

PULNiX

TM-1400

General Description

The TM-1400 is a miniature, high-resolution (1.4 megapixels) monochrome progressive scan CCD camera. The imager resolution is 1392 x 1040 pixels and the frame rate is 15 and 30 frames per second. The interline transfer CCD permits full vertical and horizontal resolution of high-speed shuttered images. The electronic shutter has speeds up to 1/16,000 sec. and can be reset asynchronously by external pulse control.

The TM-1400 has a patent-pending, PULNiX exclusive, built-in dual 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. It also provides fast 10-bit to 8-bit pre-processing for effective image feature enhancement. The camera has both analog and digital (RS-644) output for interfacing with frame grabbers.

All camera-control functions are externally controlled via a user-friendly RS-232C graphical interface provided by PULNiX.

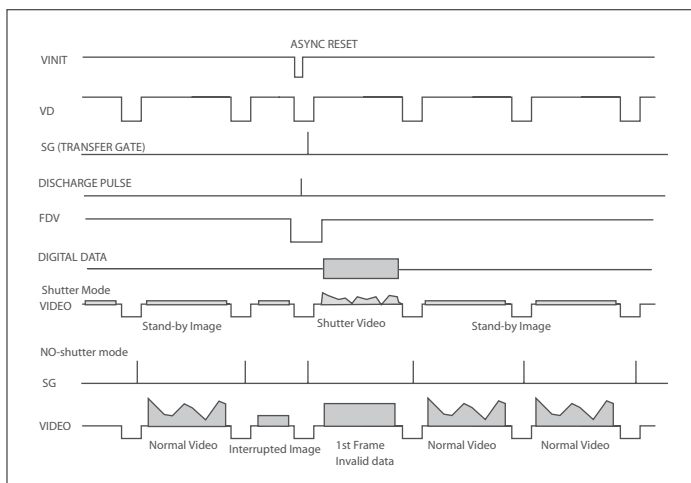
Applications for the TM-1400 include machine vision, medical imaging, intelligent transportation systems, high-definition graphics, gauging, character recognition, documents archiving, and surveillance.

Asynchronous Reset

The TM-1400'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 two 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 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.



Product Summary

- High-resolution 1/2" progressive scan 1392(H) x 1040(V) interline transfer CCD imager
- Miniature 44x44x64 mm housing with high-rel connector
- Digital RS-644 (LVDS) output and analog output
- 15 frames and 30 frames per second selectable
- Maximum dynamic range control with PULNiX-exclusive, patent-pending built-in look-up table (Gamma, knee, user parameters)
- Full frame integration
- Image center partial scan (500, 250 lines)
- Full-frame shutter to 1/16,000 sec.
- Asynchronous reset, no-delay shutter and read-out-inhibit control for multiple-camera applications
- RS-232 external control
- Near IR sensitivity and high gain CCD output
- Color version (RGB Bayer CFA) is available (TMC-1400)

Electronic Shutter

The TM-1400 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 (double the speed at 30 fps mode).

The CCD discharges when discharge pulse is applied via internal shutter control. With a negative pulse to VINIT, the camera resets and purges the CCD 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 1040 lines of vertical resolution, as compared to a conventional CCD camera which captures only half the vertical lines per shutter.

Integration

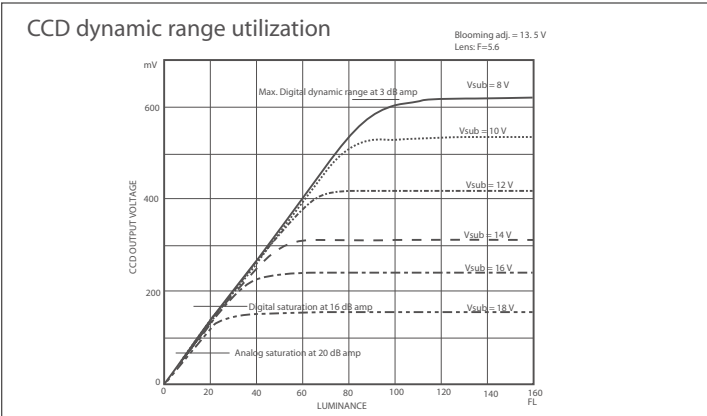
The CCD imager of the TM-1400 can be exposed for longer than the normal scan timing of 1/15 sec. This integration feature provides extra sensitivity for dark-environment applications. The progressive-scan imager permits a full frame of resolution in non-interlace format. Integration is achieved by applying INTEG signal to pin #11 of the 12-pin connector or pin #6 of the 31-pin connector, or by feeding VINIT pulse width control up to 1 sec of the pulse width.

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 25.0MHz 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-1400 uses a 1/2" CCD with 4.65 μm x 4.65 μm pixel and three-phase vertical shift register structure. The well capacity is 8,000 electrons. The theoretical dynamic range is 8,000:30 = 267:1 (48 dB).

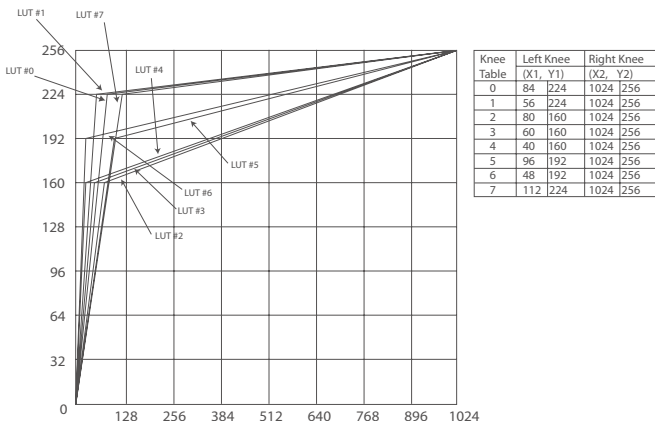
A typical CCD camera does not use the full dynamic range due to the nominal gain and the output specification such as RS-170. The typical CCD camera has its gain set at 16 to 22 dB and the RS-170 video level is 714 mV. Using 20 dB gain for the calculation, CCD output is limited to 714/10 = 71.4 mV. Since 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.

Programmable LUT and Knee Control (patent pending)

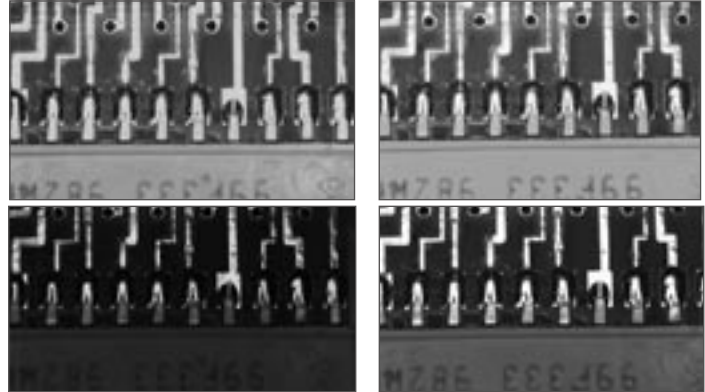
The TM-1400 has a built-in LUT (look-up table) for dynamic range control.



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.

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 bits to be segmented into three regions. The look-up table selection can be made either by variable knee curve or by direct input of the knee coordinates.



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.

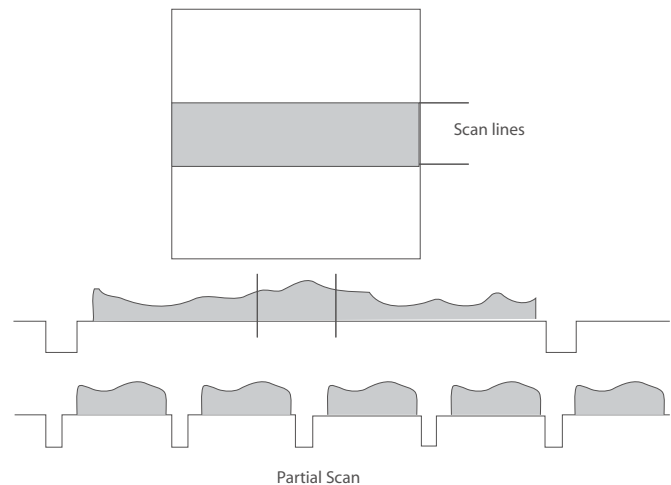
Scan Mode

Full Progressive Scan

Normal scanning mode for the TM-1400 is 1392 x 1040 pixels. The standard speed with single-channel output is 30 frames/sec. at the pixel clock of 50.0 MHz. (It can also be set to run 15 frames per second at 25.0 MHz.) Unlike an interlace scan camera, the TM-1400 reads every line from top to bottom, resulting in all lines being obtained per captured image frame with electronic shutter.

Partial Scan

500 lines and 250 lines partial scan is selectable. It outputs image center of 500 lines and 250 lines. At 500 lines the frame rate is 56 frames/sec. At 250 lines, it is 99 frames. Standard partial scan control is only available in 30fps mode.



Partial Scan

External Sync

The TM-1400 accepts an external sync. of standard HD and VD at TTL level for general locking to a system sync. and clock. External sync. is available for 30-frame mode only. The frequency requirement is as follows:

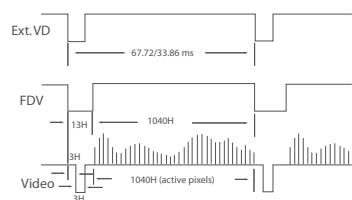
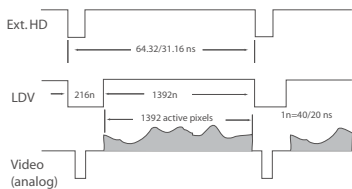
$$f_{HD} = 31.09 \text{ KHz} \pm 2\%$$

$$f_{VD} = 29.5 \text{ Hz} \pm 2\%$$

(Internal Master clock = 100.0 MHz,

Pixel clock = 25.0 or 50.0 MHz)

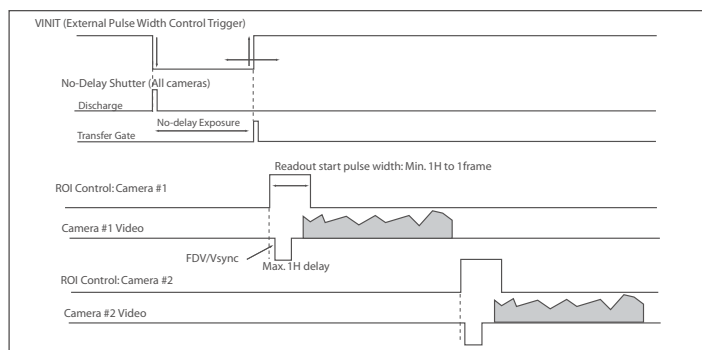
Please contact PULNiX for TM-1400 timing charts.



No-delay Shutter and Read-out-inhibit

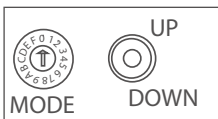
For multiple-camera applications such as 2D or 3D measurement and multi-angle inspection, simultaneous image capturing at an exact shutter timing for all cameras is a critical requirement. The TM-1400's **async pulse width control mode** provides no-delay shutter as standard. Regardless of internal pulse timing, it discharges at VINIT's 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, image capturing is exactly simultaneous.

The TM-1400 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 works like CCD memory. When ROI is high, it clocks out the CCD data. This helps a single frame grabber process multiple images in pipeline processing (sequential process).



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 overwrites the rear panel switch settings.



Connector and Pin Configurations

Mode Switch	Up/Down Switch	Functions
0 Switch Disabled	Switch Disabled	None
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 8 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: 500, Dwn: 250	Partial selection
F Scan Format1	Up: 30 fps, Dwn: 15 fps	Custom option scanning

Digital Output Connector



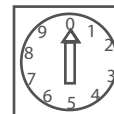
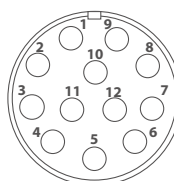
31-Pin Connector (MQ21-031-113-4300)

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 (TTL)	In
5	EXT HD (TTL)	In	21	EXT VD (TTL)	In
6	INTEG/ROI (TTL)	In	22	N/C	
7	N/C		23	GND	
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 GND
3 GND (analog)	9 HD in
4 Video out	10 RXD(RS232)
5 GND (digital)	11 INTEG/ROI
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	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

(For 30 fps mode, the shutter speed doubles)

SPECIFICATIONS

Imager	1/2" progressive scan interline transfer CCD
Active Area	6.47mm x 4.84mm
Active Pixels	1392 (H) x 1040 (V)
Cell size	4.65µm x 4.65µm
Display Mode (Active Pixels)	1392 (H) x 1040 (V) @ 15/30 Hz 1392 (H) x 500, 250 (V) @ partial scan
Sync*	Internal/external auto switch HD/VD, 4.0 Vp-p impedance 4.7K Ω VD=15 / 30 Hz ± 2%, non-interlace HD=15.55 / 31.09 kHz ± 2%
Data clock output	50.00 / 25.00 MHz
Resolution	Digital: 1392 (H) x 1040 (V), Analog: over 900 TV lines (H) x 800 TV lines (V)
S/N ratio	48 dB min (AGC off)
Min. illumination	1.0 lux, f=1.4 (no shutter) @ 30 fps Sensitivity: 50µ V/e-
Video output	Analog: 714 mV, 75 Ω (900 mV white clip) Digital output: 8-bit RS-644

AGC	OFF
Gamma	Programmable LUT (1.0 std)
Lens mount	C-mount (use > 2/3" format lenses)
Power req	12V DC ± 10%, 380 – 520 mA (current measured at 25°)
Operating temp†	-10°C to 50°C
Vibration	7Grms (10 Hz to 2000 Hz) Random
Shock	70G
Size (W x H x L)	44mm x 44mm x 64mm (1.73" x 1.73" x 2.51")
Weight	133 grams, 4.7 oz (without tripod)

MUST BE ORDERED SEPARATELY	
Opt. Functions	Adjustable back-focus front end, 12 fps, 24 fps
Opt. Accessories I/O	30DG-02 digital output cable CS-232E serial communication kit
Power cable	12P-02S power cable with open leads
Power supply	PD-12UUP series (includes power connector)

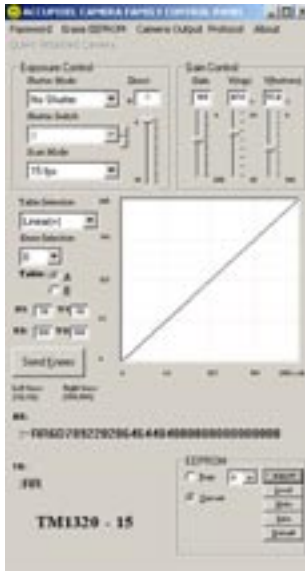
* External sync only at 30 fps.

† Image quality will degrade with increasing temperature.

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-1400 camera:

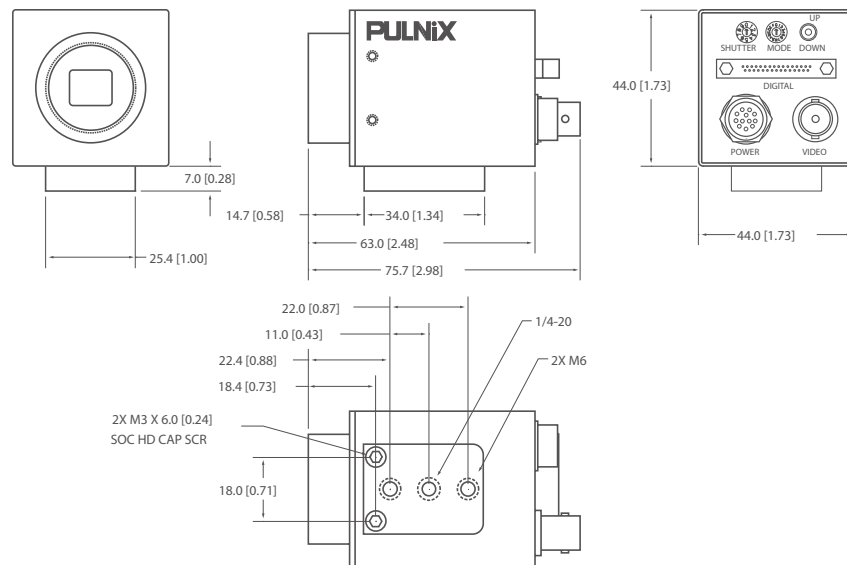
- Shutter control for manual async. and pulse width control
- Gain control
- A/D reference voltages control for Vtop and Vbottom
- Save settings
- Load settings
- Report settings
- LUT setting and graphic display
- Scanning mode selection and Option selections



Camera parameters can be uploaded from the 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, a software disk, and a 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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