Cambridge Technology

CRS (Counter Rotation Scanner) User's Manual

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Revision K

www.CambridgeTechnology.com

Contact Information

Americas

25 Hartwell Ave.
Lexington, MA 02421
U.S.A.
TEL: +1 (781) 541-1600
FAX: +1 (781) 541-1601
E-mail:
Scanners@camtech.com

Europe

Munchener Strasse 2a
D-82152 Planegg
Germany
TEL: +49 (89) 31707-0
FAX: +49 (89) 31707-250
E-mail:
Scanners-Europe@camtech.com

Asia

1F, NOF Kanda Iwamoto-cho Bldg
3-8-16, Iwamoto-cho
Chiyoda-ku, Tokyo 101-0032,
Japan
Tel: +81 (3) 5825-8853
Fax: +81 (3) 5825-8858
E-mail:
scanners-asia@camtech.com

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1 IMPORTANT INFORMATION

1.1 ESD WARNING

The OEM electronics that *Cambridge Technology* manufactures - including galvanometers and servo controllers - are electrostatic discharge (ESD) sensitive. Improper handling could therefore damage these electronics. *Cambridge Technology* has implemented procedures and precautions for handling these devices and we encourage our customers to do the same. Upon receiving your components, you should note that it is packaged in an ESD-protected container with the appropriate ESD warning labels. The equipment should remain sealed until the user is located at a proper static control station*.

Note: Any equipment returned to the factory must be shipped in anti-static packaging.

(*) A proper static control station **should** include:

1. A soft grounded conductive tabletop or grounded conductive mat on the tabletop.
2. A grounded wrist strap with the appropriate (1 Meg) series resistor connected to the tabletop mat and ground.
3. An adequate earth ground connection such as a water pipe or AC ground.
4. Conductive bags, trays, totes, racks or other containers used for storage.
5. Properly grounded power tools.
6. Personnel handling ESD items should wear ESD protective garments and ground straps.

1.2 Warranty Information

The Customer shall examine each shipment within 10 days of receipt and inform *Cambridge Technology* of any shortage or damage. If no discrepancies are reported, *Cambridge Technology* shall assume the shipment was delivered complete and defect free. *Cambridge Technology* warrantees products against defects up to 1 year from manufacture date, barring unauthorized modifications or misuse. Repaired product is warranted 90 days after the repair is made, or one year after manufacture date - whichever is longer.

Contact Customer Service to obtain a Return Materials Authorization number *before returning any product for repair*.

All orders are subject to the *Cambridge Technology* Terms and Conditions and Limited Warranty. Visit our website for the latest version of these documents and other useful information.

IMPORTANT: Optical Scanners are normally tuned, serialized and warranted as a matched set for optimized performance. Mismatched components negatively affect performance and void the warranty. A matched set typically consists of galvanometer motor, mirror load, electronic driver board and interface cable.

1.3 Customer Support

Cambridge Technology has support services to address your questions or concerns with either the product or manual you are using. Before calling for assistance, be sure to refer to any appropriate sections in the manual that may answer your questions. Call *Cambridge Technology's* Customer Service Department Monday through Friday between 8 A.M. and 5 P.M. local time (GMT –05:00 Eastern Time (US & Canada)).

The customer service personnel will be able to give you direct assistance and answers to your questions.

2 INTRODUCTION

The benefits of laser technology are becoming increasingly more apparent in a number of markets. These markets include, but are not limited to, inspection systems, bio-scientific analysis, microscopy, medical equipment, and imaging systems. As applications demand the use of laser technology, equivalent demands are being made on devices that can dynamically redirect laser energy. Industries need for a high speed scanning device which has a large aperture angle product and excellent repeatability characteristics are what prompted General Scanning to develop a series of resonant Counter Rotating Scanners (CRS).

Through the use of beryllium mirrors and improved torsion rod design, the CRS is produced with scanning frequencies of 4 and 8 kHz. Using bi-directional scanning methods, scanning frequencies of 16 kHz can be achieved. In comparison to rotating polygon scanners, the CRS has the ability to achieve high scanning speeds, up to video rate, at a comparatively low cost, with reduced impact in the overall system design.

2.1 Important Operating Notes

Be sure to consider the following when integrating the CRS scanner into your final system:

- Moving at extremely high speeds, the CRS mirror is susceptible to damaging collisions with the tiniest of particles. For this reason, it is necessary to ensure that the scanner's mirror is placed in a completely dust free environment to avoid degradation to the mirror's surface.

- The audible noise created by the CRS scanner is inherent of resonant scanner technology. Placing the scanner in a large mounting structure and enclosing the unit will help reduce the noise significantly.

3 DESCRIPTION

The CRS is a compact, high frequency resonant scanner that operates at nominal frequencies of 3938 or 7910Hz. The scanner features two oscillating torsion rods that are mechanically tuned to resonate in opposite phase. These torsional motions set up equal and opposite torques that cancel at the torsion rod attachment to its housing. Theoretically, the result is a mechanical oscillator that is reactionless and eliminates all external vibration. To minimize cross-axis wobble (repeatability), the torsional masses at the end of the oscillating torsion rods have been mass-balanced along the rotational axis of the scanner. Typical scanning angles are 15° Optical Peak to Peak (OPTP). Scanning angles of 24° OPTP and 26° OPTP are approachable using 4 kHz and 8 kHz CRS scanners, respectively.

Clear apertures for the 4 and 8 kHz scanners are 10mm and 4.7mm, respectively. Optical grade beryllium, due to its superior stiffness-to-weight ratio, is used for CRS mirrors. The mirrors are available with enhanced aluminum or silver coatings. Silver coatings provide reflectivity properties at 45° angle of incidence (AOI) of greater than 90% @ 400nm, and 95% @ above 550nm. Custom mirror coatings may be customer specified.

The scanner connector has four conductors, two provide current to the drive coil, and two provide proportional feedback current derived from the velocity of the mirror (Figures 3.1 & 3.2). This velocity pick-off maintains self-oscillation and amplitude control of the scanner using the General Scanning, CRS Driver Board that is discussed later in this document. Due to the exceedingly high quality factor (Q) possessed by the torsion rod, the CRS requires very little power. Typical quiescent scanner power is 1W.

4 DRIVER BOARD

The CRS Driver Board has been designed specifically to take into account the scanner's slight variation in phase characteristic and Q. The board consists of a self-oscillatory loop that keeps the scanner at mechanical resonance.

4.1 Amplitude Control

Amplitude calibration and adjustment is performed using R7. This adjustment is factory set and due to risk of permanent damage to the scanner, only experienced personnel should make adjustments to this potentiometer. Amplitude control is determined with an analog voltage between 0V to 5V applied to J3 pin 1. Also used for amplitude control are two TTL bits applied to J3 pins 5 and 6. A digital 00 through 11 applied to these pins reduce the CRS' amplitude by a factor of 1 through 4, respectively. The calibrated voltage applied to J3 pin 1 is compared with scanner velocity feedback voltage and acts as a control loop. Typical step and settle with the amplitude control loop is on the order of 6msec. An amplitude stability of 0.02% of peak amplitude is indeed a result of the high bandwidth of the amplitude control loop.

4.2 Sync Pulse Description

Sync pulse phase adjustment (R48), is used to fine tune the sync pulse activation. Using this potentiometer, the sync signal generated on the driver board can be phase adjusted relative to the mirror position. With the 4 kHz CRS this adjustment range is approximately ±5uSec, which corresponds to approximately ±6% of the 85uSec active scan period for uni-directional scan field with 88% amplitude scan efficiency. Though the sync signal is hard-wired to connector J2, W1 acts as an enabling jumper to provide the sync signal to J3 pin 8. This is provided for use with auxiliary equipment such as the CRS Pixel Clock.

4.3 Driver Pinout Definition

The following table shows the connector pinouts and Test Point assignments for the CRS driver board.

Table 4-1: Driver / Scanner Pinouts

[J1] 8kHz Scanner Connector	
Pin	**Signal**
1	Ground
2	Velocity Coil Start
3	Velocity Coil Return
4	Drive Coil Return
5	Drive Coil Start

[J4] 4kHz Scanner Connector		
Flat Cable Pinouts		**Signal**
At Driver	*At Scanner*	
1	4	Velocity Coil Start
2	3	Velocity Coil Return
3	2	Drive Coil Return
4	1	Drive Coil Start

J2 Aux. Connector	
Pin	**Signal**
1,2,3	+5Vdc Output
4	TTL Sync. Pulse
5,6,8	Digital Ground
7,9,10	Analog Ground
11,12	-12Vdc Output
13,14	+12Vdc Output

J3 Main Connector	
Pin	**Signal**
1	Zoom High (0-5V)
2	Zoom Return
3	Signal Ground, Digital
4	Relay Shutoff (Active Low)
5	SEL 0 (Scaling Bit 0)
6	SEL 1 (Scaling Bit 1)
7	Analog Ground
8	CRS Sync (W1 dependent)
9,10	+5Vdc
11,12	Analog Ground
13,14	+15Vdc
15,16	-15Vdc

Test Points	
TP	**Signal**
1	Scanner Drive
2	Scanner Drive Return
3	Velocity Coil
4	Velocity Coil Return
5	Analog Ground
6	Integrator Out
7	Velocity
8	Rectified Velocity

5 PIXEL CLOCK

The pixel clock is used to linearize spot placement throughout the scan field. The CRS has a sinusoidal angular displacement with a frequency equal to the scanner's resonant frequency. The angular velocity is a cosine function derived from the mirror position. Figure 5.1 shows the relationship between the CRS scan angle and its velocity. The pixel clock board provides a velocity-corrected pixel clock that continually changes speed to match the scanner's angular velocity variation and resonant frequency. For example, using a constant-speed pixel clock, pixels would be spread out at the middle of the scan and compressed at the edges of the scan field. Minimal scan distortion is achieved with the linearizing pixel clock that spaces the pixels equidistant across the scan field. The Pixel Clock is also used to correct for small scan-to-scan resonant frequency variations and distortions due to lenses in the beam path. These inconsistencies, which are inherent in scanner manufacturing and implementation, are compensated through the use of a programmable look-up-table.

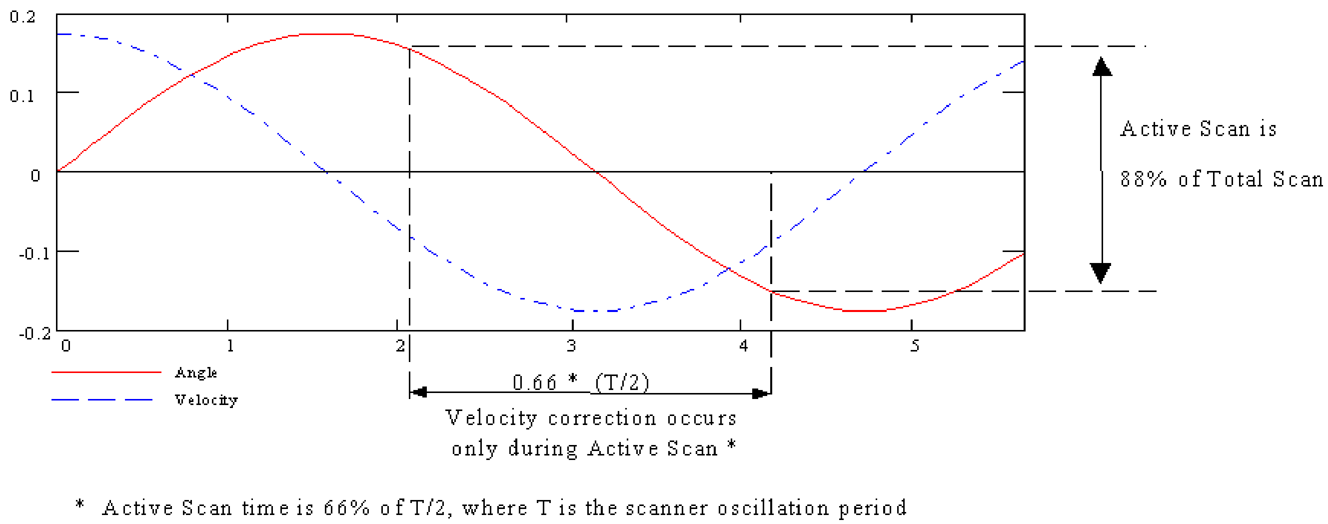

Figure 5.1: CRS Scan Angle and Velocity

Jumper W1 determines output characteristics of the pixel clock. Installed, the pixel clock output will be gated with the pixel enable signal, therefore, only providing output when the pixel enable is high. Not installed, the pixel clock output will be provided constantly. Jumper W3 connects the analog and digital grounds. Installation may be necessary in some system configurations. LED D1 is provided to verify phase locking between the CRS and Pixel Clock. When illuminated, phase lock is not being achieved which indicates there is a problem.

Table 5-1 shows the approximate range of clock rates for each scanner at a given pixel resolution.

Table 5-1: Pixel Clock Rates

SCANNER FREQ	PIXELS/LINE	MIN CLOCK*	MAX CLOCK*
4kHz	1024	7.5 MHz	15 MHz
8kHz	512	7.5 MHz	15 MHz
This chart assumes an amplitude efficiency of 88% (or 66% in time) for a unidirectional scan.			

* Nominal rate only. The actual rate depends on the lens correction used, and on the exact scanner frequency.

5.1 Pixel Clock Pinout Definition

Table 5-2: Pixel Clock Pinout

J1 (Data Output)*	
Pin	**Signal**
1,2,7,8,9	N/A
3,4,5,6	Analog Ground
13,16,19,22	Digital Ground
14	Pixel Enable +
15	Pixel Enable -
17	RS422 Pixel Clock +
18	RS422 Pixel Clock -
20	Phase Lock Active High +
21	Phase Lock Return -
23,24	N/A

J2 (Power and Sync)	
Pin	**Signal**
1,2,3	+5Vdc Input from Drive Board
4	Scanner Sync
5,6,8	Digital Ground
7,9,10	Analog Ground
11,12	-12Vdc Input from Drive Board
13,14	+12Vdc Input from Drive Board

* Note: Pins 14/15, 17/18 and 20/21 must be connected to a differential line receiver. Never connect pins 15, 18 or 21 to GND – doing so will cause the Pixel Clock to lose lock until the GND is removed.

6 APPLICATION NOTES

Applications of the CRS include confocal microscopy, inspection of glass and metal, WEB inspection, and two-axis imaging/inspection. Typically, the CRS is used to deflect the laser in one axis with an alternate method being used to move either the laser or the subject in the perpendicular axis. As the laser or subject is moved perpendicular to the CRS' scan axis, the laser light will illuminate the subject in a raster fashion. Using optical isolation techniques, illuminated light can be distinguished from reflected light from the subject. De-scanning the reflected light from the subject using the CRS will create a collimated source of light reflected from a finite portion of the subject's area. Focusing this light onto an optical sensor such as an avalanche photo diode (APD), photo diode, linear array, or photo multiplier tube provides a "volts per luminous" intensity signal for the reflected light. This is the Luma signal.

Provided from the Pixel Clock PCB are the signals 'Pixel Clock Output', 'Pixel Enable', and 'Scanner Sync'. The Pixel Clock Output (pixel clock) is provided as a means in which the Luma signal can be clocked into imaging hardware as a pixel with a finite intensity. Pixel Enable is provided to determine the corrected linear portion of the sinusoid. When high, valid pixel information is available. When low, the pixel information is invalid due to the mirror changing direction. If the Pixel Enable signal is insufficient for providing horizontal timing, digital circuitry will need to be implemented using the Pixel Clock and Pixel Enable signals to create a horizontal sync pulse. Scanner Sync is provided as means in which to determine the direction of the scan mirror. This signal can be used to implement bi-directional scanning. Cross axis (vertical) timing is not provided with the CRS hardware. These timing signals, if imaging on a WEB would be provided from its controller hardware/software. If a galvanometer is being used to deflect the laser as opposed to moving the subject, cross axis (vertical timing) is provided from the cross axis galvanometer's command input signal.

7 TYPICAL SYSTEM CONFIGURATION

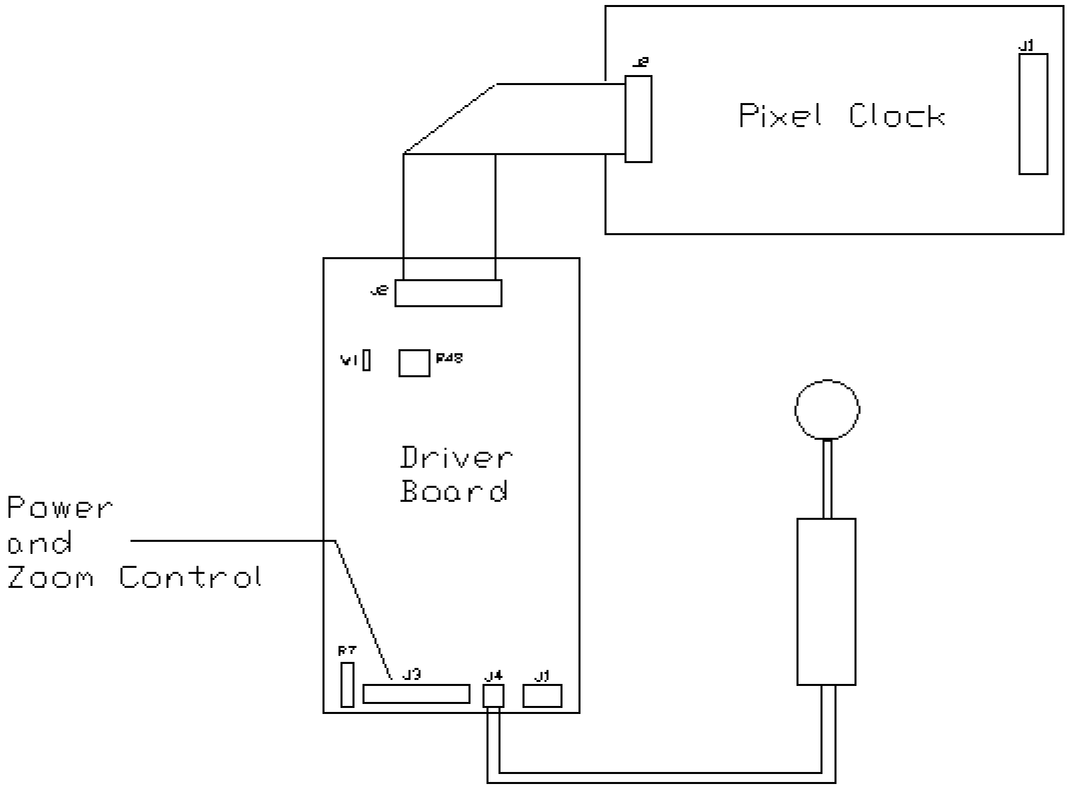

Figure 7.1: Typical CRS System Configuration

Typically, CRS orders are provided with the following associated hardware: Pixel Clock PCB; Driver Board PCB; PCB interconnect cable; and possibly, in the case of the 4 kHz CRS, a scanner interconnect cable. When your equipment is first received, inspect all components for damage that may have occurred during shipping. If damage has occurred, please notify General Scanning immediately, and return the damaged goods. Otherwise, proceed in setting up the CRS system by connecting J2 of the Pixel Clock PCB to J2 of the Driver Board using the scanner interconnect cable. Both the PCB connectors and the cable connectors have pin #1 designated by a small triangle stamped into the connector housing. Align the triangles while mating the connectors, this ensures correct orientation. Connect the CRS scanner to the driver board using either the interface cable (4 kHz), or the pigtail connector from the scanner (8 kHz). The driver board mating connectors for the 4 kHz and 8 kHz scanners are J4, and J1, respectfully.

Power supplies of ±15Vdc and +5Vdc will be necessary for proper CRS operation. Reference the Driver Board J3 'Main Connector' pin assignments for the application of power. This is the only connector in which external power supplies are necessary due to the Driver Board having on-board regulators that provide power to the Pixel Clock.

Signals 'Zoom High' and 'Zoom Return' are used to adjust the amplitude of the scan angle. Applying a 0-5Vdc to these pins will adjust the scan amplitude. Note: Scanners are calibrated such that +5Vdc equates to the maximum scan angle. Damage may occur if the voltage exceeds +5Vdc.

8 CONNECTOR INFORMATION

Figure 8.1: CRS 4 kHz Connector

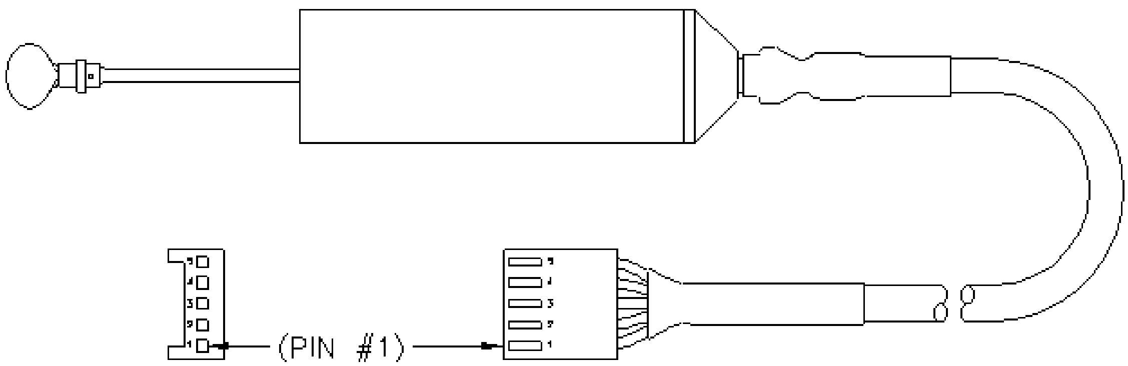

Figure 8.2: CRS 8 kHz Connector

Table 8-1: Pixel Clock Connectors

Connector	Circuits	Mfg.	Type	Mate
J1	24	3M	3627-6302	3626-7624 or equivalent
J2	14	3M	3314-6302	3385-6600 or equivalent

Table 8-2: Driver Connectors

Connector	Circuits	Mfg.	Type	Mate
J1	5	Molex	22-12-1052	22-01-1053 or equivalent
J2	14	3M	3314-6302	3385-6600 or equivalent
J3	16	3M	3408-2302	3452-7000 or equivalent
J4	4	AMP	104074-7	487545-1 or equivalent

END OF DOCUMENT