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B. Base Tool Changer

QC-18—Electric Tool Changer

1. Product Overview

The QC-18 Electric Tool Changer consists of a Master plate assembly and a Tool plate assembly.

> **CAUTION:** Do not use the QC-18 Tool Changer in an application where water is present or other fluids are being passed. Using the QC-18 Tool Changer in an application where water is present or other fluids are being passed, can cause injury to personnel and damage to equipment.

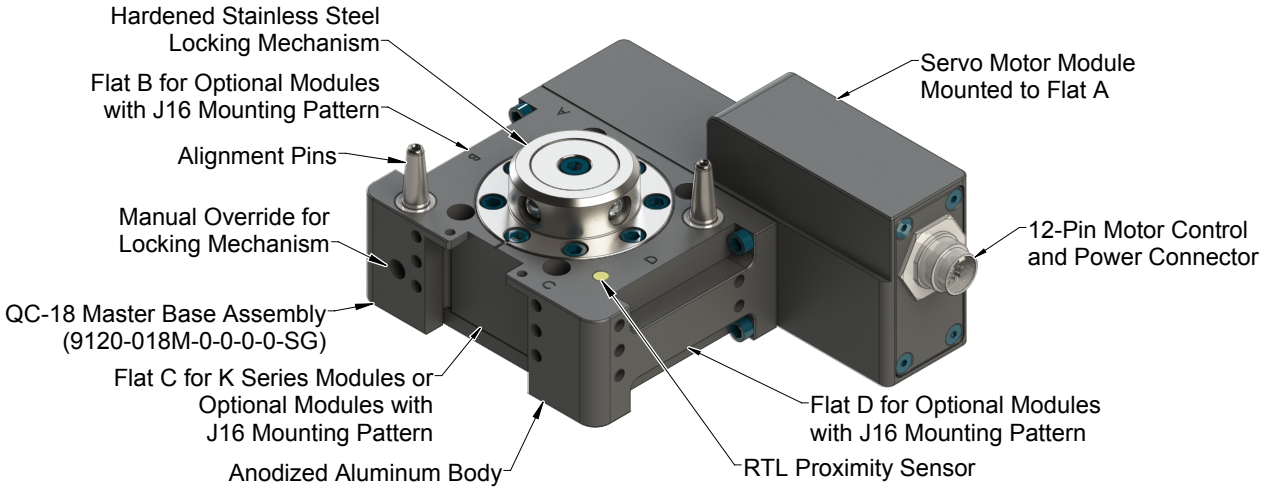
1.1 Master Plate Assembly

The Master plate assembly includes an anodized aluminum body, a hardened stainless steel locking mechanism, and hardened steel alignment pins. The Master has (4) Flats, Flat A is specifically for mounting the servo motor module. Flat C supports both K series modules and optional modules with J16 mounting patterns. Flats B and D support optional modules with J16 mounting patterns.

The servo motor module has an integrated controller and high torque motor (refer to *Section 1.3—Servo Motor Module* for more details).

A PNP DC proximity sensor is designed into the body of the Master plate to verify Tool plate presence when coupled. The sensors provide a ready to lock (RTL) signal through the control module.

Figure 1.1—Master Plate Assembly with Servo Motor Module



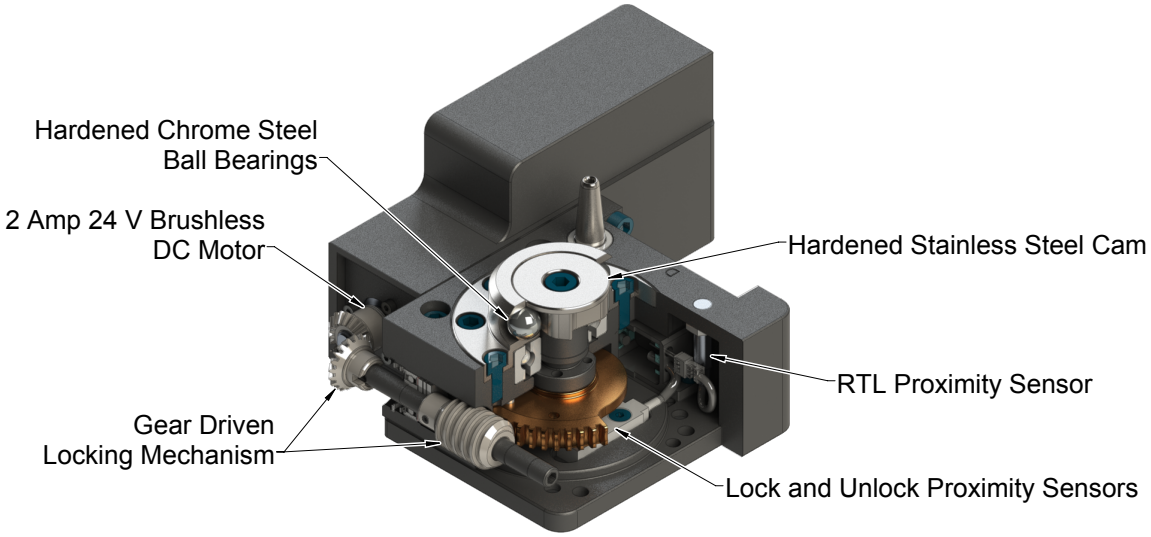
The Master provides a mounting pattern with (2) dowel pins for locating the Master and includes (4) mounting fasteners (M4 socket head cap screws) (refer to *Section 8—Drawings* for mounting details).

PNP DC Proximity sensors are designed into the body of the Master plate to verify the lock/unlock position of the locking cam. The sensors provide the Lock and Unlock (L/U) signals through the motor controller (refer to *Figure 1.2*).

The locking mechanism consists of a male coupling with holes that retain hardened chrome steel ball bearings. A hardened stainless steel cam is gear driven by a 24V brushless DC servo motor. Tapered pins located on the Master body mate with holes in the Tool body to ensure repeatable alignment during the coupling process.

An extreme pressure grease is applied to the cam, male coupling, ball bearings, and pins to enhance performance and maximize the life of the Master assembly.

Figure 1.2—Locking Mechanism

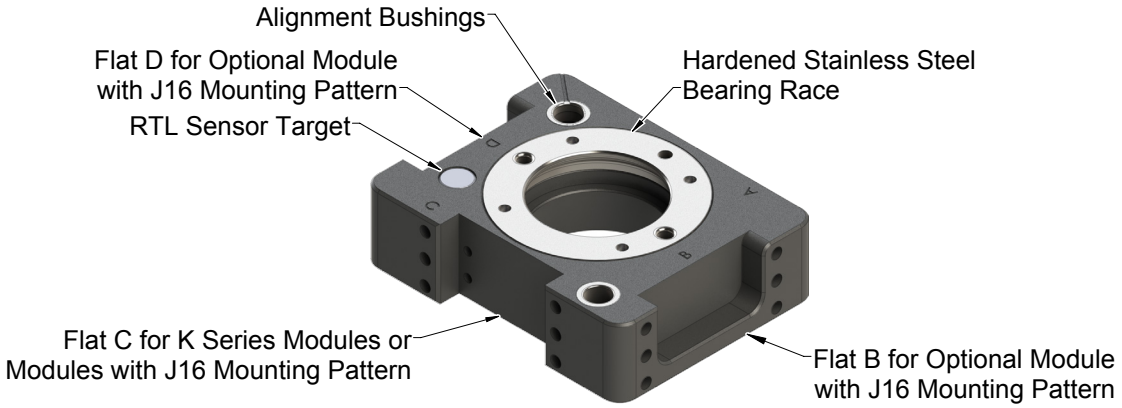


1.2 Tool Plate Assembly

The Tool plate assembly includes an anodized aluminum body, a hardened stainless steel bearing race, and hardened steel alignment bushings. A sensor target is built into the Tool body so the RTL proximity sensor in the Master body can sense the Tool presence.

The Tool has (4) flats, Flat A is not used for mounting modules because the servo motor module on the Master requires the space a module would occupy. The Flat C supports both K series modules and optional modules with J16 mounting patterns. Flats B and D support optional modules with J16 mounting patterns.

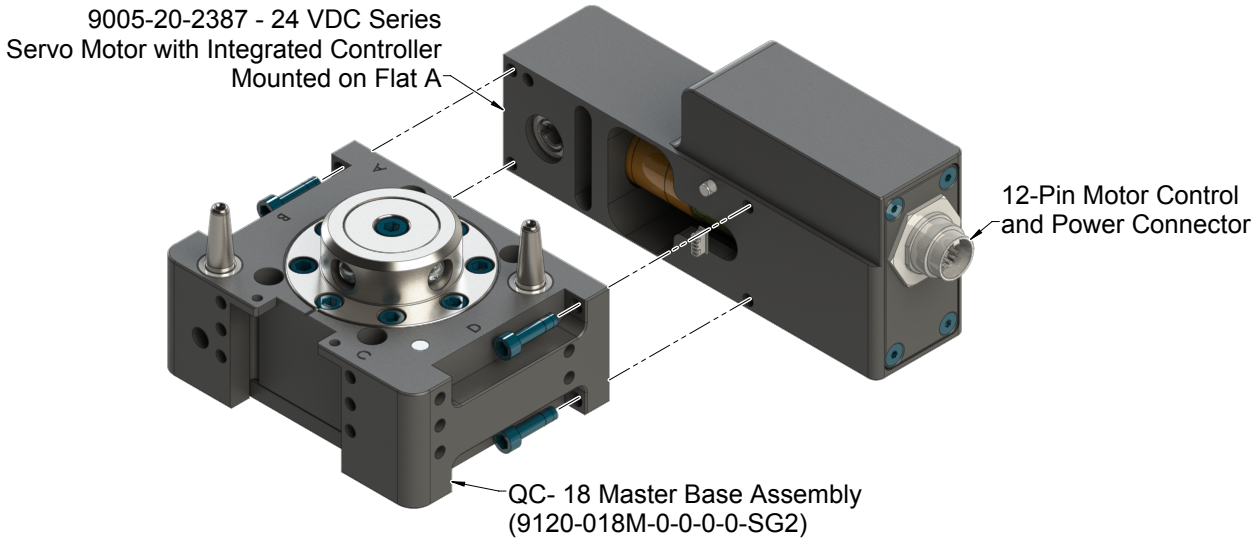
Figure 1.3—Tool Plate Assembly



1.3 Servo Motor Module

The 9005-20-2387 servo motor module has an integrated motor controller and a 24VDC brushless servo motor with sensor feedback. The module is equipped with a 12-pin connector to interface with a customer cable.

Figure 1.4—Servo Motor Module

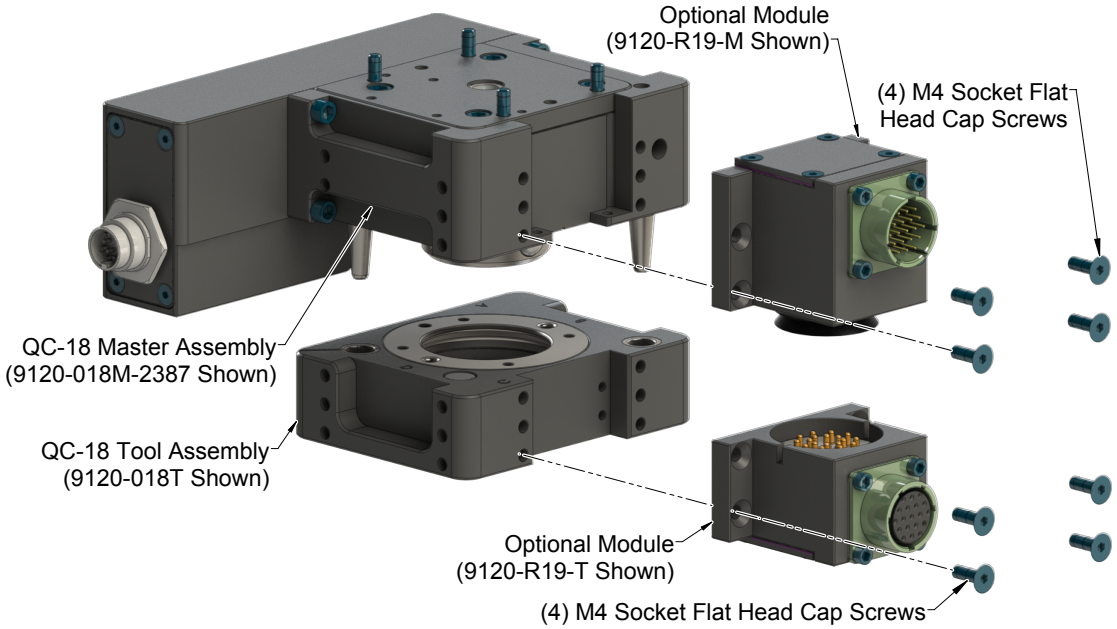


1.4 Optional Modules

There are (3) Flats available for mounting of the optional modules for support of various utility pass through, such as signal and power.

For assistance in choosing the right modules for your particular application, contact an ATI Sales Representative.

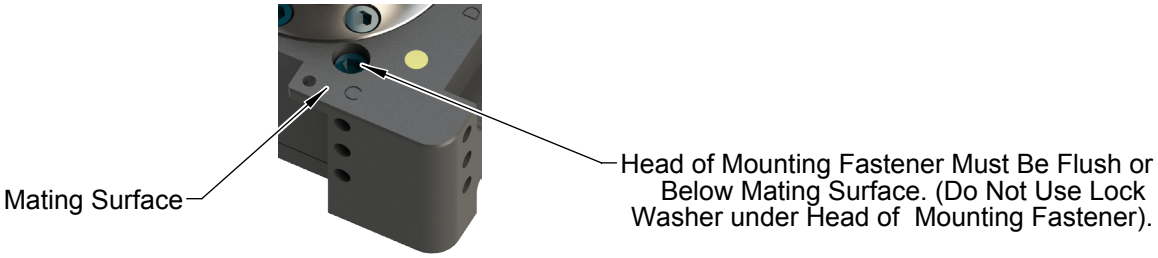
Figure 1.5—Optional Modules



2. Installation

The Master plate assembly is attached to the robot arm and may require an interface plate to match mounting patterns or create space to accommodate hollow wrist utilities. The Tool plate assembly is attached to the tooling and may require an interface plate to match mounting patterns (refer to *Section 8—Drawings* for specific mounting pattern details).

WARNING: Do not use lock washer under the head of the mounting fasteners or allow the mounting fasteners to protrude above the mating surfaces of the Master and Tool plates. Allowing fasteners to protrude above the mating surface will create a gap between the Master and Tool plates and not allow the locking mechanism to fully engage, this can cause damage to equipment or personal injury. Make sure the mounting fasteners are flush or below the mating surfaces of the Master and Tool plates.



WARNING: Do not perform maintenance or repair(s) on the Tool Changer or modules unless the Tool is safely supported or placed in the tool stand, all energized circuits (for example: electrical, air, water, etc.) are turned off, pressurized connections are purged and power is discharged from circuits in accordance with the customer specific safety practices and policies. Injury or equipment damage can occur with the Tool not placed and energized circuits on. Place the Tool in the tool stand, turn off and discharge all energized circuits, purge all pressurized connections, and verify all circuits are de-energized before performing maintenance or repair(s) on the Tool Changer or modules.

WARNING: Mounting fasteners must have a thread locker such as Loctite 242 or equivalent applied to the threads unless they have a pre-applied thread locker. Fasteners may come loose resulting in injury to personnel or damage to equipment. Use fasteners with pre-applied thread locker or apply thread locker to all mounting fasteners.

CAUTION: Do not use fasteners that exceed the thread depth in the Tool Changer (refer to *Section 8—Drawings* for details on mounting hole thread depth). Secure the Tool Changer with the proper length fasteners. This is true for both robot and tool interfaces.

Table 2.1—Optional Module Fastener Size, Class, and Torque Specifications

Mounting conditions	Fastener Size & Property Class	Recommended Torque	Thread Locker
Optional Module or adapter plate to Master or Tool plate, Supplied Fasteners	M3 x 0.5 Class 12.9		Pre-applied Adhesive or Loctite 222
	Socket head cap	10 in-lbs (1.13 Nm)	
	Socket flat head cap	8 in-lbs (0.9 Nm)	
	M4 x 0.7 Class 12.9		
	Socket head cap	15 in-lbs (1.69 Nm)	
	Socket flat head cap	10 in-lbs (1.13 Nm)	

2.1 Master Interface

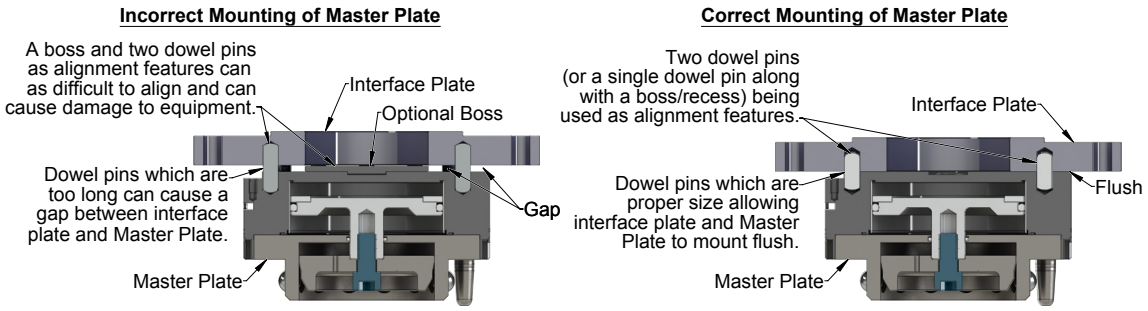
The Master assembly is attached to the robot arm. The Master plate is designed with mounting features such as a boss and/or bolt and dowel holes. These features are used to accurately position and secure the Master to the robot.

An interface plate is utilized to adapt the Master plate to a specific robot flange that is not compatible with the Master plate mounting features. Custom interface plates are available upon request (refer to *Section 8—Drawings* of this manual for technical information on mounting features).

If the customer chooses to design and build an interface plate, the following should be considered:

CAUTION: Do not use more than two alignment features when securing a Master plate to an interface plate. Using more than two alignment features can cause damage to equipment. Use either two dowel pins or a single dowel pin along with a boss/recess feature to align the Master plate with the interface plate.

CAUTION: Do not use dowel pins that are too long that will not allow the interface plate and Master body to mate flush with each other. Using dowel pins that are too long will cause a gap between the interface plate and the Master body causing damage to the equipment. Use the proper size dowel pins that will not extend further than allowed by the Master body.



- The interface plate should be designed to include bolt holes for mounting and either two dowel pins **or** a dowel pin and a boss for accurate positioning on the robot and Master plate. The dowel and boss features are important to prevent rotation (refer to robot manual for robot mounting features).
- The thickness of the interface plate must be great enough to provide the necessary thread engagement for the mounting bolts.
- Dowel pins must not extend out from the surface of the interface plate farther than the depth of the dowel holes in the Master plate.
- If a boss is used on the Master plate, a recess of proper depth and diameter must be machined into the interface plate to correspond with the boss on the Master plate.
- Mounting bolts should not be too long, such that a gap is formed at the interface.
- The interface plate must be properly designed to provide rigid mounting to the Master plate.
- The interface plate design should take into account clearances required for Tool Changer module attachments and accessories.

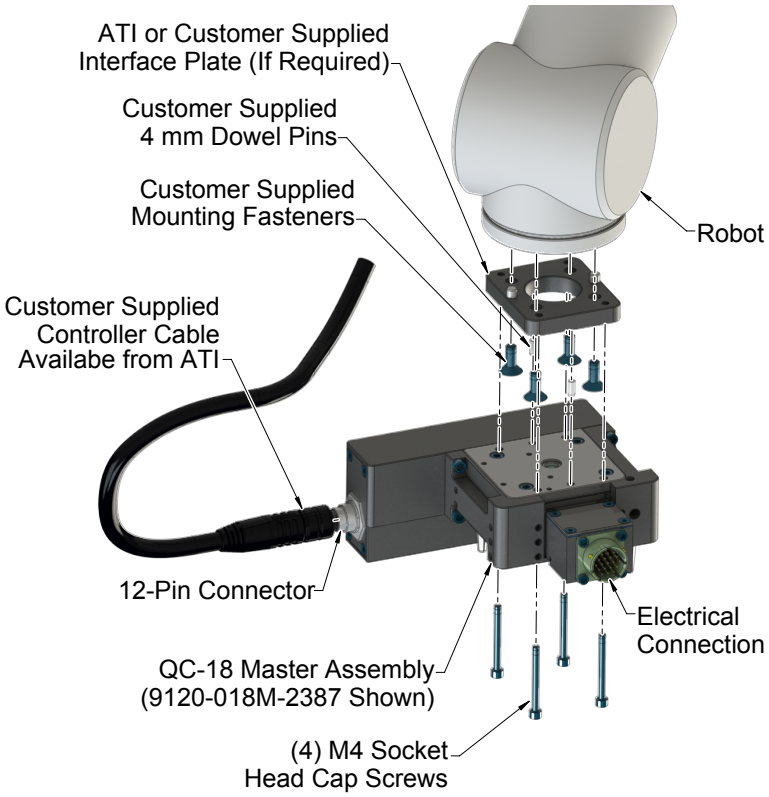
2.2 Master Plate Installation

Tools required: *4 mm hex key, torque wrench*

Supplies required: *Clean rag*

1. Make sure mounting surface of the Master plate and robot arm or interface plate are clean and free of debris.
2. If an interface plate is required, attach the plate to the robot using appropriate mounting fasteners and torque values.
3. Attach the Master plate assembly to the interface plate using the (4) M4 socket head cap screws provided. Tighten to 15 in-lbs (1.7 Nm).
4. Connect and route the cable and secure per customer cable routing requirements.
5. Connect controller to customer interface cable to the 12-pin connector on the QC-18 servo motor module and connect cable to customer interface as prescribed in *Section 2.8—Electrical Connections*.
6. Connect any electrical connection to optional modules.
7. If installation is complete, the Master plate may be put into normal operations.

Figure 2.1—Typical Master Plate Installation



2.3 Master Plate Removal

Tools required: *4 mm hex key*

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic).
4. If needed, disconnect all utilities (for example: electrical, pneumatic, and hydraulic).
5. Note: support the Master plate while removing the fasteners. Remove the (4) M4 socket head cap screws connecting the Master plate to the robot arm or interface plate.

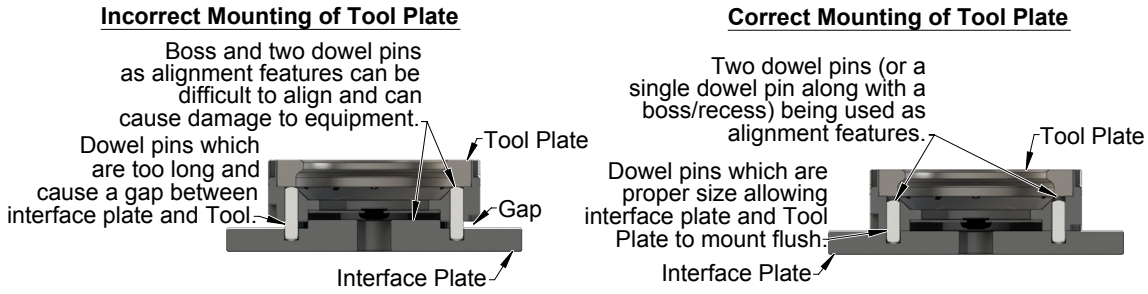
2.4 Tool Interface

The Tool plate is attached to the customer's tooling. It may be necessary for an interface plate to be utilized to adapt the Tool plate to customer's tooling. The Tool plate is designed with alignment features (dowel holes and a recess) to accurately position and bolt holes to secure the Tool plate to customer's tooling. Custom tool interface plates can be supplied by ATI to meet customer's requirements (see *Figure 2.2*).

If the customer chooses to design and build a tool interface plate, the following should be considered:

CAUTION: Do not use more than two alignment features when securing a Tool plate to an interface plate. Using more than two alignment features can cause damage to equipment. Use either two dowel pins or a single dowel pin along with a boss/recess feature to align the Tool plate with the interface plate.

CAUTION: Do not use dowel pins that are too long that will not allow the interface plate and Tool body to mate flush with each other. Using dowel pins that are too long will cause a gap between the interface plate and the Tool body causing damage to the equipment. Use the proper size dowel pins that will not extend further than allowed by the Tool body.



- The interface plate should be designed to include bolt holes for mounting and either two dowel pins **or** a dowel pin and a boss for accurate positioning on the customer tooling and Tool plate. The dowel and boss features are important to prevent rotation.
- Dowel pins must not extend out from the surface of the interface plate farther than the depth of the dowel holes in the Tool plate.
- The thickness of the interface plate must be great enough to provide the necessary thread engagement for the mounting bolts. Fasteners should be chosen to meet minimum recommended engagement lengths while not exceeding the maximum available thread depth. Use of bolts that are too long can cause damage to the tool side changer.
- The plate design should take into account clearances required for Tool Changer module attachments and accessories.
- If a boss is to be used on the interface plate, a boss of proper height and diameter must be machined into the interface plate to correspond with the recess in the Tool plate.
- The tool interface plate should be designed with a hole in its center to allow for manually returning the locking mechanism to the unlocked position under adverse conditions (i.e. unintended loss of power and/or air pressure). The center access hole should be kept small [minimum recommended hole diameter: 1" (25.4 mm)] to prevent debris from contaminating the locking mechanism while operating in dirty environments. Even greater protection will result if the standard race cover with removable access plug is used. [Note: Through hole diameter in plate: .563" (14.3 mm). Grommet outside diameter: .88" (22.5 mm)].

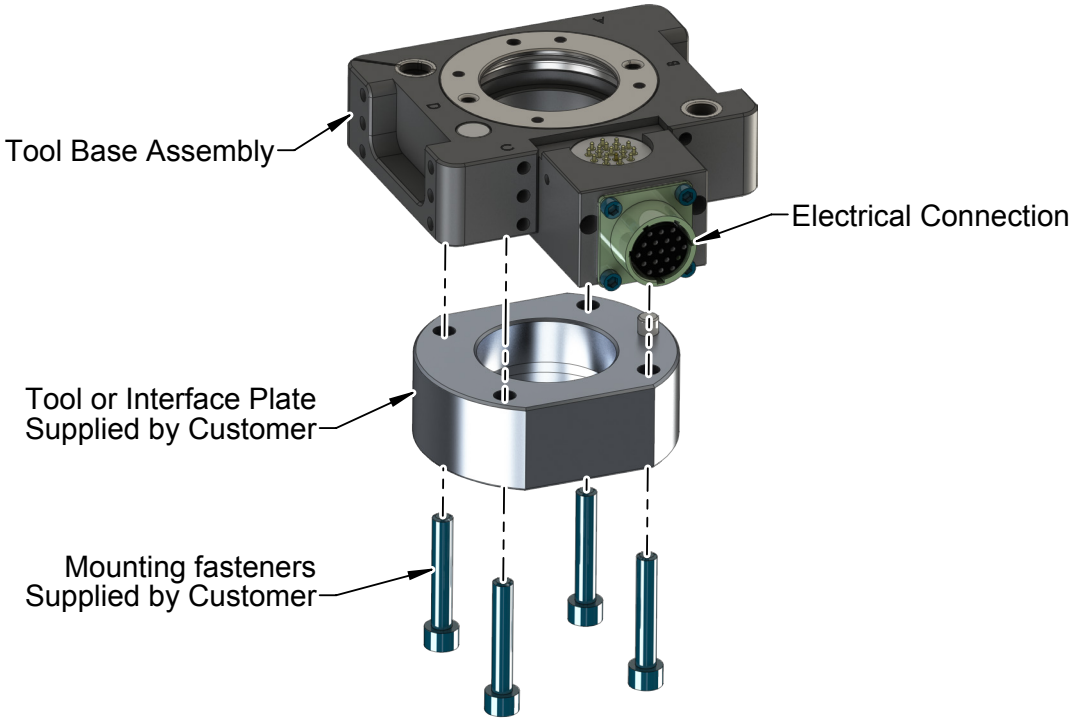
2.5 Tool Plate Installation

Tools required: *4 mm hex key, torque wrench*

Supplies required: *Clean rag*

1. Make sure the mounting surface of the Tool plate and tool interface plate is clean and free of debris.
2. Attach tool or interface plate to the Tool plate assembly using the customer supplied M6 mounting fasteners. Tighten to appropriate torque.
3. If required attach tool hanger, refer to the tool stand installation and operation manual.
4. After Tool base is secured, connect any electrical connection to optional modules.
5. If installation is complete, the Tool plate may be put into normal operations.

Figure 2.2—Typical Tool Installation



2.6 Tool Plate Removal

Tools required: *4 mm hex key*

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic).
4. If needed, disconnect all utilities (for example: electrical, pneumatic, and hydraulic).
5. Remove the fasteners connecting the Tool plate to the tooling or tool interface plate.

2.7 Optional Module Installation

The optional modules are typically installed on Tool Changers by ATI prior to shipment. Installation and removal are outlined in the following section: Tool Changers are compatible with many different types of modules.

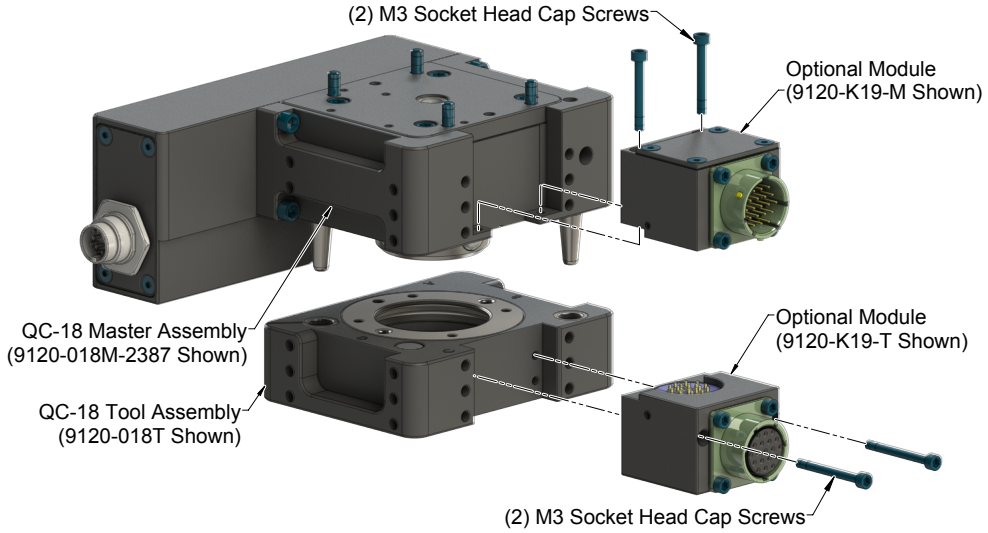
2.7.1 K Series Module Installation

Tools required: *2 mm or 2.5 mm hex key, torque wrench*

Supplies required: *Clean rag, Loctite 222*

1. If the Tool Changer is in service, place the Tool safely in the tool stand and uncouple the Tool Changer to allow clear access to the Master and Tool plates.
2. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic circuits).
3. Make sure mounting surfaces of the Tool plate, Master plate, and modules are clean and free of debris. Align optional module on flat A of Master or Tool plate assembly.
4. If not using fasteners with pre-applied adhesive, apply Loctite 222 to M3 mounting fasteners. Secure module with (2) M3 mounting fasteners using a 2 mm or 2.5 mm hex key (refer to *Table 2.1* for proper torque for your specific mounting fasteners).
5. Remove all protective caps, plugs, tape, etc from the module prior to operation.
6. Safely resume normal operation.

Figure 2.3—K Series Module Installation



2.7.2 K Series Module Removal

Tools required: *2 mm or 2.5 mm hex key*

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic).
4. Disconnect any cables, air line, etc. if required.
5. Remove the (2) M3 socket head cap screws using a 2 mm or 2.5 mm hex key. Note: For the module on the master, the Master plate may have to be removed (refer to *Section 2.3—Master Plate Removal*).
6. Remove the module from the Master or Tool plate.

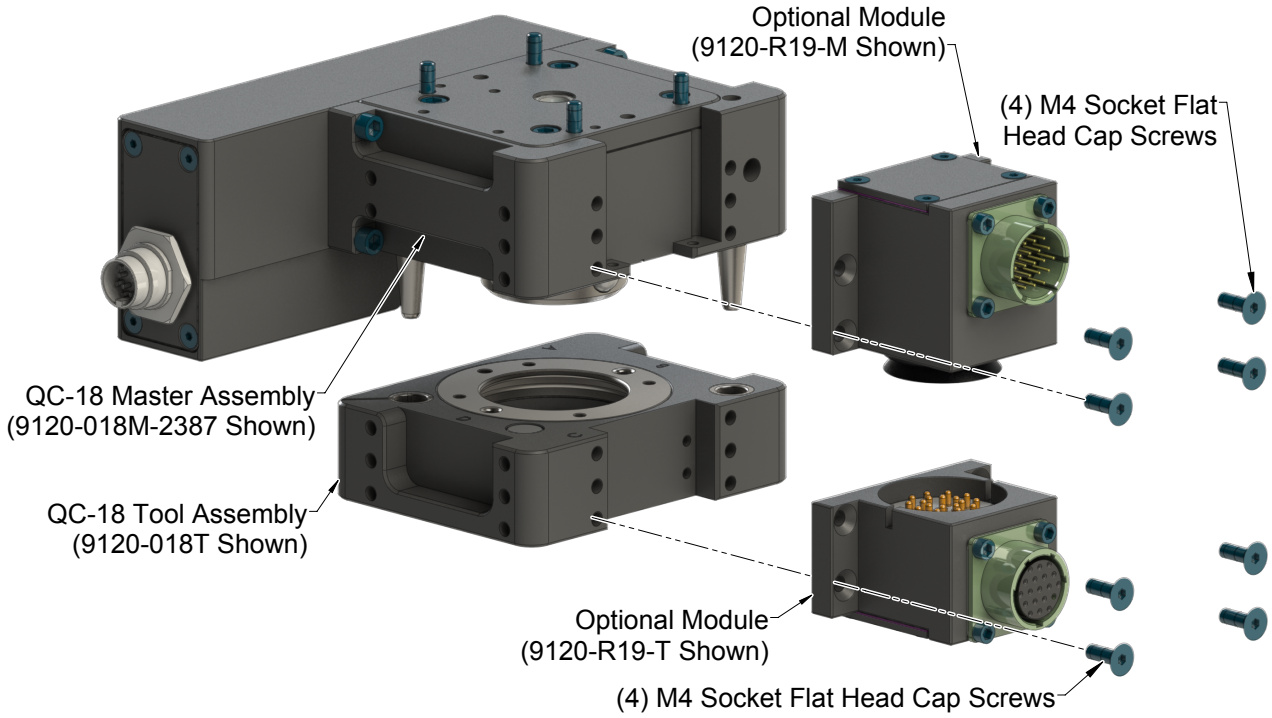
2.7.3 J16 Series Module Installation

Tools required: *2.5 mm or 3 mm hex key, torque wrench*

Supplies required: *Clean rag, Loctite 222*

1. If the Tool Changer is in service, place the Tool safely in the tool stand and uncouple the Tool Changer to allow clear access to the Master and Tool plates.
2. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic circuits).
3. Make sure mounting surfaces of the Tool plate, Master plate, and modules are clean and free of debris. Align optional module on the Master or Tool plate as shown in *Figure 2.4*.
4. If not using fasteners with pre-applied adhesive, apply Loctite 222 to (4) M4 socket head cap screws or (4) M4 socket flat head cap screws. Secure module with (4) M4 mounting fasteners using a 2.5 mm or 3 mm hex key (refer to *Table 2.1* for proper torque for your specific mounting fasteners).
5. Remove all protective caps, plugs, tape, etc from the module prior to operation.
6. Safely resume normal operation.

Figure 2.4—J16 Series Module Installation



2.7.4 J16 Series Module Removal

Tools required: *2.5 mm or 3 mm hex key*

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic).
4. Disconnect any cables, air line, etc. if required.
5. Remove the (4) M4 socket head cap screws or (4) M4 socket flat head cap screws using a 2.5 mm or 3 mm hex key, and lift the module from the Master or Tool plate.

2.8 Electrical Connections

ATI can supply an optional 1 m patch cable that has a 12-pin connector for the servo motor module and an unterminated-end or pigtail connection that customers can that customers can patch into their cable for connection back to the robot controller. Signal information of the pigtail connector is in the following table.

CAUTION: Poor cable routing can result in wires and cables being pinched in the joint between the Tool Changer halves. Failure to observe this point may result in premature failure of the cable and connection. Properly route and secure all cables, particularly on the Master side.

Table 2.2—Pigtail Connection on the Cable

Signal	Type	Voltage	Description
RTL	Input	24 V nominal Active High	The RTL signal is from the ready-to-lock proximity switch that is an independent sensor signal powered from circular connector pins ‘M/E’ (24 V / 0 V).
Latch	Output	24 V nominal Active High	Latch signals the Tool Changer to lock. The signal is powered from circular connector pins ‘H/D’ (24 V / 0 V).
Unlatch	Output	24 V nominal Active High	Unlatch signals the Tool Changer to unlock. The signal is powered from circular connector pins ‘H/D’ (24 V / 0 V).
Locked	Input	24 V nominal Active High	Locked reports the Tool Changer’s locked status. sThe signal is powered from circular connector pins ‘M/E’ (24 V / 0 V).
Unlocked	Input	24 V nominal Active High	Unlocked reports the Tool Changer’s unlocked status. The signal is powered from circular connector pins ‘M/E’ (24 V / 0 V).
24 V	24 V nominal Power	21 to 30 V	Power supply for the motor, control circuitry, and status signal reporting. Minimum of 4.2 A current source is required. The actual requirement depends on the cable length and the power wires’ gage. [1]
0 V	Ground	0 V	Ground returns for 24 V power. [1]

Note:

1. Although there are two pairs of power/ground pin connections, it is highly recommended to feed the connections from the same power supply.

Figure 2.5—System Diagram

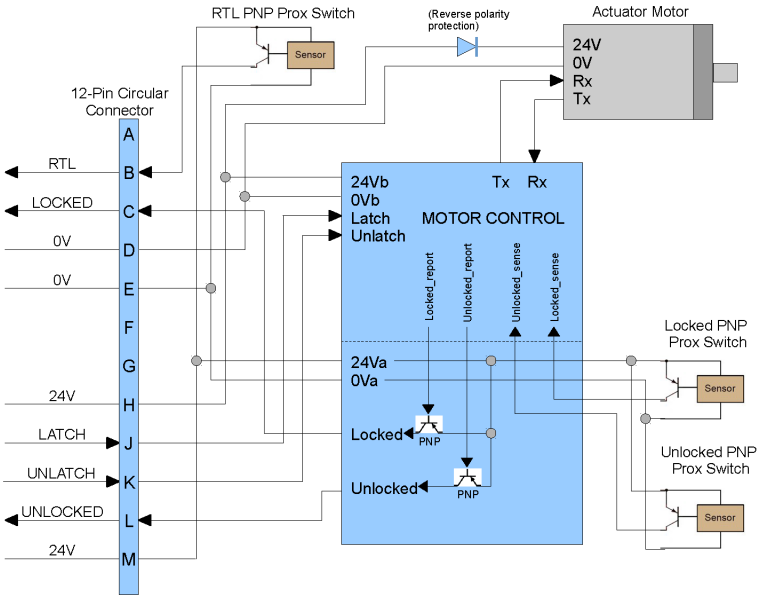
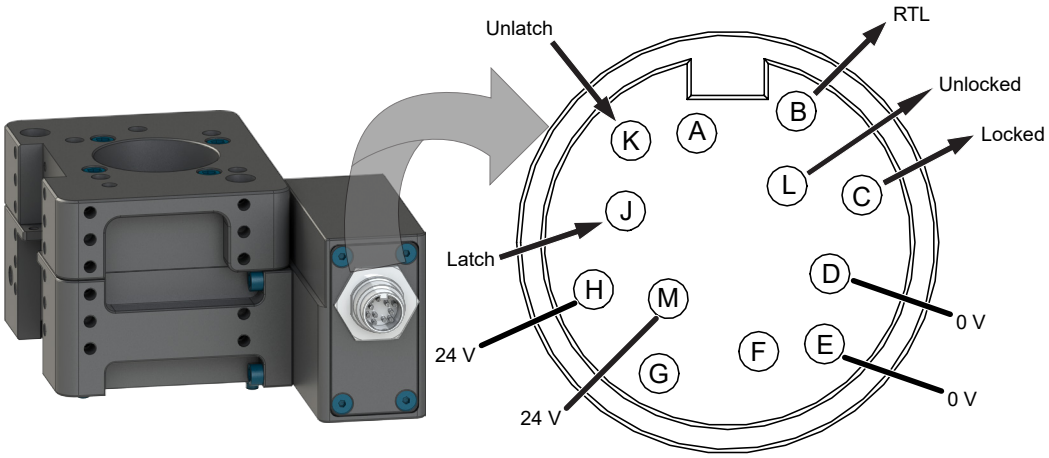


Figure 2.6—12-pin, Male Circular Connector on the Servo Motor Module



2.8.1 QC-18 Power Supply Setup and Requirements

In industrial automation applications, a common practice is to use one power supply for control logic and inputs (typically named “US1” or input power) and a different power supply for actuators and outputs (typically named “US2” or output power). In these workcells, a dead-man switch or other safety switch is often used to interrupt or shut off actuator/output power so that people may safely enter the workcell.

However, it is recommended to use the QC-18 with a single un-switched power supply that is wired to both pairs of 24 V / 0 V pins on the QC-18’s M16 connector. This wiring is recommended because then the QC-18 motor position is actively maintained at all times while the Tool Changer is coupled and ensures a fully-locked condition.

If the power to the QC-18 is interrupted, the motor loses its encoder zero position (home position). Note: If power is interrupted, the QC-18 remains safely coupled but some freeplay is possible. When power is restored, the QC-18 automatically attempts to resume the lock function, but the robot should not be run in automatic mode until the QC-18 encoder zero position (home position) is reset. The encoder zero position (home position) resets after the next “Unlatch” command is completed. Therefore, upon restoring power, it is recommended to return the tooling or end-effector, which is attached to the QC-18, to the storage nest (or other safely-supported location). Then perform a single drop-off and pick-up sequence before resuming automatic robot operation. This re-homing process guarantees the QC-18 reaches a fully locked state in subsequent tool changes.

A 24 V / 5 A power supply is recommended for robust operation, because the minimum electrical requirements at the QC-18’s M16 connector are 21 V / 4.2 A. The 0.2 amps are for part of the logic circuitry and the 4 amps are for the moment when the motor locks the tool changer. When unlocking, it doesn’t require as much: around 2.5 amps more or less. In between locks and unlocks, it consumes around 1 amp or less. Understand that the 4.2 amps is a minimum requirement and can increase depending on cable length and wire gages between the power supply and the QC18.

3. Operation

The Master locking and drive mechanism is mechanically driven to couple and uncouple with the bearing race on the Tool plate. The Master plate utilizes drive torque from a motor module to provide lock and unlock forces to the locking mechanism.

The following procedures provide general guidelines for operational sequence of the QC-18 Tool Changer. The motor controller electronics and software provide operational behavior that is intended to ensure proper operation and prevent damage to the unit.

NOTICE: All Tool Changers are initially lubricated using MobilGrease® XHP222 Special grease. The end user must apply additional lubricant to the locking mechanism components and alignment pins prior to start of service (see *Section 4.2—Cleaning and Lubrication of the Locking Mechanism and Alignment Pins*). Tubes of lubricant for this purpose are shipped with every Tool Changer. Note: MobilGrease XHP222 Special is a NLGI #2 lithium complex grease with molybdenum disulfide.

The robot should be programmed to minimize misalignment during coupling and uncoupling. Additionally, the tool stand should be durable and not allow deflection, under uncoupled Tool weight that will take alignment of the Tool Changer plates outside of accepted offsets. See *Figure 3.1* and *Table 3.1* for recommended maximum allowable offsets prior to coupling. In some cases, greater offsets than shown in *Table 3.1* can be accommodated by the Master and Tool plates but will increase wear.

Lock up should occur with the Master plate in the No-Touch™ locking zone (refer to *Table 3.1*) but not touching the Tool plate. As locking occurs, the Master plate should draw the Tool plate into the locked position.

Figure 3.1—Offset Definitions

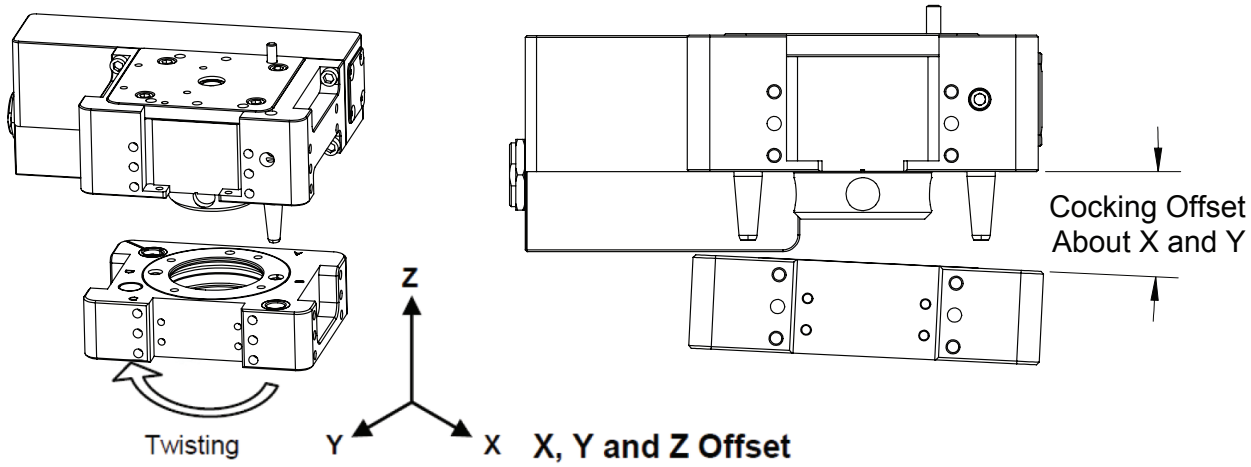


Table 3.1—Maximum Recommended Offsets Prior to Coupling

Model	Z Offset (Max)[1]	X and Y Offset (Max) [2]	Cocking Offset (Max)	Twisting Offset (Max)
QC-18	0.04” (1.0 mm)	±0.04” (1.0 mm)	±0.7°	±1°

Notes:
1. Maximum values shown. Decreasing actual values will minimize wear during coupling/uncoupling.
2. Actual allowable values may be higher in some cases but higher offsets will increase wear during coupling.

3.1 Power Loss During Operation

In the event that the motor and motor controller loses power during operation and if the Tool Changer is within locked sensing range, immediately stop operation and restore power. The motor controller is designed to apply a small force with the motor to maintain the Tool Changer in the locked position. When power is lost, a slight separation between the Master and Tool plates might occur but the Tool Changer will not uncouple it will remain in a fail-safe condition but I/O (sensor inputs) will be lost between Master and Tool (refer to *Section 3.3—Fail-Safe Condition* for more information).

3.2 Procedure for Tool Pickup

CAUTION: The locking mechanism must be in the unlock position when attempting to couple the Tool Changer. Failure to adhere to this condition may result in damage to the unit and/or the robot

NOTICE: When the unit powers up, the QC will remain in place until a Latch or Unlatch output signal is received. A +24V signal on the Latch will make the QC lock. A +24V signal on the Unlatch wire will make the QC Unlock. Once a signal is received, the QC will move to that location until the cycle is complete. The unit homes itself during the first unlatch after power-up. Therefore, the first latching and/or unlatching cycles will be slightly slower but still meet the transition time of within 1 second.

1. Verify the Unlock signal is ON and the Locked signal is OFF. Indicates the Tool Changer is in the Unlocked position.
2. Position the Master above the Tool and move the Master into position. The mating surfaces of the Master and Tool should be parallel and within 0.04” (1 mm) of each other before coupling to minimize wear on the locking mechanism.

CAUTION: Make sure that the tapered alignment pins from the Master enter the alignment holes on the Tool. The alignment pins should be relatively concentric with the alignment holes such that they do not rub against the edge.

3. (Optional) Verify that the RTL (Ready to Lock) signal is ON. This ensures that the Master is within 1 mm of the Tool.
4. If the Unlatch command is ON, turn it OFF. Turn the Latch command ON. Within 1 second, the Master will lock.

CAUTION: The Unlatch and Latch output signal must be on for a minimum of 50 ms or the QC will not respond.

5. Verify the Unlocked signal is OFF and the Locked signal is ON. This indicates that the Tool Changer is in the Locked position.
6. Move the tool away from the tool stand.

3.3 Fail-Safe Condition

In the event of power loss to the locking mechanism the Tool Changer **will not uncouple**. A slight separation between the Master and Tool plates might occur just after power loss but at this point the worm gear teeth will not back drive without power being applied to the unlatch command. This feature provides the Tool Changer with a fail-safe mechanism.

Positional accuracy may not be maintained during power loss but will be regained once power is re-established to the motor module.

CAUTION: Do not use the Tool Changer in the fail-safe condition for extended periods of time. Do not transport the Tool Changer in the fail-safe condition. Possible damage to the locking mechanism could occur.

3.4 Procedure for Tool Drop Off

1. Position the robot to place the tool securely in the tool stand.
2. If the Latch command is ON, turn it OFF. Turn the Unlatch command ON. Within 1 second, the Master will unlock.

NOTICE: The Unlatch and Latch output signal must be on for a minimum of 50 ms or the QC will not respond.

3. Verify the Unlocked signal is ON and the Locked signal is OFF, indicating the Tool Changer is in the Unlocked position.

NOTICE: The Unlocked signal should read “ON” and the Locked signal should read “OFF”. Any other condition indicates a problem and the robot program should be halted.

4. Move the Master away from the tool.

3.5 Recommended Sequence of Operations

Use this Recommended Sequence of Operations procedure as a general guide when programming a robot or PLC for use with a Tool Changer and control/signal modules. This procedure is intended for "automatic" modes used during normal application processes.

3.5.1 Typical Start

1. Upon power-up, the robot and Tool Changer Master are free of the stand or storage location, the Tool Changer is uncoupled and the Tool Changer locking mechanism may be fully retracted (unlocked condition) or fully extended (missed Tool condition, for example: **Locked** and **Unlocked** inputs are false). The Tool is by itself in the tool stand.

   a. On the QC-18, no other direct feedback signals like are true, for example: **Tool Present**.

   b. There is one independent **Ready-to-Lock** input to allow detection of proximity to the tool, but the QC-18 Master does not keep track of its status. This signal is only available to the robot or PLC.

2. Ensure the Master is **Unlocked** (The Master must be unlocked prior to entering the Tool so that the ball bearings do not impinge on the Tool bearing race.)

   a. The **Unlatch** output command is made true.

   b. If the Master is already in the **Unlocked** position and the previous command had been unlatch, then the Unlatch command is ignored.

   c. If the Master is not already in the **Unlocked** position and the internal encoder has not been homed (zero position determined), then the Master uses a current-based method to reach the unlocked position and then internally sets that position to be zero (home).

   d. If the Master is not already in the **Unlocked** position and the internal encoder has been homed previously, then the Master uses the standard position-based method to reach the unlocked position. If the Master doesn't reach the homed position within tolerance, the Master retries once again before aborting.

3. The Master enters the Tool aligning the ball bearings with the Tool bearing race.

   a. The **Latch** output command is made true.

   b. If the Master is already in the **Locked** position and the previous command had been Latch, then the Latch command is ignored.

   c. If the Master is not already in the **Locked** position and the internal encoder has not been homed (zero position determined), then the Master uses a current-based method to reach the locked position.

   d. If the Master is not already in the **Locked** position and the internal encoder has been homed previously, then the Master use the standard position-based method to reach the locked position. If the Master doesn't reach the locked position within tolerance, the Master retries twice before aborting.

3.5.2 Alternate Start

1. Upon power-up, the robot and Tool Changer Master are coupled with the Tool. Internally, the Master reads that the lock sensor detects the Master is within the positional range of the locked region. However, the robot or PLC cannot detect if the Master and Tool were completely coupled while power was off, since the unit has not yet homed and the encoder count is undefined.

   a. Under these conditions, an automatic procedure occurs where the Master uses the current-based method to retighten into the locked position.

   b. The Master then reports that it is in the **Locked** position.

2. Ensure that the coupled Master and Tool are in the tool stand to unlock.

   a. The **Unlatch** output command is made true.

   b. The Master is in the **Locked** position but it has not previously been homed, so the Master uses a current-based method to reach the unlocked position. Then internally the Master sets that position to be zero (home).

3.6 Tool Storage Considerations

NOTICE: Tool stand design is critical to operation of the Tool Changer. Improperly designed tool stands can cause jamming and excessive wear of the Tool Changer components.

Tool plates with customer tooling attached may be stored in a tool stand. ATI provides compatible tool stands designed for durability, longevity, and maximum adaptability to fit most customers' applications. The ATI Tool Stand Small (TSS) system is compatible with ATI Tool Changer sizes QC-001 to QC-41. The TSS systems ystems can be configured in a variety of arrangements and are available with additional modular accessories such as covers and tool sensing. For products available, contact an ATI representative or refer to the following ATI webpage: *http://www.ati-ia.com/products/toolchanger/toolstand/small/SmallStand.aspx*. Another resource is the *ATI TSS manual*: *https://www.ati-ia.com/app_content/Documents/9610-20-1068.pdf*.

For some Tool Changers, ATI can provide a Teaching Aid to assist users with teaching the robot how to couple the Master with the Tool in a tool stand. For more information, refer to the ATI webpage for Teaching Aids: *https://www.ati-ia.com/products/toolchanger/TeachingAid.aspx*.

If the customer supplies the tool stand, the tool stand should include the following design considerations:

- Provide a fixed, repeatable, level, and stable position for tool pick-up and drop-off.
- Support the weight of the Tool Changer Tool plate, tool interface plate, optional modules, cables, hoses, and customer tooling without allowing deflection in excess of the offsets specified.
- (Preferred) the Tool should hang vertically in the tool stand so that gravity assists to uncouple the Tool plate from the Master plate during unlocking.
- It is possible to design tool stands that hold tools in the horizontal position, but the necessary compliance must be provided during coupling and uncoupling. In general, horizontally positioned tool stands cause more wear on the locking mechanism and locating features of the Tool Changer and tool stand. Furthermore, horizontal pick-up and drop-off of the Tool plate increases wear on the robot arm.
- A variety of methods may be used to position the Tool in the tool stand. A common method is to use tapered alignment pins and bushings. Robot programming and positional repeatability are critical aspects of successful Tool pick-up and drop-off.
- Install a debris shield to cover Tools and modules to protect them in dirty environments, such as grinding or welding. Alternatively, position tool stands in areas that are shielded from weld spatter, fluids, adhesives, or other debris.
- For proximity sensors, consider the following:
    - Install a proximity sensor that detects the presence of the Tool in the tool stand. The sensor may be used prior to coupling to ensure the Tool is seated in the stand. Sensors may also be used as the robot starts to move away after uncoupling. Sensors provide a safety measure if a Tool becomes jammed in the stand or if the Tool fails to release from the robot.
    - Position the proximity sensor so that the sensing face is vertical to prevent metal shavings, weld spatter, or other debris from falling on the sensor and creating false readings.

4. Maintenance

WARNING: Do not perform maintenance or repair(s) on the Tool Changer or modules unless the Tool is safely supported or placed in the tool stand, all energized circuits (for example: electrical, air, water, etc.) are turned off, pressurized connections are purged and power is discharged from circuits in accordance with the customer specific safety practices and policies. Injury or equipment damage can occur with the Tool not placed and energized circuits on. Place the Tool in the tool stand, turn off and discharge all energized circuits, purge all pressurized connections, and verify all circuits are de-energized before performing maintenance or repair(s) on the Tool Changer or modules.

NOTICE: The cleanliness of the work environment strongly influences the trouble free operation of the Tool Changer. The dirtier the environment, the greater the need for protection against debris. Protection of the entire EOAT, the Master, the Tool and all of the modules may be necessary. Protective measures include the following:

1) Placement of tool stands away from debris generators.
2) Covers incorporated into the tool stands.
3) Guards, deflectors, air curtains, and similar devices built into the EOAT and the tool stand.

4.1 Preventive Maintenance

The Tool Changer and optional modules are designed to provide a long life with regular maintenance. A visual inspection and preventive maintenance schedule is provided in the following table depending upon the application. Detailed assembly drawings are provided in *Section 8—Drawings* (refer to module sections for detailed preventive maintenance steps for all utility modules).

Table 4.1—Maintenance

Application(s)	Tool Change Frequency	Inspection Schedule
General Usage Material Handling Docking Station	> 1 per minute	Weekly
	< 1 per minute	Monthly
Welding/Servo/Deburring, Foundry Operations (Dirty Environments)	All	Weekly

Checklist

Mounting Fasteners

- ☐ Inspect fasteners for proper torque, interferences, and wear. Tighten and correct as required.

Ball Bearings/Alignment Pins/Bushings/Bearing Race

- ☐ Inspect for wear and proper lubrication. MobilGrease XHP222 Special is a NLGI #2 lithium complex grease with molybdenum disulfide additive is suggested for locking mechanism and alignment pin lubrication. Over time, lubricants can become contaminated with debris. Therefore, it is recommended to thoroughly clean the existing grease and replace with new as needed (refer to *Section 4.2—Cleaning and Lubrication of the Locking Mechanism and Alignment Pins*).
- ☐ Inspect for excessive alignment pin/bushing wear, may be an indication of poor robot position during pickup/drop off. Adjust robot position as needed. Check tool stand for wear and alignment problems. To replace worn alignment pins (refer to *Section 5.3.2—Alignment Pin Replacement*).
- ☐ Inspect for wear on the ball bearings/bearing race, may be an indication of excessive loading.

Sensors and Cables

- ☐ Inspect sensor cable connectors for tightness, if loose tighten connections.

Electrical Contacts/Pin Block (Modules)

- ☐ Inspect for damage, debris, and stuck/burnt pins. Clean pin blocks as required (refer to *Section 4.3—Pin Block Inspection and Cleaning*).

Seals (Modules)

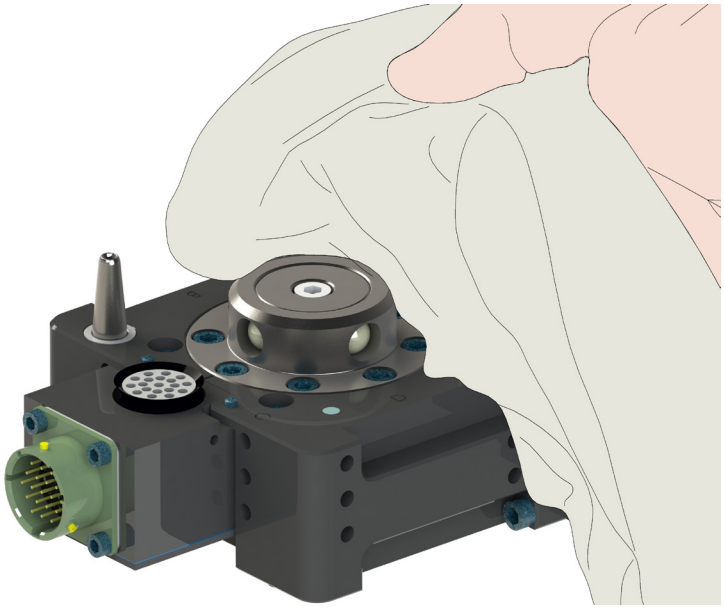
- ☐ Inspect for wear, abrasion, and cuts (refer to *Section 5.3.1—V-ring Seal Replacement*)

4.2 Cleaning and Lubrication of the Locking Mechanism and Alignment Pins

Supplies required: *Clean rag, cotton swabs, NLGI #2 lithium complex grease*

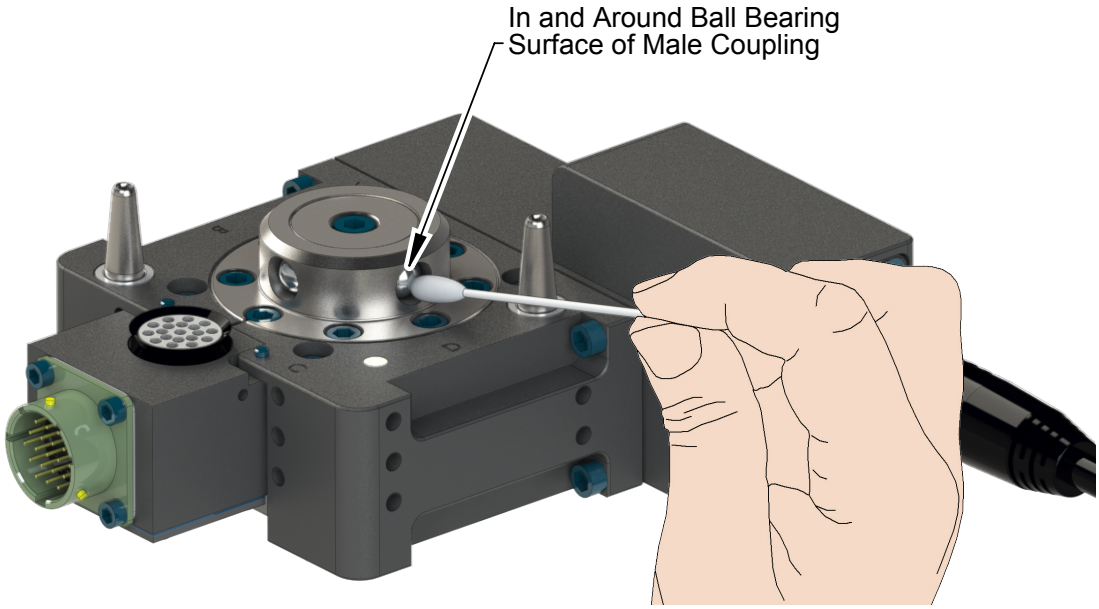
1. Place the Tool in a secure location.
2. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic circuits).
3. The locking mechanism must be in the unlock state before cleaning.
4. Use a clean rag to thoroughly remove the existing lubricant and debris from the ball bearings, the male coupling, the cam, and the alignment pins.

Figure 4.1—Cleaning Ball Bearings and Outer Surfaces of Male Coupling



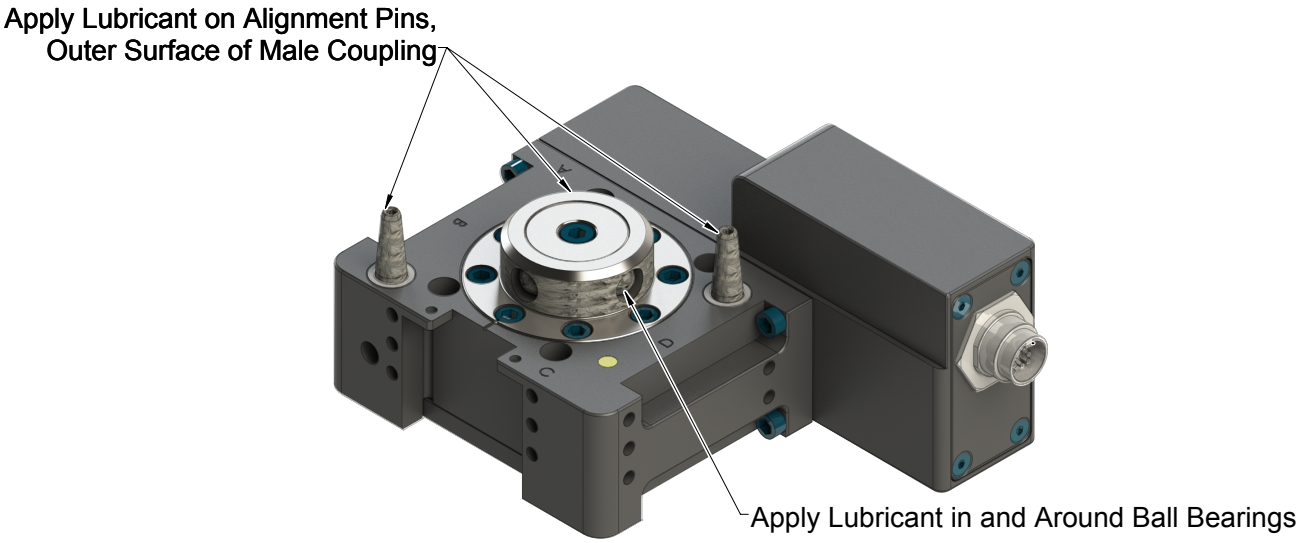
5. Use a clean cotton swab to thoroughly remove the existing lubricant and debris from the balls, rotate the balls to clean the in and around the balls.

Figure 4.2—Cleaning Ball Bearings of Locking Mechanism



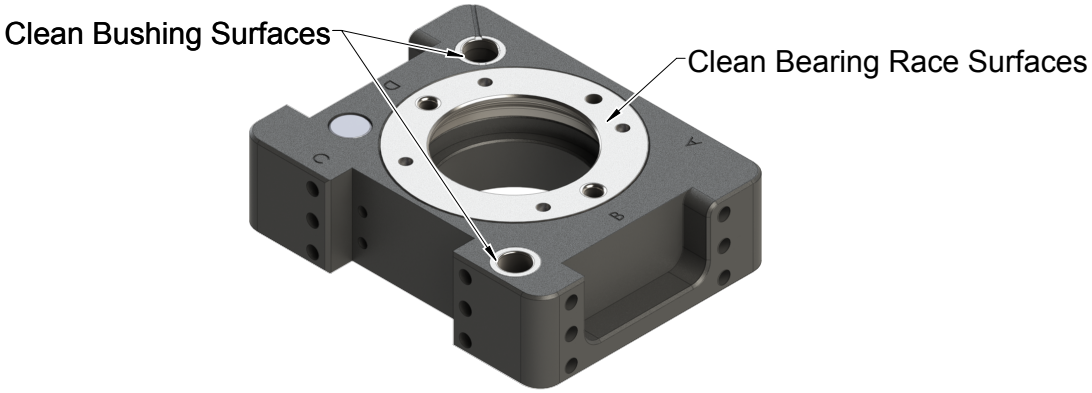
6. Check each ball bearing to make sure it moves freely in the male coupling. Additional cleaning may be necessary to free up any ball bearings that are sticking in place.
7. Apply a liberal coating of lubricant to the ball bearings, male coupling, and alignment pins.

Figure 4.3—Apply Lubricant to Locking Mechanism



8. Use a clean rag to thoroughly remove the any lubricant and debris from the bearing race and the bushings from the Tool plate.

Figure 4.4—Clean Tool Plate Surfaces of Locking Mechanism



9. No application of lubrication is necessary on the Tool plate components.
10. Safely resume normal operation.

4.3 Pin Block Inspection and Cleaning

Tools required: *Nylon Brush (ATI part number 3690-0000064-60)*

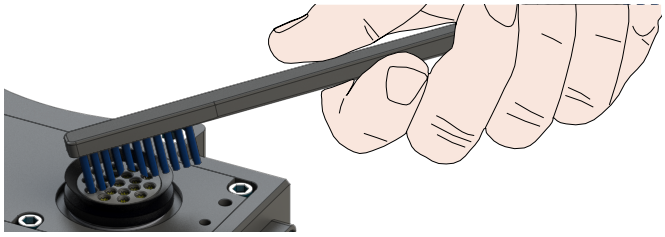
1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic circuits).
4. Inspect the Master and Tool pin blocks for debris or darkened pins.

Figure 4.5—Inspect Master and Tool Pin Blocks

5. If debris or darkened pins are present, use a vacuum to remove the debris, and clean using a nylon brush (ATI part number 3690-0000064-60).

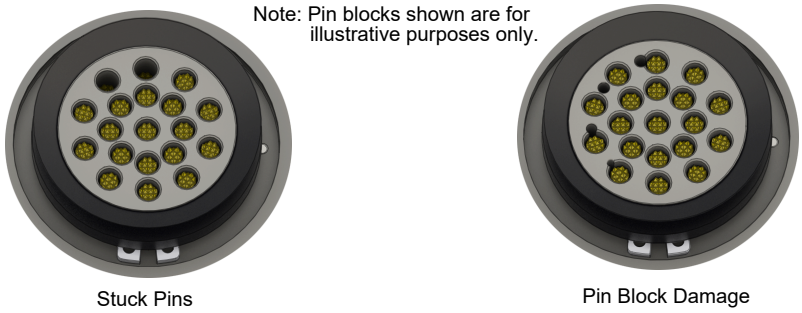
NOTICE: Do not use an abrasive media and/or cleaners or solvents to clean the contact pins. Using abrasive media and/or cleaners or solvents will cause damage to the contact surface or cause pins to stick. Clean contact surfaces with a vacuum or non-abrasive media such as a nylon brush (ATI part number 3690-0000064-60).

Figure 4.6—Clean Pin Blocks with a Nylon Brush



6. Inspect the Master and Tool pin blocks for stuck pins or pin block damage.

Figure 4.7—Stuck Pin and Pin Block Damage



7. If pins become stuck or if there is damage to the pin block, contact ATI for either a possible pin replacement procedure or module replacement.
8. Safely resume normal operation.

5. Troubleshooting and Service Procedures

The following section provides troubleshooting and service information to help diagnose conditions and repair the Tool Changer or control module.

WARNING: Do not perform maintenance or repair(s) on the Tool Changer or modules unless the Tool is safely supported or placed in the tool stand, all energized circuits (for example: electrical, air, water, etc.) are turned off, pressurized connections are purged and power is discharged from circuits in accordance with the customer specific safety practices and policies. Injury or equipment damage can occur with the Tool not placed and energized circuits on. Place the Tool in the tool stand, turn off and discharge all energized circuits, purge all pressurized connections, and verify all circuits are de-energized before performing maintenance or repair(s) on the Tool Changer or modules.

5.1 Troubleshooting Procedures

The troubleshooting table is provided to assist in diagnosing issues that may cause the Tool Changer not to function properly.

Table 5.1—Troubleshooting

Symptom	Cause	Resolution
Unit will not lock or unlock	Debris caught between Master and Tool plates	Clean debris from between Master and Tool plates. Verify mounting fasteners are secure and does not protrude above mating surfaces.
	Ball bearings and/or cam are not moving freely in male coupling.	Clean and lubricate as needed to restore smooth operation (refer to *Section 4.2—Cleaning and Lubrication of the Locking Mechanism and Alignment Pins*)
	Motor controller is not operating correctly.	Check cabling to and from motor controller, replace cabling if damaged.
		Replace servo motor module
	Master plate and Tool plate are not within specified No-Touch zone when attempting to lock.	Check Tool is properly seated in tool stand (refer to *Section 3.6—Tool Storage Considerations*) Re-teach robot to bring Master plate and Tool plate closer together prior to attempting to lock.
	Ready To Lock (RTL) sensor is not activated indicating Tool is not positioned properly	Check Tool is properly seated in tool stand. Re-teach robot to bring Master and Tool closer together prior to attempting to lock. Check all cables for damage and they are connected properly to signal control/signal module. Replace damaged cables as necessary. Check RTL sensor is not damaged. Replace damaged RTL sensor as necessary, contact ATI for possible pin replacement procedures or module replacement.
	Motor is not operating correctly.	Replace if damaged (refer to *Section 5.3.3—Servo Motor Module Replacement*). If Tool Changer is in locked position refer to *Section 5.2—Manual Actuaion*.
Units Equipped with Electrical/Servo/Control/Signal Modules		
Loss of Communication	Debris in and around contact pins. Contact Pin worn or damaged.	Inspect V-ring seal for damage, replace damaged seal (refer to *Section 5.3.1—V-ring Seal Replacement*)
	Cable connections loose or cables damaged	Check cable connection are secure and cables are not damaged.

5.2 Manual Actuation

Tools required: *3 mm hex key*

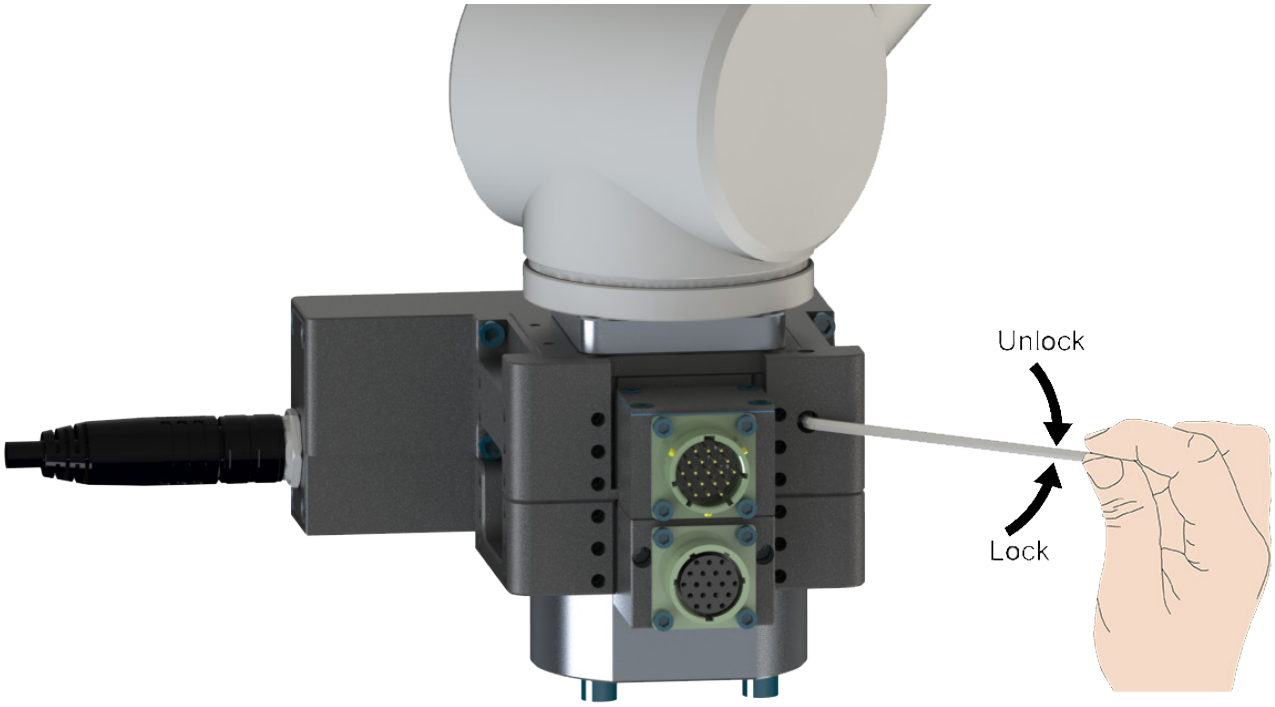
In certain cases it may be necessary to manually unlock or lock the Tool Changer. This can be done by using a 3 mm hex key and accessing the unit's drive shaft from the side of the Master plate assembly as shown in *Figure 5.1*. It takes approximately (8) turns to fully unlock the unit.

WARNING: Do not manually unlock the Tool Changer without supporting the tool. An unsupported tool could cause damage to equipment or injury to personnel. Support the tool before attempting to manually unlock the Tool Changer.

CAUTION: Never couple or uncouple the unit without first disconnecting and discharging the power that passes through the contacts. This is especially true if high voltage circuits are involved. Arcing and contact damage will occur if this is not observed. Always disconnect and discharge electrical power from both upstream and downstream modules.

NOTICE: Depending on the module installed on Flat C, it may be necessary to remove the module to access to the manual unlock mechanism. To remove the module refer to *Section 2.7.4—J16 Series Module Removal*.

Figure 5.1—Manual Unlock



5.3 Service Procedures

Component replacement procedures are provided in the following section:

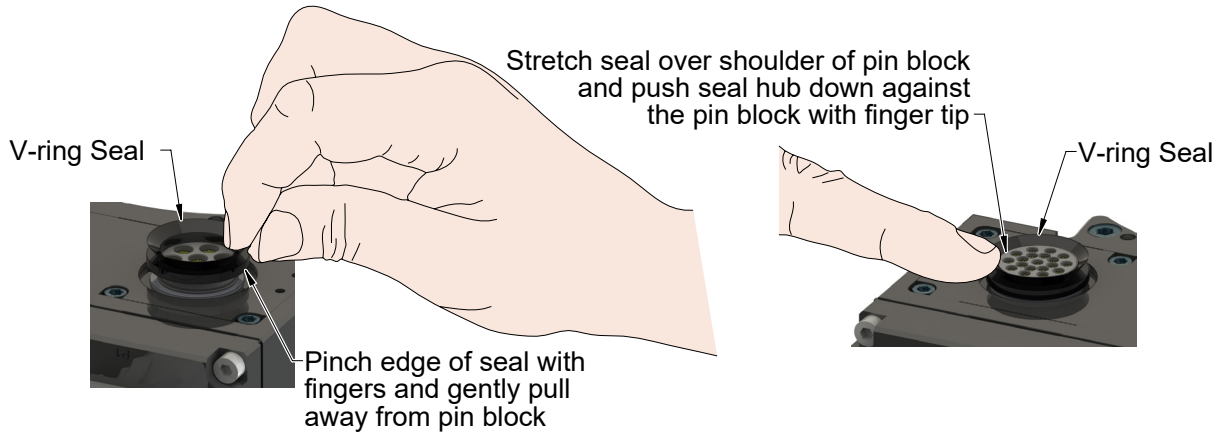
5.3.1 V-ring Seal Replacement

Parts required: *Refer to Module Manual.*

The seal protects the electrical connection between the Master and Tool module. Replace the seal if it becomes worn or damaged.

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (for example: electrical, pneumatic, and hydraulic circuits).
4. To remove the existing seal, pinch the edge of the seal and pull the seal away from the pin block on the Master module.
5. To install a new seal, stretch the new seal over the shoulder of the pin block.
6. Push the seal hub down against the pin block.
7. Safely resume normal operation.

Figure 5.2—V-ring Seal Replacement



5.3.2 Alignment Pin Replacement

Parts required: *Refer to Section 6.1—Master Plate - Model 9120-018M-2387-0-0-0-SG2 Serviceable Parts.*

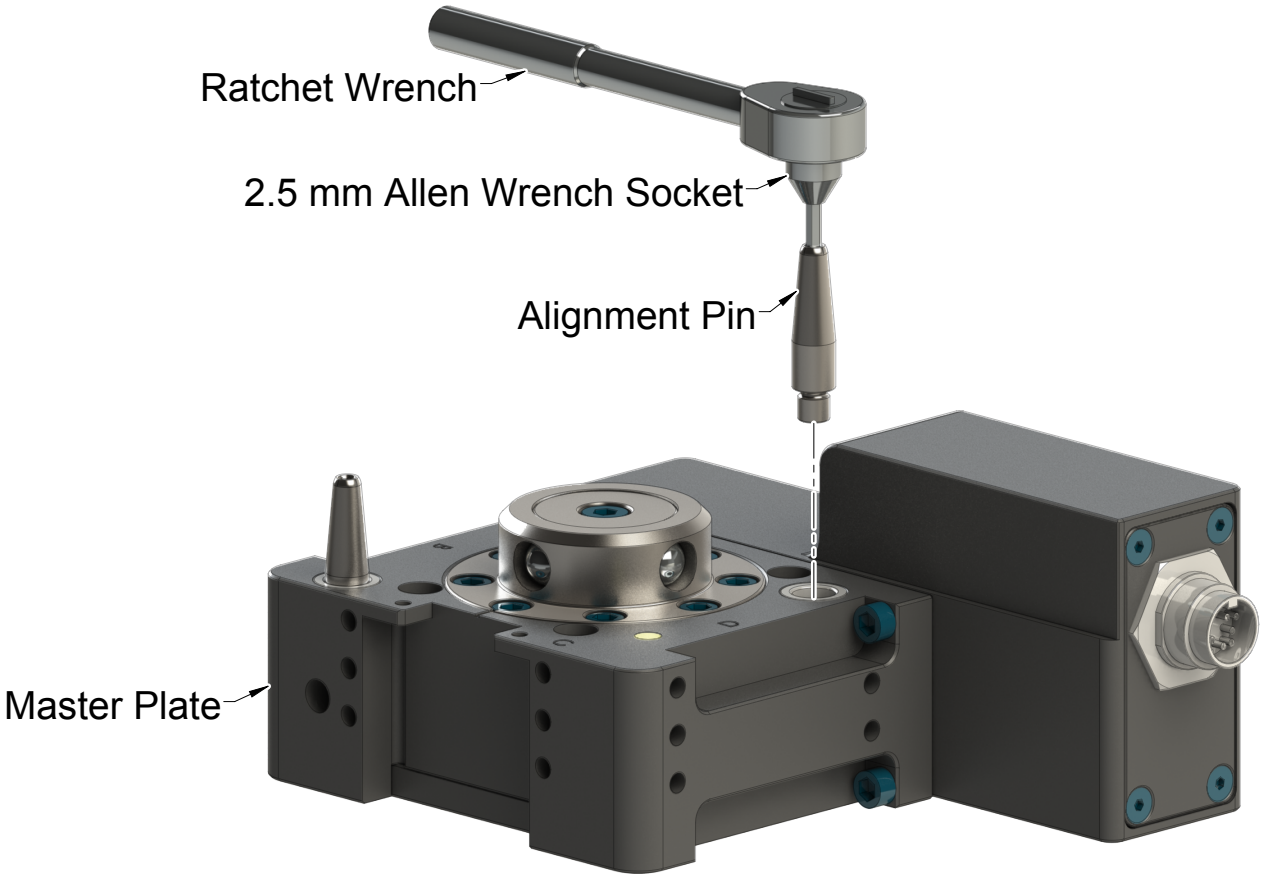
Tools required: *4 mm hex key, torque wrench*

Supplies required: *NLGI #2 lithium complex grease*

1. Place the Tool in a secure location.
2. Turn off and de-energize all energized circuits (for example: electrical, air, etc.).
3. Unscrew the alignment pin from the Master plate using a 2.5 mm hex key (see *Figure 5.3*).

NOTICE: If for any reason the pin cannot be removed using the hex key in the tip, it may be necessary to remove it by other means, such as locking pliers.

Figure 5.3—Replace Alignment Pin



4. Apply Loctite 242 to threads of new alignment pin and install into Master plate using a 2.5 mm hex key. Torque to 18 in-lbs (2.0 Nm).
5. Apply MobilGrease XHP222 Special grease to the alignment pin (see *Section 4.2—Cleaning and Lubrication of the Locking Mechanism and Alignment Pins*).
6. Safely resume normal operation.

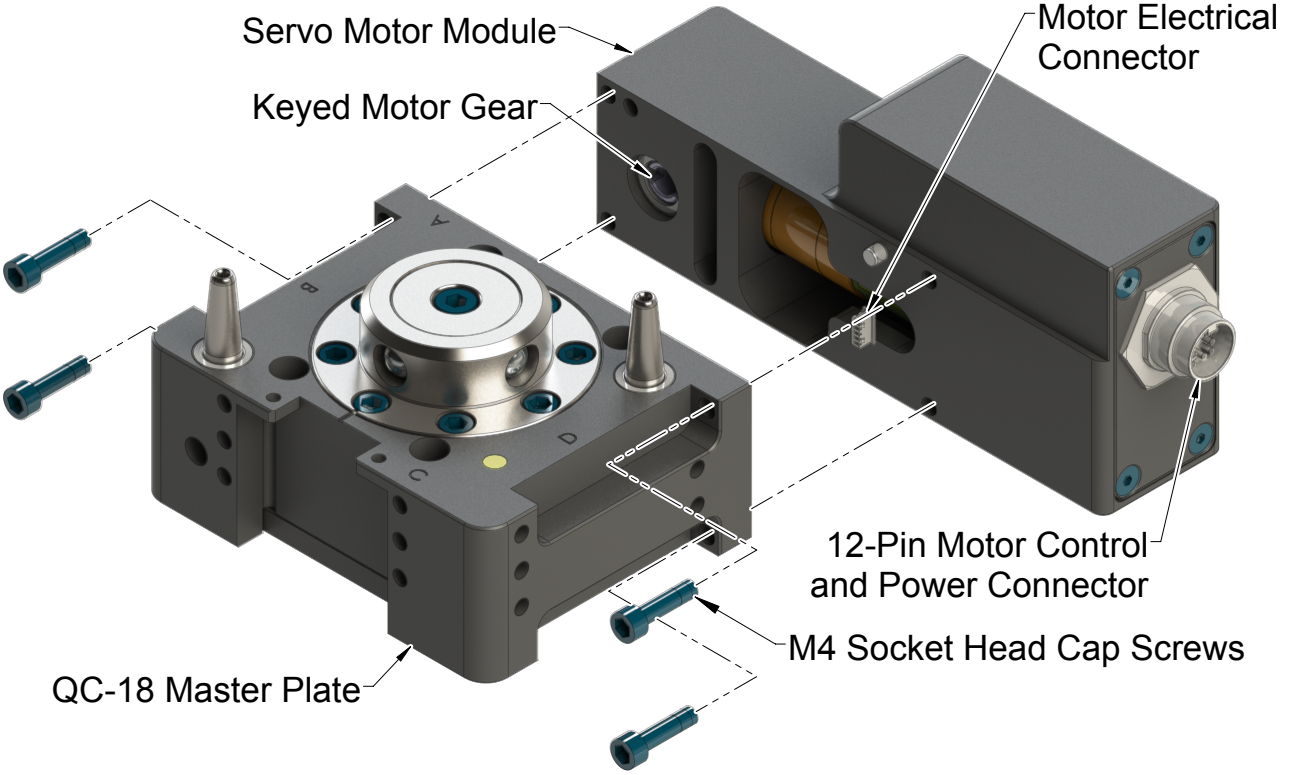
5.3.3 Servo Motor Module Replacement

Parts required: *Refer to Section 6.1—Master Plate - Model 9120-018M-2387-0-0-0-SG2 Serviceable Parts.*

Tools required: *4 mm hex key, torque wrench*

1. Place the Tool in a secure location.
2. Turn off and de-energize all energized circuits (for example: electrical, air, etc.).
3. Remove any optional module mounted on Flats B and D.
4. Disconnect the customer interface cable from the 12-pin connector.
5. Using a 4 mm hex key, remove the (4) M4 socket head caps screws mounting the servo motor module to Flat A (refer to *Figure 5.4*).
6. Remove the servo motor module and disconnect the motor electrical connector from the sensor connector (refer to *Figure 5.5*).

Figure 5.4—Replace Servo Motor Module

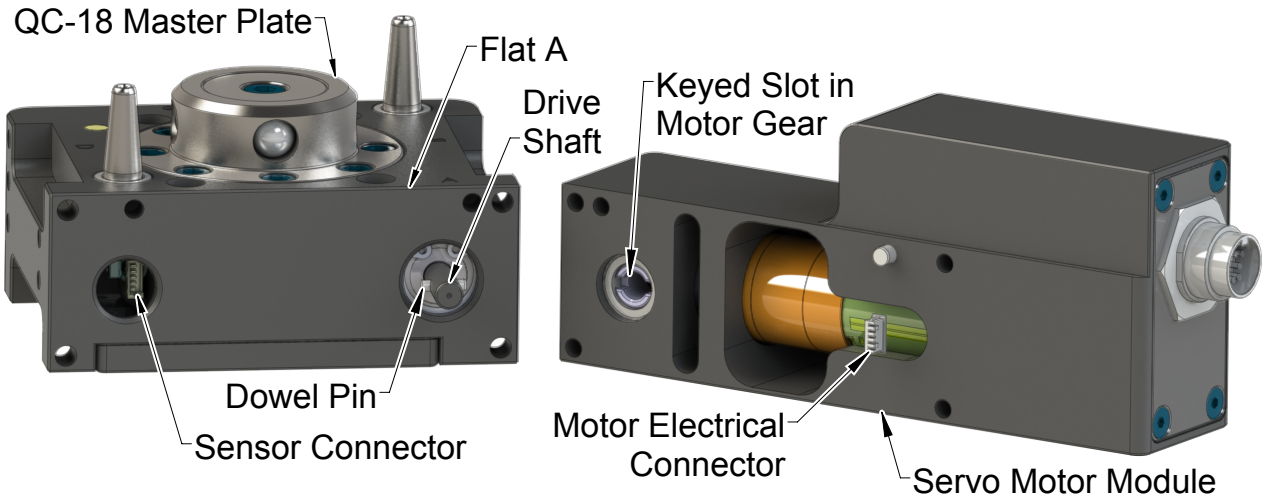


7. Connect the motor electrical connector of the new servo motor module to the sensor connector of the Master plate (refer to *Figure 5.5*).

NOTICE: When installing the new servo motor module be careful not to pinch the wires. Always make sure wires are safely tucked into the servo motor module before installing the servo motor module.

8. Install the new servo motor module onto the Master plate, orient the dowel pin in the drive shaft with the keyed slot in the motor gear.

Figure 5.5—Master Plate Flat A



9. If fastener does not have pre-applied adhesive, apply Loctite 242 to threads of (4) M4 socket head caps screws and install into the servo motor module using a 4 mm hex key. Torque to 25 in-lbs (2.82 Nm).
10. Connect the customer interface cable to the 12-pin connector.
11. Safely resume normal operation.

6. Serviceable Parts

6.1 Master Plate - Model 9120-018M-2387-0-0-0-SG2 Serviceable Parts

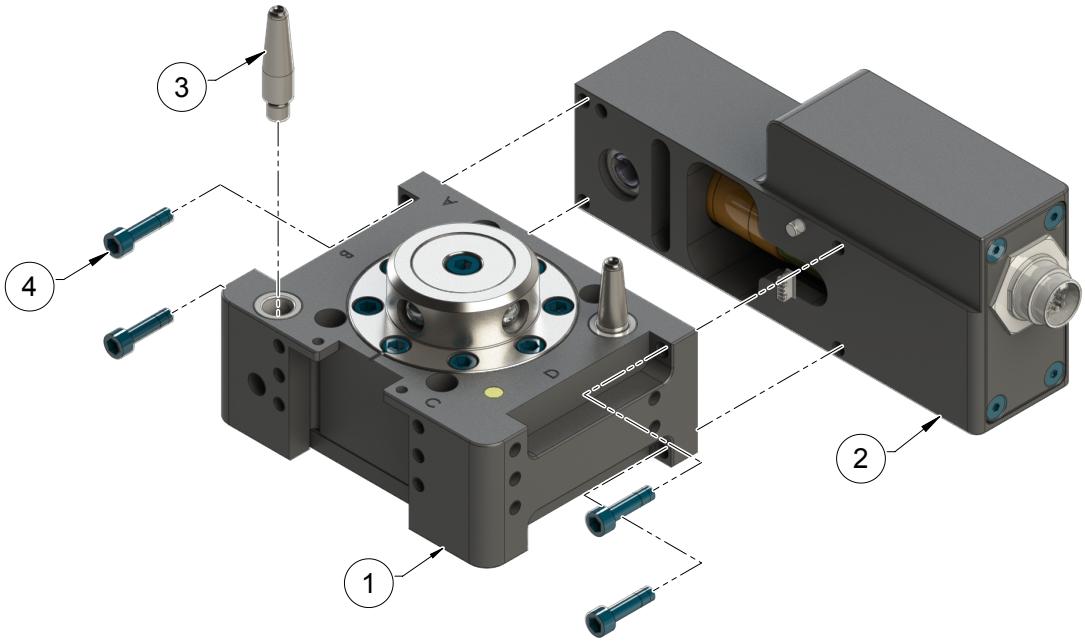


Figure 5.6—QC-18 Master Plate			
Item No.	**Qty**	**Part Number**	**Description**
1	1	9120-018M-0-0-0-0-SG2	Complete QC-18 Master Plate Assembly
2	1	9005-20-2387	EQC Motor Sub Assembly
3	2	3700-20-1373	Mono Alignment Pin, QC-100, A2 (Replaces 9005-20-1074)
4	4	3500-1062016-15A	M4x16 Socket Head Cap Screw, Class 12.9, Blue dyed Magni-565, ND Microspheres Epoxy, Yellow.

6.2 Tool Plate Serviceable Parts

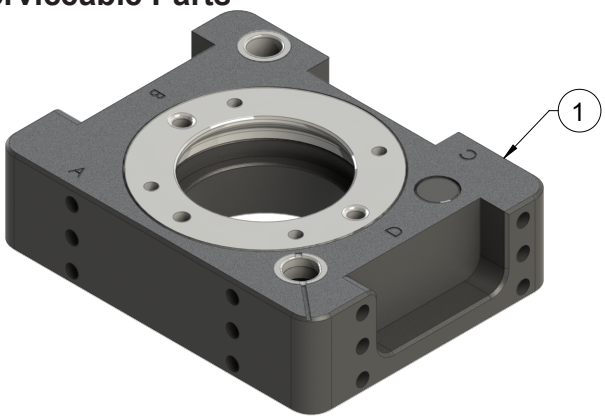


Table 5.2—Standard Tool Plate			
Item No.	**Qty**	**Part Number**	**Description**
1	1	9120-018T-0-0-0-0	Complete QC-18 Tool Plate Assembly

6.3 Accessories

Table 5.3—Accessories	
Part Number	**Description**
3690-0000064-60	Brush, Blue Nylon All Purpose (Contact Pin Cleaning)

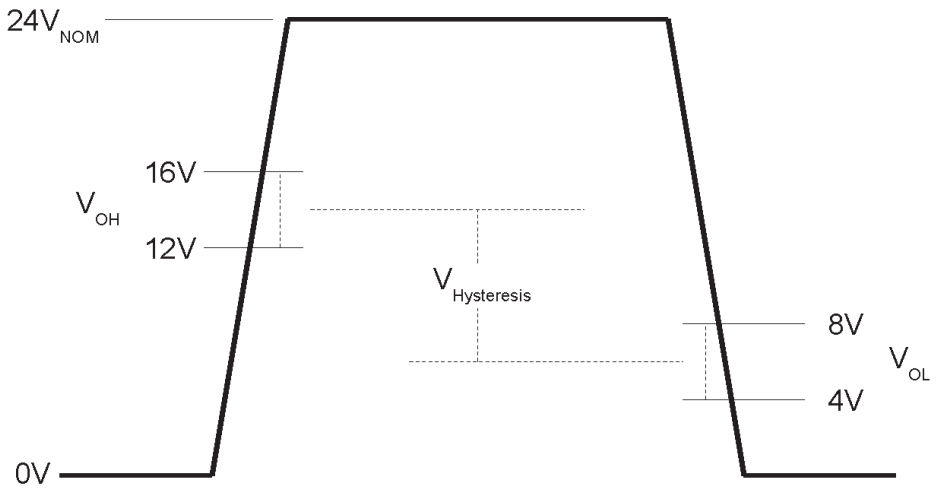
7. Specifications

Table 5.4—Master and Standard Tool Plate		
Parameter	**Value**	**Description**
Recommended Max Payload	39.6 lbs (18 kg)	The mass attached to the Tool Changer.
Static Moment (x/y)	500 lbf-in (56.5 Nm)	Maximum recommended working load for optimum performance of the Tool Changer
Static Torsion (z)	690 lbf-in (78 Nm)	Maximum recommended working torque for optimum performance of the Tool Changer
Operating Temperature Range	-4 to 122°F (-20 to 50°C)	Operating temperature range.
Operating Voltage	21-30 VDC	24 V / 0 V connections
Operating Current	4.2 A peak during locking	24 V / 0 V connections
Weight (coupled, no access.)	3.93 lbs (1.78 kg)	Combined weight of Master and Tool plate assemblies
Master Weight	3.1 lbs (1.4 kg)	Weight the Master plate assembly
Tool Weight	0.92 lbs (.42 kg)	Weight the Tool plate assembly
Max. Recommended distance between Master and Tool plate	0.04 in. (1.0 mm)	No-Touch locking technology allows the Master and Tool plates to lock with separation when coupling.
Positional Repeatability	0.0006” (0.015 mm)	Repeatability tested at rated load at one million cycles.
Time to Lock / Unlock	1 second	Approximate time for the signal to be sent and read
Master Side Mounting Pattern	Custom 55 mm X 40 mm	Refer to *Section 8—Drawings*
Tool Side Mounting Pattern	ISO 63 mm	Refer to *Section 8—Drawings*
Number of Module Flats	3	Available Patterns: Flat A – Motor (Master), open (Tool) Flats B & D – J16 Style Flat C – J16 Style, or K Series

7.1 Latch and Unlatch Voltage Specification

Figure 5.7—Latch and Unlatch Output Electrical Characteristics						
Parameter		Conditions	Rating			Unit
			Minimum	Typical	Maximum	
V_{OL}	Low-level output voltage	Operating voltage and temperature range	4.0		8.0	V
V_{OH}	High-level output voltage	Operating voltage and temperature range	12.0		16.0	V
I_O	Output current	at 24 V nominal	N/A	3		mA

Figure 5.8—Latch / Unlatch Voltage Waveform Characteristics

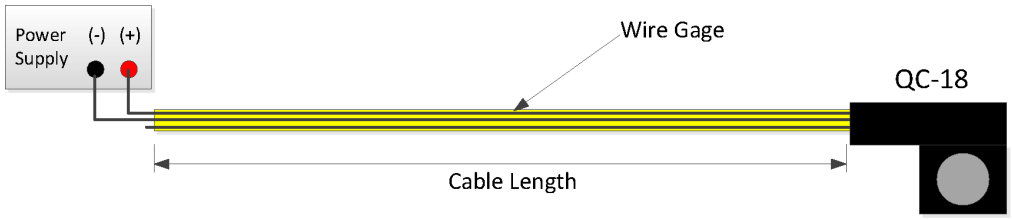


7.2 Current Requirements and Cable Length vs Voltage Drop

Being driven solely by electricity, the QC-18 has minimum requirements for voltage and current delivered to its input connection. Since electric power must travel the length of cable from the power supply to the QC-18, the user must correctly account for the supply voltage setting and gage size of wires in the cable. Use the proper cable to meet the input electrical requirements of the QC-18.

For the QC-18, ensure that the minimum input voltage is 21 volts and the minimum available current supply is 4 A. To determine the maximum allowed cable length, refer to the following tables as an aid.

Figure 5.9—Cable Length Diagram



To be at least 21 V at the end of the QC-18 cable, the user must account for the voltage drop from the power supply. The voltage drop varies according to wire gage size and cable length. The longer the length of cable needed (higher resistance), the smaller wire gage (thicker wire) needed to compensate and meet the minimum 21 V requirement at the QC-18 end of the cable.

The maximum cable lengths for a range of wire gages from 22 AWG to 14 AWG at three different power supplies are provided in the following tables.

For a power supply set to 24 V and for the voltage to be at least 21 V at the QC-18 end of the cable, the maximum allowed voltage drop through the cable is then 3 volts.

Figure 5.10—Max Cable Lengths Allowed with a 24 V Power Supply

Wire Gage (AWG)	Maximum Vdrop	Maximum Amp Spike	Ohms per 1000 ft	Maximum Allowed Cable Length	
				ft	m
22	3	4	16.6	22.6	6.9
20	3	4	10.45	35.9	10.9
18	3	4	6.58	57.0	17.4
16	3	4	4.16	90.1	27.5
14	3	4	2.59	144.8	44.1

For a power supply set to 27 V and for the voltage to be at least 21 V at the QC-18 end of the cable, the maximum allowed voltage drop through the cable is then 6 volts. So the maximum cable lengths are longer compared to the first table.

Figure 5.11—Max Cable Lengths Allowed with a 27 V Power Supply

Wire Gage (AWG)	Maximum Vdrop	Maximum Amp Spike	Ohms per 1000 ft	Maximum Allowed Cable Length	
				ft	m
22	6	4	16.6	45.2	13.8
20	6	4	10.45	71.8	21.9
18	6	4	6.58	114.0	34.7
16	6	4	4.16	180.3	55.0
14	6	4	2.59	289.6	88.3

For a power supply set to 27 V and for the voltage to be at least 21 V at the QC-18 end of the cable, the maximum allowed voltage drop through the cable is then 9 volts, So the maximum cable lengths are even longer compared to the 24 and 27 V power supplies.

Figure 5.12—Max Cable Lengths Allowed with a 30 V Power Supply

Wire Gage (AWG)	Maximum Vdrop	Maximum Amp Spike	Ohms per 1000 ft	Maximum Allowed Cable Length	
				ft	m
22	9	4	16.6	67.8	20.7
20	9	4	10.45	107.7	32.8
18	9	4	6.58	171.0	52.1
16	9	4	4.16	270.4	82.4
14	9	4	2.59	434.4	132.4

8. Drawings

Drawings are available on the *ATI website* or by contacting an ATI representative.