, pixel clock locking
<b>I/O accessories</b>	30DG-02 digital output cable CS-232E serial communication kit

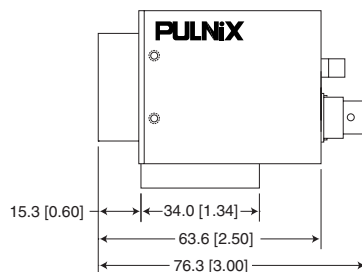
\* This option not available at time of publishing. Please check with PULNiX for current availability.

\*\* Image quality will degrade with increasing temperature.

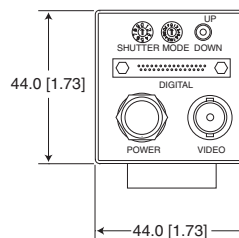
Front End



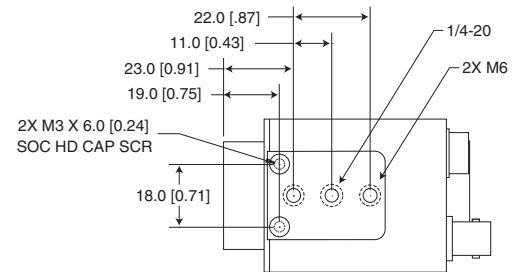
Side View



Back Panel



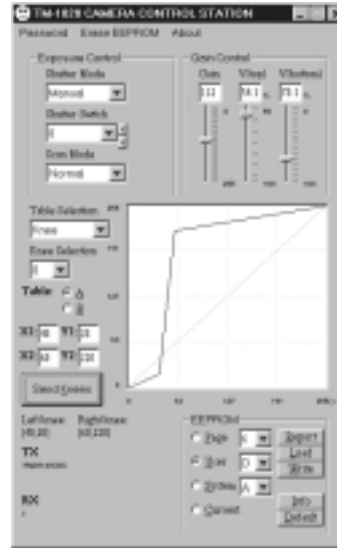
Bottom Panel



## Graphical User Interface

A user-friendly graphical user interface (GUI) is provided in the CS-232E kit. This interface allows users to control the following functions of the TM-1020-15 camera:

- **Shutter control** for manual, async. and pulse width control
- **Gain control**
- **A/D reference voltages control** for Vtop and Vbottom
- **Save settings**
- **Load settings**
- **Report settings**
- **LUT setting and graphic display**
- **Scanning mode selection and Option selections**



Camera parameters are uploadable from PC to the camera. Once these parameters are stored in EEPROMs, an instantaneous change from one setting to another can be done with a delay of few frames in between.

## Serial Communication Kit

The serial communication kit CS-232E consists of serial cable RS-232B-12, software disk, and quick-start guide. The RS-232B-12 cable has a 12-pin connector on the camera end and a 9-pin d-sub connector (RS-232) and a 12-pin connector (power and sync signals) on the other end.

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71-0042 Rev. B