Robotic Inspection Vehicle

RIV 802

Document ID: RIV 802 User Manual

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This symbol indicates important product information.

This symbol indicates Protective Conductor Terminal.

RIV 802 Robotic Inspection Vehicle

July 2024 – Version 1

Contents

WARNING

This Handbook is written to give guidance as to the use and application of the Robotic Inspection Vehicle in normal circumstances. However, as the use of the equipment and interpretation of the results is beyond the control of Iris Power, Iris Power cannot assume any liability for particular results and actions resulting from them. The user is expected to study the enclosed practical and theoretical explanations and methodology and then consider the best application of the test system in their circumstances.

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1. Introduction

The magnetically supported Robotic Inspection Vehicle (RIV) has been developed to provide an automated scanning method for the EL CID stator core interlaminar insulation test equipment. The vehicle allows scanning of the stator bore of a generator or large motor, in order to more efficiently test the integrity of the stator lamination insulation. The equipment can also be adapted to carry other lightweight attachments for stator inspection, i.e. mini-camera or stator wedge tightness probe. A single control unit is used to provide power and control to the vehicle and camera module.

1.1. Application

The Robotic Inspection Vehicle was designed primarily for testing stator cores with EL CID, and the rotor removed. There is also the potential to use the RIV for testing machines by insertion into the air-gap, with the rotor in place if the rotor retaining ring to stator gap is sufficiently large. On turbogenerators, although the stator to rotor body gap may be sufficient, the overriding constraint may be the dimensions and shape of the entrance gap and access to this part of the machine for the RIV insertion and working purposes.

The RIV consists of two drive units connected by lockable straight or curved sliding bars to allow vehicle width adjustment. Each drive unit has a row of permanent magnets beside a rubber track. Each rubber track is driven by its own motor and gearbox. The RIV has a built-in system to guide it along the stator teeth. The guidance system uses magnetic sensors located at each drive unit to detect the edges of the stator teeth.

When the slot wedges are lower than the stator core top surface, optional mechanical guides may be used to improve the RIV navigation on slippery surfaces.

The curvature of the bore can vary greatly between machines and the RIV **must** be adjusted properly to follow it. An adjustment set screw is incorporated in each drive unit of the Robotic Inspection Vehicle to adjust that drive unit for stator bores of various diameters.

A distance encoder is mounted on one of the drive units and sends distance information to the control unit when vehicle is moving.

The RIV is capable of carrying two flexible Chattock Potentiometer coils for making EL CID measurements in double scan test mode. The ends of the Chattock Coil are clamped into guides mounted on each end of the drive units. The guides on the vehicle are spring loaded so that the Chattock Coil presses lightly against the stator teeth compensating for uneven tooth surfaces.

The camera module, which is part of the kit, has provision for mounting to the front or the side of the Robotic Inspection Vehicle. The camera may be used to complement EL CID or Stator Wedge Tightness Testing or used for general visual inspection (subject to overall payload and control cabling restraints). The field of view of the camera is usable in two alternative direction modes providing rotation in either the in-line (the axis of the RIV/stator slot) or lateral (transverse to the axis of the RIV) planes, with remote control for rotation and focus. The camera module can be mounted on the front of one, or on the side of any drive unit of the RIV, see Section 2.3.

The RIV is connected to the RIV Control Unit (RCU) via a single multicore vehicle control cable. The RIV end the cable is split into two with connectors to enable connection to the two drive units. The cable connectors are paired with the corresponding half of the vehicle and can mate only with the correct drive unit. The cable carries power for the motors, signals from the magnetic sensors and pulses from the distance encoder. A separate control and video signal cables connect the camera module to the Control Unit, see Figure 2-18 for connection details.

RCU is based on an industrial PC running Windows 7 and using a National Instrument card to provide interface for vehicle and camera controls. The RIV kit contains a key-board that should be used for basic Windows operations, such as transfer of images from the PC within RCU to a USB memory stick.

2. Hardware

WARNING:
The vehicle contains strong magnets therefore appropriate measures must be taken when handling the vehicle to prevent operator injury or vehicle damage. The magnetic force holding the Robotic Inspection Vehicle onto a steel surface is greater than 100 N (22-pound force) and it is important to lift the Robotic Inspection Vehicle by means of the two width adjustment bars. Incorrect alignment (setting of the span between two drive units and/or setting of the curvature) may cause lack of adhesion and/or failure of the vehicle to follow the correct track.

2.1. RIV Control Unit (RCU)

The RIV Control Unit is powered and will operate from nominal input voltages of 85-264 Volts ac at 50/60 Hz without adjustment. It must be connected to a power supply that has a reliable ground connection. The power cord entry module is a fuse holder as well. There is a separate POWER indicator lamp, indicating presence of voltage. The unit is not equipped with batteries. The Control Unit is switched on by OFF-RUN-SETUP switch, see Figure 2-1.

Figure 2-1 RIV Control Unit

The function of the five buttons on the left side of the screen is the same in both RUN and SETUP modes, from top to bottom:

- FORWARD-moves vehicle in direction of its encoder and camera.
- STOP-stop the vehicle, active in Auto and Manual mode of distance control.

- REVERSE-moves the vehicle in direction opposite of location of its encoder and camera.
- AUTO/MANUAL- changes the way vehicle will stop; AUTO (automatically stop at predefined Set Distance), or by STOP button.
- SAVE FRAME-activate sequence of photo capture and save the file to Photos folder.

The SPEED encoder is used to control vehicle speed and reset distance counter to 0 in both RUN and SETUP modes.

The SET encoder has different functions in both RUN and SETUP modes:

RUN Mode Behavior	
Set Encoder Click	Toggles between NORMAL and INVERSE direction of the distance output to EL CID SPU
Set Encoder Rotation	Changes the slot number; only active when the vehicle is stationary.
Speed Encoder Click	Resets distance counter to 0.
Speed Encoder Rotation	Changes the vehicle speed.
SETUP Mode Behavior	
Set Encoder Click	Cycles through the setup fields on the setup screen.
Set Encoder Rotation	Toggles the distance unit between cm and inches when the Unit setup field is selected. Sets the auto-stop distance when the Auto Stop setup field is selected. Sets the LED level when the LED setup field is selected. Note that when the LED level is set to 0, camera is disabled. Sets the camera exposure setting when the Exposure setup field is selected. Sets the forward guiding balance when the FWD Balance setup field is selected. Sets the reverse guiding balance when the REV Balance setup field is selected.
Speed Encoder Click	Resets distance counter to 0.
Speed Encoder Rotation	Changes the vehicle speed.

Figure 2-2 below shows the RCU screen with AUTO STOP distance of 10 cm selected and camera connected.

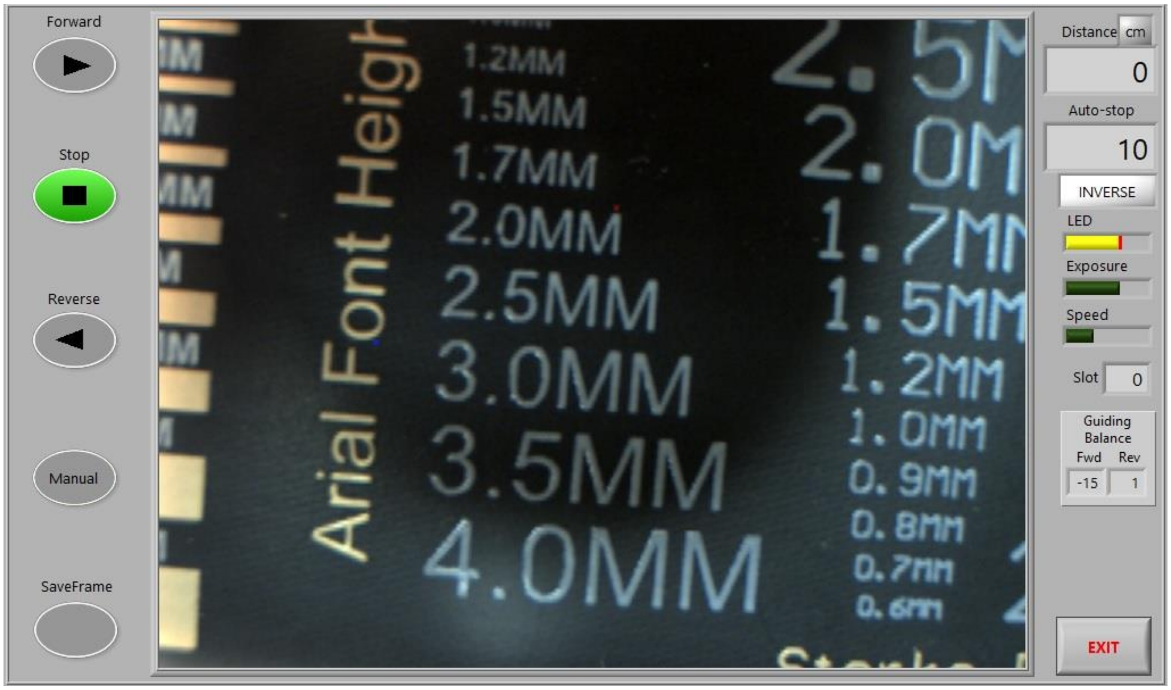


Figure 2-2 RIV RCU screen, Auto stop at 10 cm.

2.2. Vehicle

The vehicle consists of two drive units, one with a distance encoder, and one without. The two drive units should be connected using a set of bars, straight or curved. To set proper spacing between the two drive units, measure the width between the outer edges of two adjacent stator teeth; i.e. the width of two teeth plus one slot on the machine to be tested. This distance is referred to as the **EL CID Test Width**, and is used to ensure that the built-in magnets and edge detecting magnetic sensors of the RIV are correctly positioned with respect to the stator teeth and slot width.

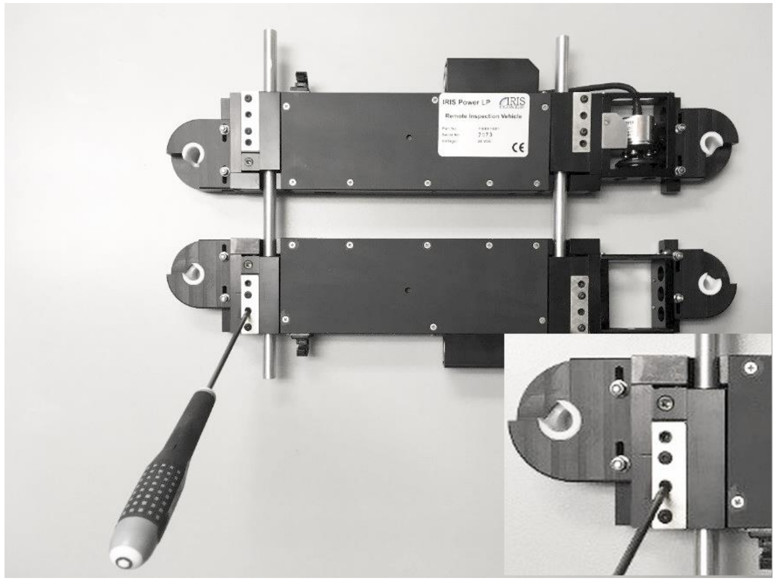


Figure 2-3 Adjusting the Span Between the Drive Units

Loosen the socket-headed width adjustment locking screws (four on each drive unit, total of eight) on the cross bar clamp blocks (see Figure 2-3 above).

NOTE:
The adjustment screws are kept in place by the retainer plate, and excessive loosening of the screws will deform the plate.

Insert the selected bars into both drive units and adjust the RIV width such that the mechanical guide plates are set to a distance 4mm greater than the **EL CID Test Width** (see Figure 2-4 below). Use the guide plates for measuring the distance even if they will not be used when running the RIV. For example, if the **EL CID Test Width** is measured as 120 mm, set the distance to 124 mm.

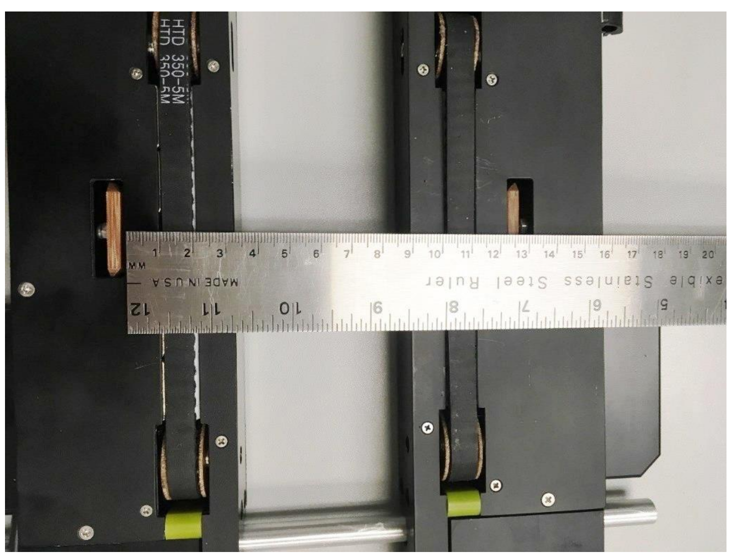


Figure 2-4 Measuring the Vehicle Span; Set for an EL CID Test Width of 120 mm

Tighten the eight screws to temporarily secure the position of the two halves of the vehicle. Mechanical guide plates are held in place with 5.5 mm hexagon head bolt, and if necessary after loosening that bolt, might be pushed down through the round opening located in the center of each drive unit, visible in Figure 2-43. After lowering the guides, tighten the hexagon head bolt, seen in Figure 2-5.

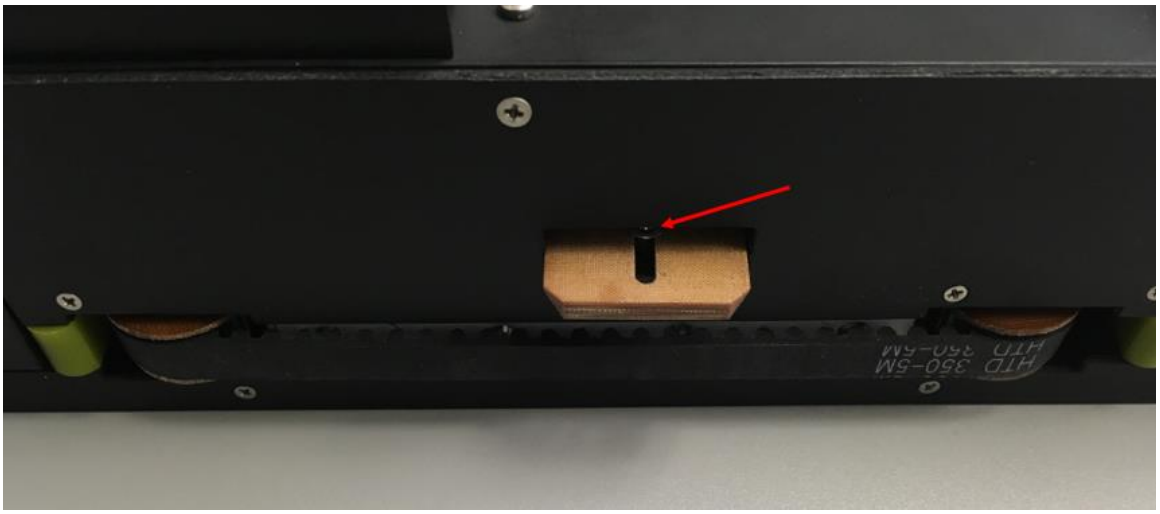


Figure 2-5 Mechanical Guide in Lowered Position, 5.5 mm bolt indicated by red arrow

Curvature adjustment of the Robotic Inspection Vehicle is normally most conveniently carried out with the RIV in the stator bore, if it is accessible. Place the Inspection Vehicle in the correct position centrally over two teeth and turn the socket-headed Curvature Adjustment Screws shown in Figure 2-6 until the base of each drive unit is parallel with its respective tooth surface, see Figure 5-2 for reference. Ensure that both halves are set to the same angle; there is only one set screw per drive unit. Recheck the width setting after adjusting the curvature and adjust if necessary.

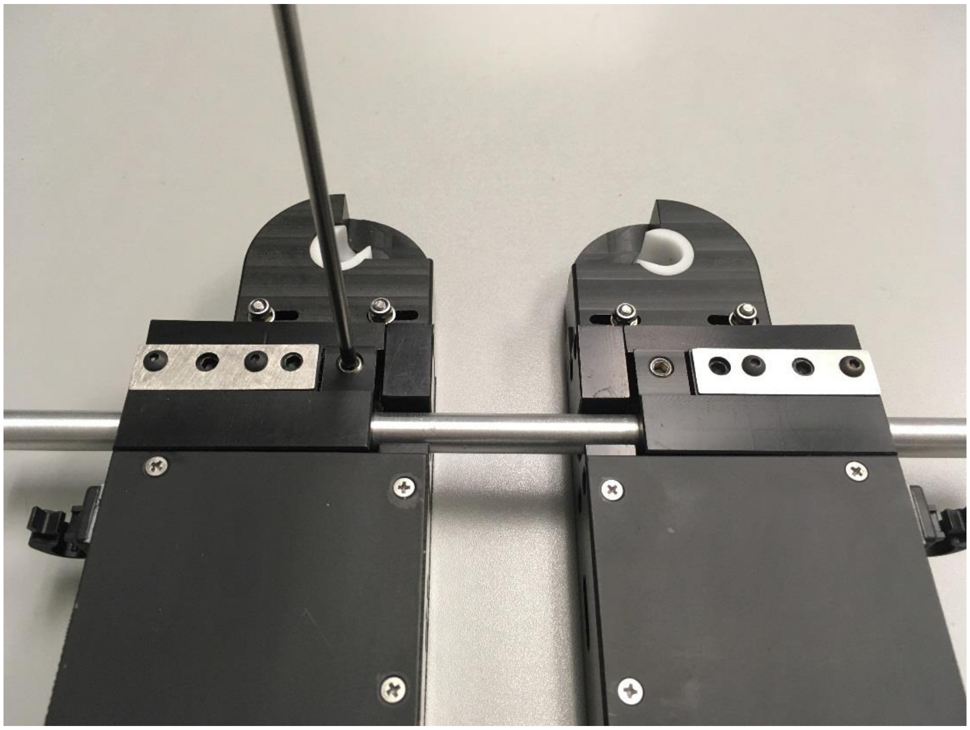


Figure 2-6 Curvature Adjustment

WARNING:
Do NOT force the vehicle along the track as excessive force may cause damage to the gearboxes and the tracks; light hand pressure is sufficient to move the vehicle a few centimeters.

NOTE:
Verify that the outer edges of the Chattock Sensor are aligned approximately 1 mm inside the outer edges of the teeth. Adjust as necessary by releasing two 5.5 mm nuts on each Chattock holder and set the correct position, see Figure 2-8.

2.3. Camera Module

The camera module can be installed in two orientations, for axial/in-line scanning or for lateral scanning.

2.3.1. In-Line Scanning Mode

For use in the in-line scanning mode, the camera module is fitted to the drive unit which does not incorporate the encoder wheel assembly. The front of the drive unit on a standard configuration RIV has provision for a removable mounting plate for the attachment of camera module.

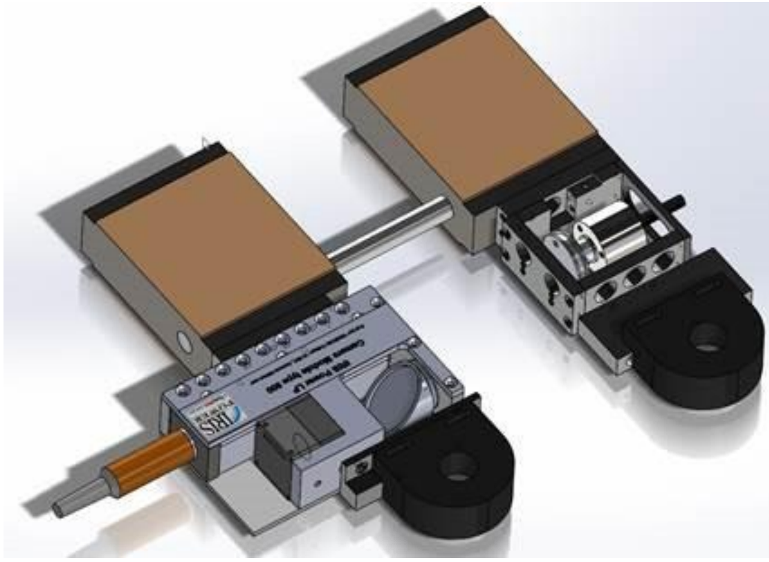


Figure 2-7 Camera installed for in-line scanning

The following steps describe camera installation for scanning in in-line mode:

- Remove two 5.5 mm nuts, flat washers and the Chattock holder.

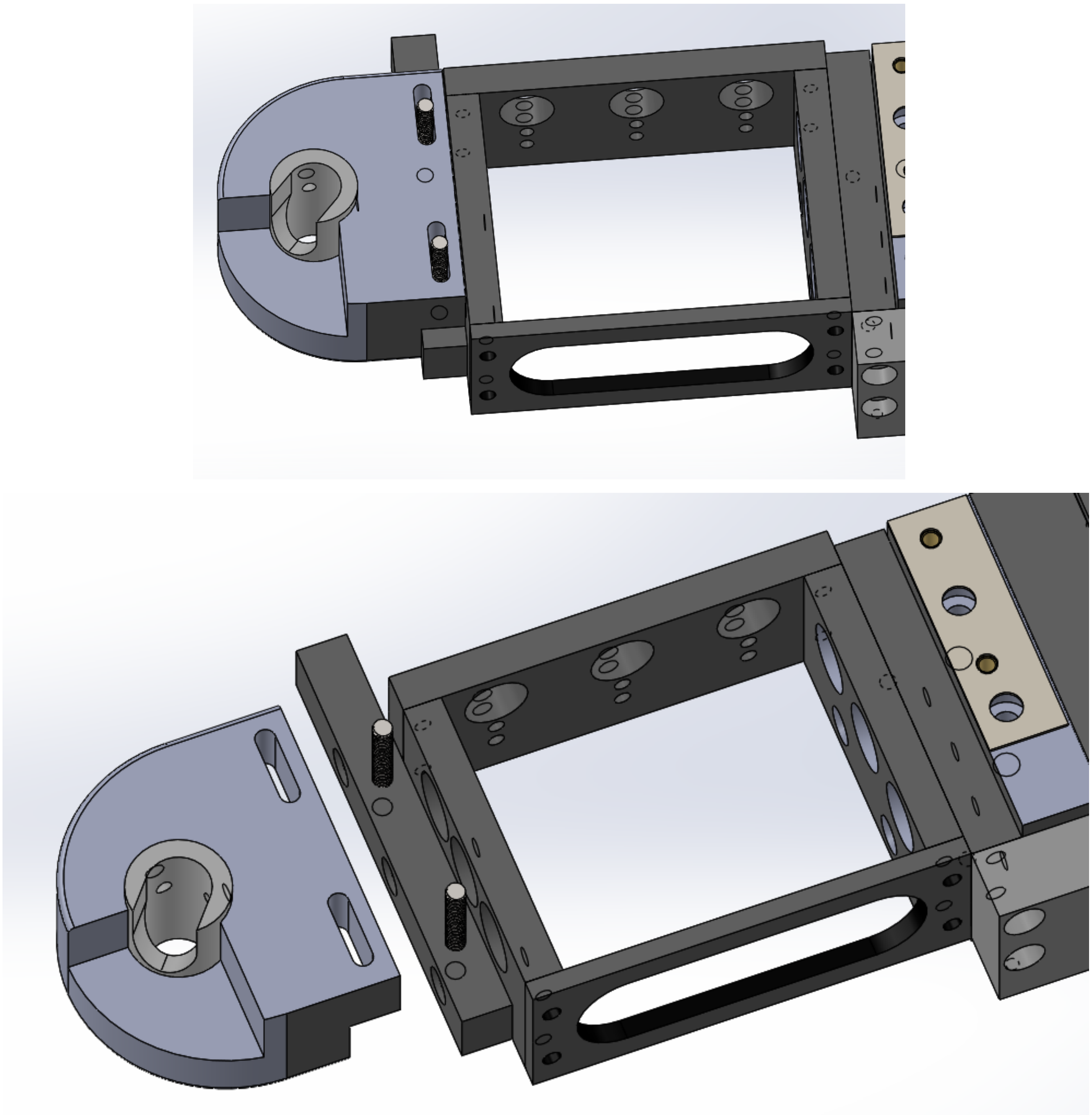
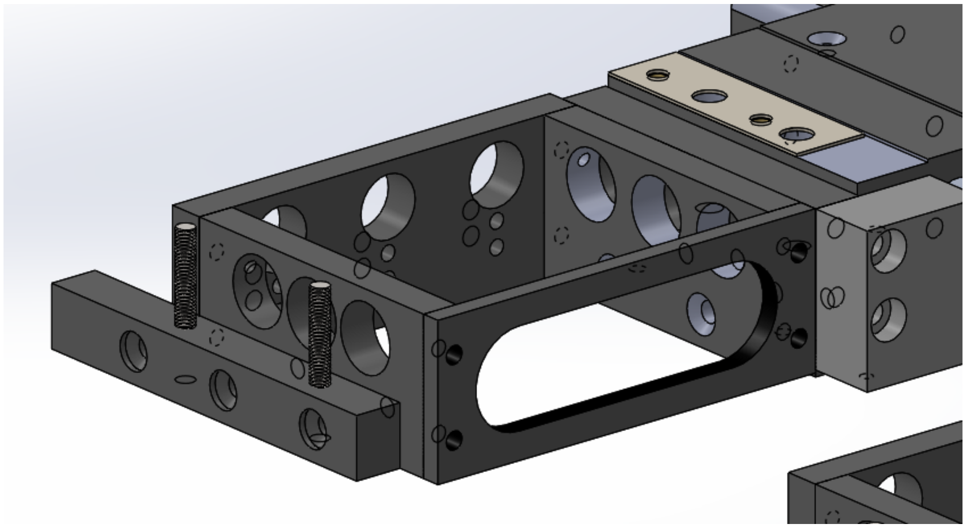


Figure 2-8 Remove Nuts and Chattock Holder

- Using a flat head screwdriver remove the Chattock holder plate (with two vertical threaded studs) and then remove the two screws holding the Chattock holder spacer on to the RIV body.



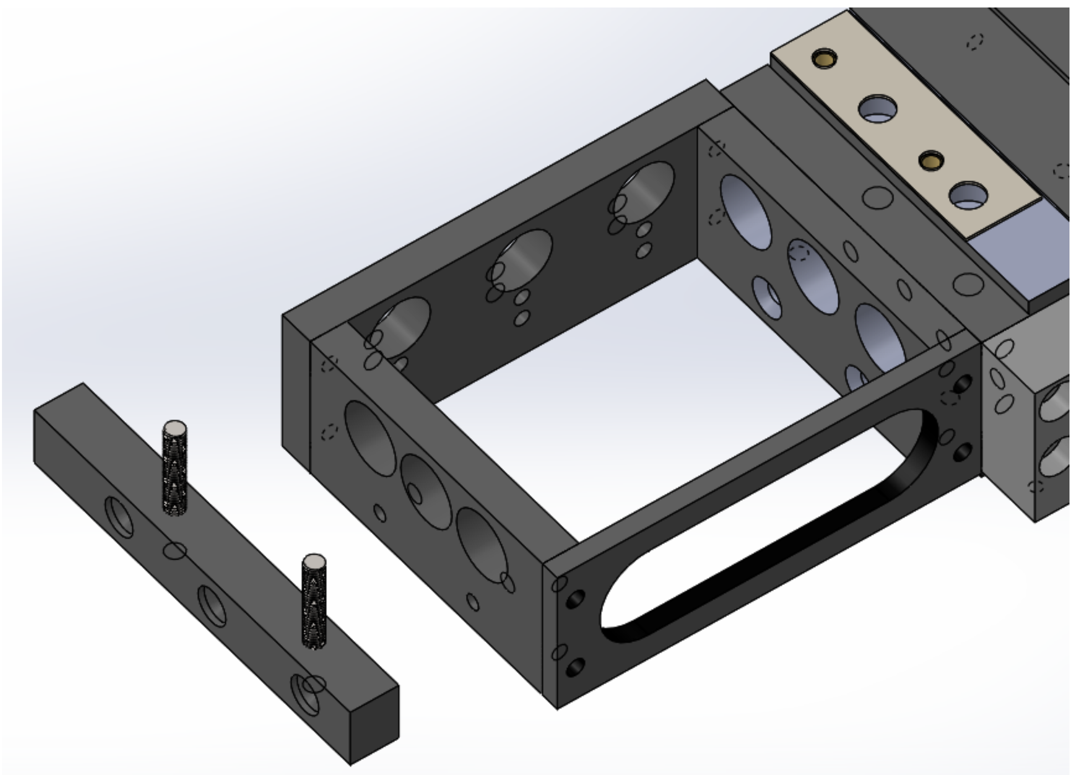


Figure 2-9 Remove Chattock Holder Plate

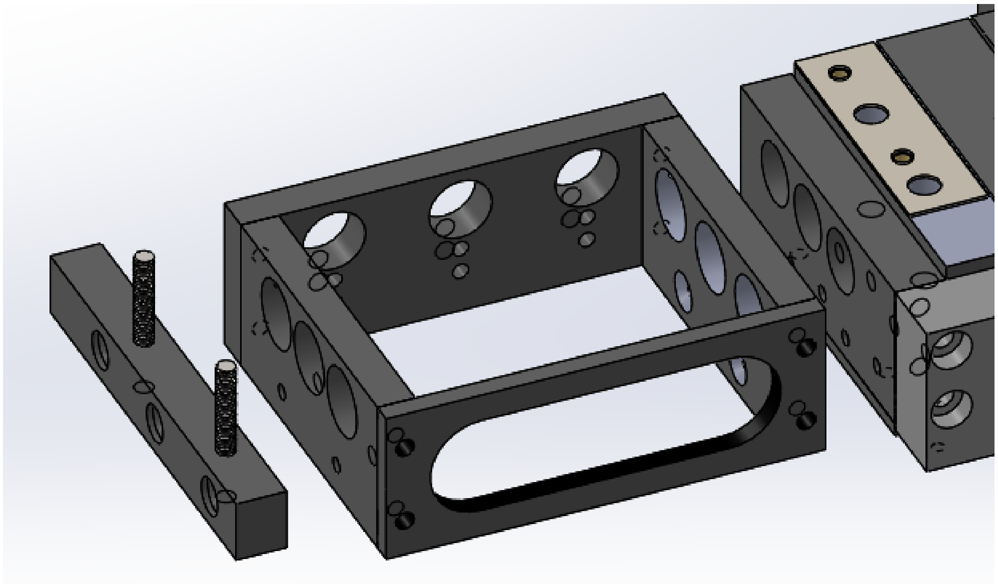


Figure 2-10 Remove Chattock Holder Spacer

- Remove the camera module mounting plate from camera and install it as shown, using two M3 counter head screws. Use low strength LOCTITE to secure screws in place.

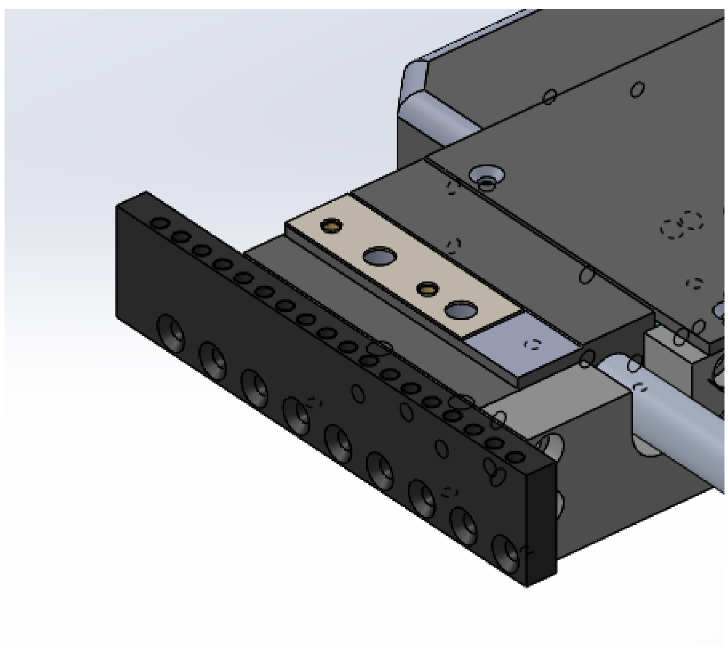


Figure 2-11 Install Camera Mounting Plate

- Attach the camera module to mounting plate with two M3 screws secured by low strength Loctite.

NOTE:
The top surface of camera module mounting plate incorporates a number of mounting holes (tapped for M3 screws) for attachment of the camera module. At least two screws should be used.

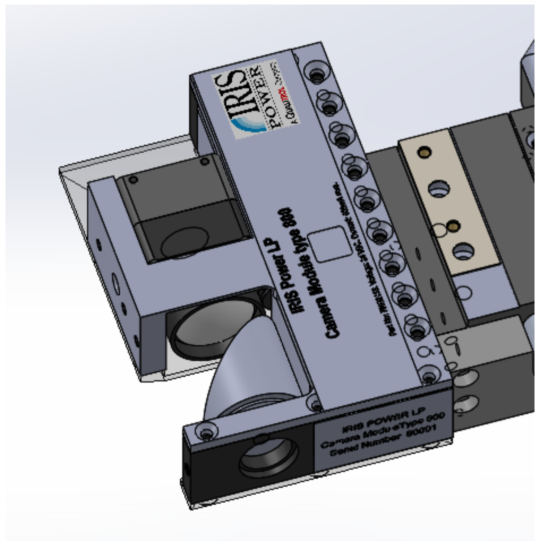
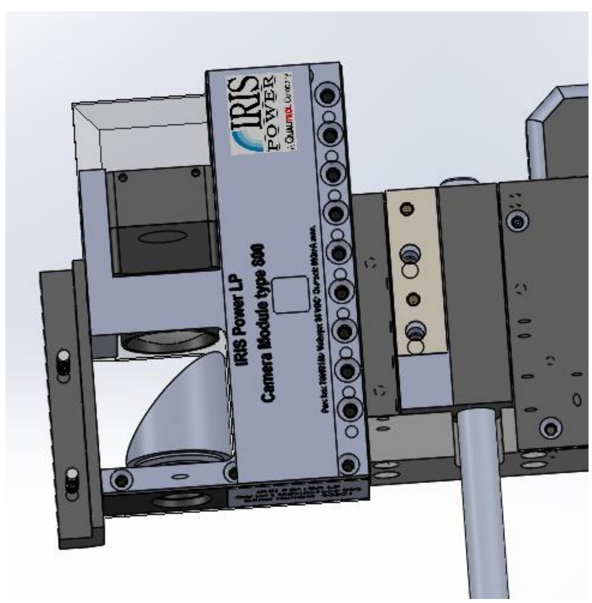


Figure 2-12 Install Camera Module

- If the RIV will be used to perform an EL CID stator core test at the same time, attach the Chattock mounting angle for camera to the camera body using M3x6mm flat SS screws, see Figure 2-13, and then reinstall the Chattock holder. Make sure that Chattock outside edge is aligned with the edge of the slot and the Chattock on the opposite end of the vehicle.



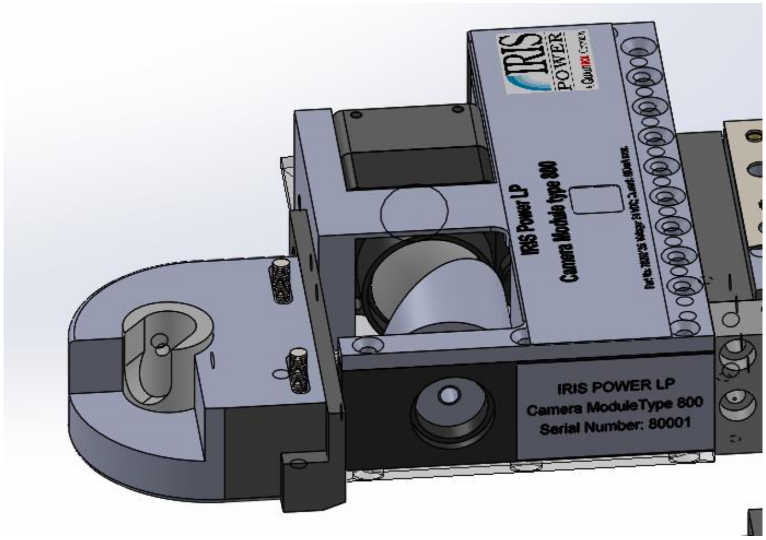
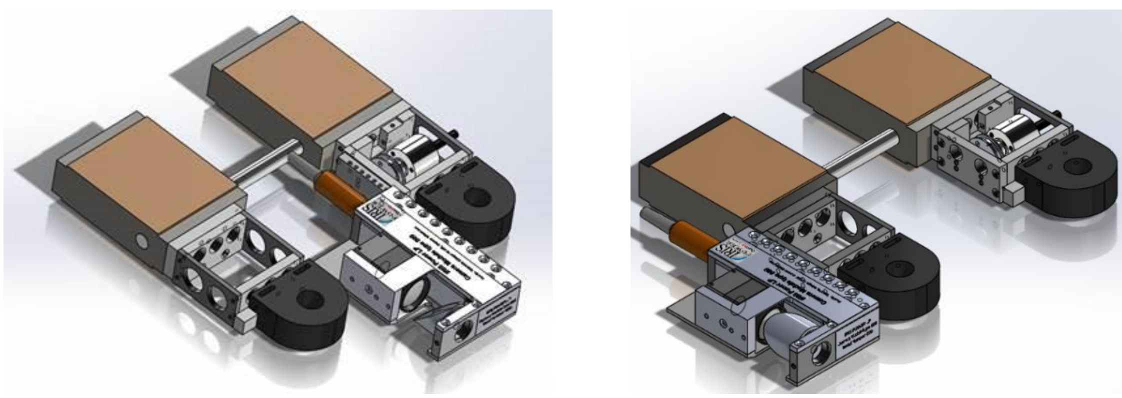


Figure 2-13 Attach Chattock Holder (optional)

2.3.2. Lateral Scanning Mode

For use in the lateral scanning mode, the camera module may be fitted to the drive unit which incorporates the encoder wheel assembly or the other one, Figure 2-14 right, depending on minimum spacing between the drive units. Both drive units on a standard configuration RIV have provision for a removable camera module mounting plate installation.



Camera Mounted Between the Drive Units | **Camera Mounted on the Side**

Figure 2-14 Lateral Scanning Options

The following steps describe camera installation for scanning in lateral mode:

- If necessary, remove the Chattock holder and Chattock holder plate, as described in Section 2.3.1. Attach the camera module mounting plate to the side of the spacer (lower row of threaded holes) using screws provided and secure them with low strength Loctite.

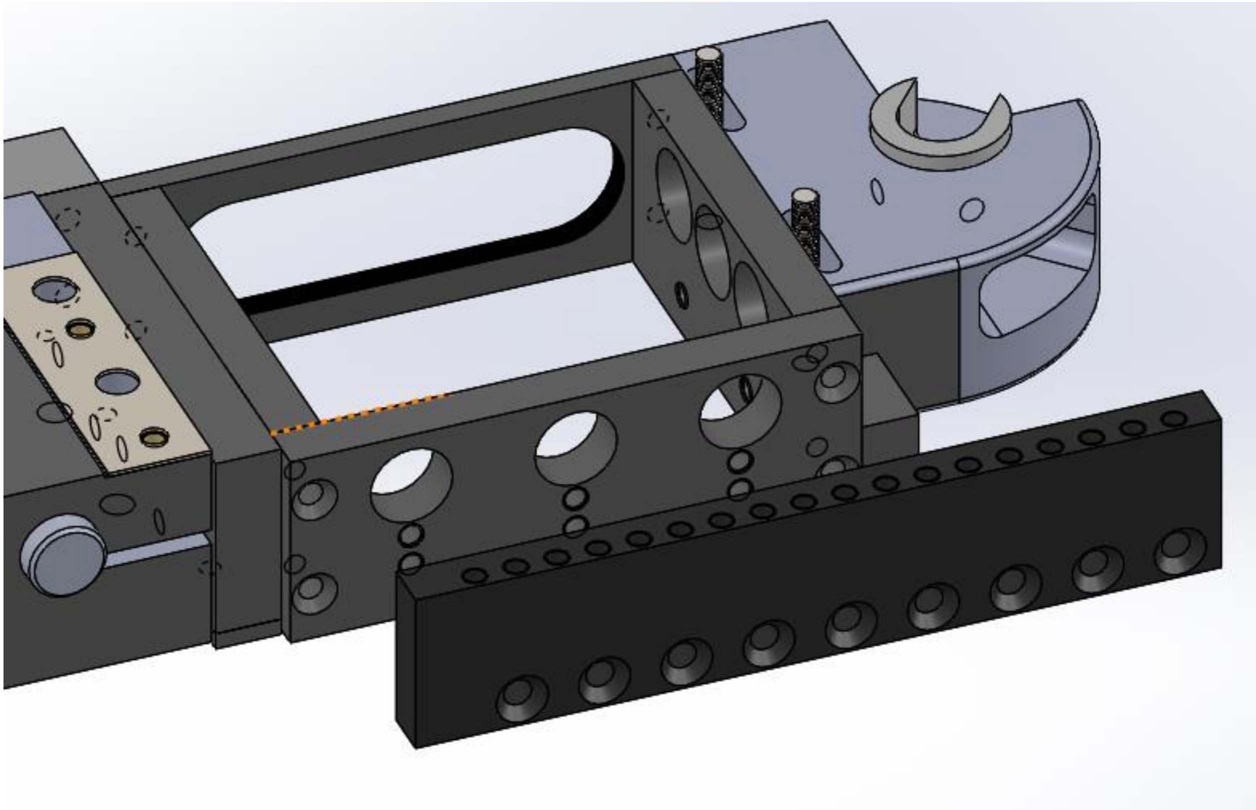


Figure 2-15 Camera Mounting Plate

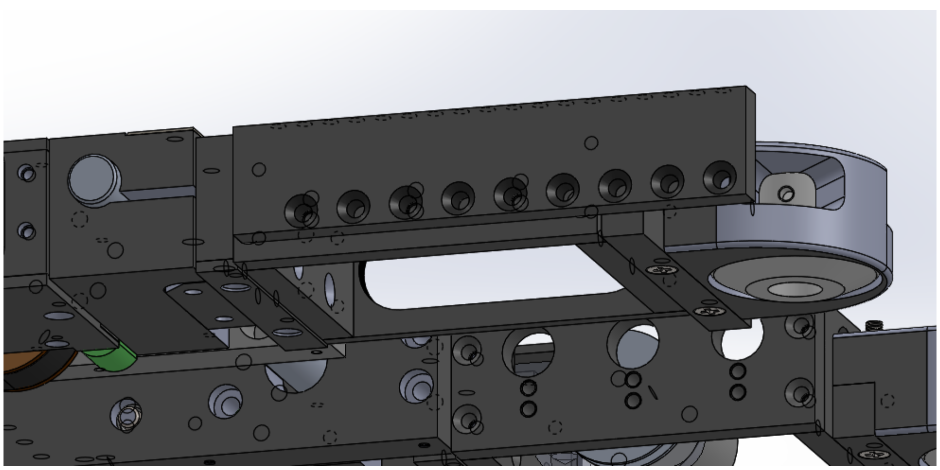


Figure 2-16 Attach Camera Mounting Plate

- Attach the camera module to mounting plate with two M3 screws secured by low strength Loctite.

NOTE:
The top surface of camera module mounting plate incorporates a number of mounting holes (tapped for M3 screws) for attachment of the camera module. At least two screws should be used.

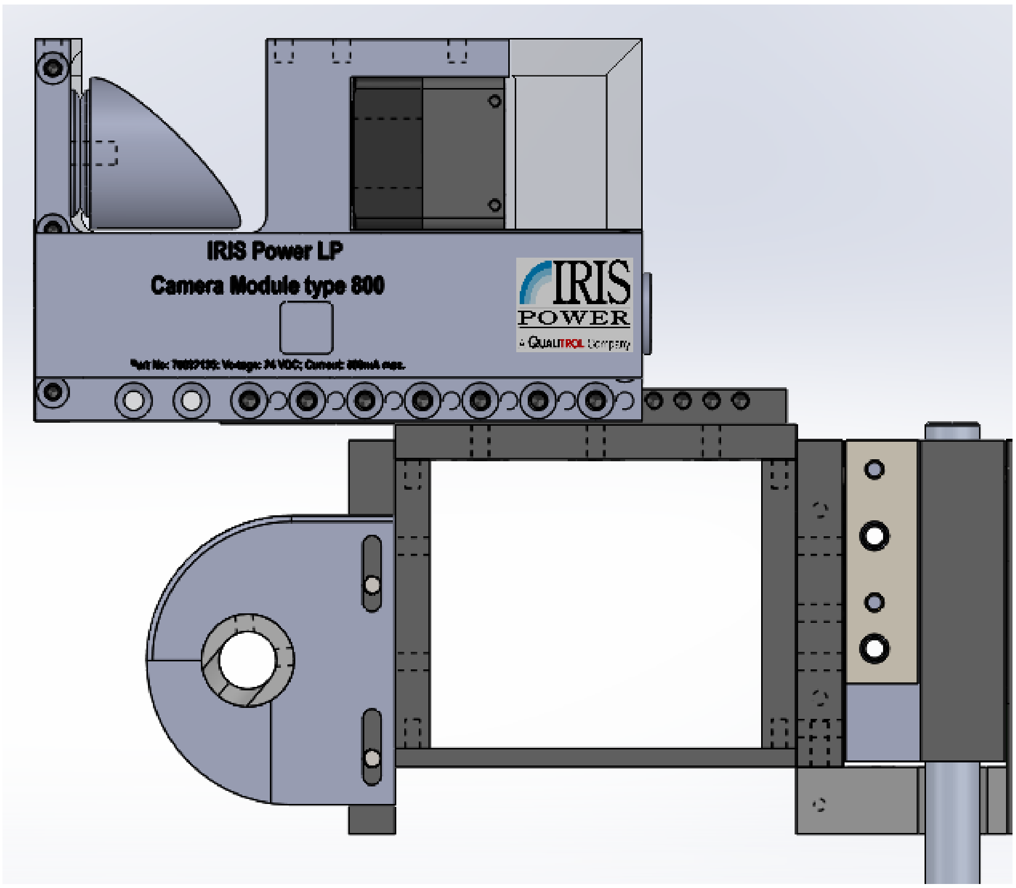


Figure 2-17 Attach Camera

- If the RIV is being used to perform an EL CID stator core test at the same time, re-attach Chattock holder plate and Chattock holder.

2.4. Cable Connections

The RCU is connected using the following cables, all connectors are on the back of the unit:

- Power cord to grounded outlet, 100-240 Vac 50/60 Hz
- RIV Vehicle control cable from RCU VEHICLE connector to each vehicle unit, two different connectors are used for two drive units
- Camera control cable from RCU CAMERA connector to camera module
- Video signal cable from any USB port on RCU to camera module USB port
- RIV to EL CID Distance cable from RCU X-AXIS connector to EL CID SPU X-AXIS input.

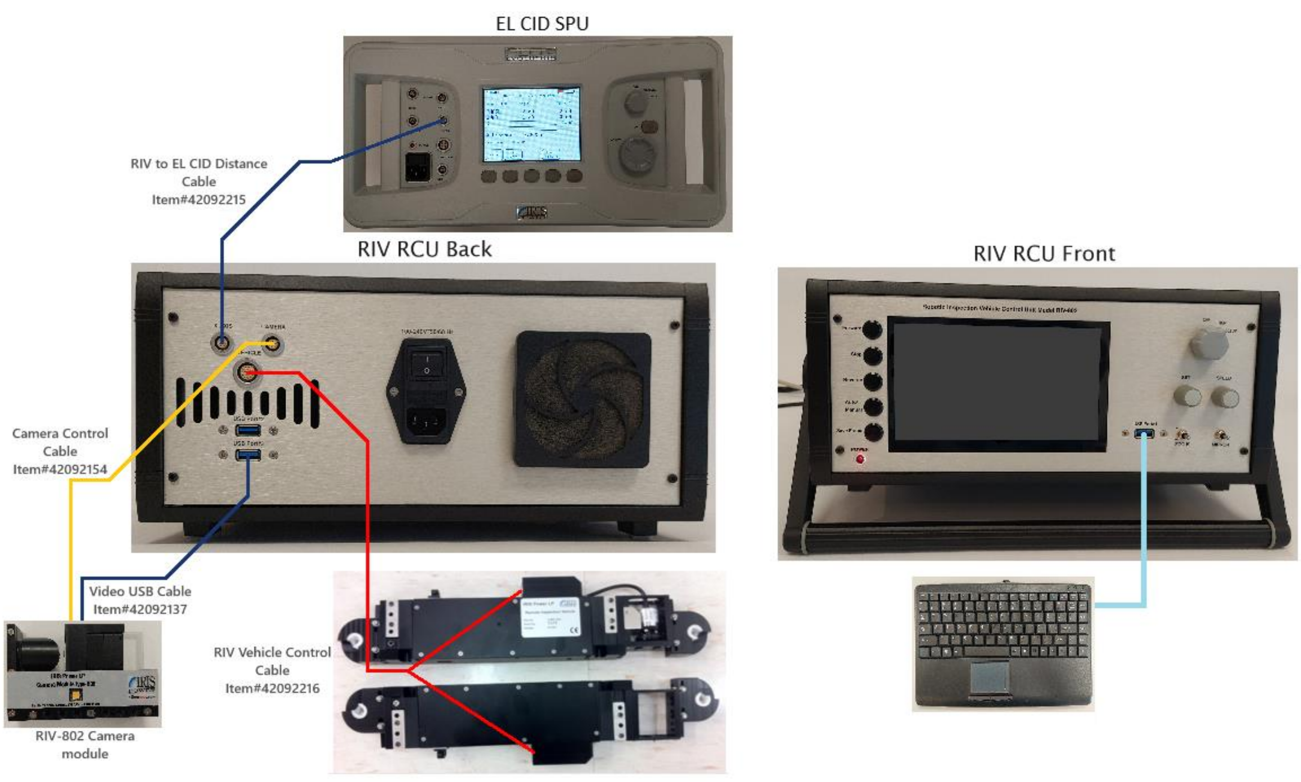


Figure 2-15 Cable Connections

NOTE:
The power cord MUST be connected to an energized outlet BEFORE turning on the RCU.

3. Quick-Start

Connect the RCU to a power outlet in the range of 100-240 Vac, and all other cables, as described in Section 2.4. Turn the OFF-RUN-SETUP knob to RUN. After approximately 40 seconds the SPU screen will show the following display:

Figure 3-1 RCU Starting Screen

The RIV can now be controlled by FWD, STOP and REV buttons in Manual mode without any additional setup, although some setup may be desired.

The distance travelled will be displayed in the upper right corner, in units selected (cm or inch). The distance is determined by the trailing wheel on the Robotic Inspection Vehicle encoder. Positive and negative distances are displayed and these correspond to forward and backwards distances relative to the reference point which may be reset to zero by click on the SPEED encoder control button. Count direction may be reversed by means of the NORMAL/INVERSE function, activated by click on the SET encoder. This will also reverse the electrical distance output information to EL CID SPU, which is a convenient “fix” in the case that the RIV is accidentally launched on the stator core in the opposite travel direction.

The speed of the vehicle can be controlled by SPEED encoder.

3.1. Additional Setup (optional)

To set measurement units (cm or inch) and Auto-stop distance, turn the OFF-RUN-SETUP knob to SETUP. Using the SET encoder click function select the field to be modified, starting with top left (cm/in) and rotating the same control select desired unit; see Figure 3-2 below.

Figure 3-2 Distance Unit Selection

On the next click, the following field, Auto-stop, will be selected. Rotate the SET encoder knob to adjust auto-stop distance. This could be the length of the flat part of the stator core to be tested, or a length of a single stator wedge, if wedge tightness test is to be performed.

Figure 3-3 Auto-Stop Distance Setting

To operate RIV in this mode, the Auto/Man selector control needs to be in Auto position; press the Auto/Man button. The green indicator means that RCU is in Auto stop mode, see Figure 3-4.

Figure 3-4 Auto-Stop Mode Indication, Auto selected

During the out (forward) and back (reverse) journeys check that the Chattock potentiometer is correctly aligned with respect to the stator teeth (riding on outside edges of the teeth) and that each end makes light contact with the stator surface. If the alignment is incorrect the Robotic Inspection Vehicle width, or possibly the Chattock holders span, should be readjusted.

3.2. Camera Controls

The camera module of the system has provision for mounting to the front of the Robotic Inspection Vehicle and may be used to complement EL CID or Wedge Tightness Testing, or used for general visual inspection, subject to overall payload and control cabling restraints. The camera control and video cables can be connected at any time. If the Camera module is not recognized by RCU, disconnect and connect USB video cable and verify that LED setting is not at the minimum.

The field of view of the camera is usable in two alternative direction modes providing rotation in either the in-line (forward to the axis of the RIV) or lateral (transverse to the axis of the RIV) planes, see Section 2.3.

The RIV control unit includes an integrated LCD display to allow monitoring of camera position for visual inspection and camera controls. To control focus and direction of view, use the two rocker switches, marked FOCUS and MIRROR. Intensity of illumination and exposure level can be controlled with the RCU in SETUP mode using sliding controls, marked LED and Exposure.

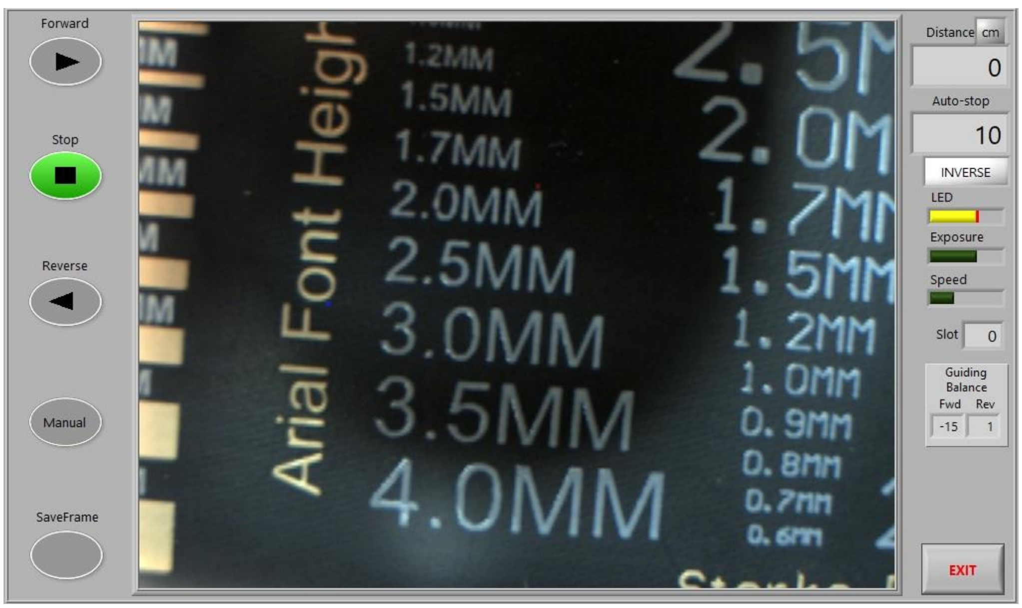


Figure 3-5 Camera LED Control Active

To change settings, switch the RCU to SETUP mode, and using the click function of the SET encoder to switch fields, adjust lighting and exposure by rotating the SET encoder. The camera will be turned OFF if the LED level is reduced to zero.

Still photos of the camera image can be saved using the Save Frame button; see Figure 3-6. Videos cannot be saved to RCU, but camera Video USB cable can be connected to a

PC. If Ximea Camera Software Package is installed on the PC, PC could be used instead of RCU as display and for video recording.

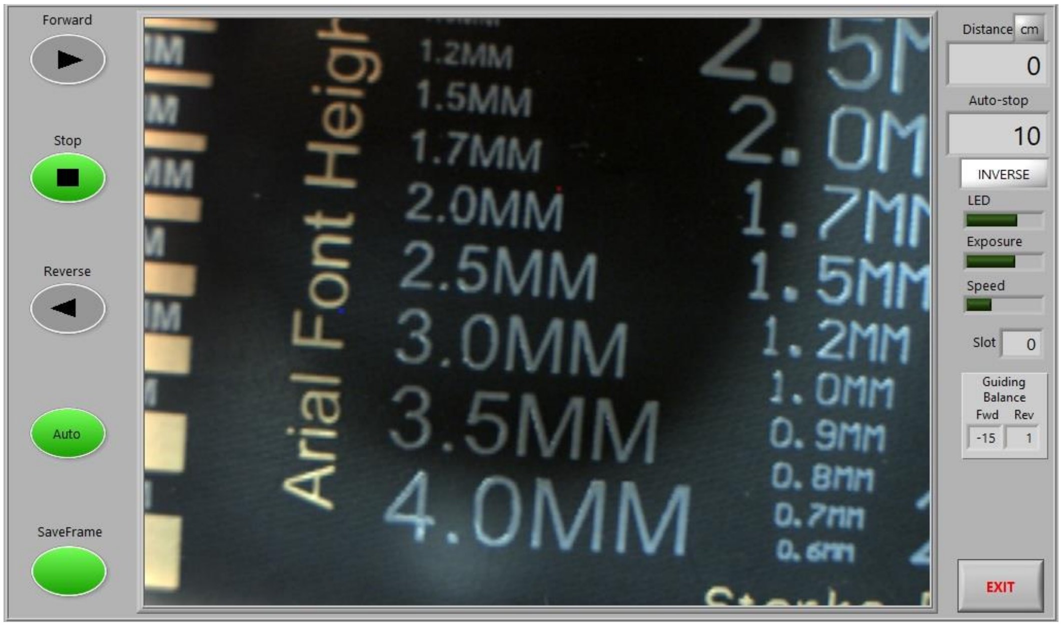


Figure 3-6 Save Frame Function Activated

NOTE:
It is good idea to adjust the light and exposure and verify the slot number, controlled by SET encoder in RUN mode, and distance information before saving the photo.

All pictures will be saved within the RCU, in the Pictures folder; the file name will be automatically created using the following rule: DATE_TIME_SLOT NUMBER_ DISTANCE.

To transfer the files from the RCU to an external device, connect a USB stick or external drive to one of the three USB ports on RCU and using a keyboard connected to another USB port on RCU, click on Exit or press ALT+TAB on a keyboard to switch from Camera/RIV control application to the Windows operating system running in the RCU.

Figure 3-7 Alt+Tab to Windows

Select the Pictures directory on C drive and copy pictures from that folder to an external device.

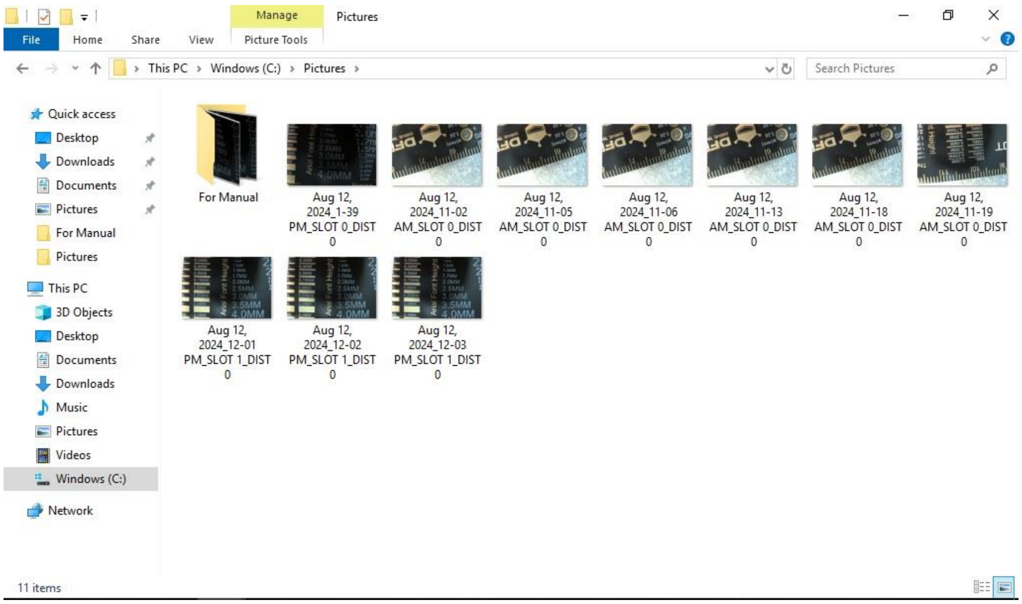


Figure 3-8 Copy Pictures from RCU

3.3. EL CID Measurements

Detailed test procedures for using the Robotic Inspection Vehicle to traverse a stator with the EL CID sense coil (Chattock Potentiometer) will be dependent upon the nature of the stator, in particular the shape of the end or step iron and the requirement for specific tests in these areas.

The RIV should be equipped with Chattock sensors on both sides of the vehicle, to enable scanning of the complete length of the flat part of the stator core with access from one side of the machine only. One Chattock sensor is used to record the data in forward motion and the other one in reverse motion. The EL CID Evolution SPU should be prepared for this test mode as described in section 3.3, and ELAN software adjusted for Dual Scan test mode.

It is often convenient to set up EL CID equipment at the exciter end of the stator as the exciter may have been removed leaving a clear working area. A suitable worktop is required for the equipment.

3.4. Recording EL CID Responses

The EL CID test instrument provides the test response (PHASE or QUAD signals) in the normal way for recording purposes but requires an indication of position along the length of the stator core (X Axis). This would be provided by the hand trolley under normal circumstances. When using the Robotic Inspection Vehicle, the RIV Control Unit outputs a signal, derived from the vehicle encoder wheel, which should be connected to the EL CID equipment to provide the distance or X-Axis, information. Use provided cable to connect the X-AXIS output on RCU to X-AXIS input on EL CID SPU, see the connection diagram, Section 2.4.

EL CID SPU should be adjusted to receive the signal from RIV, by changing the X Axis Select from Trolley to RIV. Select the appropriate X-Axis Select line using the ^ and v Softkeys on EL CID SPU, then select the RIV by pressing the > Softkey, and confirm with the OK button.

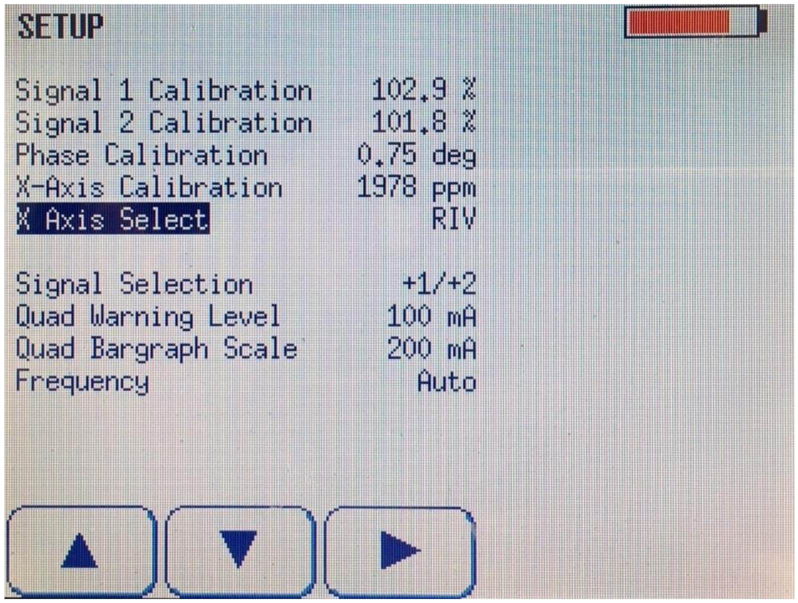


Figure 3-9 EL CID SPU Setup Screen, RIV Selected

After that, calibration of distance is required. It is recommended that this is done in the stator core that is being tested, as this will allow the calibration to include any variations due to vent gaps etc.

Calibration values are stored separately for the RIV and Trolley, and are expressed as Pulses Per Meter (ppm). Thus if the same RIV or Trolley are to be re-used on essentially the same core, then the saved calibration may be sufficient but should be verified before each test.

Select the X-Axis Calibration line with the ^,v Softkeys, then press Calibrate Softkey and follow the instructions on EL CID SPU screen.

To calibrate the X-Axis, connect the RIV X-AXIS output to the EL CID X-AXIS input as for a test. The basis of the calibration is to move the RIV a known distance (in increments of one meter) for which the SPU then computes the ppm value. On a short core that is less than 1m long, the distance can be calibrated instead on a table or floor. The most convenient way of performing this calibration is to set RCU Autostop distance to 100 cm (1m) and drive the vehicle forward in Autostop mode.

Having determined the length of test run as 1 m, if necessary press Distance Softkey on EL CID SPU and use the Rotary control to set the distance of 1m, confirming with OK button on the SPU. Then set the RIV at the start point, press the Start Softkey on EL CID SPU, and traverse the set distance with RIV (press FWD on RCU in auto stop mode with 100 cm defined as Autostop distance). The display will show the ppm value increasing as the pulses are counted. At the end of the test run, make sure that the encoder wheel does not move any more, then return to the SPU and press the OK button to confirm the calibration. A useful check that all is well is to then run the RIV back to the start point and check the distance shown on EL CID SPU returns to 0m within a few mm.

This calibration must be done before recording EL CID readings with the computer; otherwise the data may be presented in the wrong place.

In addition to distance calibration, signal calibration is also required. Follow the instructions on EL CID SPU and calibrate both Chattocks to be used on RIV. To proceed with measurement EL CID SPU should be enabled to collect data from two Chattocks, by selecting +1/+2 if the two Chattock results are the same polarity, or +1/-2 if it is desired to reverse the second. Select the one that causes both Signal Inputs to record the same polarity PHASE signal when placed in the excited bore for test. (The final PHASE polarity for both may be inverted if negative by reversing the Reference Sensor orientation on the excitation cable.)

The Chattock to be used in forward motion (installed at the rear of the RIV) should be connected to Signal Input 1 for the Forward scan, and the other Chattock (installed on the front of the RIV) should be connected to Signal Input 2 for the Backward scan. The ELAN software, in Dual Scan mode, will automatically select the correct Signal Input for recording Forward/Backward.

Since the RIV is not able to leave the bore, the Start and Return positions in ELAN setup should be set such that the relevant Chattock scans the appropriate part of the core; see Figure 3-10 for a typical RIV EL CID scan using two Chattocks in double scan mode.

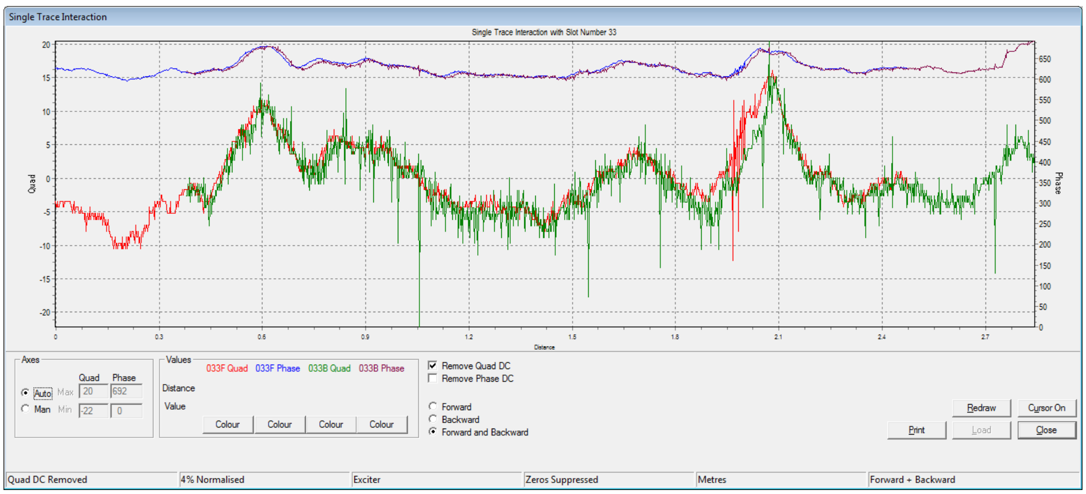


Figure 3-10 Typical RIV EL CID Scan Result

The second part of preparation for EL CID test is ELAN software setup. For more details, refer to EL CID User Manual.

NOTE:
If the RIV orientation on the core is different from desired, switching between NORMAL and INVERSE distance counting will help produce an accurate trace on a PC connected to EL CID SPU without changing the RIV orientation.

3.5. Wedge Testing using RIV

RIV can also be equipped with modules for wedge tightness testing. For more details, refer to SWA RIV Probe User Manual.

4. Technical Data

Functional	
Power Requirements	85-264 Vac 50/60 Hz <50 VA CAT II
Fuse	2A-T
Spacing Bar Pairs	200 mm (7.8”) straight 250 mm (9.8”) straight 250 mm (9.8”) 5º angle 250 mm (11.8”) 10º angle
Vehicle Speed	2 m/min to 6 m/min – approx. (6.6 ft/min to 19.7 ft/min - approx.) Continuously adjustable
Maximum Vehicle Payload	2 kg (4.4 lb)
Guidance	Automatic using magnetic sensors, Retractable mechanical support guides
Distance Measurement	Optical encoder wheel
Outputs	X-Axis pulses for Digital EL CID

Environmental	
Operating Temperature Range	0ºC to 50ºC (32ºF to 122ºF)
Storage Temperature Range	-20ºC to 60ºC (-4ºF to 140ºF)
Relative Humidity	0-95% RH (non-condensing)
EMC	EN61326-1, Class A
Safety	EN61010-1
Compliance/Approvals	CE mark

Physical	
Tractor Dimensions, approximate L x W x H	350 mm x 180-300 mm x 30mm (13.8” x 7.1”-11.8” x 1.2”)
Minimum Slot Pitch	65 mm (2.6”)
System Components Weight	11 kg (24.2 lb)
Cased and Packed Weight	29 kg (63.9 lb)

5. Practical Considerations

5.1. Mechanical Slot Guides

If the surface of the stator bore is dirty or slippery the Robotic Inspection Vehicle will normally still perform correctly. However, in order to proceed in a horizontal direction when on the side walls of the stator core, it will point slightly upwards to counteract slippage, and this could give rise to inaccuracies in the position of the Chattock. In these circumstances it may be advantageous to use the additional retractable mechanical support guides which ride on the edges of the stator slots/teeth. In order to be able to use the guides, the design of the core must be such that the slot wedge is sufficiently below the tooth surface to provide a guidance edge.

To lower the mechanical guides, loosen the locking nuts, which are accessible from the underside of the Robotic Inspection Vehicle. A small access hole on the top surface of the Robotic Inspection Vehicle permits the guides to be pushed down. Re-tighten the locking nuts. Check that the position of the guides is such that they fit closely to the outside edges of the stator teeth. Readjust the guide depth and Robotic Inspection Vehicle width as necessary.

5.2. Radial Cooling Ducts

Some generators have large radial cooling ducts (12.5 mm and larger), and although the Robotic Inspection Vehicle will normally traverse these satisfactorily it may again be advantageous to use the mechanical side guides.

5.3. Loss of Guidance

If at any time the Robotic Inspection Vehicle fails to self-steer correctly, turn off the power to the control unit. Remove the Robotic Inspection Vehicle from the stator teeth and check the underside to ensure that there is no magnetic or other debris present. Clean off any debris. Position the Robotic Inspection Vehicle on a flat surface with the drive tracks uppermost, switch on and check that both the tracks are running at similar speeds before putting the Robotic Inspection Vehicle back on the stator teeth.

If there is no obvious problem but the left and right track speeds are still uneven (i.e. the vehicle does not go straight), the guidance system may have become unbalanced due to circuit drift due to time or environmental effects. This may be corrected by means of the RIV Control Unit Guidance Balance controls. Turn the OFF-RUN-SETUP switch to SETUP position. Using SET encoder click function, select either Fwd or Rev field and rotating the encoder adjust the settings. This function is active while vehicle is stationary or moving. If adjusted when vehicle is stationary, the vehicle should be driven in both directions to verify the new settings.

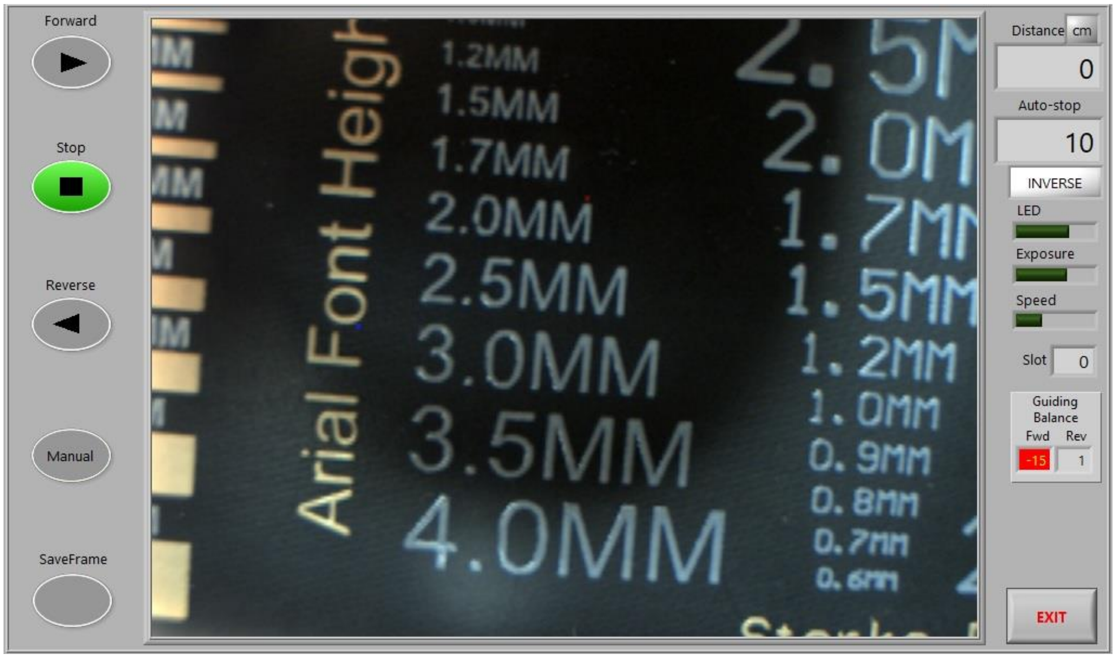


Figure 5-1 Balance Controls

The balance controls should initially be set for equal track speed in the low speed with the tracks uppermost as described above, taking care that no magnetic material is near the Robotic Inspection Vehicle body underside (i.e. on the track side, now uppermost).

The tracks should be adjusted to run at equal speed, using the FWD GUIDANCE BALANCE control when running forward, and the REV GUIDANCE BALANCE control when running in reverse. If necessary, further adjustment can be done once RIV is placed on the stator core and span between the drive units properly adjusted.

The effect of a slight unbalance does not affect the ability of the Robotic Inspection Vehicle to steer along the slots but may give rise to a small offset away from the central running position.

5.4. Overview of Rotor-in-Place Testing

The Robotic Inspection Vehicle (RIV) was designed originally for testing stator cores with Digital EL CID with the rotor removed. The RIV may also be used as a platform to carry other modules in order to perform additional test and inspection functions (i.e. wedge tightness testing and visual inspection). The benefits in comparison with manual methods of scanning are the more consistent speed that can be achieved, reduction of human fatigue on a large machine and consequent increase in test speed, and increased viability of testing by one person. There is also the potential to use the RIV for testing machines by insertion into the air-gap with the rotor in place if the air-gap is sufficiently large.

NOTE:
Iris Power does not warrant or guarantee that it is suitable for any particular Rotor-in-Place testing. The user must make that determination and assumes responsibility for any associated risk and damage. The following investigations, determination of suitability and correct preparations are the sole responsibility of the user.

On turbo-generators, although the stator to rotor gap may be sufficient, the overriding constraint may be the dimensions and shape of the entrance gap of the rotor and access to this part of the machine for RIV insertion and working purposes. On hydro-generators, access to the rotor ends is normally less restrictive compared with turbo-generators with fewer constraints to partial dismantling. Although the available rotor pole to stator gap is often less, other options to make use of gaps between rotor poles or to remove one or more poles may exist. Both these options require the ability to rotate the rotor during a test.

Where EL CID tests are to be carried out, consideration must also be given to the method to be used for excitation of the stator core and the effects of possible non-uniformity of the field due to the presence of the rotor. Access to both ends of the rotor/stator may be necessary to complete the excitation loop. This usually requires further dismantling on turbo-generators. In certain situations, under carefully controlled conditions, it may be possible to use the rotor to carry the EL CID excitation current in the form of a single turn.

NOTE:
Full single-turn voltage may appear between ground and the insulated end of rotor, creating hazardous conditions, if the voltage is higher than 30V.

The size of the air-gap and entrance gap should be considered and assessed against the RIV dimensions and any test sensors that are intended to be carried. Note that the nominal RIV height (30mm) could be increased by sensors, their cables etc.

In addition, in the case of a smaller bore radius (i.e. on a smaller turbo-generator) the cross-bars may become higher than the side carriages-RIV drive units. This is due to them hinging on the outside of the carriages, see Figure 5-2. This can be reduced and even eliminated by use of the angled bars supplied. These consist of one set of 200mm long bars angled at 5 degrees, and a second set 250mm long angled at 10 degrees. A few minutes of experimentation will determine the best choice in any particular case.

WARNING:
In the case that the user chooses to make a rotor-in-place test, then they should be aware of the risks and take maximum precautions against failures in the use and control of the equipment. In particular, it is necessary to prevent a situation whereby the RIV becomes totally entrapped inside the machine, requiring machine dismantling to recover it. The following general considerations are provided as guidelines, but Iris Power assumes no liability for their use in any particular situation and does not warrant that these or other guidelines or considerations provided will result in a successful outcome, which is solely the responsibility of the test engineer.

Details of the machine to be tested or inspected should be checked to ensure that use of the RIV is feasible. Although the stator to rotor gap may be adequate, the entry might be obstructed by the design of the end rings etc. It should be ensured that there is no obstruction or narrowing that might entrap the RIV. Ventilation baffles may mean that only part of the bore can be accessed, as the RIV cannot be steered around such obstructions.

A strong, (non-metallic if EL CID testing), recovery cord should be attached to the RIV cross bar to aid recovery if the power fails, or if the RIV becomes stuck. Do not rely on the RIV power and control cables being strong enough (they could also be unnecessarily damaged or detached if pulled hard). Note that excessive reverse force on the RIV motor gearboxes may cause gear transmission damage. Disconnection of the RIV control cable connector from the RIV control unit will decrease the motor braking effect.

Tape together all the leads and cords that will enter the machine as one cableform, so that loose leads cannot become snagged. Ensure this cableform is manually fed out and gathered back in as the RIV progresses. It must not pose a risk of becoming trapped under the RIV (which may lose magnetic adhesion or jam due to riding up over it), or drag the RIV such that it does not achieve reliable traction and goes off course.

The RIV is guided along the slot by magnetic sensors that sense the slot edge. Follow the instructions in this handbook closely to ensure that the RIV is set to the correct pitch for the machine. If the RIV fails to follow the slot and goes off course sideways, it is at risk of jamming crossways round the circumference of the machine.

Before deployment check that the RIV travels in an approximate straight line in slow speed on a flat non-magnetic surface both forwards and backwards, and if not trim the control unit adjustments as given in Section 5.3.

To provide confirmation of correct RIV operation, it is useful to check the RIV guidance system on a dummy track. This should preferably be at least 2m long, made of a pair of steel bars fastened or glued to a non-magnetic (i.e. wooden) backing, simulating the stator teeth and spaced at the pitch of the slots in the machine.

Run the RIV up and down this test track, both with the track horizontal, and on edge to simulate the side of a turbo-generator. The RIV will “crab” slightly when on edge to compensate for the inevitable slippage, but should follow the slot. The degree of slippage will depend upon relative smoothness of the track surface and the lateral grip provided to the RIV tracks, and this may be different from that of the actual stator bore surface.

The use of the mechanical guides on stators with recessed wedges will normally reduce “crabbing” considerably. However, the guides should not be deployed during this guidance test as they may mask sensor malfunction. Failure of the RIV magnetic sensors at the leading end of the RIV to follow the “tooth” edge would indicate a fault with the guidance system; the RIV uses sensors at both ends dependent upon drive direction.

The test track also allows setting of the Chattock spacings in the holders, although subsequent adjustment may be required after final RIV adjustment for curvature of the stator (see Figure 5-2 below).

It is **critical** that the curvature of the RIV is set correctly, so that only the drive tracks contact the stator and provide maximum degree of adhesion. If the body of the RIV drags on the stator, it may lose traction and/or go off course.

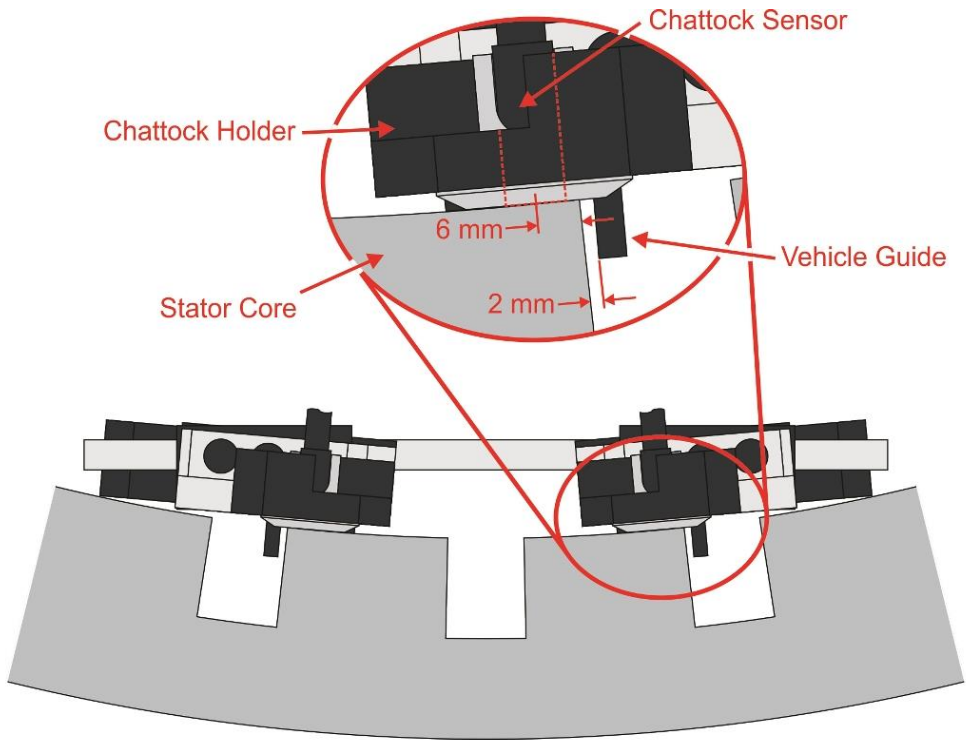


Figure 5-2 RIV Angle and Span Adjustment

If the stator wedges are recessed below the level of the stator tooth top surface, consider using the guidance side plates to ensure the RIV cannot wander off track.

The generator should be surveyed in advance to check that the detail assumptions are correct and that all expected pre-test work has been or can be carried out.

To launch the RIV into the air-gap, often some sort of ramp or chute is required. This should be planned and a solution designed in advance. A chute (usually steel to allow the RIV to adhere to it magnetically) is appropriate, held so that the RIV may be driven down it into the air-gap directly onto the start of the stator.

For rotor-in-place tests, the accuracy of the distance display will be especially important for Stator Wedge Tightness testing to ensure that the position of the RIV (and hence the position of the RIV SWA Probe on each wedge) is known. The checks advised in the handbook should be carried out. A Camera is recommended to allow sight of where the wedges are in practice. If wedges are of the same length, Autostop distance should be set to the length of the wedge and RIV can be driven in such increments; resetting the distance travelled after each wedge tested.

6. Maintenance

WARNING:
If for any reason the bottom covers are removed, care should be taken not to damage or strain the magnetic sensors attached to the covers or the leads attached to them.

WARNING:
It is important that no small items, particularly those of metal, are lost inside the stator bore. The Remote Inspection Vehicle has therefore been assembled utilizing both captive parts and screw locking adhesives. If any locked components are removed similar screw locking measures should be used on re-assembly.

6.1. Cleaning

It is necessary to keep the underside of the vehicle clean and free from grease and metallic particles. Greasy contamination will affect the ability of the vehicle to follow the teeth correctly. Metallic particles, particularly ferrous materials, may affect the steering system and prevent correct operation of the vehicle.

The surface of the vehicle can be cleaned with solvents such as Isopropyl Alcohol. Care should be taken not to soak the vehicle in these substances but wipe the surface using a cloth moistened with the solvent.

6.2. Track Drive Belt Tightness

In normal use the track tension should not require regular adjustment.

6.3. Fuses

The Control Unit is fitted with power input module fuses. Replace fuses ONLY with the value specified.

6.4. Iris Power LP Contact Information

Email:	Technical Support – techsupport.iris@qualitrolcorp.com General Inquiries – info@irispower.com Sales – sales.iris@qualitrolcorp.com Field Service – fsadmin@irispower.com Field Service Scheduling – scheduling@irispower.com
Phone:	+1-905-677-4824 Between 09:00 and 17:00 (GMT-5hrs)
Fax:	+1-905-677-8498
Address:	Iris Power LP 3110 American Drive Mississauga, ON L4V1T2 Canada

If technical support is required, please provide the following information (the more information about the issue, the faster the resolution):

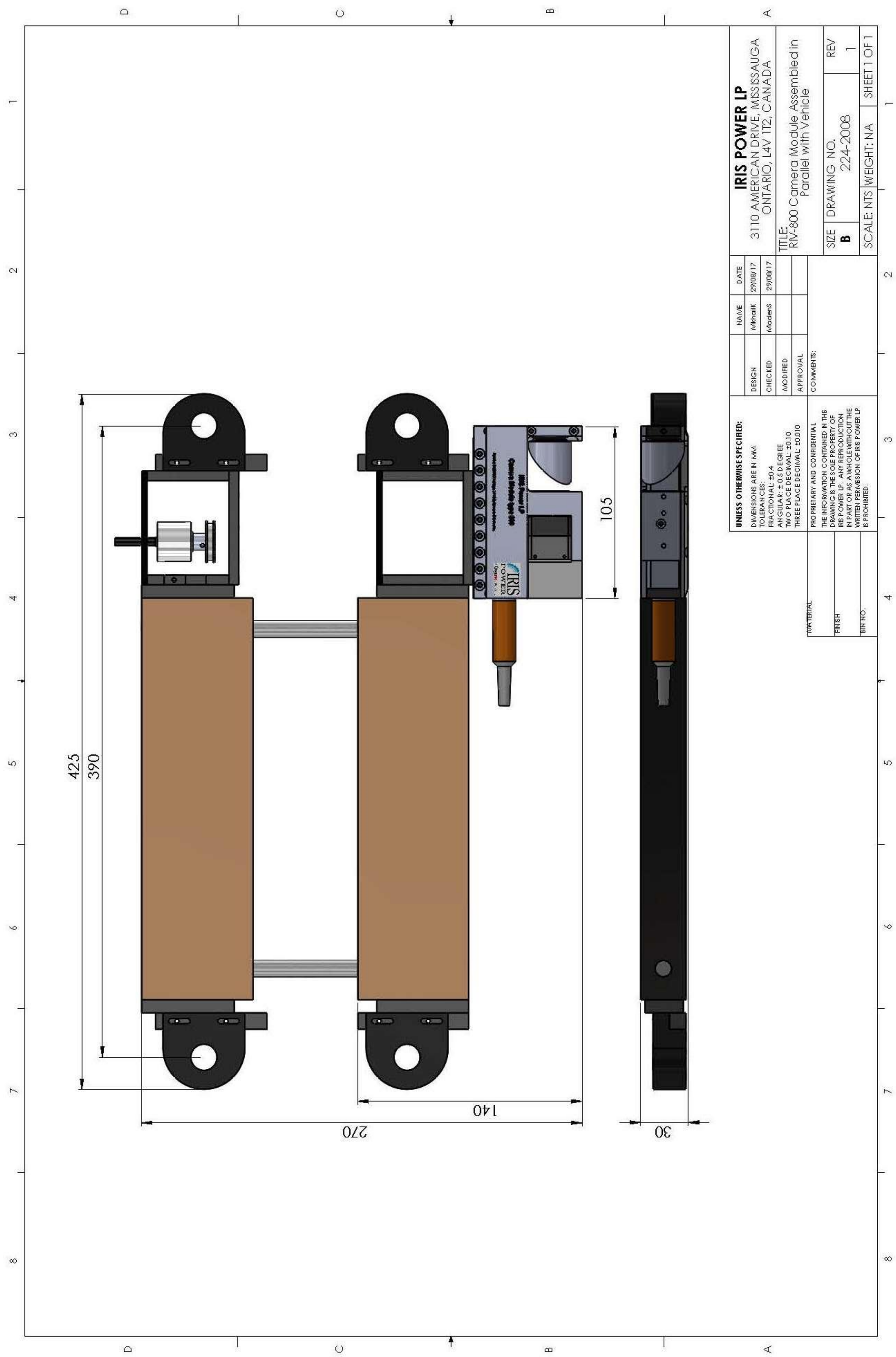
- Contact data (name, e-mail address, telephone number)
- RIV 802 serial number
- Hardware and Software versions
- Symptoms
- On-site troubleshooting results

Other company and product details are available at www.irispower.com.

7. Appendix

7.1. Content List and Drawings

Robotic Inspection Vehicle Kit - Model RIV 802				
Item #	**Description**	**Item#**	**Qty**	**UOM**
1	RIV-802 Control unit ASSY	70092079	1	EA
2	RIV-802 Camera module ASSY	70092135	1	EA
3	240V Power Cord - 2m	4201713.5	1	EA
4	Worldwide Earthed Grounded Adapter	4209601	1	EA
5	Flat Head Machine Screw M2.5 x 10mm	32090902	1	EA
6	Flat Head Machine Screw M3 x 10mm	32090903	10	EA
7	Flat Head Machine Screw M3 x 18mm	32090904	10	EA
8	RIV Vehicle Control Cable	42092216	1	EA
9	Loctite 222MS 10ml, easy removable	43091152	1	EA
10	Bahco Screwdriver 4mm	54090905	1	EA
11	Wrench - Double Open End 5mm/5.5mm	54090917	1	EA
12	Ball Hex Driver 3mm	54090923	1	EA
13	Bahco Nut Driver 5.5mm	54090924	1	EA
14	Tool L-Key STD Ball Hex 2.5MM	54091491	1	EA
15	RIV vehicle include bars	62090963	1	EA
16	Flat Chattock 30cm LEMO, 15m length	70091954	2	EA
17	RIV-802 Transit case	45092225	1	EA
18	Camera Control Cable	42092154	1	EA
19	Video USB3 Cable 15m	42092265	1	EA
20	Adesso AKB-410UB Slim Touch Mini Keyboard with Built in Touchpad - USB - 88 Keys - Black	36092152	1	EA
21	RIV to EL CID Distance Cable	42092215	1	EA
22	Fuse Slo-Blo, 750 mA, 250 V, 5mm x 20mm,	46092222	2	EA
23	120V Power Cord	4201713	1	EA
24	RIV-802 User Manual	50092227	1	EA
25	Flat Head Machine Screw M3 x 6mm	32092233	10	EA
26	Chattock Mounting Angle for camera with 2 M3x25mm Flat screws (item#32091644) installed	37092200	1	


IRIS POWER LP
3110 AMERICAN DRIVE, MISSISSAUGA
ONTARIO, L4V 1T2, CANADA
TITLE:
RIV-800 Camera Module Assembled in Parallel with Vehicle
SIZE
B
DRAWING NO.
224-2008
REV
1
SCALE: NTS
WEIGHT: NA
SHEET 1 OF 1
UNLESS OTHERWISE SPECIFIED:
DESIGN
CHECKED
MODIFIED
APPROVAL
COMMENTS:
NAME
DATE
PROPRIETARY AND CONFIDENTIAL
MATERIAL
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BIN NO.
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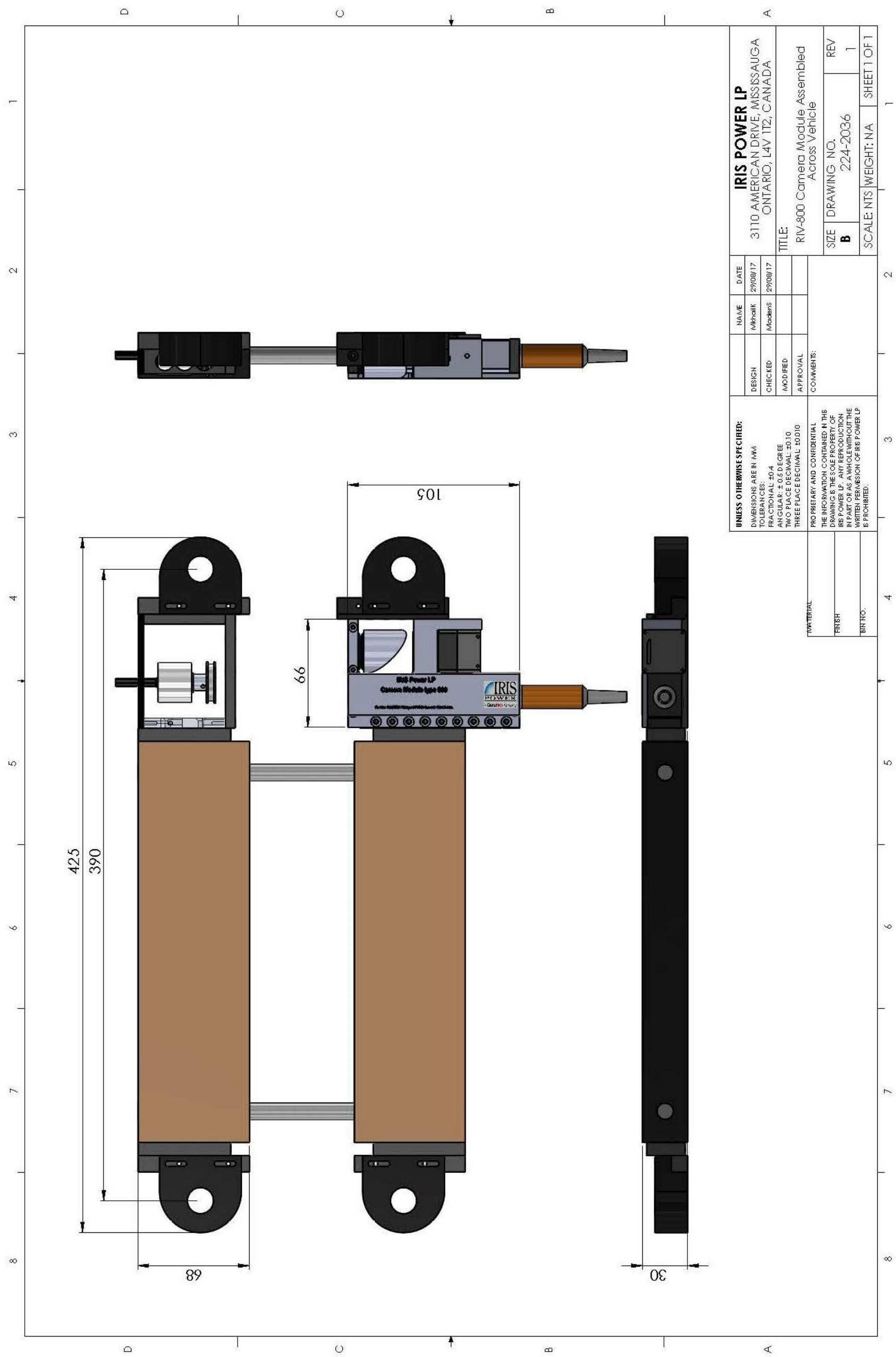
140
270
30


IRIS POWER LP
3110 AMERICAN DRIVE, MISSISSAUGA
ONTARIO, L4V 1T2, CANADA
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Across Vehicle
SIZE
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DRAWING NO.
224-2036
REV
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SCALE: NTS
WEIGHT: NA
SHEET 1 OF 1
UNLESS OTHERWISE SPECIFIED:
DESIGN
CHECKED
MODIFIED
APPROVAL
COMMENTS:
NAME
DATE
MATERIAL
FINISH
105
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425
390
89
30

Iris Power Field Services

Iris Power offers installation supervision services for all of its PD systems. Our field specialist will arrive on site and provide supervision to staff directly involved in the installation process. A written installation report is also provided.

Iris Power Educational Services

Iris Power professional training (designed to achieve hands-on performance based objectives) prepares operations, maintenance, and engineering personnel to test, configure, operate and maintain Iris Power products.

Iris Power Accelerated Delivery

Iris Power provides accelerated delivery on many products and services including replacements, spare parts and repairs.

About Iris Power

Established in 1990, Iris Power offers sensors, monitors and diagnostic solutions to evaluate the true condition of generators, motors, dry-type transformers and air-insulated switchgear in order to reduce the risk of failures and plan necessary maintenance. Iris Power condition based monitoring solutions are trusted on over 15,000 machines across power utilities and industrial sites worldwide. In 2010, Iris Power LP was acquired by Qualitrol Corporation, a global leader in condition based monitoring and an independent subsidiary of Fortive Corporation.