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Counter Rotation Scanner (CRS)

User's Manual

Revision N



Lit. No. 7OM-025 Rev. N October 21, 2015

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1 Introduction

1.1 General Notes

Cambridge Technology reserves the right to make changes to the products covered in this manual to improve performance, reliability or manufacturability.

Although every effort has been made to ensure accuracy of the information contained in this manual, Cambridge Technology assumes no responsibility for inadvertent errors. Contents of the manual are subject to change without notice.

1.2 Using This Manual

1.2.1 Purpose

This manual provides the following information for the Counter Rotation Scanner (also known as the CRS):

- Product description, installation, and operation

1.2.2 Scope

This manual covers the CRS only. Refer to the controller vendor's documentation for information on how to integrate the CRS to a controller.

1.2.3 Revision History

The following table shows the revision history for this document.

Table 1 - Revision History

REVISION	DATE	Changes from previous revision
N	October 21, 2015	Update of this manual per ECO 8770

1.3 Obtaining Technical Assistance

If you encounter a problem:

1. Review all of the information contained in this manual.
2. Consult your own internal people about the issue.

If you need further assistance, call Cambridge Technology, Monday through Friday, 9 A.M. until 4:30 P.M. (Eastern Standard Time) at 781-266-5700. You may also send an e-mail to Support-us@cambridgetechnology.com.

3. See the inside front cover of this manual for International, European, and Asian contact information.

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1.4 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, the shipment will be considered as delivered complete and defect-free. Cambridge Technology warranties products against defects up to 1 year from manufacture date, barring unauthorized modifications or misuse. Repaired product is warrantied for 90 days after the repair is made, or one year after manufacture date - whichever is longer.

Contact Customer Service at +1-781-266-5700 to obtain a Return Materials Authorization (RMA) number before returning any product for repair.

All orders are subject to the Cambridge Technology Terms and Conditions and Limited Warranty. Contact your local sales office for the latest version of these documents and other useful information.

Customers assume all responsibility for maintaining a laser-safe working environment. OEM customers must assume all responsibility for CDRH (Center for Devices and Radiological Health) certification.

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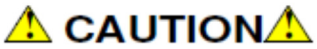
2 Safety

Please read all operating instructions completely before installing and using a CRS.

2.1 Safety Labels and Symbols

The following safety labels and symbols are used throughout the system documentation:

Table 2 - Safety Labels and Symbols

Label	Meaning
	Serious bodily injury or death
	Potential for serious bodily injury
	Potential for property damage and/or minor bodily injury
	SHOCK HAZARD—Electrical voltage is present. Take appropriate measures to protect yourself from electrical shock.
	LASER HAZARD

2.2 General Safety Guidelines



Laser Radiation

Do not stare directly into a laser beam.

Follow all system laser safety requirements during installation and operation.



Shutter Safety

Where practical, Cambridge Technology recommends the use of an internal shutter mechanism to prevent unwarranted emission of laser radiation. If this is not possible, consult the laser vendor to design a proper safety shutter that, when activated, will eliminate all possibility of exposure exceeding Class 1 limits. The safety shutter should be located between the laser and the input aperture of the CRS. This is the user's responsibility

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Use of controls, adjustments, or procedures other than those specified in this manual without consulting a competent safety professional may result in component damage, and/or exposure to potential hazards. Always follow established industrial safety practices when operating equipment.

This system is designed to be operated in conjunction with a laser. Therefore, all applicable rules and regulations for safe operation of lasers must be known and applied when installing and operating the system. Since Cambridge Technology Inc. has no influence over the employed laser or the overall system, the customer is solely responsible for the laser safety of the entire system.

2.3 Safety/Cautions

⚠ WARNING	Use of controls, adjustments, or procedures other than those specified in this manual, without consulting a competent safety professional, may result in component damage, and/or exposure to potential hazards. Always follow established industrial safety practices when operating equipment.
⚠ CAUTION ⚠	Always check your application program BEFORE running it. Errors can cause system damage.
⚠ CAUTION ⚠	Electronic boards are fragile! Handle and store with care. Protect electronic components from dust, humidity, electromagnetic fields, static electricity, chemicals, and mechanical stress.

2.4 System Safety

⚠ CAUTION ⚠	To avoid damage to optics (such as lenses or mirrors), do not use a laser power setting that exceeds the laser power handling limit for each optic.
⚠ CAUTION ⚠	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.
⚠ CAUTION ⚠	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.
⚠ CAUTION ⚠	The audible noise created by the CRS is inherent of resonant scanner technology. Placing the scanner in a large mounting structure and enclosing the unit will help reduce the noise significantly.

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2.4.1 Back-reflections

Any flat or curved surface (including protective windows) between scanning mirrors and the work field will have back-reflections where some percentage of the beam propagating toward the work field will reflect from this surface and will travel back towards the scanning system. Although, the absolute laser power of the backwards propagating beam may be low, the beam may come to a focus on or close to a scanning system optic and the laser damage may occur due to the power density of the laser beam. **It is the user's responsibility to make sure that any back-reflections from any surface downstream of the scanning system is managed properly.**

2.4.2 Direct Laser Damage

The power handling limits of mirrors and lenses can vary depending on laser parameters such as beam size, laser power, pulse duration, and pulse energy. **It is the user's responsibility to ensure that the laser parameters are appropriate for the exact scanning system that he or she is using. The standard warranty does not cover damage caused by laser power settings that are above the maximum limits for each optic.**

Please contact Cambridge Technology if you are not sure about the power limitations of your scanning system.

2.5 ESD Caution

⚠ CAUTION ⚠ 	ESD HAZARD! The electronics that Cambridge Technology manufactures—including the galvanometers and servo controllers in the CRS—are electrostatic discharge (ESD) sensitive. Use appropriate anti-static wrist straps and/or work area equipment to prevent damage to the scanning system.

Upon receiving your components, note that they are packaged in an ESD-protected container with the appropriate ESD warning labels. The equipment should remain sealed until it is in a proper static control station.

A proper static control station should include the following:

- A soft grounded conductive tabletop or grounded conductive mat on the tabletop
- A grounded wrist strap with the appropriate (1 Meg) series resistor connected to the tabletop mat and ground
- An adequate earth ground connection such as a water pipe or AC ground
- Conductive bags, trays, totes, racks, or other containers used for storage
- Properly grounded power tools

Personnel handling ESD items should wear ESD protective garments and ground straps.

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

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3 Product Introduction

3.1 System Description

The CRS is a compact, high frequency resonant scanner. 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 as shown in the following figure.

Table 3 - Typical Scanning Angles

Scanner (see Note 1)	Operating Frequency	Scan Angle Optical Peak-to-Peak (OPP)	Clear Aperture (see Note 2)
4kHz	3938 ± 50Hz	15° (see Note 3)	9.3 mm x 12.0 mm (see Note 4)
8kHz	7910 ± 15Hz	15° (see Note 5)	5.0 mm x 7.2 mm
10kHz	10,000 ± 50Hz	12°	5.0 mm x 7.2 mm
12kHz	12,000 ± 50Hz	10°	5.0 mm x 7.2 mm

Note 1: These are the currently available CRS models. Custom permutations of the CRS have been made in the past (e.g., a 4kHz rotor in an 8kHz stator). Some custom permutations of the CRS are still available. If you have any questions about them, call CTI Technical Support.

Note 2: The ellipse is the minor diameter by the major diameter. For example, the ellipse for the 8kHz scanner is 5.0 mm x 7.2 mm.

Note 3: A special-order 4kHz scanner of 22° OPP is available. Contact CTI Technical Support for details.

Note 4: The 4kHz scanner has a semi-elliptical aperture. See *Appendix A - Outline Drawings* on page 22 for more details.

Note 5: A special-order 8kHz scanner of 26° OPP is available. Contact CTI Technical Support for details.

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.

The scanner contains two wire coils; one drives the rotor and the other provides a proportional feedback current derived from the velocity of the mirror. This velocity pick-off allows a driver board to maintain self-oscillation and amplitude control of the scanner. 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.

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3.2 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.

3.2.1 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.

3.2.2 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. The adjustment range is approximately +/-6% of the active scan period for a uni-directional scan field. The sync pulse also tells the direction of rotation. It also must be used as the master clock signal in an integrated system.

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3.3 CRS Driver Board Pinouts and Test Points

This section contains the connector pinouts for the CRS Driver Board and the CRS Test Points.

3.3.1 J1 Connector Pinouts

The following table contains the pinout drawing for the J1 Connector.

Note: The J1 Connector is used for the 8kHz, 10kHz, and 12kHz CRS.

Table 4 - Galvo Connection for the 8kHz, 10kHz, and 12kHz CRS

Figure 1 - Board Connector	 **Figure 2 - Galvo Connector**

The following table contains descriptions of the J1 Connector signals.

Table 5 - J1 Connector Signal Descriptions

Pin	Signal Description
	Drive Coil Start
	Drive Coil Return
	Velocity Coil Return
	Velocity Coil Start
	Ground

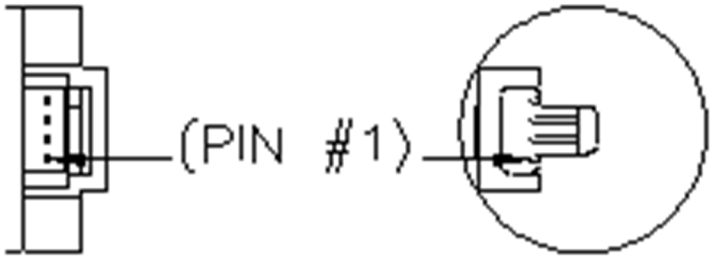
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3.3.2 J4 Connector Pinouts

The following figure contains the pinout drawing for the J4 Connector.

Note: The J4 connector is used for the 4kHz CRS.

Table 6 - Galvo Connection for the 4kHz CRS

Figure 3 - Board Connector	 **Figure 4 - Galvo Connector**

The following table contains descriptions of the J4 Connector signals.

Table 7 - J4 Connector Signal Descriptions

Pin	Signal Description
	Drive Coil Start
	Drive Coil Return
	Velocity Coil Return
	Velocity Coil Start

3.3.3 J2 Auxiliary Connector Pinouts

The Pinouts and signals for the J2 Auxiliary Connector are described in the Pixel Clock Manual (Lit. No. P0900-0171).

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3.3.4 J3 Main Connector Pinouts

The following figure contains the pinout drawing for the J3 Main Connector.

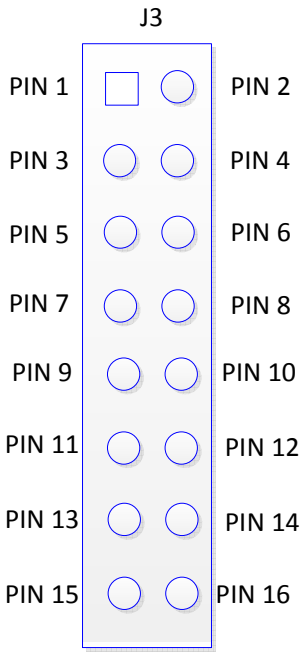


Figure 5 - J3 Main Connector Pinouts

The following table contains descriptions of the J3 Main Connector signals.

Table 8 - J3 Main Connector Signal Descriptions

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

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3.3.5 Test Points on the CRS Driver Board

The following figure shows the locations of the Test Points on the CRS Driver Board.

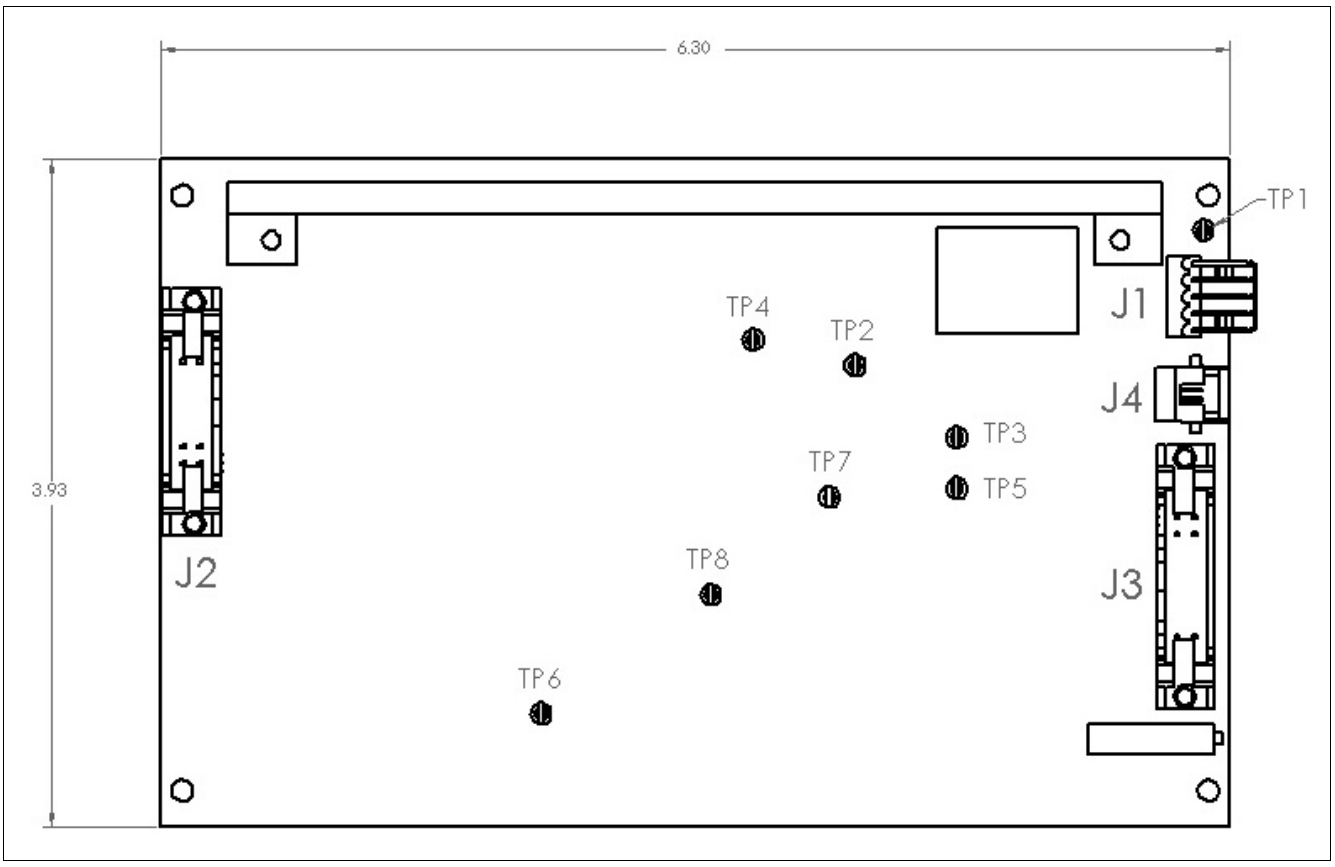


Figure 6 - Test Points on the CRS Driver Board

The following table contains descriptions of the Test Points on the CRS Driver Board.

Table 9 - CRS Driver Board Test Point Descriptions

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

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3.4 Driver Board Connectors

The following table identifies the number of circuits, manufacturer, type and mate for each driver board connector in the CRS.

Table 10 - Driver Board Connectors

Connector	Circuits	Manufacturer	Part Number	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

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4 Theory of Operation

4.1 System Overview

The Counter Rotation Scanner (CRS) features two mechanically oscillating torsion bars tuned to oscillate in opposite phase. This motion produces a mechanically oscillating mirror.

The CRS connector has a motor drive coil (TP1, TP2) and a velocity coil (TP3, TP4). The output from the velocity coil is proportional to the velocity of the CRS mirror. The velocity feedback from the velocity coil is used to provide self-oscillation and amplitude control of the scanner. The velocity signal (U9B) is fed into a full wave rectifier (U10) and in turn into an integrator (U4B). The integrator output is input to a voltage controlled variable gain amplifier (U7) that controls the scan angle amplitude. The high pass filter (U6B) adds phase shift to the system to contribute to the self-oscillation of the scanner. A power amplifier (U8) drives current into the CRS motor coil.

Pins 1 and 2 on the connector J3 are used to adjust the amplitude of the scan angle. The input voltage can be varied between 0-5V. Potentiometer R7 performs the scan angle amplitude calibration adjustment. Pin 4 is an input that allows the user to control a relay that can be used to disconnect the motor from power amplifier (U8). Pins 5 and 6 are inputs that allow the user to divide the calibrated scan angle by factors from 1 to 4.

The velocity feedback signal (U9B) is sent into a phase shift circuit (U3B). Comparator U11 produces a sync pulse output which can be adjusted using potentiometer R48.

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4.2 Block Diagram for the CRS

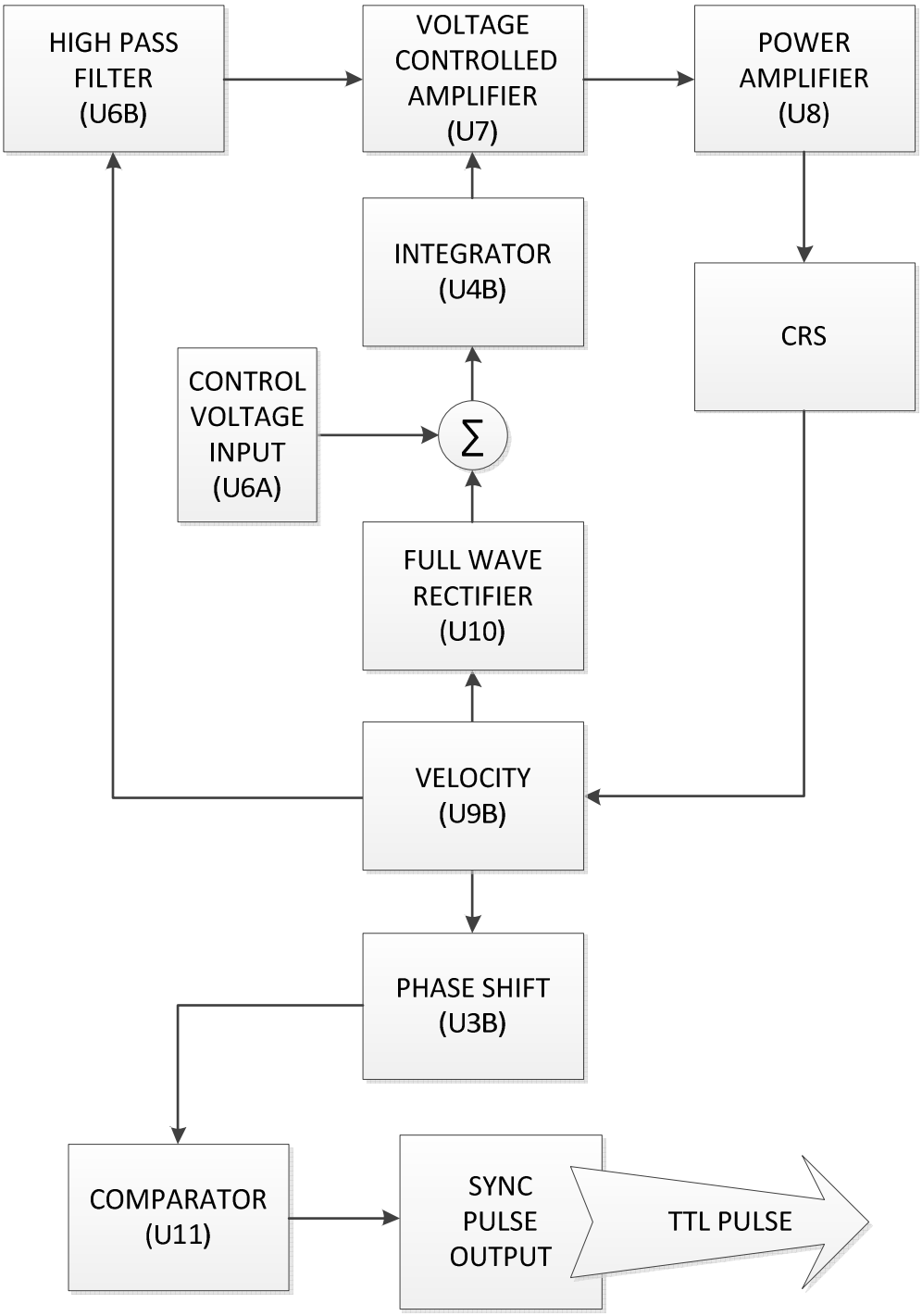


Figure 7 - Block Diagram for the CRS

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Appendix A - Outline Drawings

This appendix contains outline drawings for the installation of the CRS.

A.1 4kHz CRS

The following figure is the outline drawing for the 4kHz CRS, including the semi-elliptical clear aperture.

Note: Dimensions are in inches [millimeters].

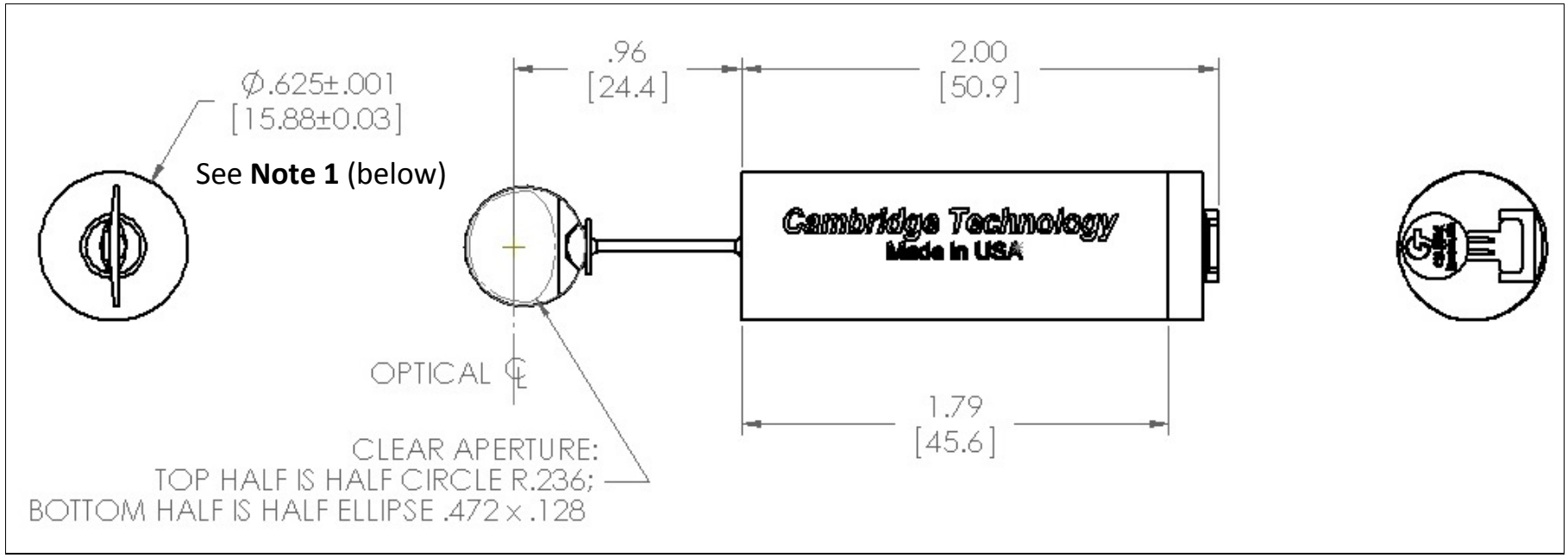


Figure 8 - Outline Drawing for the 4kHz CRS

Note 1: Mount on this surface.

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The following figure contains the pinouts for the 4kHz CRS external connector.

Table 11 - Galvo Connection for the 4kHz CRS

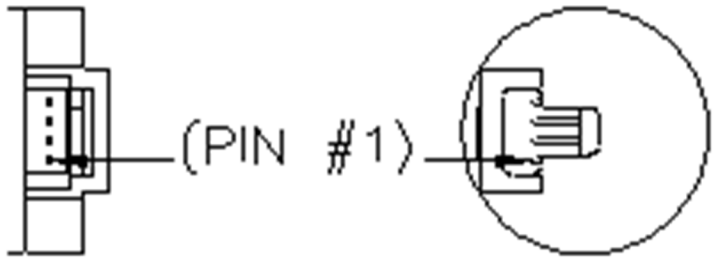


Figure 9 - Board Connector

Figure 10 - Galvo Connector

The following table contains a description of each pin on the 4kHz CRS external connector.

Table 12 - J4 Connector Signal Descriptions

Pin	Signal Description
	Drive Coil Start
	Drive Coil Return
	Velocity Coil Return
	Velocity Coil Start

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A.2 8kHz, 10kHz, and 12kHz CRS

The following figure is the outline drawing for the 8kHz, 10kHz, and 12kHz CRS.

Note: Dimensions are in inches [millimeters].

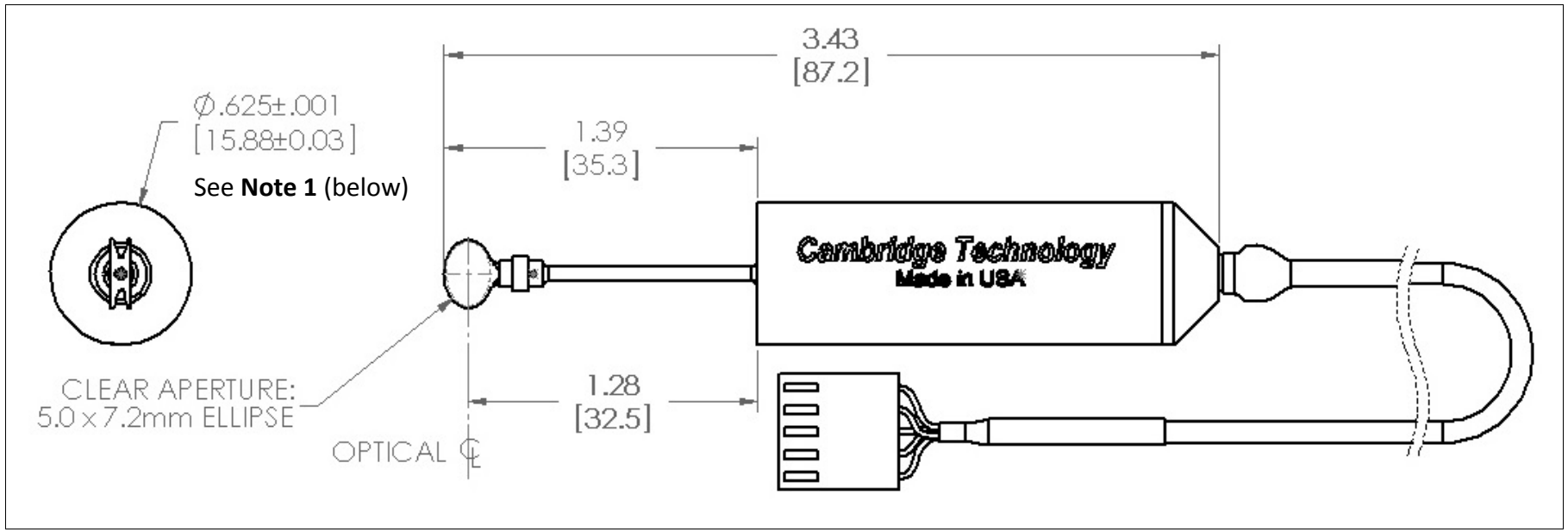


Figure 11 - Outline Drawing for the 8kHz, 10kHz, and 12kHz CRS

Note 1: Mount on this surface.

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The following figure contains the pinouts for the external connector on the 8kHz, 10kHz, 12kHz CRS.

Table 13 - Galvo Connection for the 8kHz, 10kHz, and 12kHz CRS

Figure 12 - Board Connector

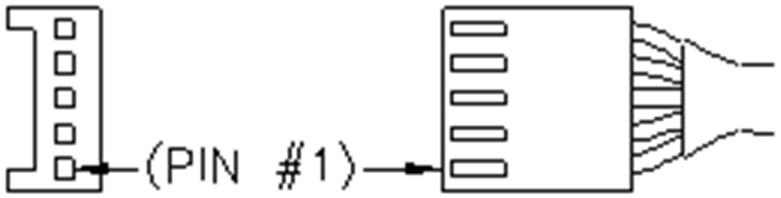


Figure 13 - Galvo Connector

The following table contains a description of each pin on the 8kHz, 10kHz, 12kHz CRS external connector.

Table 14 - J1 Connector Signal Descriptions

Pin	Signal Description
	Drive Coil Start
	Drive Coil Return
	Velocity Coil Return
	Velocity Coil Start
	Ground

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A.3 8kHz CRS with 4k Stator

The following figure is the outline drawing for the 8kHz CRS with a 4k Stator.

Note: Dimensions are in inches [millimeters].

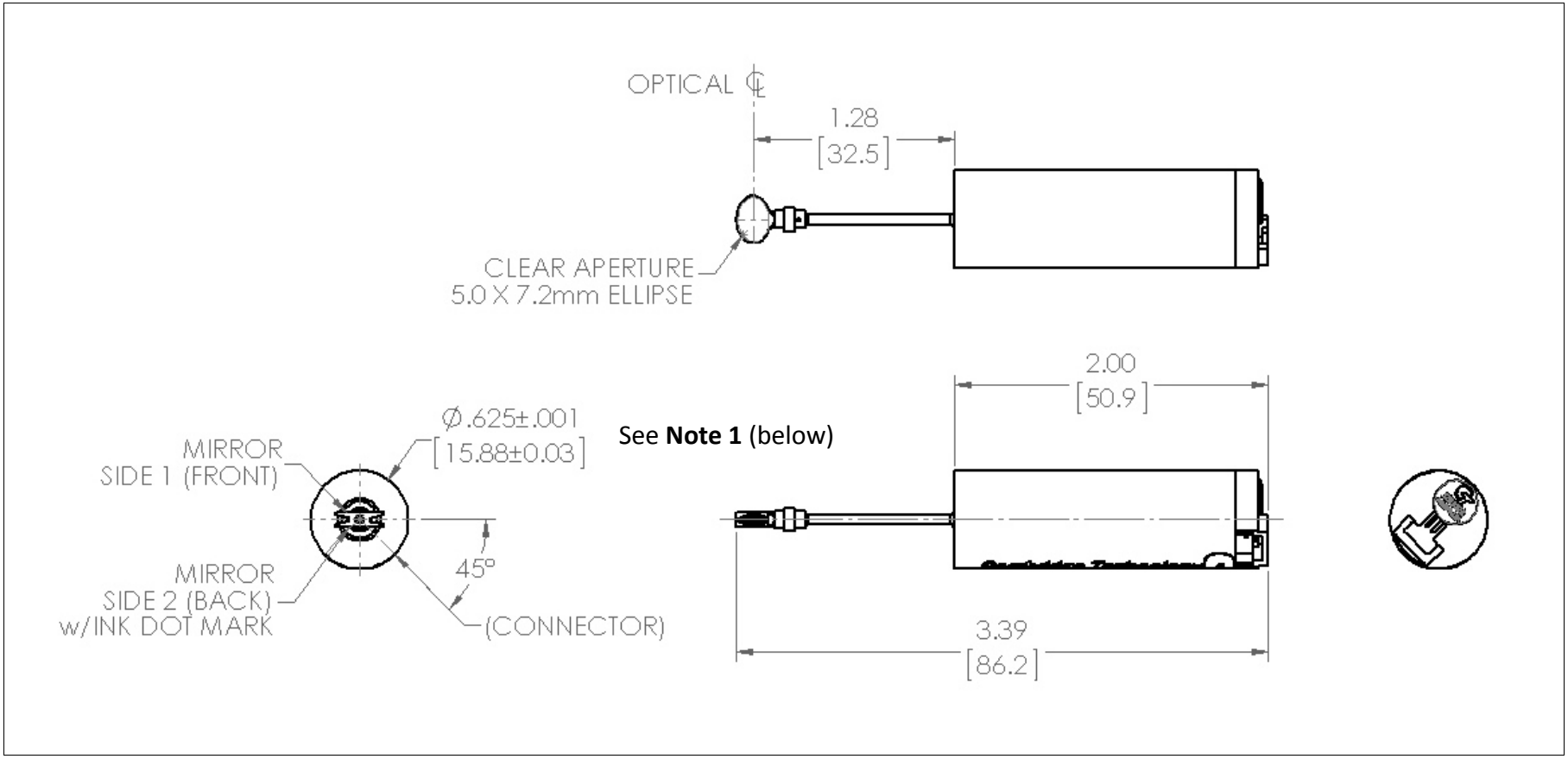


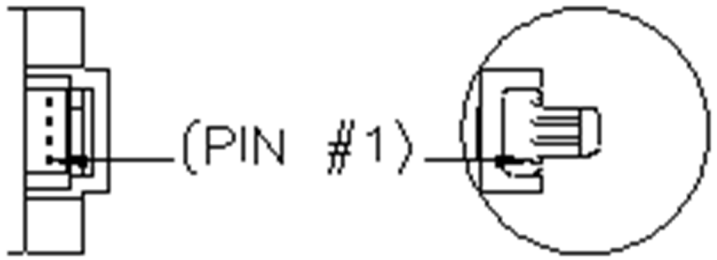
Figure 14 - Outline Drawing for the 8kHz CRS with a 4k Stator

Note 1: Mount on this surface.

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The following figure contains the pinouts for the 8kHz CRS with a 4k Stator.

Table 15 - Galvo Connection for the 8kHz CRS with a 4k Stator

Figure 15 - Board Connector	 **Figure 16 - Galvo Connector**

The following table contains a description of each pin on the external connector of the 8kHz CRS with a 4k Stator.

Table 16 - J4 Connector Signal Descriptions

Pin	Signal Description
	Drive Coil Start
	Drive Coil Return
	Velocity Coil Return
	Velocity Coil Start

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Appendix B - Schematic Diagram

The following figure contains the main schematic diagram for the CRS. *Figure 18 - Details from the Main Schematic Diagram for the CRS* on page 29 contains details for the following schematic diagram.

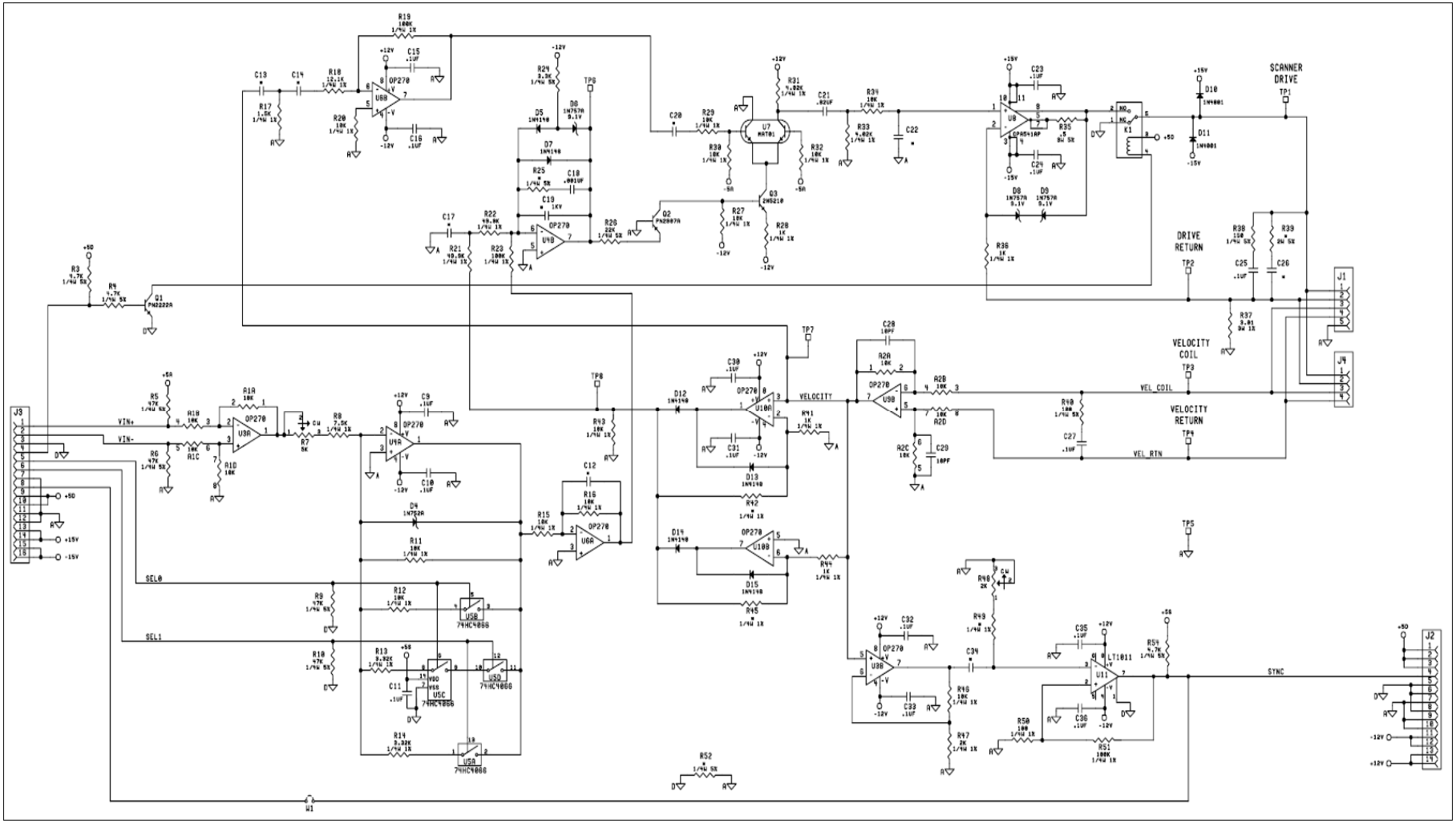


Figure 17 - Main Schematic Diagram for the CRS

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The following figure contains details for the main schematic diagram for the CRS, which is on page 28.

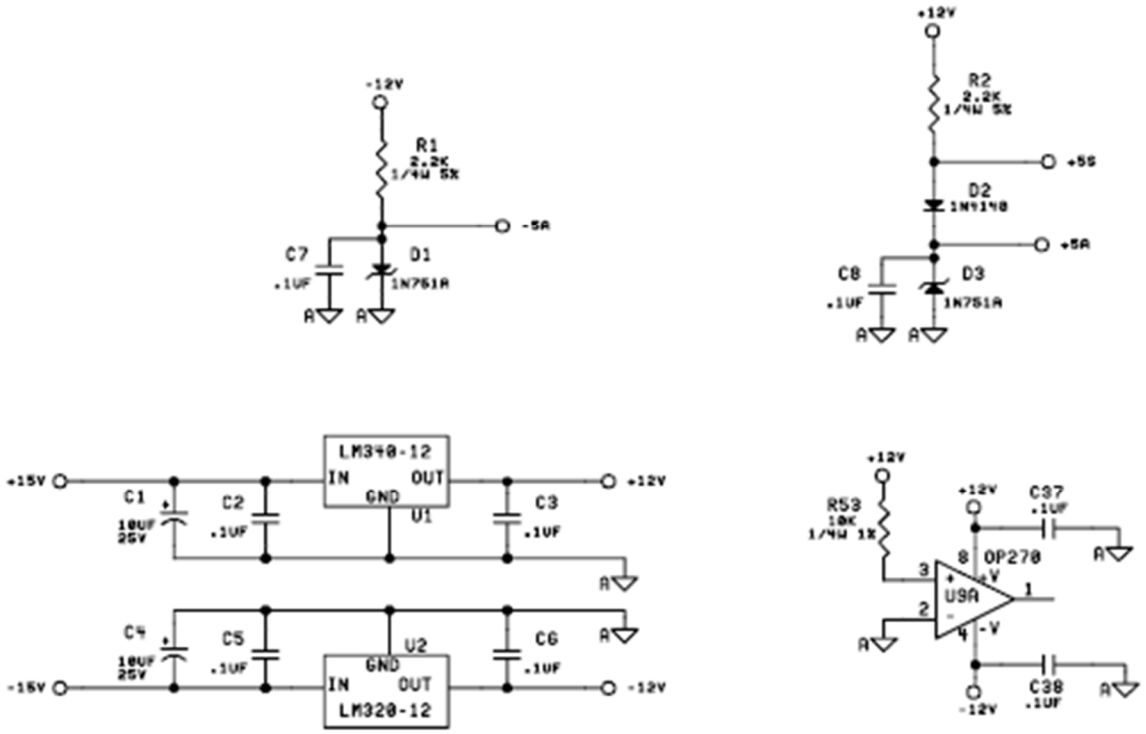


Figure 18 - Details from the Main Schematic Diagram for the CRS

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