Model 6210H
Galvanometer Optical Scanner

INSTRUCTION MANUAL

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1.0 Introduction and Warnings

This manual was written to help the customer use the Model 6210H scanner successfully. There are several warnings and precautions written throughout this manual. Read this manual carefully. It is possible to damage the scanner by exposing it to rough handling or contaminants.

As the demand for speed and accuracy of today's optical systems increases, so does the need for high performance, high accuracy scanners. This scanner was designed for just those applications that require ultra-high speed and accuracy.

Note: Throughout this manual the terms mechanical angle and optical angle will be used. For all applications the mechanical angle refers to the angular change of the scanner shaft. For most optical systems the optical angle is the angular change of the beam. For these optical systems, the:

optical angle = 2 x mechanical angle

WARNING! Upon system shutdown or malfunction, the scanner has the ability to point the beam anywhere within ~200° optical. It is up to the end user to limit the exit window of the laser beam in order to provide laser safety.

CAUTION! Ensure that the scanner and/or the XY mount have adequate heatsinking to allow scanner operation. Never operate the scanner without a heatsink! The scanner will suffer irreparable damage if allowed to overheat! For more information, refer to Section 3.2. The Cambridge Technology XY mount is a sufficient heatsink only if bolted to a customer supplied adequate heatsink to conduct away the heat. It is recommended the customer use thermal grease between the scanner body and the XY mount to maximize heat dissipation.

Note: These scanners are high performance devices that require some special handling. Never let them impact a hard surface especially on the front shaft. Do not pull or push with anything other than light finger pressure on the front shaft or damage to the front bearing can occur. Do not expose the scanner to extremes of temperature outside the operating limits shown in the specifications **Section 2.0**. Do not let any foreign material, e.g. dust, dirt, solvent, water, oil, etc. come in contact with the front bearing. It is located right at the front end of the scanner. Foreign material inside the bearing will reduce bearing life.

Note: As with any high performance motor, resonances created during power up, power down, normal operation, or during tuning can cause serious motor degradation or failure. Always keep the motor under proper servo control and do not let the motor swing uncontrolled into the bumper stops.

Note: Lead free solder (SAC 305) should be used to solder or unsolder any connections on the position detector board. This scanner is now fully RoHS compliant. Using leaded solder can result in failed solder joints due to incompatibility of the two types of solder and will make the entire assembly non-RoHS compliant.

2.0 Specification

Note: All angles are in mechanical degree unless stated otherwise.

Scanner MODEL NO.	6210H	Tolerance	Units/Notes
Mechanical Specifications			
Rated Excursion, Rotor[1]	±20	Min	degrees
Bumper Stop Angle, Initial Contact[1]	±26	±4	degrees
Optical Aperture, Two-Axis, Std.	3, 6	-	millimeters
Rotor Inertia	0.018	±10%	gm-cm^2
Recommended Load	0.000 - 0.18	-	gm-cm^2
Torque Constant	2.79E+04	±10%	dyne-cm/amp
Coil Resistance	3.72	±10%	ohms
Coil Inductance	109	±10%	μhenries
Back EMF Voltage	48.7	±10%	μv/degrees/s
Thermal Resistance, Rotor-to-Case	2.0	Max	°C/watt
Maximum Rotor Temperature	110	Max	°C
Maximum RMS Current	2.4	Max	amps
Maximum Peak Current	8	Max	amps
Maximum RMS Power	30	Max	watts
Fuse Rating	3	-	amp., fast-blo
Settling time[2]	100	Typ	μsec
Scanner Weight	17	Typ	grams
Case Operating Temperature	0 – 50	-	°C

Position Detector, PD[3]

Linearity	99.9	Min	% over ±10°
	99.5	Typ	% over ±20°
Scale Drift	50	Max	PPM/°C
Zero Drift	15	Max	uradians/°C
Repeatability, Short Term	8	Max	μrad.
Output Signal, Diff. Mode	12	±20%	μa/°diff.@I_{COM}=155μa
Output Signal, Common Mode	155	±20%	μa@I_{LED}= 30 ma
PD Power Requirements	30	±20%	ma, DC
	1.4	Nom	volts.

Mounting Requirements: A single axis scanner mount must dissipate 3 watt/°C. for a mount temperature of 40°C. An XY mount must dissipate 6 watts/°C for a mount temperature of 40°C. See **Section 3.2** for more information.

Notes: 1. 6210HM40 is reduced to ±10° excursion and ±14° initial contact.
2. Setup for settling time: Using CTI's recommended servo, CTI's 3mm Y-mirror, moving a 0.1° step, and settled to within 99% of the final position.
3. Using the Cambridge Technology, Inc. Position Demodulator circuit.

3.0 Description of Operation

3.1 Overview

The 6210H has a moving-magnet actuator, which means the rotor or working part of the scanner is a magnet. A moving magnet motor has no saturation torque limit and very little electrical inductance. Thus extremely high torque can be generated very quickly. This is essential for systems that need short step response times.

Two practical factors limit the amount of torque that can be generated by a moving magnet scanner. Peak torque is limited by the mechanical failure limit of the rotor assembly due to stator current in excess of the peak current specification. Rms torque is limited by the maximum power (I^2R losses in the stator coil) the scanner can conduct away. When the maximum rms current has been reached (with adequate heatsinking) the stator has reached its maximum temperature, and thus the motor has reached its maximum rms torque level. Extremely high performance can be achieved in part because both the peak torque limit and maximum power that the stator coil can dissipate are very high.

The angular position of the shaft is detected by an optical sensor located on a small circuit card, the position detector board, on the back of the scanner. The output signal of this sensor is a differential current signal that is fed back to the drive electronics, closing the servo loop and allowing very fast and accurate mirror positioning. A typical position demodulator circuit is included with this manual. Cambridge Technology strongly recommends using this circuit to all customers that do not buy the CTI driver electronics.

The 6210H is now available in a variety of connector versions so that the smallest scanner in the world is now one of the most flexible to integrate. The standard 6210H comes with the standard or “straight” connector which points directly back away from the mirror. For other applications where overall scanner length is critical, the 6210HR has a “right-angle” version of the same connector. This allows the optical enclosure to be designed very near the back of the scanner. Also, a “connector-less” version, the 6210HL, is offered to further reduce the scanner’s overall size. The 6210HL uses a smaller position detector board and a cable that directly solders to the scanner. This allows for the ultimate in space constrained design. And finally there are two other connector styles available: The 6210HB and 6210HBR. Refer to **Section 5.1** for Outline Drawings.

3.2 Mounting Scheme

Special attention should be given to the mechanical integration of the scanner into the optical system. The customer must provide an adequate path for conducting away heat generated by the scanner body. The maximum temperature that the scanner body should be allowed to attain is 50°C. This is below the temperature at which a person feels pain; thus the scanner should **never** get too hot to touch! The XY mount should ideally have very low thermal resistance to the ambient temperature. The heatsink must dissipate the full heat generation of both scanners in an XY application while only allowing the scanners to rise to that 50°C maximum case temperature. An example of a mount that has adequate heatsinking is shown in **Section 5.1**. The exact amount of heatsinking required directly depends on the scanner, the customer's load, and the customer's application.

To calculate the necessary heatsinking for the 6210H, there are two approaches.

1. Worst case analysis: This assumes that there are two scanners bolted to a common heatsink and both are dissipating their full power. At 30 watts each, that is 60 watts. We must also assume that the ambient temperature is below 50°C, the maximum case temperature the scanner should ever be allowed to attain. Let's assume the ambient temperature is 40°C. Then the heatsink must have a thermal resistance from the scanner body-to-ambient equal to

$$R_{TH} = (50 - 40)°C/60\text{watts} = \underline{0.166°C/\text{watt}}$$

   Another representation is the thermal conductivity of the heatsink instead of its thermal resistance. This is just the reciprocal of the thermal resistance or

$$G_{TH} = 1/R_{TH} = 1/(0.166°C/\text{watt}) = \underline{6.0\text{watts}/°C}$$

2. If it is known that the scanners will not be run at their maximum power, then the actual dissipation can be used. This will result in a smaller heatsink. The same rules apply, i.e. the scanner body cannot go higher than 50°C, but since it isn't dissipating the full rms power, the heatsink can be smaller.

   To use this method, the maximum rms power must be known. The simplest way to do this is to measure the maximum rms current and then calculate the power.
   a. Run each scanner using the application's command waveform (using an adequate heatsink. If necessary, use method 1. above).
   b. Measure the maximum rms current at each servo's "Current Monitor" using a "true rms" voltmeter.
   c. Square this rms current, multiply this by the coil resistance (3.7ohms), then finally multiply this by 1.4. (Note: The 1.4 is a multiplier to account for the coil's increase in

resistance with temperature. It has nothing to do with the relationship between rms and peak voltages.) Thus,

$$P_{MAXRMS} = I_{MAXRMS\text{-}X}^2 * R * 1.4 + I_{MAXRMS\text{-}Y}^2 * R * 1.4$$

The resulting number, P_{MAXRMS} can now be substituted into the above calculation in place of the 60 watts. Remember to include both the X and Y scanners if applicable when performing this calculation. Thus the thermal resistance for a heatsink with an ambient temperature of 40°C is

$$R_{TH} = (50 – 40)°C/ P_{MAXRMS}$$

If any part of this procedure is not completely understood, contact CTI for technical assistance.

For the 6210H scanner, the only valid mounting surface is the <u>long</u> cylindrical section of the body. See the Outline Drawing in **Section 5.1** at the end of this manual. The scanner must be mounted by this surface to adequately transfer the heat out. A cylindrical, compression-style mount made of aluminum is preferred. The mount should attempt to contact as much of the mounting surface as possible to minimize the thermal resistance. The mount should then be bolted to another thermally conductive plate to finally conduct the heat away to ambient.

It is recommended to use high quality thermal grease between the scanner body and the XY mount to conduct away the maximum amount of heat possible. If there is any doubt about the operating temperature of the scanner, mount a thermocouple to the scanner body and measure the case in situ. This is the only reliable way to verify the scanner is not overheating.

Never attempt to mount the scanner by its position detector or serious overheating will occur!

Caution! Never run the scanner without a heatsink attached. The scanner body will heat very quickly and irreparable damage will occur, thus voiding the warranty.

3.3 Mirrors

The 6210H is designed to have the mirror glued directly into a slot in the end of the output shaft. This minimizes the extra inertia required to hold the mirror in a removable mount. The standard slot width is shown in the outline drawing in **Section 5.1**. Contact Cambridge Technology, Inc. directly for availability of other custom slot widths.

3.3.1 Mirror Replacement Kit

The Mirror Replacement Kit, 62XXMRK-ABC is not included standard with a 6210H, but is offered as an option. The suffix "ABC" represents the coating (A) and the angle (BC) of the mirror. Therefore, a visible coated mirror for 60 degrees of beam swing will have V60 for a suffix.

Please read this entire procedure before performing any tasks. All aspects must be clearly understood before proceeding.

Supplied Material:

1.) Mirror Alignment Fixture, two piece:
   a) Alignment Tool.
   b) Plunger
2.) One 3MM X 1 mm thick mirror
3.) One 3MM Y 1 mm thick mirror
4.) 5-Minute Epoxy

Additional Necessary Material:

1.) Soldering Iron
2.) Fine Tweezers
3.) X-ACTO Precision Razor Knife, or equivalent

3.3.2 Replacement Mirror Removal Procedure

The broken mirror is removed by placing a clean, tinned soldering iron on the epoxy bond and not the end of the motor shaft.

Notes: While the mirror is being removed, be very careful to:

1. Remove the heat once the mirror is loose; overheating will damage the scanner.

2. Keep all foreign material from contacting the motor bearing.

Heat is applied to the epoxy only until the mirror loosens and moves side to side. Light pressure from your fingers, tweezers or a razor knife should accomplish the movement. Remove the mirror at this point.

All old epoxy is to be removed from the slot in the motor shaft using tweezers or a razor knife. Remember to hold the scanner with the shaft pointing downwards so the excess glue does not fall into the bearing.

3.3.3 Replacement Mirror Mounting Procedure

The Mirror Replacement Kit contains a two-part stainless steel fixture. The larger piece, referred to as the Alignment Tool, slips over the drive housing of the 6210H. The Alignment Tool has a semi-circular window for viewing the mirror installation and curing processes. The smaller piece, the Plunger, has ends that are machined for the two different mirror widths. Refer to CTI drawing D04733, 62XXMRK Instruction Drawing, to identify the appropriate end of the Plunger for the mirror being replaced. This drawing has two views of the Plunger with the mirrors captured in the appropriate Plunger ends. The distinguishing feature of the Plunger end designed to install the Y Mirror is identified by D04733.

If necessary, clean the mirror(s) prior to installation using methanol and a cotton swab or lens tissue. For cleaning after installation use **EXTREME CAUTION** to ensure that any solvent used does not come in contact with the front bearing of the scanner. (Holding the scanner with the mirror facing downwards and wiping away from the scanner is mandatory.) Serious and permanent damage to the motor could result.

As the replacement mirrors are polished on both sides, use caution to ensure that the coated side of the mirror is mounted in the desired orientation. The X mirror is rectangular in shape and is substantially smaller than the Y mirror. The proper orientation of the X mirror is with the long dimension perpendicular to the axis of rotation. Refer to **Section 5.1** D04733, 62XXMRK Instruction Drawing, before gluing for proper mirror orientation.

The Y mirror is the longer of the two and has four chamfers. The proper orientation of the Y mirror is with the long dimension parallel with the axis of rotation. Again refer to D04733 before gluing. ****Note: The replacement mirror(s) should be tested to ensure that it would easily fit into the slot in the output shaft before applying any epoxy.**

Gently slip the replacement mirror into the slot in the appropriate Plunger end using care that the mirror is well aligned in all three axes. A small amount of pressure is necessary to displace the rubber O-ring. The O-ring will hold the mirror in place.

Mix a small amount of 5-minute epoxy, being careful to use equal portions of both epoxy components. After thorough mixing, a very small amount of mixed epoxy is applied to the slot in the 6210H output shaft, just enough to fill the slot. As the 6210H mirrors are of very small mass, only a **very small** amount of epoxy is necessary. Refer to D04733 to see how much epoxy is required and for the proper orientation. The Alignment Tool is now gently slipped over the end of the 6210H. Orient the window of the Alignment Tool so that the flat surface of the mirror is either facing towards or facing away from the window, as is appropriate for the mirror being replaced.

Gently slip the Plunger into the Alignment Tool while observing the 6210H output shaft through the window in the Alignment Tool. It may be necessary to rotate the Plunger to align the mirror to the slot in the output shaft. Gently slip the mirror to the bottom of the slot of the output shaft. The mirror should be centered side-to-side, and its axis of symmetry aligned to the scanner’s axis of rotation.

Allow the 6210H and mirror replacement fixture to sit undisturbed until the epoxy is fully cured. This will take anywhere from 15 to 90 minutes depending on mixing procedure accuracy and ambient temperature. After the epoxy has fully cured, remove the Plunger and alignment tool.

3.3.4. The 6210HS Solid Shaft Motor

For larger loads a mirror mount has been developed that glues directly to the shaft. This increases the stiffness between the shaft and mirror allowing for higher speeds. However, due to the increased complexity involved with this design, it is advised to return systems that have broken or damaged mirrors for replacement to CTI.

3.4 Cabling

The Model 6210H and 6210HR motors have been optimized to be as small as possible but still use a connector. The 6210H employs a small, straight 8-pin Amp connector. The 6210HR uses a right angle version of this connector. The standard cables for both are:

Cable	Scanner	Board
6010-19-XXX	6210H, 6210HR	678, 670 servos – 9Pin-D connectors
6010-22-XXX	6210H, 6210HR	671 servo – Amp and Molex connectors
6010-29-XXX	6210H, 6210HR	677, 673 servo – Amp connector

The -XXX refers to the length of the cable in inches.

The Model 6210HL motor has been further optimized. This connector-less design employs direct cabling to minimize the overall package size. Depending on the customer's requirements a cable may be attached at the factory or a cable kit, can be provided. The following cables are used for 6210HL scanner:

Cable	Scanner	Board
6010-8L-XXX	6210HL	678, 670 servos – 9Pin-D connectors
6010-21L-XXX	6210HL	671 servo – Amp and Molex connectors
6010-29L-XXX	6210HL	677, 673 servo – Amp connector

The -XXX refers to the length of the cable in inches.

The Model 6210HB and 6210HBR have connectors that are compatible with the new higher power connectors used on the 6215HB and 6220HB. They are not necessary for the maximum operation of the 6210H, but they are offered as an option. The cables designed for these connectors are:

Cable	Scanner	Board
6010-36-XXX	6210HB, 6210HBR	678, 670 servos – 9Pin-D connectors
6010-37-XXX	6210HB, 6210HBR	671 servo – Amp and Molex connectors
6010-38-XXX	6210HB, 6210HBR	677, 673 servo – Amp connector

The -XXX refers to the length of the cable in inches.

Refer to the outline drawings in **Section 5.1** for the outline drawings of all these motor versions.

If the scanner arrives with its cable already attached, be careful not to stress the connections near the scanner end. The wires may break which could cause scanner failure or damage. Always secure the cable when integrating the scanner into the system in such a manner that prevents excessive strain on the PD board. Any force on the PD board may cause the scanner to shift position.

If a 6210HL scanner was ordered without the cable attached, refer to **Section 3.4.1,** Attaching the Cable to the Motor.

If the cable length needs to be changed, refer to **Section 3.4.2,** Modifying the Cable Length.

Please read the entire procedure before attaching the cable or modifying its length. All aspects must be clearly understood before proceeding.

3.4.1 Attaching the Cable to the Motor

This procedure should be used when the cable end to be attached to the motor has been properly prepared. The cable is properly prepared when it leaves Cambridge Technology, but if the cable length needs to be modified, or if a wire is damaged during assembly, refer to **Section 3.4.2,** Modifying the Cable Length, shown below.

Materials Required:

1.) Soldering iron with a small width tip
2.) Solder
3.) Wire cutters - small

Procedure:

1.) Before attaching the cable to the motor ensure that holes 1, 2, and 7 through 11 have been properly de-soldered. There should be no solder left in these holes. DO NOT de-solder holes 3 through 6. These are for internal connections within the motor and must be left connected.

2.) Refer to Wiring Diagram drawing D03762 or D04963 in **Section 5.1** to show the proper connections for the respective cable purchased. Be careful to follow the wiring diagram exactly.

****Caution!** If a wiring mistake is made, the scanner could be damaged!

3.) When soldering the connections, use caution to avoid overheating the individual wires. Their insulation is fragile and easily damaged. The wires should enter the board from the side of the scanner's rear cover. Apply heat and the solder from the other side of the board. Use caution not to create a solder bridge between the pads and the scanner housing.

4.) Cut off any excess wire that protrudes from the far side of the soldered hole to minimize the possibility of shorting.

****Caution:** Do not attempt to clean the flux off of the solder connections. The cleaner may enter the scanner and contaminate it.

5.) Relieve cable strain near the scanner as needed. This will keep undue strain off the soldered connections. Do not attach any kind of strain relief to the motor itself.

3.4.2 Modifying the Cable Length

This procedure should be used when the length of the cable provided is too long or has become damaged and needs repair.

Materials Needed:

1.) Soldering iron with a small width tip
2.) Solder
3.) Wire cutters – small
4.) Wire strippers for wire #24 awg., or #26 awg.
5.) Heat gun
6.) Heat shrink tubing kit provided
    a.) 1/16" wide by 1/4" long
    b.) 3/16" wide by 1/2" long

Procedure:

1.) Cut the cable to the desired length. Ensure both cables are cut to the same length or uneven tension will be placed on the wires after soldering.

2.) Use one piece of 3/16" wide by 1/2" long heat shrink tubing on each cable and slide them up the cable about 3 – 4 inches. Do not shrink the tubing at this time.

3.) Carefully cut 3/8" of the jacket off the cables without "nicking" the insulation of the wires within. Strip off the foil shield within each cable.

4.) On the two-conductor cable, cut the drain wire off at the point the jacket ends. The drain wire is the one without insulation.

5.) On the four-conductor cable, twist the drain wire naturally, and slide the 1/16" wide by 1/4" long heat shrink tubing on it. Leave about 1/8" of bare wire exposed at its end.

6.) Heat the 1/16” piece of tubing at this time. Use caution not to overheat the insulation on the wires.

7.) Strip 1/8” of insulation from the other four conductors of this cable and the two conductors of the other cable. On 6010-8L’s all of the conductors are #24 awg., and on 6010-21L-XXX and 6010-29L-XXX, all are #26 awg. Tin the exposed ends of all conductors. Do not use excessive solder or the wires may not pass through the holes in the scanner’s position detector board. Use only enough solder to hold the wires together, but not so much that you cannot see the individual strands.

8.) Slide the 3/16” heat shrink tubing back down the cables so that only 3/16” of insulation from the individual wires is exposed. Ensure that an adequate length of wire has been left so that each can reach its respective hole on the scanner. Heat the 3/16” tubing at this time. Do not melt the wire insulation; it is fragile.

3.5 The 6210HM

For situations that require reduced angles, a different bumper design is employed which limits the rotation angle of the front stop pin of the scanner. These –M version scanners use a two-digit suffix which denotes the intended use angle in peak-to-peak optical degrees. For example, 6210HM40 has an intended use angle of 40 degrees p-p optical or +/-10 degrees mechanical. The bumpers hit at an angle of ~+/-14 degrees. This allows an XY design to be optimized for this reduced angle, thus making the space between the scanners less, which allows the Y mirror to be much shorter. Thus, the primary reason for using –M bumpers is in XY systems.

Note!: When the scanner hits the bumper hard, such as during an instability, the scanner will still travel an additional 8 – 10 degrees mechanical beyond the point where the stop pin first contacts the bumper. When designing an XY system with possible interference between the mirrors, the customer must take this fact into account.

3.5.1 Field Replacement of the Bumpers

In the rare circumstance that a bumper must be replaced in the field, please refer to D06249 the 6200H/10H/15H Bumper Field Service Instructions drawing in **Section 5.1.** and follow the procedure below.

1.) Turn off the power to the scanner and unplug its cable if possible.
2.) Turn the rotor so the mirror and stop pin are centered between the two bumper stops.
3.) Remove each bumper by gently pulling up on their outer corners and remove them from the face of the scanner.
4.) Place each new bumper on the appropriate retainer post on the face of the scanner and press them firmly so they are seated completely. Be careful to place them with the small lip on the bumper facing towards the face of the scanner. This lip must be fully engaged under the retainer post on the face of the scanner for the bumper to work properly. Please study the detail view of D06249 in **Section 5.1.** to make sure the bumper is installed correctly.

After the new bumpers are installed, make sure if changes are needed in the electronics to reduce the overposition trip point that this is done before turning on the power.

Please contact CTI if any part of this procedure is not completely understood. .

4.0 Limited Warranty

The 6210H scanner is warranted to be free of defects in materials and workmanship for one year from the date of shipment. Cambridge Technology, Inc. will repair or replace, at our option, any part of the system which upon our examination is found to be defective while under warranty. Obligations under this warranty are limited to repair or replacement of the equipment. Cambridge Technology shall not be liable for any other damages of any kind, including consequential damages, personal injury, or the like. Opening the scanner assembly itself will void this warranty. Damage to the system through misuse will void this warranty. Cambridge Technology pursues a policy of continual product development and improvement. We reserve the right to change published specifications without prior notice.

5.0 Appendix

5.1 Schematics and Mechanical Drawings

The following drawings are included in this section:

1. Series 6000 Position Demodulator Components	D01747
2. 6210H Outline Drawing	D05833
3. 6210HL Outline Drawing	D05978
4. 6210HR Outline Drawing	D06144
5. 6210HB Outline Drawing	D05979
6. 6210HBR Outline Drawing	D05980
7. 6210HS Outline Drawing	D05982
8. 6210HSB Outline Drawing	D05985
9. 6210HSBR Outline Drawing	D05986
10. 6210HSL Outline Drawing	D05987
11. 6210 Preferred Mounting Block	D03800
12. 62XX/6010-8L Wiring Diagram	D03762
13. 62XX/6010-21L Wiring Diagram	D04963
14. 62XX/6010-29L Wiring Diagram	D05897
15. 62XXMRK Instruction Dwg	D04733
16. 62XXH Numbering Scheme	D05950
17. 6200H/10H/15H Bumper Field Service Instructions Dwg	D06249