Track User Guide

UMI-33-TRACK

CRS *It's all about time*

Track User Guide

Revision		
Number	**History**	**Date**
001	First Release as UMI-33-TRACK for F3t, T475, and T265, with C500C	99-05

Preface

This user guide contains general information, installation instructions, and principles of operation for the CRS Robotics track. Additional information is available in the following documents:

- *F3 Robot System User Guide*
- *A465 Robot System User Guide*
- *A255 Robot System User Guide*
- *Application Development Guide*
- *RAPL-3 Language Reference Guide*

Additional copies of this manual, or other CRS Robotics literature, may be obtained from the Sales Department.

Training courses are offered at our facility in Burlington, Ontario, Canada, or can be conducted at your facility. For additional information, contact Customer Support.

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Where to Begin

This track manual is a supplement to the *F3 Robot Arm User Guide,* the *A255 Robot Arm User Guide* and the *A465 Robot Arm User Guide*, and to the *C500C Controller User Guide*.

Read together similar sections in both the track user guide and the arm user guide. For example:

- For safety, read Safety Precautions in this *Track User Guide* for precautions specific to the track, as well as Safety Precautions in the F3, A465, or A255 *Arm User Guide*.
- To install the track and arm, read *Installation* in this guide for installation of the track, and *Installation* in your *Arm User Guide* for installation of the arm to the track.

Throughout this manual, warnings are marked by an "!" icon in the left margin. *Failure to comply with these warnings can result in damage to the robot, tooling, work pieces, or personal injury.*

This guide is task-based and uses various navigational aids to help you quickly find the topics and information you need.

- If you are installing the robot track and arm yourself, read the Installation chapters first.
- If the track was installed by CRS or a distributor, read the Operation chapter.

The *Installation* section of the track guide also has guidelines for designing your workcell to get the best performance and life from your robot/track system. It is important to read this section before designing your workcell to ensure that no problems arise as a result of the workcell and track support structure design.

Before attempting to follow a procedure or examples, read the entire section first.

Contents

CHAPTER 1

Introduction

A track robot system consists of a robot arm mounted on a track. This combination of robot arm and track is controlled by a C500C controller. The track provides the robot arm with an additional axis of motion and an expanded working area. The track robot is a robot arm mounted on a saddle (a mobile platform) which rides on linear rails, giving it six coordinated axes of motion for a T265 system, or seven coordinated axes of motion for a T475 or an F3T system.

Because there are many possible hardware and software configurations for track systems, the design and software for your track installation may differ from the typical track installation described in this user guide.

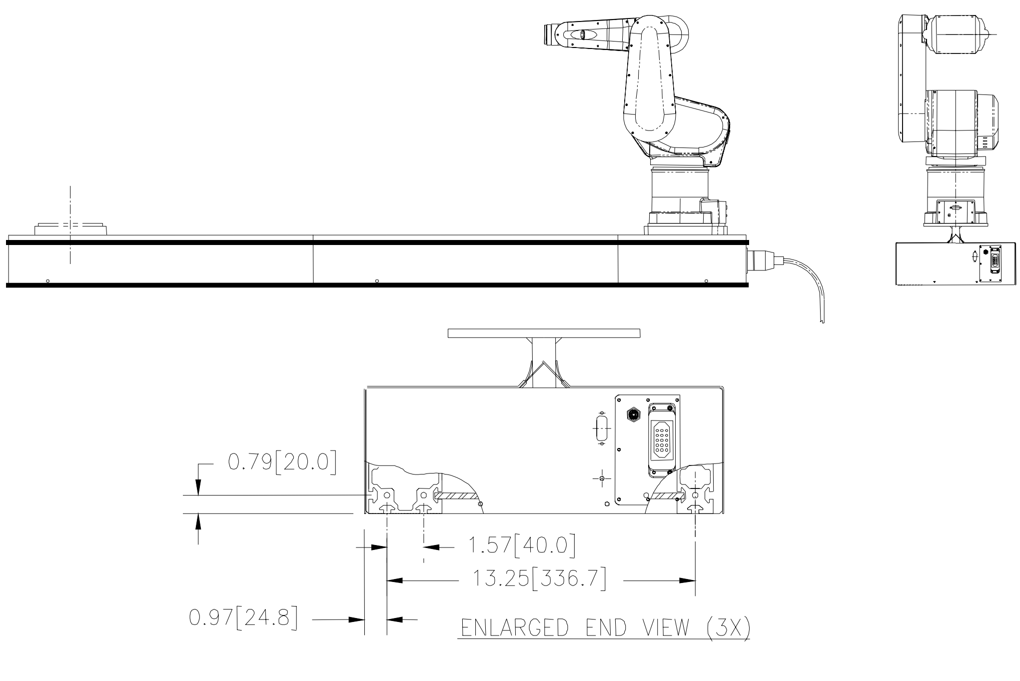


Figure 1– General view of F3T track at **ready** position. End view shows slots for mounting from below.

Options

- Mounting bracket “A” (for track supported from beneath) with fasteners (see page 21.)
- Modular track table
- Custom cabling for sensors or other apparatus
- F3 Calibration Kit
- A465 Calibration Kit
- A255 Calibration Kit
- Inverted track option
- Track Maintenance Kit
- Track Service Kit

CHAPTER 2

Safety Precautions

This chapter describes safeguards and the operating environment for safe use of the robot track.

Safeguards

These safeguards for the track are in addition to the safeguards described in the Safety Precautions section of your *Robot System User Guide*.

Personal injury or robot damage can occur from unsafe operation or handling.

Danger! The robot track, like the arm, is capable of fast movement without warning. Never enter or obstruct the workspace while the robot is in use. *Install safeguards to prohibit access to the workspace when the robot is in use. Refer to your Robot System User Guide for more details.*

Emergency Stops (E-Stops)

The emergency stop (e-stop) circuit of the controller removes power to the track robot system. When this power is removed, fail-safe brakes engage to prevent the robot from moving due to gravity or inertia. Brakes are installed on the track motor shaft and in the arm on joints 2 and 3.

To ensure safety, you must install additional e-stop buttons:

- At the robot track and arm location
- Within human reach on any approachable side of the robot track and arm location
- Outside the total workspace of the track, arm, gripper, and payload.

Refer to your *Robot System User Guide* for details on e-stop installation and operation.

Barriers and Presence-Sensing

When calculating the robot workspace and locating barriers, include the length of track travel as well as the arm, gripper, and payload dimensions.

Barrier

- Ensure that the barrier is beyond the total possible workspace.
- Have sufficient clearance from the arm to avoid trapping or crushing.

Presence-Sensing Devices

- Ensure that your presence-sensing devices are far enough from the workspace to stop robot motion before an intruder can reach the workspace.

Electrical Ground

Ground the track to an industrial grounding rod. If a grounding rod is not available, use a utility ground. Ground straps on the cables at the track saddle must be connected to the robot arm (T265, T475).

Adjustable Track Hardstops and Software Stops

It is possible to reduce the amount of track travel both mechanically and in software. See “Installation” for the procedure.

Robot Care

The robot, including the track, is a precision instrument and must be handled with care.

Pressure and Weight

Do not allow the track’s metal covers to be used to support any weight. Bent or deformed covers can cause binding, drag, or other damage to the track.

Liquids and Chemicals

Do not allow liquids or chemicals inside the track housing, especially inside the drive compartment.

If liquids or chemicals spill into the track housing, stop the track immediately. Remove main power at the controller, remove the metal covers, and clean.

CHAPTER 3

Specifications and Dimensions

This chapter describes the hardware and software characteristics of the track. For the arm or controller, see the Specifications chapter of your arm user guide and controller user guide.

The following topics are outlined in this section:

Track Dimensions

Track Length

The overall length of any track is the travel length plus 16.53 inches [420 mm].

Nominal Length	Travel Length	Overall Length
1 metre	1000 mm [39.37 in]	1420 mm [55.91 in]
2 metre	2000 mm [78.7 in]	2420 mm [95.27 in]
3 metre	3000 mm [118.1 in]	3420 mm [134.6 in]
4 metre	4000 mm [157.5 in]	4420 mm [174.0 in]
5 metre	5000 mm [196.8 in]	5420 mm [213.4 in]

Track Width and Height

The track width and height is specified in the table below:

Track Type	Width	Height of Enclosure	Height to Robot Mounting Surface
all tracks	392.9 mm [15.47 in]	138.7 mm [5.46 in]	201 mm (7.41 in)

Track Weight

The track alone weighs approximately 50 kg/m [110 lbs/yd]. Refer below for the approximate weight of the robot arms.

Track	F3T Arm	T475 Arm	T265 Arm
50 kg/m [110 lbs/yd]	52 kg [115 lbs]	32 kg [70 lbs]	17 kg [37 lbs]

Saddle Dimensions

The saddle is the platform on which the arm is mounted and which travels the length of the track. The height of the saddle above the track housing is shown in the drawing below.

Work Surface

In determining the level of the work surface relative to the level of the saddle, consider that the robot arm can extend below the level of the saddle in a limited range, as shown in the figures in the next section entitled "Reach".

You can construct a work surface:

- At the same level of the saddle
- At a level in the clearance between the saddle platform and the track housing
- At another suitable level

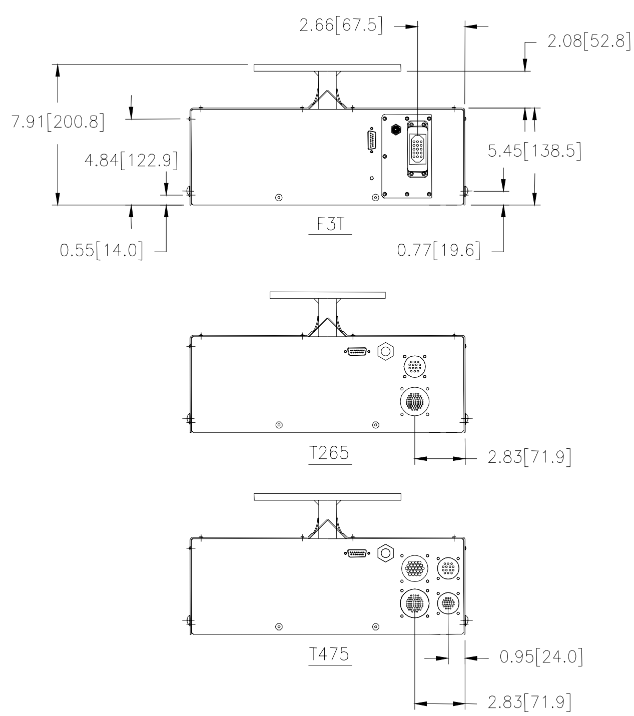


Figure 2 – End view of tracks

Reach

The workspace of a track robot is defined by the travel length of its track and the reach of its arm with its tool and payload.

Robot Maximum Arm Reach (with CRS Robotics Servo Gripper)				
		F3T	T475	T265
Horizontal outward from the base (J1) axis	to tool flange	710 mm [27.95 in]	711.2 mm [28.00 in]	558.8 mm [22.00 in]
	to finger platform of CRS servo gripper	821.1 mm [32.32 in]	820.8 mm [32.31 in]	655.7 mm [25.81 in]
Vertical upwards from track saddle along the Z axis	to tool flange	960 mm [37.80 in]	1041.4 mm [41.00 in]	812.8 mm [32.00 in]
	to finger platform of CRS servo gripper	1071 mm [42.16 in]	1151.0 mm [45.31 in]	909.6 mm [35.81 in]
Vertical Downwards below the track saddle	to tool flange	182.4 mm [7.18 in]	76.2.0 mm [3.00 in]	50.8 mm [2.00 in]
	to finger platform of CRS servo gripper	293.4 mm [11.55 in]	185.7 mm [7.31 in]	147.6 mm [5.81 in]

Reach Limits

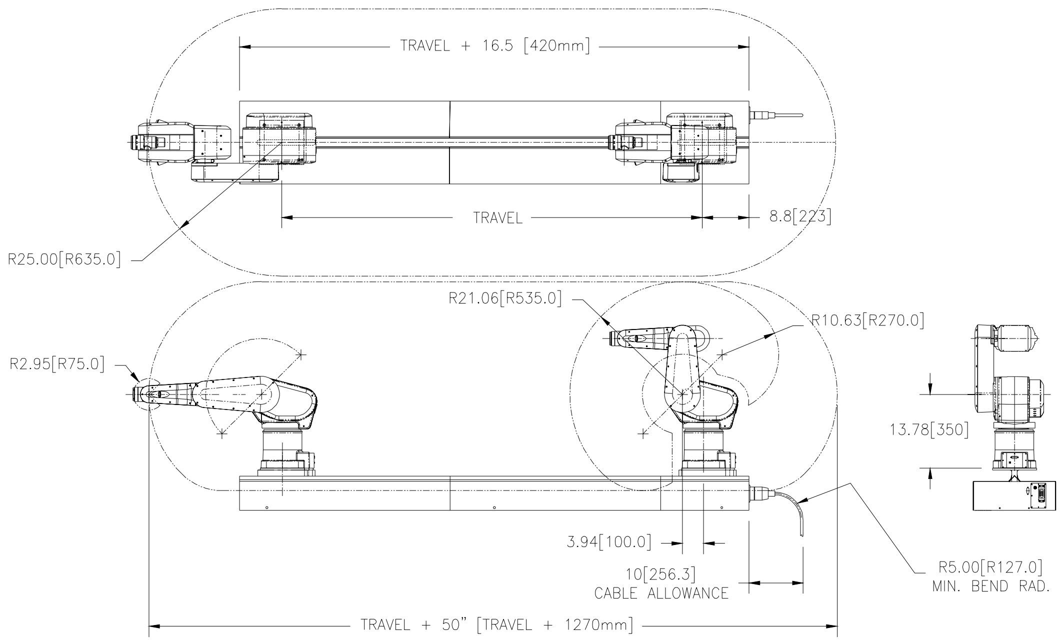


Figure 3 - F3T Reach Limits

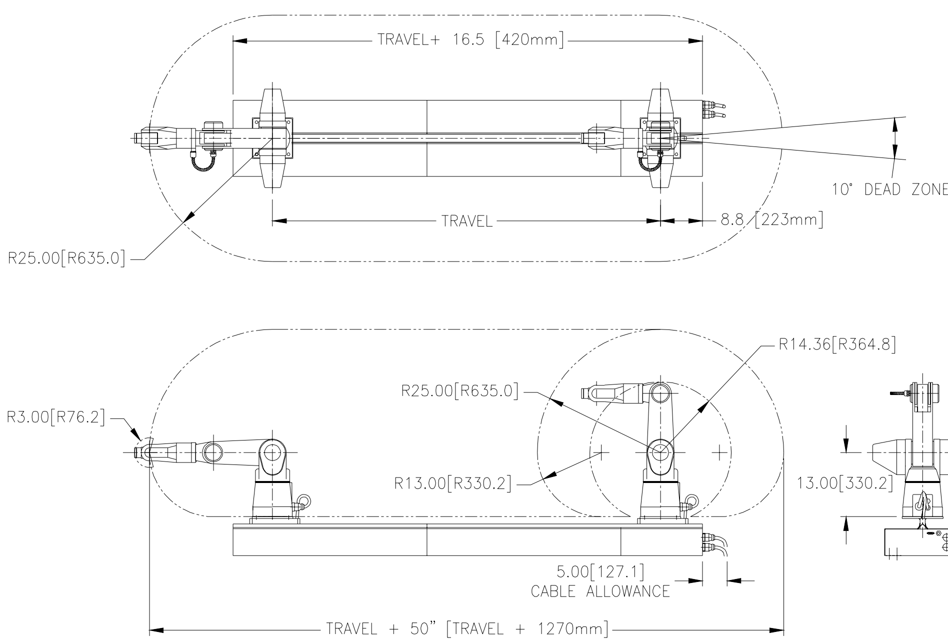


Figure 4 - T475 Reach Limits

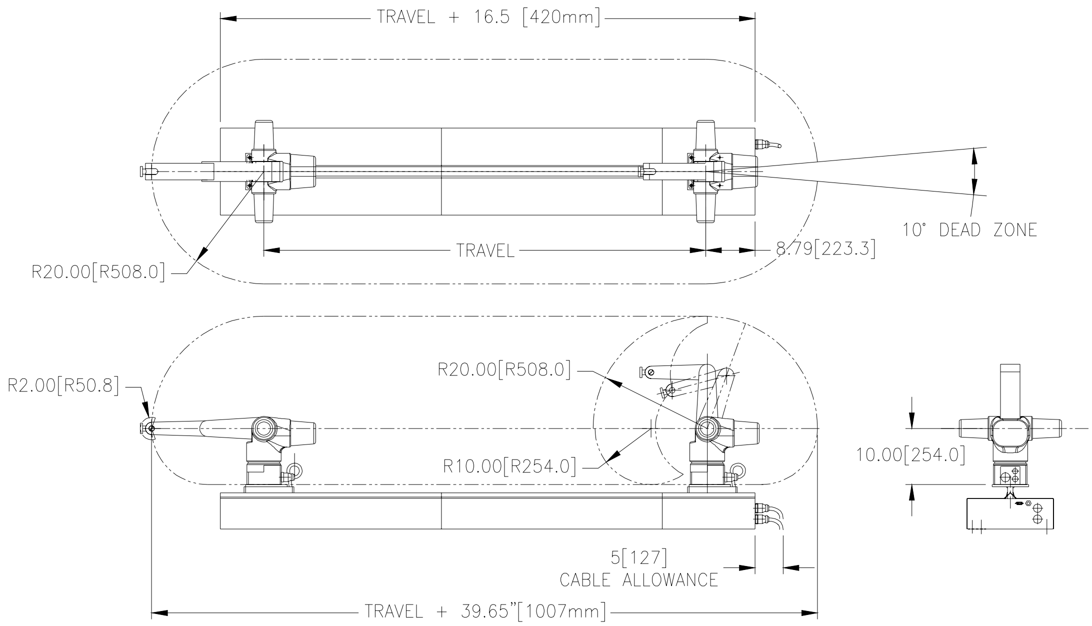


Figure 5 - T265 Reach Limits

Tool Offsets Using Servo Gripper

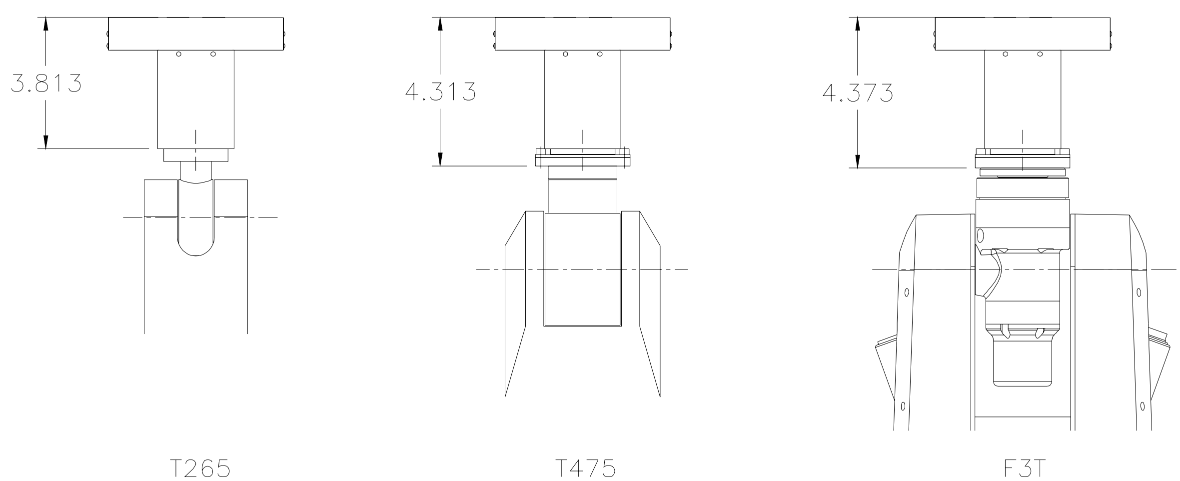


Figure 6 – Offset values from robot tool flange to servo gripper finger mounting surface.

Performance Specifications

This section outlines the following specifications:

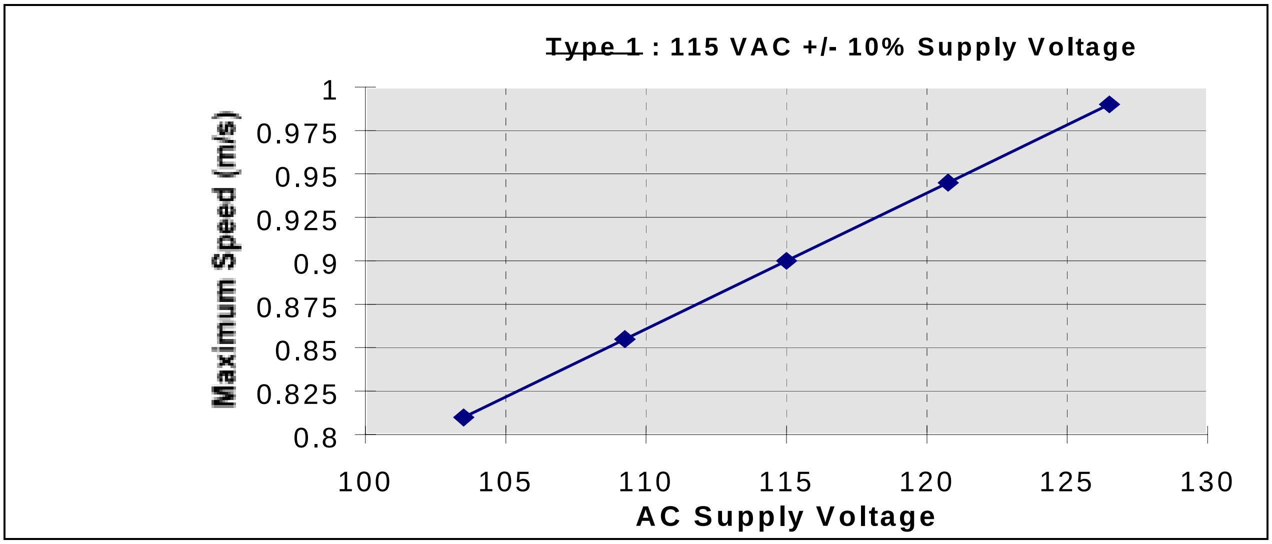
- F3t Track Specifications
- T465 Track Specifications
- T265 Track Specifications

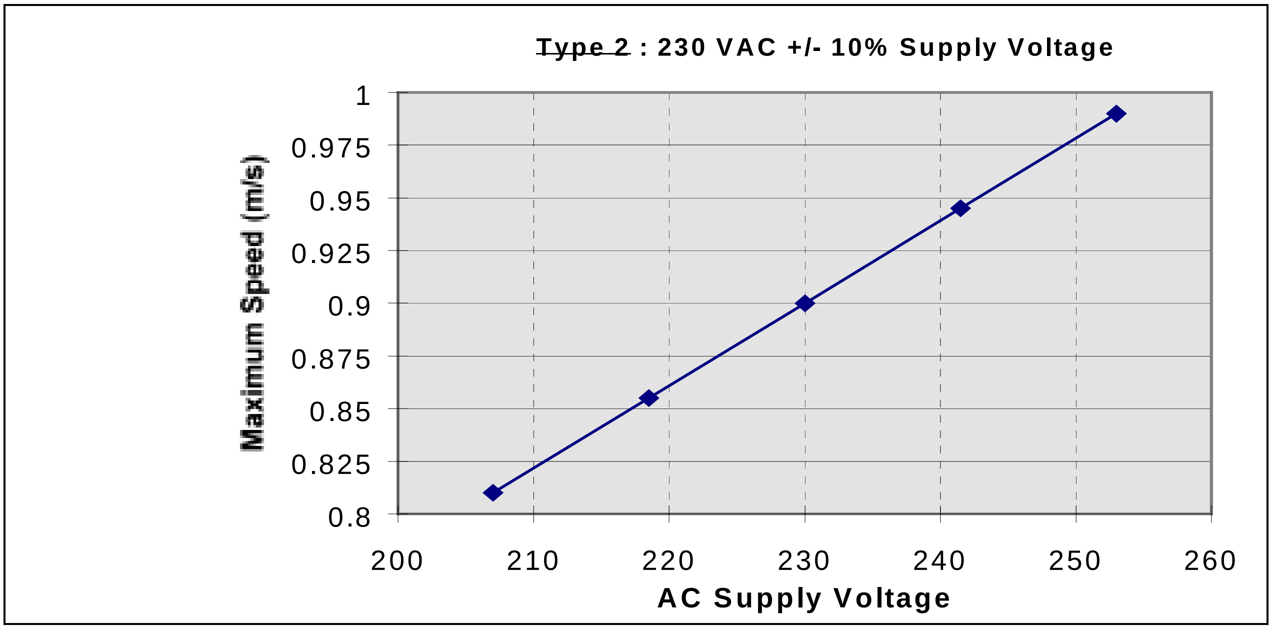
F3t Track Specifications

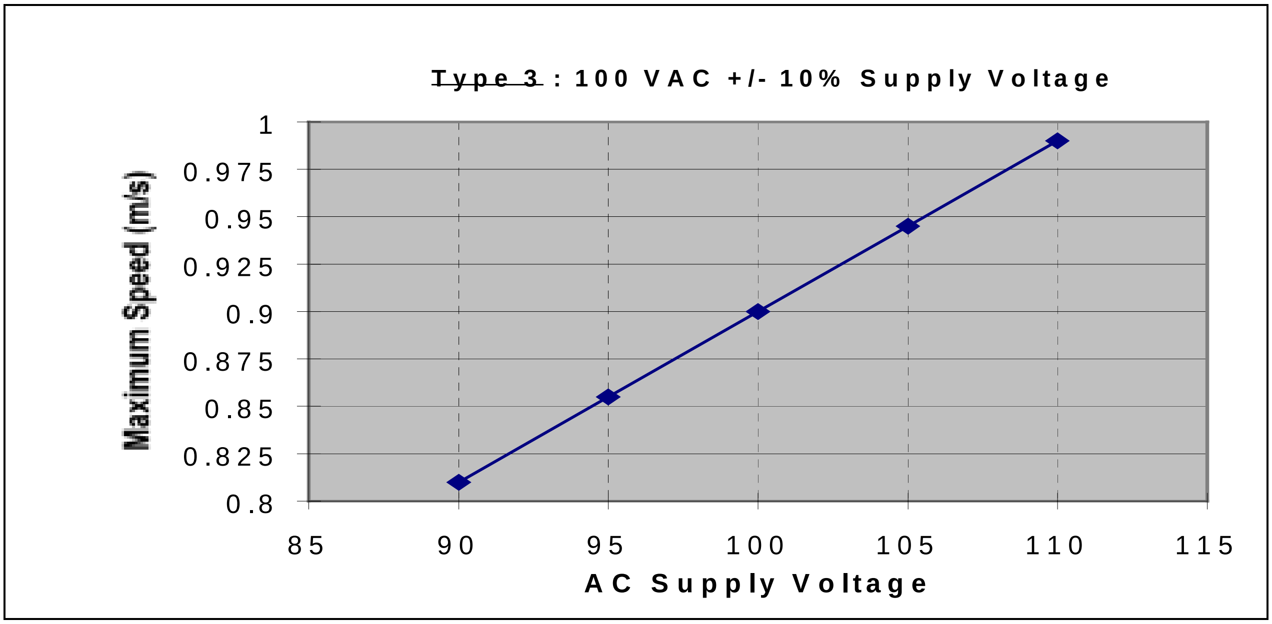
Track Speed

The maximum track speed is 0.9 m/s for a “standard cycle”. A standard cycle is a combined robot and track motion in which each robot joint moves approximately 90 degrees and the track moves 2m.

The AC line voltage supplied to the system can affect the maximum track speed. The de-rating curves for each of the 3 system setup voltages are shown below.

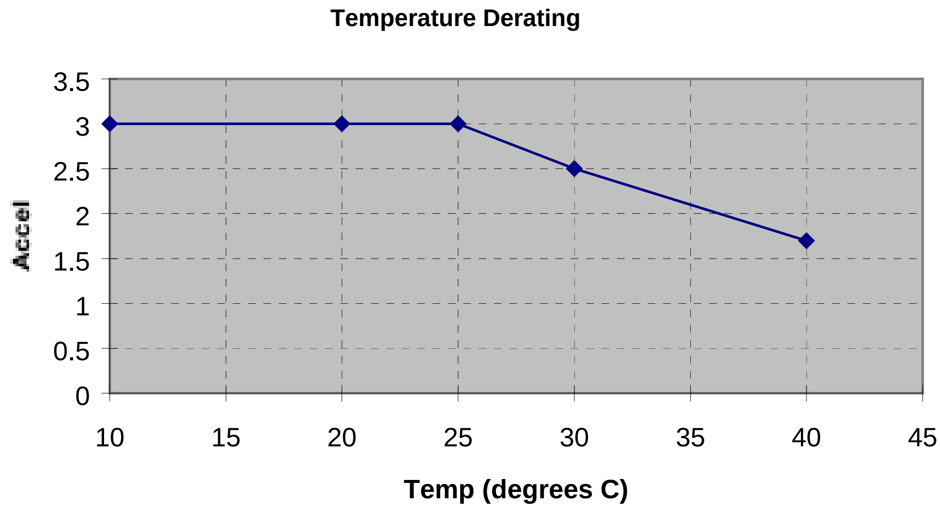






Track Acceleration

The maximum track acceleration is 3.0 m/s^2 for a “standard cycle”. The acceleration must be reduced when the track is operated in an environment where the ambient temperature exceeds 22 degrees Celsius. The de-rating curve is shown below.



Robot Payload

Payload is the same as the robot without the track: 3kg at 100% speed.

Repeatability

The F3T track axis has a repeatability of 0.003" (0.08mm).

T475 Track Specifications

Track Speed

The maximum track speed is 0.8 m/s. This speed is using the standard 10:1 gear ratio and the servo amplifier inside the C500 controller.

Track Acceleration

The maximum track acceleration is 3.0 m/s^2 for a standard cycle.

Robot Payload

Payload is the same as the robot without the track: 3.0 kg. at 80% arm speed and 2.0 kg. at 100 % arm speed. Further details are in the A465 derating specifications.

Repeatability

The T475 track axis has a repeatability of 0.003 in. [0.08 mm].

T265 Track Specifications

Track Speed

The maximum track speed is 0.8 m/s. This speed is using the standard 10:1 gear ratio and the servo amplifier inside the C500 controller.

Track Acceleration

The maximum track acceleration is 3.0 m/s^2 for a standard cycle.

Robot Payload

Payload is the same as the robot without the track: 2.0 kg. at 80% arm speed and 1.0 kg. at 100 % arm speed. Further details are in the A255 derating specifications.

Repeatability

The T265 track axis has a repeatability of 0.003 in. [0.08 mm].

Other Specifications

Track Proximity Sensor

The track contains a 12 VDC sourcing proximity sensor used to detect the robot's home position. The sensor is located near the zero location, 0.5 in. [13 mm] from the connector end hard stop.

Brake and Brake Release Specifications

The track contains a brake that stops the track axis from moving when arm power is removed. The brake is a failsafe electromagnetic brake that releases when energized.

F3t robot systems shipped after August 1998 include a red brake release button just below the auxiliary DB-15 connector at the base of the robot. When you hold in the button, the brake is released allowing the robot to be manually moved along the track. The brake is released only when the button is pressed. When you stop holding in the button, the brake is re-engaged, when the arm power is off.

Air Supply

For pneumatic type grippers, use only dry, clean, filtered, non-lubricated air at a maximum of 100 psi [689 kPa].

Umbilical Cable Bend Radius/Clearance

Care must be taken not to stress the umbilical cables connecting the controller and the track. In particular, cables should not be bent at a radius less than 10 times their diameter for fiber optic cables and 6 times their diameter for copper cables. This is particularly important in the F3t umbilical since it contains fiber optic elements which can be damaged by bending sharply. It is best to leave a comfortable amount of clearance between the connector end of the track and a wall or partition. The recommended distance is 10 feet for a F3t or 5 feet for a T265 or T475.

Software Parameters

Software parameters for your track robot are factory preset in the controller memory according to the size and specifications of your system. They are set for optimal robot performance.

Under normal operation, it should not be necessary to adjust these parameters. However it may be necessary to make changes in these parameters, for example, if you change your controller, track or robot amplifier, or replace an original robot encoder or servo motor. Contact the CRS Customer Support group for details.

Warning: These operating parameters are factory set. They should not be changed unless advised by the CRS service group. Changing these parameters may lead to premature system failure, or cause unpredictable robot behavior which could cause serious injury or equipment damage.

The table below lists typical software parameters for the robot's track axis.

Command	Parameter	F3t Track Axis	T475 Track Axis	T265 Track Axis
XPULSES_SET	Encoder pulses per turn	2048	1000	1000
XRATIO_SET	Gear ratio (Encoder-turns/inch [m])	1.694 [0.06669] for all tracks		
\DIAG\XZERO	Axis zero location	Connector end hardstop + 0.5 in [12.7 mm] for all tracks		
GAIN_SET	Servo gains (PID):			
	P term	2560	15	15
	I term	16	0.1	0.1
	D term	4096	100	100
MAXVELS_SET	Maximum travel speed	35.43 in/sec [900 mm/sec]	31.5 in/sec [800mm/sec]	31.5 in/sec [800mm/sec]
ACCEL_SET	Maximum acceleration	118.0 in/sec^2 [3000 mm/sec^2]	118 in/sec^2 [3000 mm/sec^2]	118 in/sec^2 [3000 mm/sec2]

CHAPTER 4

Installation

Installing a track robot differs from installing a fixed position robot regarding the mounting platform, grounding requirements, and electrical and umbilical connections.

Where applicable, follow the installation procedures described in this chapter instead of those in your *Robot System User Guide*.

Installation Roadmap

Typically, installing a track robot requires the following tasks:

1) Design your work cell, see page 21
2) Unpack the track and arm (packed separately), see page 24
3) Mount the track, see page 25
4) Mount the arm on the track saddle, see page 27
5) Connect the cables from the controller to the track, and from the saddle to the arm, see page 30
6) Check the robot and track servo network, see page 33
7) Configure your system, see page 35
8) Home the T265 and T475, see page 38
9) Re-home the F3T, see page 40
10) Adjust the Track Axis Hardstops (if necessary), see page 44

The last three procedures require that you have installed the controller (with its power/fuse module correctly inserted) and you have a computer running Robcomm3 terminal utility. Refer to the *Robcomm3* section of the *Application Development Guide* for details.

Gathering Tools and Supplies

You need the following tools and supplies to install the track.

Procedure	Tools/Equipment	Supplies
Unpacking	Phillips (cross) screwdriver lifting device (if available)	
Mounting the Track	tools appropriate for fasteners used	shims, fasteners optional brackets
Mounting the Arm	**F3T** - 10mm hex key	**F3T** – 4 X M12x1.75x 35mm socket head cap screws
	T265 – 5/16" hex key	**T265** – 2X 3/8-16x2", 2X 3/8-16x 3½ " socket head cap screws
	T475 – 3/8" hex key	**T475** – 4 X ½-13 X 2" socket head cap screws
Connecting Cables	small Phillips (cross) screwdriver 2.5mm hex key	
Checking Controller AC Fuses	small standard (slotted) screwdriver	
Adjusting the Hardstops	5 mm hex key	
Configuring Track	measuring device personal computer with terminal emulation software	
Checking Feedback	personal computer with terminal emulation software	

Task 1: Design Your Work Cell

The track must be installed with the saddle horizontal (robot mounting surface). The track should never be installed with the saddle inclined or vertical.

Danger! The robot track has been designed for horizontal operation only. The belt, motor, transmission and brake have been sized for loads in a horizontal plane*. Inclination of the track at any angle other than 0 degrees may lead to a serious component failure and a dangerous condition.*

In all cases, the track must be securely supported. For best results, support the track from below with a strong structural sub-frame. The standard lab table manufactured by CRS Robotics provides such a sub-frame.

When laying out your work cell, keep in mind;

- access for installation
- access to the robot and track components for preventative maintenance and servicing
- access to instruments or devices for teaching locations

Designing a Supporting Frame (Subframe)

When designing a subframe, specify the height of the support pieces for the track to be as even as possible. A target flatness spec is 0.014 inches/yard (0.4mm/metre). If the height cannot be adjusted to meet this, use shims during installation.

The track weighs approximately 110 lb/yd [50 kg/m]. The F3 arm weighs 115 kg [52 lb], the A465 arm weighs 32 kg [70 lb], and the A255 arm weighs 17 kg [37 lb].

Supporting the Track

You can support the track using one of the following three options:

- Supported from Beneath, see page 21
- Suspended Below the Table, see page 22
- Inverted, see page 23

Supported from Beneath

For best results, rest the bottom of the track on a table top or subframe. The T-shaped saddle mounting plate can extend through a channel in a working surface above the track.

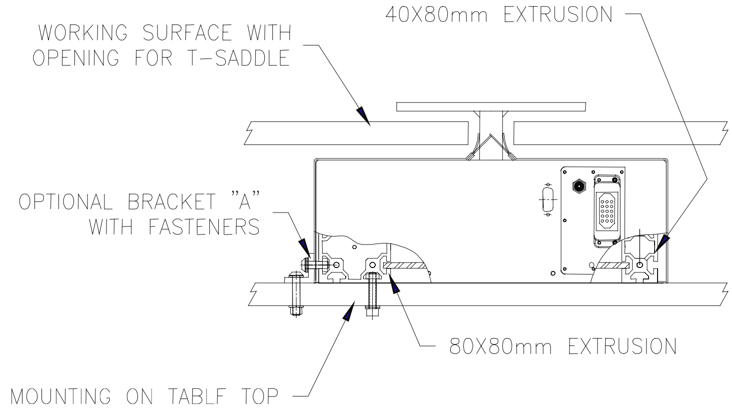


Figure 7 - Detail of track installed with support from beneath, showing optional mounting brackets, end view.

To fasten the track:

- Install slot nuts at 1 metre increments in the inner slot on the bottom inner groove of the 80x80mm extrusion.

  or

- Use mounting brackets “A” as shown in the drawing.

For tracks supported from below, *fasten only* the larger 80x80mm extrusion to the table or subframe. This support allows the second extrusion to flex in order to maintain proper alignment of the linear bearings.

The weight of the track plus the fasteners in the 80x80 extrusion inner groove are adequate to maintain positional accuracy.

Note: If there is concern about this mounting method and it is felt that the smaller 40x80mm extrusion must also be secured, the published tolerance for the alignment of the linear bearings is “parallel within 0.002 in.” (0.05mm). Installation to this tolerance will ensure that the track bearings do not fail prematurely. Some suggestions for achieving this positional tolerance are covered in Task 3: Mount the Track on page 25.

Suspended Below Table

If there is no strong support for the track from below, the track can be suspended below the underside of the table using an adequately designed sling. The table must be made of a strong material and braced well so that it does not sag or distort under the weight of the track and robot.

To fasten the track:

- Install slot nuts at 1 metre increments in the inner slot on the bottom inner groove of the 80x80mm extrusion.

  or

- Use mounting brackets “A” as shown in the drawing.

For tracks supported from below, *fasten only* the larger 80x80mm extrusion to the table or subframe. This support allows the second extrusion to flex in order to maintain proper alignment of the linear bearings.

The weight of the track plus the fasteners in the 80x80 extrusion inner groove are adequate to maintain positional accuracy.

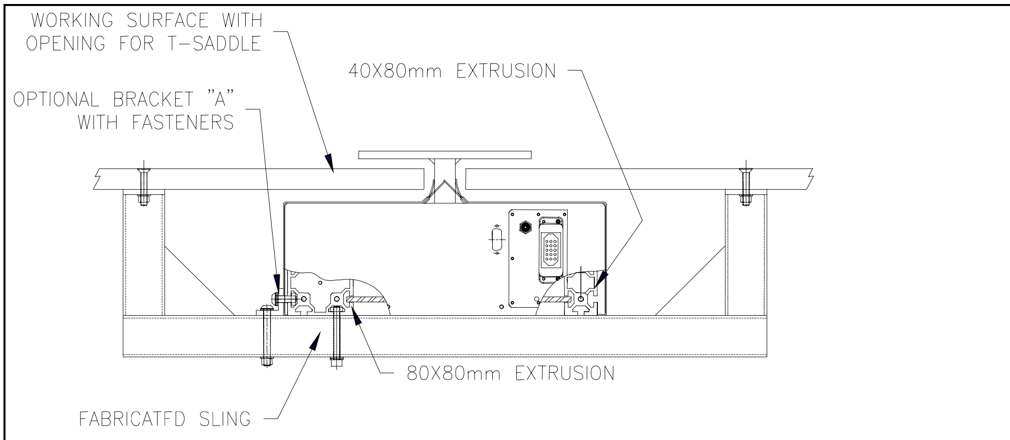


Figure 8 - Track installed suspended below a table, end view.

Inverted

The track can be mounted in an inverted configuration provided that the track has been ordered from the factory with the inverted track option. This option involves factory installation of additional supports inside the track to support the cable carrier.

Warning! Operation of a track in the inverted orientation without the inverted track option support pieces will cause damage to the cable carrier.

When mounting the inverted track:

- Use both track extrusions as mounting points.
- Ensure that the recommended tolerances for mounting surface flatness and linear bearing parallelism be maintained.

Some suggestions for achieving the positional tolerances are covered in Task 3: Mount the Track on page 25.

Note: Use of the optional bracket “A” for mounting the inverted track is not recommended. Refer to the following schematic for details.

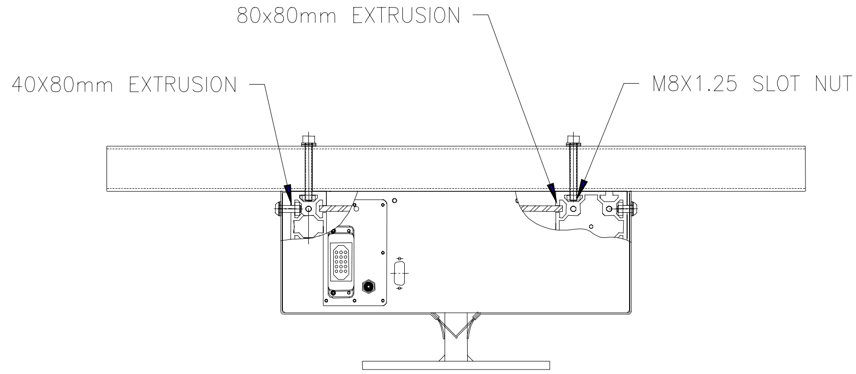


Figure 9 - Track installed inverted below beam.

Task 2: Unpack the Track

You need:

- A slot-head or Phillips screwdriver
- A hoist, forklift, or several persons

Note: As you unpack, keep all packaging materials.

The track is packed in the plywood shipping crate with blocks of polystyrene underneath the track, beside the track on all sides and ends, and on top of the track. Wooden braces, (2 in. [50 mm]) x (4 in. [100 mm]) x (width of crate), hold down the polystyrene and the track in the crate. No other fasteners secure the track to the crate.

To unpack the track:

1. Open the top of the crate by removing the screws.
2. Unscrew the wooden braces. (The screws are through the outside of the plywood crate into the braces.)
3. Remove the braces and some polystyrene.

Warning! Lift safely to prevent injury. *The track weighs approximately 100 lbs./yd [approximately 50 kg/m].*

3. Lift the track out of the crate and place it on a secure surface. Ensure that the track is supported at spacing no greater than the spacing of the pre-drilled mounting bracket holes (approximately every metre).

Task 3: Mount the Track

For best results, secure the track using the inner 8mm slot in the 80x80mm extrusion and 6 or 8mm slot nuts. If you cannot do this, use the optional mounting brackets (see Figure 8 in the Supported from Beneath section for details on fastening the track to the supports.

To mount the track:

1. Construct an adequate supporting structure for the track to operate in your work cell.

   Consider the following:

   - Weight and length of the track
   - Mounting tolerances, see *Task 1: Design Your Work Cell* on page 21
   - Accessibility for service
   - Stability of the structure to minimize movement and vibration

Warning! Ensure that the mounting surface is square, level, and flat. *Otherwise the linear bearings may become overloaded and may fail prematurely.*

1. Place the track in the mounting position and align it in your work cell (if it must be centered).

   Verify that the track is supported at 1metre increments, shimming the mounting surface if necessary to meet the flatness tolerance. The flatness spec is 0.014 inches/yard (0.4mm/metre).

2. Fasten the track in place.

   - For best results, anchor the track using M6 or M8 slot nuts at 1metre intervals in the inner groove of the 80x80mm extrusion. This allows the 40x80mm extrusion to flex with the movement of the saddle carriage (upright installation only).

   - Optionally, you can anchor the 80x80mm extrusion with optional mounting brackets fastened at the points where the metal cover attaches to the track. These fastening points use M8x1.25 fasteners.

3. If you are installing an inverted track, or feel that it is necessary to anchor both sides of an upright track, perform the following step to prevent overloading of the linear bearings:

   a) Pre-drill mounting holes to allow the use of M6 or M8 mounting bolts and slot nuts.

      - The slot nuts can be slid into the grooves on the underside of the track.

      - It is recommended that the holes be drilled considerably oversized to allow adjustment (or allow for frame variations).

      - Use a heavy wide flange washer under the head of the mounting bolt.

   b) Snugly install all of the fasteners. Then, tighten all of the fasteners in only the 80x80mm extrusion.

Note: The 40x80mm extrusion should be fully tightened only after the robot has been mounted in the saddle (Task 4). This procedure ensures proper positioning and parallelism.

c) Install and connect the umbilical cables, (see Task 5: Connect the Cables on page 30 for details. Now:

- Turn on the main power to the controller (*not arm power*).
- Press the brake release and move the saddle to one end of the track.
- Tighten the mounting bolt in the 40x80mm extrusion which is below the saddle. The saddle positions the linear bearings at the proper spacing to achieve the parallelism tolerance.

d) Move the saddle until it is over the next mounting bolt.

- Tighten the mounting bolt and move the saddle to the next bolt.
- Repeat the above step all the way along the track.

Warning! Ensure that the mounting bolts are tightened progressively with the saddle. *Failure to do so may cause premature failure of the linear bearing or track motor.*

Tips:

- You can use the same procedure if you are using the optional mounting brackets.
- To position the linear bearings more accurately, remove the metal covers and use a precise measuring device to measure the distance between the rails.

e) When finished, turn off the main power to the controller and disconnect the AC power cord.

4. Ensure that the supporting structure is secure to prevent any oscillation or vibration resulting from robot arm motion or from other equipment. Extra support may be required.
5. Measure and record the inclination of the saddle in both directions (along the track axis and perpendicular to it). Use a high precision level, electronic inclinometer, or other equivalent equipment.
6. If possible, make the necessary adjustments until the saddle is as horizontal as possible — within 0.0003 radians or 0.02°.

Task 4: Mount the Arm on the Saddle

The procedure for mounting the arm to the track saddle c differs according to the type of arm being installed. Refer to the procedure particular to your robot arm listed below:

- F3T Robot Arm
- T475 Robot Arm
- T265 Robot Arm

F3T Robot Arm

You need:

- 2.5 mm hex key and 10mm hex key
- Four M12x1.75x35mm socket head cap screws — supplied with the arm.

Warning! Be careful when moving and setting down the arm. *Refer to the "Installation" section in your Robot System User Guide. The arm is heavy and awkward for a single person to lift. Improper handling may damage the arm's motor covers, wrist, gripper, elbow wiring conduit or other components.*

Before you begin:

- Ensure that the saddle platform is clean and free of any debris.
- Ensure that the bottom surface of the robot is clean and free of any debris.

To mount the robot arm on the saddle:

1. Bring the connectors and the airline out through the opening so they don't get pinched under the base when it is installed.

2. Lift the arm onto the saddle with the protrusion at the rear of the base, facing in the same direction as the connector panel at end of track.

3. Align the dowel pins in the mounting plate with the dowel holes in the base of the arm.

4. Using the supplied socket head cap screws, secure the base of the arm to the saddle.

   Note: Use the lifting hook and a lifting device if possible. If a lifting device is not available, use at least two people to lift the robot. Lift by the cast aluminum base and underside of the lower section of the lower link. Do not lift by the robot side covers, wrist or gripper. Refer to the Installation section of your *Robot System User Guide* for lifting instructions particular for your type of robot.

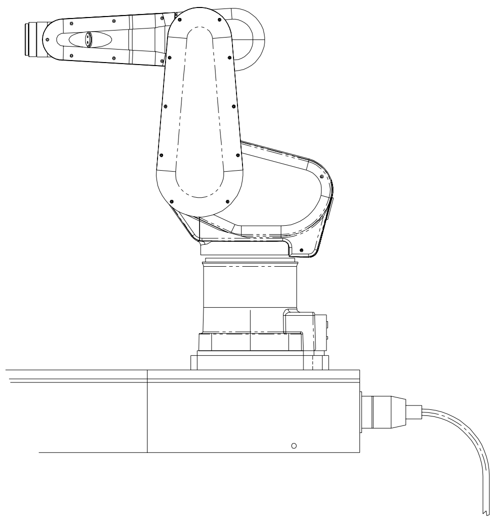


Figure 10 – F3T arm at ready position facing away from connector end of the track.

***Warning! For the inverted track, installing the robot arm can be quite awkward**. It requires more than one person to manipulate the arm into position and install the mounting bolts. The F3 arm has an M12X1.75 tapped hole on the lower front surface of the robot waist. The eye bolt supplied with the robot can be transferred to this M12 hole to aid in lifting the robot into an inverted position.*

T265 and T475 Robot Arms

You need:

- 5/16 hex key for the T265 arm
- 3/8 hex key for the T475 arm
- 2 of 3/8–16 x 2” hex socket cap screws and 2 of 3/8–16 x 3 ½” hex socket cap screws for T265 arm.
- 4 of 1/2–13 x 2 hex socket cap screws for the T475 arm

***Warning! Be careful when moving and setting down the arm.** Refer to the “Installation” section in your Robot System User Guide. The arm is heavy and awkward for a single person to lift. Improper handling may damage the arm’s motor covers, wrist, gripper, elbow wiring conduit or other components.*

Before you begin:

- Ensure that the saddle platform is clean and free of any debris.
- Ensure that the bottom surface of the robot is clean and free of any debris.

To mount the robot arm on the saddle:

1. Lift the arm onto the saddle with the protrusion at the rear of the base, facing in the same direction as the connector panel at end of track.
2. Align the dowel pins in the mounting plate with the dowel holes in the base of the arm.
3. Using the supplied socket head cap screws, secure the base of the arm to the saddle.

   Note: Use a lifting device if possible. If a lifting device is not available, use at least two people to lift the robot. Lift by the cast aluminum base and underside of the lower section of the lower link. Do not lift by the robot side covers, wrist or gripper. Refer to the Installation section of your *Robot System User Guide* for lifting instructions particular for your type of robot.

Warning! For the inverted track, installing the robot arm can be quite awkward*. It requires more than one person to manipulate the arm into position and install the mounting bolts.*

Task 5: Connect the Cables

The procedure for connecting the cables between the track and your robot arm differs according to the type of arm being installed. Refer to the procedure particular to your robot arm listed below:

- F3T Robot Arm
- T475 Robot Arm
- T265 Robot Arm

F3T Robot Arm

To connect the cables between the arm and track saddle:

1. Locate the following protruding from the base of the F3T robot:
    - Large 8-pin connector
    - 6-pin mini-Molex connector
    - 6mm air line
    - Chassis ground cable with a ring terminator secured to an internal plate by a 2.5mm fastener.
2. Locate the matching cables and air line coming out of the cable slot on the side of the saddle as well as the base plate.
3. Connect the matching cables and airline.

    Note: Be careful when connecting the matching mini-Molex connectors to each other. The notches on one connector are supposed to lock into the slots in the other; it is possible to force them together the wrong way.
4. Free the chassis ground cable inside the base protrusion.
5. Secure the chassis ground cables from the robot and the saddle slot together on the internal plate inside the base cavity.
6. Secure the base plate on the base protrusion using the Phillips fasteners you previously put aside.

You are now ready to connect the umbilical cable.

To connect the umbilical cable:

1. Ensure the controller main power switch is **OFF.**

Warning! Verify that the controller is off.

2. Locate the end of the umbilical cable, which mates with the receptacle on the controller.
3. Align the connector with the receptacle.
4. Gently push the connector into the receptacle on the controller and secure the connector with the metal latch.

5. Repeat the above steps at the track end.

T265 and T475 Robot Arms

Warning! Use only hand pressure to secure all plastic connectors. Do not use pliers. *Damage can result.*

To connect the cables:

1. Connect the cable connectors that are extending out of the saddle to the base of the robot arm. The cable ends should be bent into a loop of no less than 3 inches [7 cm] diameter.
2. When making a connection, make sure the connector keys and keyways are properly aligned. If they are not, you may damage the connector. Then carefully turn the locking ring clockwise to draw the connectors together. The motor power cable rotates about 360°.

   The feedback cable rotates about 270°. In the case of the feedback cable (with 57 pin connector), the last 10 degrees of rotation requires more force, as you compress the 0-ring in the connector.

   Stop turning when you feel it click, indicating that the connector is correctly locked in place.
3. Connect the saddle- to-arm grounding straps to the stud with the nut on the robot arm base.
4. If the robot's end effector tool is pneumatically powered, connect the air hose from the saddle carriage to the air port on the arm base, then connect your ¼ inch air bulkhead fitting on the track connector panel using a ¼ inch O.D. plastic metal air line.

Disconnecting the Umbilical Cable

F3t:

Use the following procedure to disconnect the umbilical cables.

Warning! Turn off main power whenever disconnecting the umbilical cables or cable connections from the robot arm.

1. Ensure the controller main power switch is **OFF.**
2. At the track end, release the metal latch.
3. Gently withdraw the connector from the receptacle so as not to jam the two together.

T265 and T475:

Use the following example to disconnect the umbilical cables.

Before you begin:

- Ensure the controller main power switch is **OFF**.

Warning! Turn off power. *Disconnecting the feedback cable, while the motor cable is connected and power is on, causes incomplete control of the arm and the arm* *may run out of control.*

1. To disconnect a cable end with grounding strap(s), first disconnect the grounding strap(s) from the grounding point.
2. Turn the locking ring counter-clockwise to release the connector. Pull the cable connector straight out from the connector.

Task 6: Check the Servo Network for the F3T System

This procedure checks that the servo network for the track system is being received by the controller. For this procedure, the controller must be installed. If you have not already done this, follow all procedures in the Installation chapter of your *Robot System User Guide* and then return back to this topic to check feedback.

Before you begin:

- You need a computer running the Robcomm3 terminal utility. Refer to the *Robcomm3* section of the *Application Development Guide*.
- Ensure your computer is connected to the controller front panel communication port, located behind the access door, and is running the terminal emulator.

To check the servo network:

1. Switch the controller on. Access the system shell prompt $.

   Note: If a teach pendant is installed, the system is programmed to boot with the pendant having point of control. Exit the teach pendant to pass point of control to the system shell. Refer to the *Teach Pendant* section of the *Application Development Guide* for details.

   If the sign-on message and system prompt ($) do ***not*** appear, check all serial connections and communication settings and repeat this step. If this fails to produce the sign-on message, call your CRS Robotics distributor.

2. At the system shell prompt enter:
   $ ash test
   to access the test application shell prompt **test >**

3. From the application shell prompt, enter:
   test> armstat
   This command returns and displays the status of each robot axis and the track. The status of each axes 1-7 should read OK. If the system is not OK, check the umbilical cable connections.

   Note: Do not disconnect the umbilical cable with the controller connected. You must re-boot the controller.

4. At the ash prompt, type **w1** and press **Enter.**
   test> w1
   This command continuously displays the robot *arm* position as motor pulse counts.

5. With arm power off, by hand, gently push each arm axis and the track axis in each of its directions of motion. You need push only enough to check if the pulse count increments or decrements.

   If any axis does not show + and – feedback (both directions are + or –), then re-check all umbilical connections to the robot.

Warning! Do not force the arm to move any distance with brakes on. *This may damage the arm.*

6. Once you have verified feedback for the arm axes and the track, press **Ctrl-e**. The system prompt returns.
7. Switch the controller arm power on.

Task 7: Configure the Track

The controller for your robot system comes factory-configured for the correct number of axes and track limits. The configuration parameters are stored in the file robot.cfg in the /conf directory. The factory configuration is in imperial units.

If necessary, you can alter the system settings using a configuration utility which allows you to change the:

- Units you wish to use
- Number of extra axes used in your system (a track is considered an extra axis)
- Track travel distances

Warning! Always backup the existing robot configuration file robot.cfg in the /conf directory before running the configuration utility. This ensures you can recover the existing configuration.

Before running the configuration utility, a description of the track orientation is necessary so that the units you enter for the track travel are valid.

Track Axis Position

The track travel distances are referenced from the zero position. The zero position is located at a point 12.70mm (0.50 in) from the connector-end hardstop. The travel limits are set when the system is configured using the "configuration" utility.

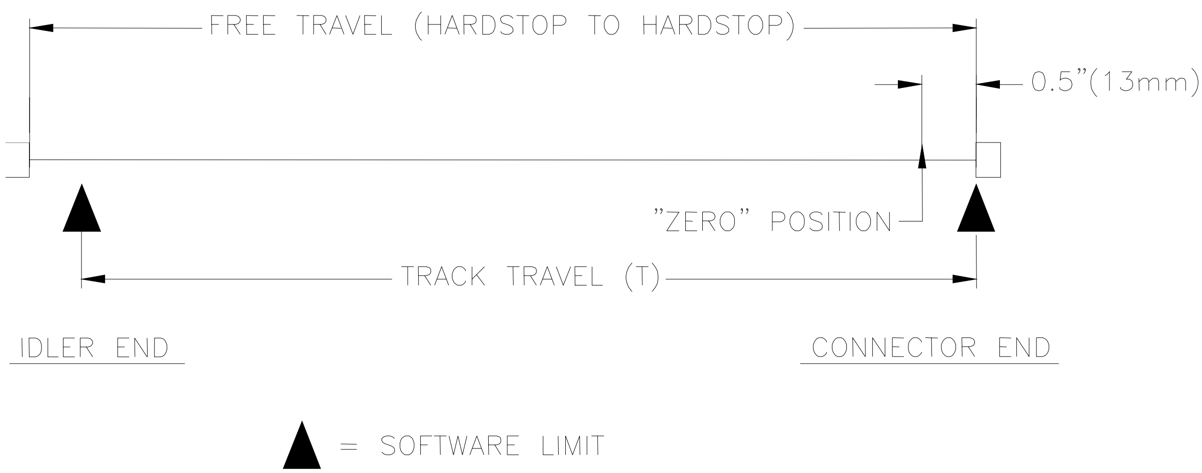


Figure 11 - Location of hardstops, software limits and zero position.

To configure the track, you need:

- A computer running the Robcomm3 terminal utility. Refer to the *Robcomm3* section of the *Application Development Guide* for details.

Before you begin:

- Determine if you truly need to reconfigure the system. Your system has been shipped to you correctly configured.
- Make sure your computer is connected to the controller front panel communication port and is running the terminal emulator.

To run the configuration utility:

1. Turn on the controller.
2. Access the system shell $ prompt.

   Note: If a teach pendant is installed, the system is programmed to boot with the pendant having point of control. Exit the teach pendant to pass point of control to the system shell. Refer to the *Teach Pendant* section of the *Application Development Guide* for details.
3. At the $ prompt enter the following command:

   $ **/diag/setup**

Notes:

- Alternately, you can change the active directory to the /diag directory with the **cd** command, and then enter **setup.**
- In systems running CROS 1.11 or earlier, the configuration utility was named **configur**.

The program requests that you enter information about your system. The following is a list of the questions with details about the responses:

```
Are your coordinates in English (0) or Metric Units(1)?
```

Response Enter **0** for English (Imperial) units or **1** for metric units.

```
Your robot has 6 axes. How many additional axes are
connected to your controller?
```

Response **1** The track is considered an extra axis.

```
Is the robot mounted to a track? (1 = yes, 0 = no)
```

Response **1**

```
Enter the positive travel limit of the track in
millimetres.
```

Response Enter the travel distance from the zero position to the hardstop at the far end of the track. If you are using the full length of the track, calculate this travel distance by subtracting the zero-positioning-distance from the total travel length of the track. For example, for a five metre track with the zero position 12.7 mm [0.5 in] from the connector end of the track, the positive travel distance is 4987.3 mm (5000.0 - 12.7) [196.3 in (196.8 - 0.5)].

Note: If you are running this configuration utility for the first time, this travel limit question will display millimetres even if you set the units to inches in the first question. Enter the distance in the unit of measure that you set in the first question.

```
Enter the negative travel limit of the track in
millimetres.
```

Response Enter the travel distance from the zero position to the hardstop at the connector end of the track. For example, if you subtracted 12.7 mm from the total travel length to obtain the answer to the previous question, enter -12.7 now.

Note: Make sure to specify a negative number. From the zero position, the direction of the travel is negative when moving toward the hardstop at the connector end of the track.

```
Do you have a servo gripper installed? (1 = yes, 0 = no)
```

Response **1** if servo gripper is installed.

0 if servo gripper is not installed.

You have completed the configuration. The following message displays in the terminal window:

```
Robot is Configured
```

You will also be asked to restart the controller. You must restart the controller to make the settings active.

Note: Until the system is restarted, you may encounter error messages. Ignore these messages and re-start the controller.

Task 8: Homing T265 and T475 Systems

When power to the controller is turned off, position data for the arm and track is lost from RAM memory. As well, there is no longer any feedback being sent from the incremental encoders on the robot arm and track axes to the controller. When power to the robot controller is turned back on, the controller initially does not know the position of the arm or track so it must be "homed".

The "homing" procedure resets the linkage between the actual position of the arm/track and the calibration data which was stored in the controller nonvolatile memory when the robot was calibrated. As long as the controller/arm are powered, the linkage remains intact.

Once the system has been installed, the system must be homed. Homing of the track axis follows automatically after homing of the arm provided that the system has been configured with an additional axis for a track. A system ordered from CRS with both an arm and a track is shipped from the factory properly configured. The A255 and A465 user manuals discuss homing the robot arms. The HOME command initiates the homing sequence.

For the T475 system, each axis, beginning with axis 1 (base rotate axis), will sequentially search for a limit switch. When the limit switch of axis 1 is triggered, this indicates that the position of the axis is within a range where the encoder should seek the zero cross pulse (a marker pulse on the encoder). Once the first axis successfully detects the zero cross pulse, the next axis (axis 2) moves to the limit switch trigger point followed by it's zero cross pulse. The remainder of the robot and track axes follow in succession.

Warning! Because each axis must move to trigger a limit switch at a particular position of axis travel, care must be taken to ensure that the robot does not collide with objects in the workcell during homing.

For the T265 system, only the track axis has a limit switch to help preposition the axis prior to homing. The arm must be prepositioned by either a) manually manipulating the arm so that it is positioned within it's home bounds or b) using a homing bracket along with a homing program to preposition the arm. Use of the homing bracket is discussed in *A265 User Manual and the Homing Bracket Manual*. As with the T475 system, the HOME command causes each axis to sequentially seek the zero cross pulse beginning with axis 1 (base rotate axis). The track homes once the robot arm successfully homes.

Procedure:

1. Ensure that the robot system is properly connected and secured (arm, track, cables, etc).
2. At the controller front panel, switch main power on and wait for sign-on messages to pass. Turn the arm power **ON**.
3. Use the teach pendant to manually move the saddle to a position close to its origin (about one foot [300 mm] away from the track connector end of the track).

4. If the robot arm is an A255, use the teach pendant to manually move the arm in joint mode so its homing markers are properly aligned.

Warning! If you choose to align the robot's homing markers by limping the joints, follow the recommended safety precautions described in the robot user's guide. *Entering the robot's workspace while it is under power is potentially dangerous.*

5. Enter HOME using the teach pendant, Robcomm terminal emulator utility, or Robcomm Dashboard.
6. If homing is successful, the system prompts you when homing is complete. Check that the markers on the arm are as illustrated in the Robot Arm User's Guide. If they are not, repeat steps 2-3.
7. If homing is not successful, the system prompts you that homing has failed. If this occurs, repeat steps 2-3.
8. Issue the READY command. The arm and track move to the READY position. (The track ready position is at the zero location - saddle 0.5 inch [13 mm] away from the hardtop). For more details on the homing program see the RAPL-3 Programming Manual

Task 9: Re-Home the F3T Robot Arm

Once the entire system is installed and configured, the arm must be re-homed. This is required since the encoder batteries for the robot (track and arm) are located in the base of the track and during shipping the encoders in the arm did not receive power from these batteries.

If the battery is run down, which happens after six weeks of being unconnected from the controller, the track must also be re-homed.

The re-homing procedure involves:

1. Re-homing the arm.
    a. Physically putting the arm in the zero position.
    b. Resetting the arm encoders.
2. Re-home the track, if necessary.
    a. Physically putting the track in the zero position.
    b. Resetting the track encoder.

You need:

- A computer (PC) running the Robcomm3 terminal utility. Refer to the *Robcomm3* section of the *Application Development Guide* for details.

Before you begin:

- Make sure your computer is connected to the controller front panel communication port, located behind the access door, and is running the terminal emulator.
- Complete the robot configuration utility to configure the track axis, and reboot the controller.
- Make certain that the arm power is off. The entire procedure should be done with the arm power off.

The re-homing procedure is required in order to zero the encoders at a known point and to read a calibration value for that point. Once re-homed based on the encoder position values, the software can pinpoint the robot location, relative to the zero location. Because the F3 and track have absolute encoders, the system does not need to be homed on a regular basis.

To re-home the F3 arm:

1. Verify that the proper calibration file robot.cal is in the /conf directory. If it is not there, download it.
2. Verify that arm power is off. If not, hit an e-stop.
3. Verify that there is no application process running on the controller by using the **ps** command. **Ctrl+e** terminates application processes started from ash, the system shell, or the teach pendant.
4. Manually back-drive the robot to align the calibration markers.
    - Some F3 robots, the marker is a pair of triangles on either side of a joint. The user should line up the opposing vertices of the triangles.

- Other robots have markers with a triangle on one side and a small alignment band on the other.

5. Reset the wrist encoders by entering the command:

   /diag/encres

   When prompted, enter module address:
   8
   (decimal) or 0x08 (hexadecimal). If there is an error message, it indicates encoder error for one or more of the wrist axes.

6. Reset the lower arm encoders by entering the command:

   /diag/encres

   When prompted, enter module address:
   16
   (decimal) or 0x10 (hexadecimal) for the lower three joints. If there is an error message, it indicates encoder error for one or more of the lower arm axes.

7. Turn off the controller and keep it off for at least 10 seconds.

8. Turn on the controller.

9. Test whether the arm has been correctly re-homed as follows:

   a. Turn on arm power.

   b. Start the application shell by entering

      ash test.

   c. Enter the command:

      calrdy

      This brings the robot into the vertical configuration.

   d. Inspect the calibration markers to ensure they are properly aligned. If any joint is mis-aligned (a pair of markers is not exactly aligned), the markers were not properly lined up in step 4. Perform these steps:

      - Turn off arm power.
      - Back-drive the joint to align the markers.
      - Align the markers near to where you aligned them in step 4, but slightly on the opposite side of the mark from where they ended up when you tested them.
      - Reset only the encoders of the mis-aligned joints. Repeat the test (steps 7 through 9).

Note: Before running an application after re-homing, check that the location variables for your applications are accurate. If they are not, re-teach the locations. Failure to confirm the location accuracy can result in equipment damage.

To re-home the track:

1. Verify that arm power is off. If not, hit an e-stop.
2. Physically move the robot to the zero position.

- If the zero position is marked with a pair of calibration markers (typical after factory calibration), align the marks on the track and the arm. Press the track brake release button (located beside the umbilical connector at the base of the arm) and physically move the track to the zero position.
- If the zero position is not marked, use the data from the configuration travel distance to find the zero position. If this data is 12.7 mm [0.5 in], press the track brake release button (located beside the umbilical connector at the base of the arm) and physically move the track.

  a. Move the robot until it hits the connector end hard stop.

  b. Move the robot 12.7 mm [0.5 in] back from the hard stop.

  Tip: For further reference you may want to mark this zero position.

Note: If your system does not have a brake release and you need to re-home your robot, contact the CRS Customer Support Group.

3. With the track at the zero position, reset the track encoder by entering the encres command at the system shell ($) prompt:
   `/diag/encres`
4. When prompted, enter module address:
   `80`
   (decimal) or 0x50 (hexadecimal).

   The **encres** program is a utility to reset the encoders, and 80, or 0x50, specifies the network address for the track.
5. Test whether the track has been correctly re-homed as follows:

   a. Move the arm down the track a short distance by pressing the track brake release button and physically moving the track.

   b. Turn on arm power.

   c. Start the application shell by entering:
   `ash test.`

   d. Enter the command:
   `w0`
   and note the number of motor pulses for axis 7 (the track).

   e. Enter the motor command for axis 7 with the negative number of motor pulses to bring the axis back to zero. For example, if w0 gives a pulses count of 5836, enter:
   `motor 7, -5836`
   This brings the robot to the zero position.

   f. Inspect the markers to ensure they are properly aligned.

Note: Before running an application after re-homing, check that the location variables for your applications are accurate. If they are not, re-teach the locations. Failure to confirm the location accuracy may result in equipment damage.

Conditions for Re-Homing and Re-Calibrating with F3T

Your robot and the track use absolute encoders which maintain data when the controller power is off. As long as the battery power to the encoders is maintained, it is not necessary to re-home the robot. Likewise, re-calibration is not required unless the calibration file is corrupted or there has been a mechanical change to the system, such as motor, encoder, or amplifier replacements.

Refer to your *Robot System User Guide* for details on homing and calibrating your CRS robot.

Re-Homing

Re-homing the track is necessary if the encoder position data is lost due to battery failure. If backup batteries fail, the track can be homed by using a similar procedure as defined above.

Re-Calibrating

Calibration may be necessary under certain conditions, such as if the calibration file is corrupted and there has not been any mechanical changes to the robot system. Simply re-load a back-up version of the system calibration.

If there has been mechanical changes to the robot system, you will need to re-calibrate the system. Simply reloading the previous calibration values is not sufficient even if the replacement parts are identical to the original.

Reload factory calibration values when:

- The calibration memory is corrupt.

Re-calibrate the system with new values when:

- You remove or replace a servo motor, encoder or belt, etc.
- You change the track travel length.

For more detail on homing and calibration, refer to your F3*Robot System User Guide*.

Task 10: Adjust the Track Hardstops If Necessary

The track's absolute ends of movement are determined by emergency hardstops at each end of travel. The hardstop contains a urethane bumper to absorb energy during a hardstop collision. The urethane can compress up to 12.7mm (0.5 in.) during a full speed collision. The hardstops are not normally used in normal robot operation, but are there to stop movement of the track if the track software limits are exceeded (during a system failure).

The track software limits are set using the configuration utility described in the Task 7: Configure the Track section on page 35.

Hardstop adjustment is usually done for safety reasons. For example, if an instrument or device has been placed within the useable end travel of the track, you can protect it in the event of a system failure, reducing the possible track travel by relocating the hardstop.

Warning! The hardstops should always be at the extremes of the software travel limit.

The hardstop consists of three parts: a fixed nut, a urethane bumper, and a floating nut.

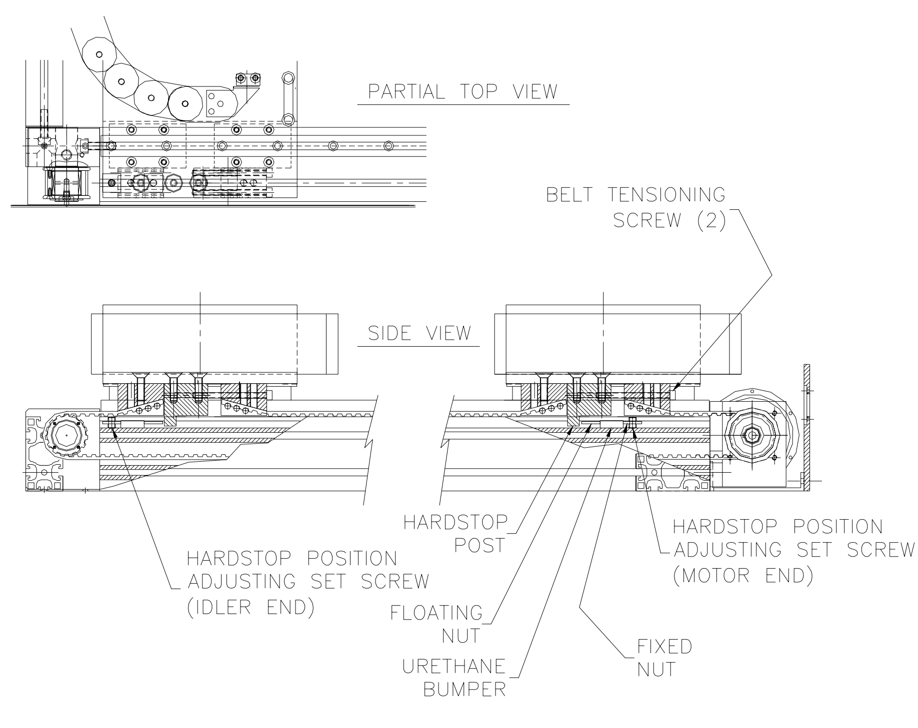


Figure 12 - Hardstop details

To adjust the hardstop positions:

1. Remove metal covers from the track to access internal components.
2. Back off and remove M6 belt tension screws from the belt tension block. Lift the belt away at the end of travel to expose the hardstop set screw.
3. Using a 4mm hex driver, loosen the set-screw in the stop's fixed nut.
4. Push the stop along the rail toward the center of travel, then move the saddle toward the end of the track, pushing the hardstop until reaching the position you want.
5. Tighten the hardstop's set screw.
6. Readjust the drive belt tension.
7. Run the configuration utility to set the new travel limits in the software. (See Task 6, "Configure the track")
8. Move the track at slow speed to check your locations. If shifting of locations has occurred, you need to re-teach your locations.

CHAPTER 5

Preventive Maintenance

In order to maintain normal operation of all CRS robot track products, preventive maintenance and inspection procedures must be scheduled and completed. Since all robot tracks and track applications are not alike, the interval and degree of preventive maintenance may vary between applications. However, it is important for each user to implement a plan for routine preventive maintenance and inspection to minimize the possibility of premature failure due to accelerated wear.

Typically, active or dynamic components are the items which require routine preventative maintenance. Identified below are the components and the characteristic used to predict the maintenance or inspection interval:

motor - speed, acceleration, “duty cycle”, accumulated motor revolutions, ambient temperature

motor brushes (T265,T475) - speed, acceleration, “duty cycle”, accumulated motor revolutions, ambient temperature

gearbox - speed, acceleration, “duty cycle”, accumulated motor revolutions, ambient temperature

reversing unit - accumulated pulley revolutions, environmental conditions

timing belt- acceleration, accumulated pulley revolutions, belt tension

linear bearing - accumulated travel, humidity, track installation accuracy

internal cabling - accumulated travel, additional cables in carrier

cable carrier - accumulated travel, track orientation (upright or inverted)

cable carrier sheet - accumulated travel, track orientation (upright or inverted)

linear cover seal - accumulated travel

encoder battery (F3T) - power-off duration, installation time

track enclosure - environmental conditions, contaminants

frame geometry - application dependent

fastener integrity - periodic, application dependent

Preventive maintenance of these items should enable each component to meet its predicted life expectancy, providing that the track has also been installed as per recommendations in the CRS track manual. The preventive maintenance items are shown in Figure 13.

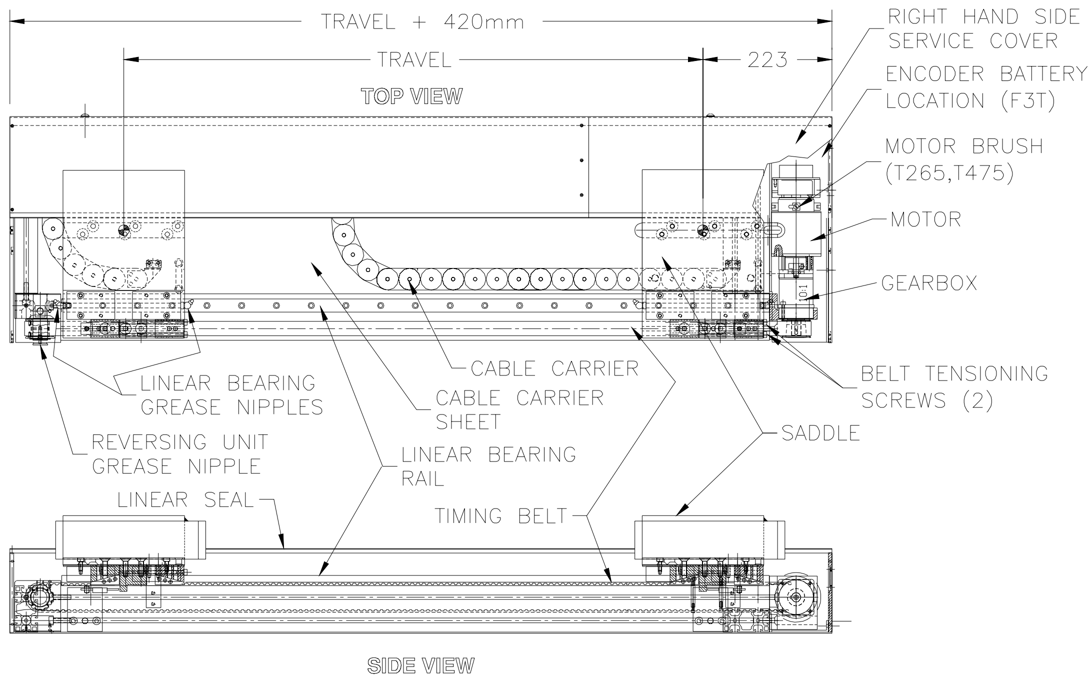


Figure 13 – Locations of Preventive Maintenance items

Access to Track Components

Most procedures require access to the internal components of the track (removal of sheet metal covers required). The design of the workcell should take this factor into consideration. For those tracks with service covers, (a pair of 420mm long covers at the connector end of the track), removal of these service covers provides access for most internal preventive maintenance tasks. See the figure below for details:

- Motor/Encoder/Gearbox
- Amplifier (F3T only)
- PCM (F3T only)
- Cable track attachment points
- Linear bearing grease fittings
- Fiber tray (F3T only)
- Belt tensioning bolts

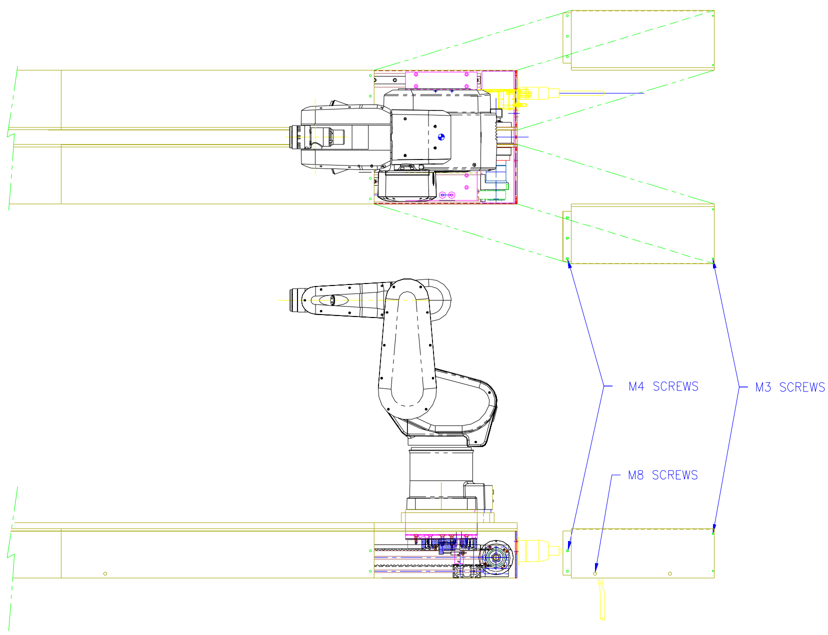


Figure 14 - For service cover removal, remove 4 M8 screws on sides, 10 M4 screws on sides and top and 8 M3 screws on sides and top.

Procedures

Below are the preventative maintenance tasks and the procedures required.

Motor brush inspection (T265,T475 tracks only)

Motor brush life is significantly affected by several factors in track applications. Typically, these are track speed, acceleration, required torque, ambient temperature and number of motor revolutions. In general, lowering any or all of these factors will extend brush life. It is important at the first service interval to perform a measurement on one of the motor brushes (all 4 brushes should wear at the same rate). By comparing this measurement to the length of a new brush, one can project the life of the motor brush (assuming the application does not change).

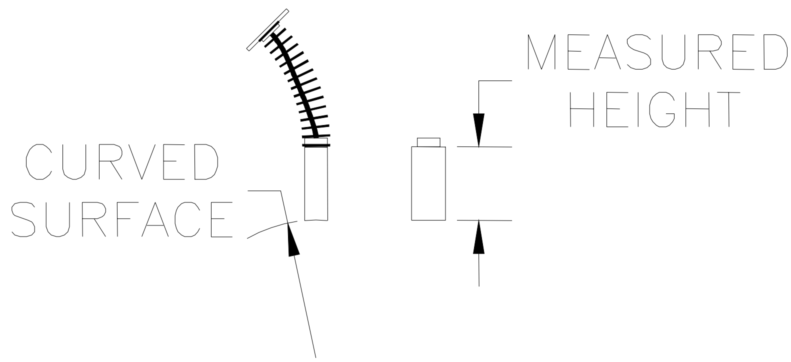


Figure 15 – 3515 Motor brush

To inspect one motor brush, use the following procedure:

1. If the track has service covers, remove the right hand cover (as viewed from the connector end of the upright track).
2. If the track does not have service covers, remove the entire right hand cover (as viewed from the connector end of the upright track). Removal implies releasing the fasteners holding the cover in place and sliding it 0.5 meters away (in the direction of track travel) from the connector end of the track. This exposes the motor. Alternatively, the end plate (holding the connectors) can be removed to expose the motor. If you choose to remove the end plate only, it may be useful to perform additional preventive maintenance tasks while you have internal access.
3. Use a slot screwdriver to remove one of the motor brush caps (appear as red or black round plastic cap on the motor). Note: there is a spring below the cap that will tend to eject the cap when it is unthreaded. Be prepared to catch the cap when it is released.
4. With the cap removed, carefully pull the brush out. It should slide out freely in one piece.
5. Check the integrity of the brush. The braided copper wire between the carbon brush and the brass spade tab should not appear burnt or melted. The carbon brush should have a rectangular cross section and

the end of the brush which contacts the commutator should have a distinctively curved profile.

6. Measure the length of the brush as shown in figure 15.
7. A new brush is 8.75mm (0.345") long. When the brush length has been reduced to 4.3mm (0.170"), it can no longer be used. Therefore, the useable length of the brush is 4.45mm (0.175"). To calculate the projected life for the motor brushes, determine how many weeks the system has been running. Use the formulas below:

Metric units
brush wear = 8.76mm - measured length
project life (# weeks) = [4.45mm / **brush wear**] x # weeks operating

Imperial units
brush wear = 0.345" - measured length
project life (# weeks) = [0.175" / **brush wear**] x # weeks operating

8. This calculation assumes the application being run does not change.
9. To reinstall the motor brush, slip the carbon brush into the brush holder, compress the spring and set the brass tab into the recess in the brush holder. Thread the brush cap into the brush holder and gently tighten it. Do not over tighten the cap as it and brush holder are brittle.

Motor Brush Change (T265,T475 tracks only)

Refer to the service manual for brush change instructions.

Gearbox Inspection

The planetary gearbox manufacturer indicates that the gearbox is lubricated for life and as such does not require any active maintenance. However, it is recommended that periodic inspections be performed in the area of the gearbox to detect any signs of oil leakage. Loss of lubrication can lead to excessive heat buildup, which may in turn cause premature failure.

Reversing Unit Inspection/Maintenance

Timing belt reversing units on tracks for s/n RT1000 to RT1129 use shielded ball bearings in their construction. Under normal conditions, these bearings should not require servicing. Conditions which can lead to premature bearing failure include excessive belt tension or extreme environmental conditions where bearings are exposed to contaminants. For preventive maintenance, the user should watch for any signs of excessive noise, friction or contaminants in the area of the timing belt reversing unit which may indicate premature failure.

Reversing units in tracks s/n RT1130 and above contain a high capacity needle bearing. This bearing should be lubricated once every 1000km of track travel or once every 6 months (whichever comes first). A grease fitting on the bearing shaft allows for addition of grease.

Tracks with s/n RT1130 -RT1139 have the grease fitting located internally at the reversing unit end of the track. The left hand cover (as viewed from the connector end of the track) must be removed. Removal implies releasing the fasteners holding the cover in place and sliding it 0.5 meters away (in the direction of track travel) from the reversing unit end of the track.

Tracks with s/n RT1140 and above have the grease fitting accessible through a hole in the side of the sheet metal cover at the reversing unit end of the track (a black plastic snap-in plug normally covers the hole).

Use a lithium based grease, NLGI 1 or 2, DIN 51818.

Timing Belt Inspection/Maintenance

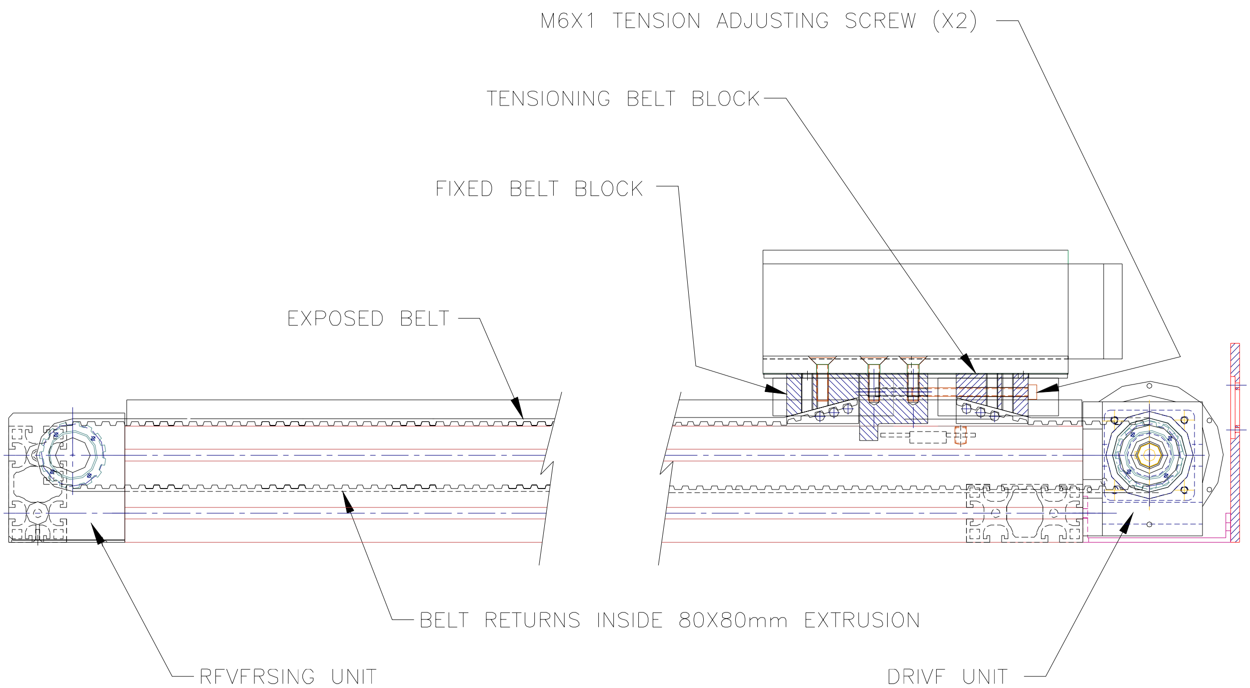


Figure 16 - Belt drive arrangement for the track's drive belt. Note the fixed end and tensioning end.

The timing belt should be inspected every 6 months for signs of fraying or cracking. Under normal conditions this should be rare.

Belt tension should be checked every 6 months and adjusted only if required. A symptom of belt looseness may be additional free play in the track saddle position, or loss of position of certain taught locations.

***Warning!* Retensioning of the belt usually necessitates recalibration of the track axis, so do not adjust tension unnecessarily**

1. To measure free play (hysteresis) in the saddle position, one method is to install a dial gauge so that it rests against the track saddle in the direction of motion. With the track axis servoing (under power), manually apply a force (2-4kg, 5-10lb) to the saddle in one direction of travel. Zero the dial gauge and apply the same force in the opposite

direction of travel. If the difference in position is greater than 0.25mm (0.010”), the belt requires additional tension.

2. To adjust the drive belt tension, remove the track’s metal housing covers.
3. Using the two M6 belt tensioning screws shown in the figure 1, tighten each screw by ½ turn. Redo the free play measurement. The amount of free play should have decreased. Continue tensioning until the amount of free play <0.25mm (0.010”). If the amount of free play cannot be reduced to <0.25mm (0.010”), there may be some other source of play in the system (worn belt teeth, worn gearbox, loose couplings). Do not excessively tension the belt (attempting to reduce free play) as it may cause premature bearing failure and/or motor failure due to the increased load.
4. Once the belt tensioning has been completed, apply a drop of medium strength thread lock to the bolts.
5. Slowly command the robot to move to one or more taught locations. If the position appears to have shifted, follow the recalibration procedure to recalibrate the track axis.

Linear Bearing Inspection/Maintenance

Three factors significantly affect the preventive maintenance schedule for the linear bearings. Accumulated travel of the linear bearings, environmental conditions, and the installation accuracy of the track all affect the life of the linear bearings.

Tracks s/n RT1000 - RT1029 require fairly frequent lubrication (application dependent). The bearing manufacturer recommends that the linear bearings be lubricated every 100km of travel. You will have to review your application to determine at what point the track will have travelled 100 km. For certain applications, this amount of travel can be reached fairly quickly (several weeks) so do not dismiss the 100km distance as being very long.

Tracks of s/n RT1030 and above have a more advanced bearing with a lubrication interval of 25,000 km. This reduces the lubrication interval significantly. It is recommended that you still do the calculation to determine when this travel distance will be achieved.

For track applications with low accumulated travels, it is recommended that the bearings be lubricated once per year to apply “fresh” grease to the system.

The method for lubrication both types of bearings is important. Grease must be applied to each of the four bearing blocks via a grease nipple on each block. For tracks with service covers, the grease nipples can be accessed by simply removing the service covers. For tracks without service covers, both left and right sets of sheet metal covers must be loosened and slid back to expose the bearing blocks below the saddle (see figure 1)

Using a lithium based grease NLGI 1 or 2, DIN 51818, pump grease into the bearing block until some grease oozes out past the seals. It is not necessary to apply grease to the rails themselves. The block lubricates the rail as it passes over it.

***Warning!**. **The bearing blocks cannot be lubricated adequately by simply applying grease to the bearing rail.** The seal on the bearing block will wipe the grease away preventing all but a tiny amount of grease from entering the bearing block. The relubrication interval is based on the loss of grease from within the bearing block, not the bearing rail. The bearings will be irreparably damaged if they are allow to loose their lubrication.*

1. For applications with particularly dirty or humid environments, it is recommended that the bearing rails be wiped down periodically to remove contaminants or iron oxide. The robot carriage should then be moved back and forth a few times on the clean rails to reapply a light film of grease back onto the rails. Some additional grease should then be pumped into the bearing blocks to replenish any grease lost during this step.
2. The installation accuracy of the track is critical to meet the life expectancy of the linear bearings. The linear bearing manufacturer recommends that the linear bearings be installed with parallelism of the rails within 0.05mm (0.002”) and height variations between rails within 0.12mm (0.005”). It would be beneficial to include in the preventative maintenance procedure a periodic check of the mounting accuracy to determine if the track position has shifted or come loose. One method to detect excessive misalignment without physically measuring the rail positions is to manually move the carriage (track in limp mode) along the length of the track and measure the force required to move the carriage. The force should be constant at any given point and will typically be 6 -7 kgf (14 -16 lbf) at a slow speed.

The following table shows the recommended lubrication schedule guidelines. Interpolate your lubrication schedule requirements based on a comparison with the heavy duty and light duty conditions defined in the table.

	Use	Lubrication Interval
Heavy	24 hrs/day 365 days/year high speed (>75% max)	9 months
Light	12 hrs/day 200 days/year low speed (< 25% max)	36 months

Internal Track Cabling

1. The track cabling which flexes as the track carriage moves back and forth requires only periodic inspection for installation anomalies. These include loosening of strain relief ties at the ends of the cable carrier, or stress points caused by the addition of extra cabling (not factory installed) in the cable carrier.
2. Once per year should be an adequate inspection interval, but if the track covers have been removed at a shorter interval for other maintenance procedures, inspection of the internal track cabling could also be included.

3. The cables should also be inspected for inclusions such as metal chips, fragments or objects which may have fallen into the track through the slot in the top of the track. These objects may cut into the covering of the cables or impede proper motion.

Cable Carrier

1. The cable carrier which contains the moving robot cables and airline requires only periodic inspections for signs of irregular operation. Once per year should be an adequate inspection interval but if the track covers have been removed at a shorter interval for other maintenance procedures, inspection of the cable carrier could also be included. Under normal conditions, the cable carrier in an upright track should last for the life of the track.
2. Inspections should include checking the fastening point of the track to the saddle post to make sure it is secure.
3. For inverted tracks where the cable carrier slides on stainless steel guides, the cable carrier should be inspected for signs of severe abrasion. A small amount of abrasion can be expected since the stainless steel guides are installed in 1 meter sections and the cable carrier must slide over the seams between guides.

Cable Carrier Sheet

1. The white polypropylene sheet on which the cable carrier slides will show signs of abrasion over time. This should be monitored as part of the preventive maintenance schedule to watch for significant accumulations of particles which slough off. These can be vacuumed out periodically. The particles do not pose any real threat but may, in an extreme situation, get mixed with grease and drawn into bearings.
2. Preventative maintenance programs for inverted tracks do not require monitoring of the cable carrier sheet, since the cable carrier does not ride on it.

Linear Cover Seal

1. The grey PVC linear cover seal should be inspected periodically for signs of severe abrasion or delamination. If the seal has started to pull away from the sheet metal cover at any point, adhesive Loctite 401 can be used to reapply the seal.

Caution**: *Follow Loctite's recommendations for the use of Loctite 401 if it is used. It is a cyanoacrylate which bonds quickly to skin.***

2. If the cover seal has been cut to allow removal of one portion of the track covers, it is recommended that the cut is spliced back together when the cover is reinstalled. Failure to splice the seam back together may result in the seal delaminating from the metal cover. The splice can be accomplished as an overlapping patch as shown in figure 3. It can be

created as a permanent patch using a piece of linear seal from the maintenance kit and Loctite 401 or using a durable adhesive tape.

Encoder Battery (F3t Track Only)

F3t Track Battery Installation and Shipping

To ensure that the absolute encoders on the F3 arm retain position data during shipping, power must be supplied to them. A battery pack located in the base of the robot provides this power. Once the robot is installed on the track however, the robot is reconfigured to accept power for the encoders (when controller power is switched off) from an alternate battery pack located in the track. This battery pack also supplies power to the track motor encoder. The encoders themselves contain a reservoir capacitor which can supply power to the encoders for a brief period of time. This allows the user to transfer the connections from one battery pack to the other without the loss of position data.

To transfer battery connection from the auxiliary battery pack to the track battery pack:

1. Once the robot has been bolted in place, remove the two M3 screws holding the plate on the rear of the robot base.
2. Carefully extract the plate. The battery pack is mounted on the other side of this plate and wires connect the battery pack to the wiring inside the arm.
3. Unplug the battery pack connector from the wiring inside the base of the robot.
    - The batteries in this battery pack should be kept as spares. They are the same nickel metal hydride batteries that are used in the track battery pack.
    - To recharge the batteries, refer to the Battery Maintenance section in the Preventative Maintenance chapter of the F3 Robot User Guide.

Warning! Once the battery pack has been disconnected from the robot arm, the components containing position data in the encoders are powered by capacitors only. This is effective for about five minutes only. *It is important to reconnect the wiring in the robot to the battery pack within the track before this 10 minute period has elapsed, otherwise the robot will require recalibration.*

4. To connect to the battery pack (and all necessary interconnections between the robot arm and the track:
    a) Find the mating connectors in both the robot base and in the cables extending from the track saddle.
    b) Connect the cables noting that the connectors are keyed to ensure one mating orientation only.

F3t Track System Battery Replacement

The batteries maintaining power to the encoders are found in the fiber tray which is located at one end of the track in the F3t system, rather than the base of the robot. They should be changed every 12 months, counting from the time you receive the system.

To gain access to the battery pack, the track covers must be removed. Once this is done, the batteries can be readily located and replaced. You have up to ten (10) minutes to change them before the encoders no longer remain active and calibration is lost.

Warning! Use only nickel-metal hydride batteries, and NOT nickel cadmium, lithium or alkaline alternatives. *The use of unsuitable batteries may lead to hazardous failure.*

You can order replacement batteries from CRS by contacting our customer support group. The part number is R-BAT-NiMH1.2. Order at least three (3) batteries.

If in the course of removing the batteries, battery pack or fiber tray and cables are disconnected, the cable connections are shown in Appendix “A”.

Track Enclosure

1. The sheet metal covers and the PVC linear seal help to keep most contaminants out of the internal components of the track. However, depending on the application, there is still a possibility that contaminants or objects can fall into the track through the small gap between the PVC seal edges. Part of the preventive maintenance program should be to check for contaminants or objects within the track.
2. The sheet metal covers which enclose the track are self supporting but cannot tolerate additional weight being placed on them. There is a fairly small clearance between the covers and the moving saddle below. The covers should be checked periodically to determine if the saddle is contacting them. Pressure can be applied to them to bend them upward if necessary.

Frame Geometry

The geometry of the frame or table in the workcell which supports the track should be checked periodically to ensure that the supports have not loosened or shifted. As mentioned in the maintenance section for the linear bearings, the tolerances for the linear bearing positions are very precise, and if the track support shifts, the linear bearing position may change with the result that the bearing life and motor life may be significantly reduced. A check of the support frame integrity and checks as described in the linear bearing maintenance section should be scheduled.

Fastener Integrity

As part of the preventive maintenance schedule, it is recommended that a general inspection of fasteners is included, particularly fasteners that are loosened (and tightened) as part of the service procedures (i.e. covers etc). Fasteners that hold the track and the robot in place should also be checked.

Upgrades

As part of its ISO9001 Quality Program, CRS Robotics is continuously developing product improvements. A number of track components have been improved during the life of the track product line, so upgrades may be available for certain of these track components, depending on the age of the track. The upgrades available are listed below by track serial number:

Table 3-Upgrades Available

Component	Improvement	Tracks Affected
Linear Bearings	1. greasing interval has gone from 100 km travel to 25,000 km travel. 2. quieter operation	RT1000-RT1129
Belt Drive unit	-sealed bearings, drive pulley directly on gearbox	RT1000-RT1129
Reversing unit	-can be lubricated without removing outer covers	RT1130-RT1139
Service access covers	-active components accessible for routine maintenance through 420mm long cover set.	RT1000-RT1139
Cable carrier extension	-cable carrier lengthened to allow cable replacement through service access covers	RT1000-RT1139

Track Maintenance Kit

A maintenance kit includes items required for track preventive maintenance. The items include:

- linear bearing grease - lithium NLGI-2 cartridge-XX oz. (grease gun required for standard grease nipples)
- Allan keys - 2mm,5mm
- Phillips #1 screwdriver
- 3515 motor brushes (4)
- 12” grey PVC linear cover seal for splicing
- 3 gram tube Loctite 401

Track Service Kit

A maintenance kit includes electronic items which have some (albeit low) probability of failure. These include:

- Sumtak encoder
- Sunx proximity switch

Preventive Maintenance Log

Use the log sheet on the next page to record the preventive maintenance

Table 4 **- Preventive Maintenance Service Log for Track s/n RT________ Model:_________ Install'n Date:_________**
history for your track.

Service Item	Service Interval	Service Date/By	Service Date/By	Service Date/By	Service Date/By	Service Date/By	Service Date/By	Service Date/By	Service Date/By
Motor brushes (T265,T475)									
Gearbox									
Reversing Unit									
Timing Belt									
Linear Bearings									
Internal Cabling									
Cable Carrier									
Cable Carrier Sheet									
Linear Cover Seal									
Encoder Battery (F3T)									
Track Enclosure									
Frame Geometry									
Fastener Integrity									

APPENDIX A

T265 Track Interface Connectors

The controller and track connectors for the T265 motor power umbilical cable are the same as for the standard A255 arm, except an extra channel is enabled for the track interface. The controller and track motor power pin-outs are described in this chapter.

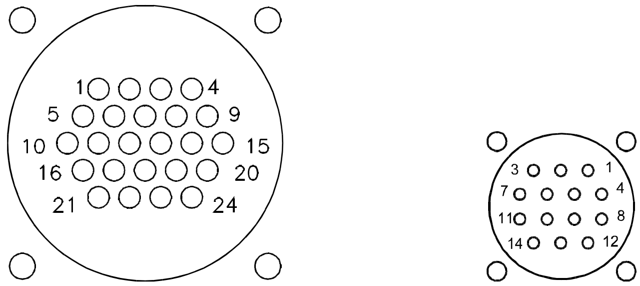
The feed back connectors for the T265 are the same as for standard A255 arm.

For more details on the A255 connectors, refer to the C500 Controller User's Guide.

Track Circuit Breaker

The circuit breaker for the track axis is located on the controller's front panel (behind the access door). It is labeled “F6”.

Track Power Connectors



The track umbilical cable connects the CPC-24 connector on controller (left) and CPC-14 connector on track (right)

Like the standard A255 robot arm, the T265 uses a power umbilical cable that connects the CPC-24 pin connector at the rear panel of the controller to a CPC-14 pin connector, in this case, on the track. A cable channel is provided for the track axis homing switch (pin #24 at the controller corresponding to pin #2 at the track). The track's 14-pin connector is connected by an internal cable to the 14-pin connector on the arm. The drawings above is of the connectors on the controller and track, the cable connectors are the mirror image.

Pin # On C500	Pin # On Track	Signal	Signal Description
1	1	Motor1+	Motor power +/-25v @2a max
2	4	Motor1-	Motor power return
3	3	Motor2+	Motor power +/-25v @2a max
4	7	Motor2-	Motor power return
5	5	Motor3+	Motor power +/-25v @2a max
6	9	Motor3-	Motor power return
7	--	n/c	
8	6	Motor4+	Motor power +/-25v @2a max
9	10	Motor4-	Motor power return
10	8	Motor5+	Motor power +/-25v @2a max
11	12	Motor5-	Motor power return
12	11	Motor6+	Motor power +/-70v @5a max
13	14	Motor6-	Motor power return
14	--	n/c	
↓		↓	
24	2	HomeSw6	Home switch, switch or Prox input, 12-40v
--	13	n/c	

APPENDIX B

T475 Track Interface Connectors

Four cables connect the controller to the track. There are the two standard cables for arm operation. Two additional cables are used for track operation. This chapter describes the connector pin-outs (on the track and on the controller) for these additional cables.

For more details on the A465 system connectors refer to the C500 Controller User's Guide.

Track Circuit Breaker

The circuit breaker for the track axis is located on the controller's front panel (behind the access door). It is labeled "F7".

Track Power CPC-14 Connector

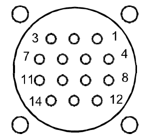
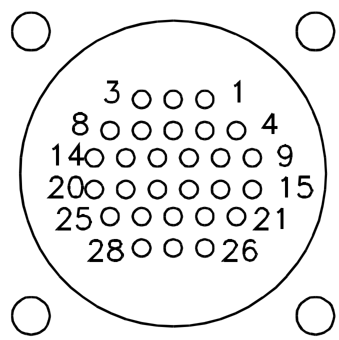


Figure 17- CPC-14 Connector

The track power umbilical cable for the T475 connects a 14-pin connector on the controller's rear option panel to a 14-pin connector on the track. Only the pins listed below are are used in these connectors. The drawing above is the connector on the controller and the track. The connectors on the cable are the mirror image of this.

Pin #	Signal	Description
1	Motor7+	Motor power +/-63v @5a max
3	Brake Power	35v @100mamp
4	Motor 7-	Motor power return
7	GND	Ground (Return) from Brake Power & Home Sw7
12	+12v	Internal power supply
13	HomeSw7	Home switch Prox input 12-40v

Track Feedback CPC-28 Connector



The track feedback umbilical cable for the T475 connects the controller's 28-pin Expansion Amplifier port to a 28-pin connector on the track. Only the pins listed below are used in these connectors. The drawing above is the connector on the controller and the track. The connectors on the cable are the mirror image of this.

Pin #	Signal	Description
9	7A	RS422+, 200Khz max pulse rate
10	7B	RS422+, 200Khz max pulse rate
11	7Z	RS422+, 200Khz max pulse rate
13	5v (Vcc)	Encoder Supply +5vdc @80mamp
15	7A*	RS422-, 200Khz max pulse rate
16	7B*	RS422-, 200Khz max pulse rate
17	7Z*	RS422-, 200Khz max pulse rate
18	GND	Encoder digital return

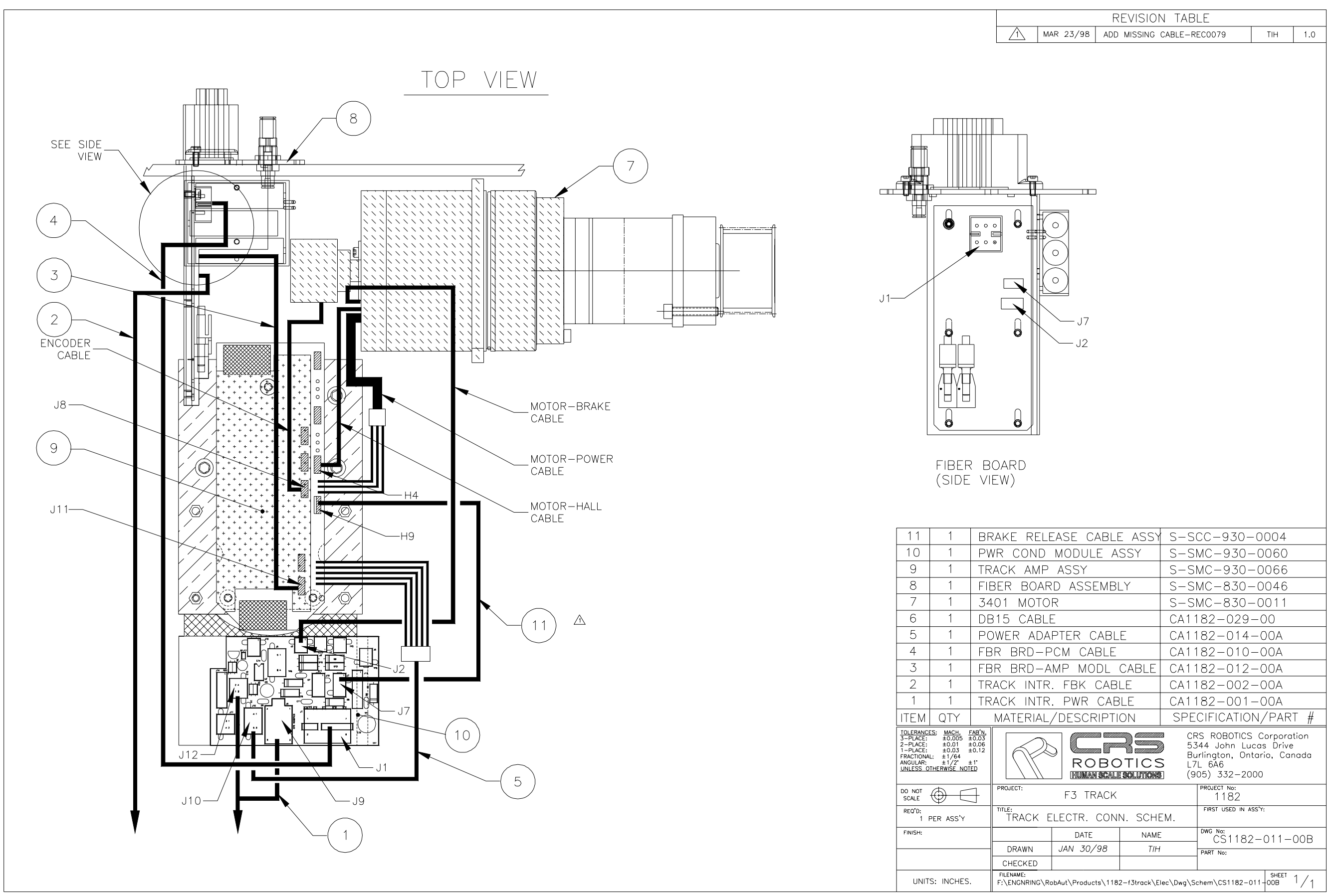
APPENDIX C

F3T Track Interface Connectors

The pinouts for the Han 15 connector can be found in the F3 user manual.

Track Amplifier/PCM Connections

The track amplifier and PCM (power conditioning module) are located within the track. These are accessible by removing the service access covers. The cable interconnects are shown below:



Glossary

This glossary contains definitions of terms used in association with the robot track. For many other terms, see the glossary in the *F3 System User Guide*.

calibration

The process of setting a precise mechanical position (zero position) for the arm and track and storing this position as an electrical encoded reference to be used whenever the robot is operating. The mechanical position data is converted to electrical position data by means of encoders on each robot/track axis.

homing (T265,T475)

When a robot system with unpowered incremental encoders is switched on, a homing procedure is required to manipulate the robot arm and track into a mechanical position where previously stored calibration data can be used to accurately position each axis relative to a reference location (zero position).

re-homing (F3T only)

When a robot system with battery-supported absolute encoders is switched on, a re-homing procedure is required to transfer initial position data from the encoders back to the controller. The arm/track does not have to move to accomplish this.

saddle

The mobile platform on which the robot arm is mounted. The saddle travels on linear bearings.

servo network

The communication and interconnection between the controller and the amplifiers that are located within the track and the F3 robot arm.

standard cycle

Combined robot and track motion in which each robot joint moves through 90 degrees and the track moves 2 m. This cycle is used in the speed and acceleration specifications.

track hardstop

A physical device that prevents the track saddle from travelling past a certain point in either direction. A hardstop is placed in the track frame t each end of the track. A post extends from the saddle and cannot travel past the hardstop. The distance between the two hardstops is the free travel of the track.

travel

The distance between the software limits of travel for the track axis. The track name (i.e. 2 meter track) will have 2 meters of travel, although the actual length of the track would be 2.42m.

track-mounted robot

A robot mounted on a mobile platform attached to a linear rail which provides the robot with an expanded working area.

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