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C. Control and Signal Modules
VJ4/VJ5—Discrete Signal Module
1. Product Overview

The VJ4 discrete control/signal module provides a means for the customer to control the Tool Changer and provide power to downstream I/O. The VJ4 Master comes equipped with four (4) M12, 5-Pin connectors used for interfacing with a customer supplied Interbus I/O module. These connections allow the customer to monitor Tool Changer Locked, Unlocked, and RTL (Ready-To-Lock) proximity sensor inputs as well as to control the Tool Changer valve Latch and Unlatch functions (see Figure 1.1). The RTL sensors in the VJ4 Master are connected in series.

The VJ4 control module was specifically designed to accommodate a Phoenix Contact Rugged Line Digital Input/Output Module, such as model IBS RL 24 DIO 4/2/4-LK-2MBD. Six M4 threaded holes are provided for mounting the Phoenix I/O module to the VJ4 Master via a Phoenix contact IBS RL AP Adapter Plate (see *Figure 1.1*). The Adapter Plate and mounting hardware are available separately from ATI (part number 3710-20-3376) **or as a 9121-VJ5-M that comes pre-assembled with the 9121-VJ4-M, IBS RL 24 DIO 4/2/4-LK-2MBD, Adapter Plate, and four (4) interconnecting cables (see Figure 1.2).**

Power for downstream Interbus devices is provided to the Master from the Interbus I/O module via an M23 male thread, 6-Pin connector. When the Tool Changer is coupled, power from the Master is passed to the Tool module using a spring-loaded pin block. A flexible boot surrounds the pin block to seal the connection from moisture and liquid while coupled. Power for end-of-arm devices is in turn provided by the Tool module via an M23 male thread, 6-Pin female connector.

Tool changing under power can cause arcing to occur between the Master and Tool side contact pins. Arcing damages the contact pins and can drastically reduce their service life. To prevent this condition, the VJ4 Master comes equipped with an Arc Prevention circuit that automatically turns off US1 and US2 power during coupling and uncoupling of the tool, when arcing is most likely to occur. Refer to *Section 3.1—Arc Prevention Circuit* for additional information.

An interface is also provided on the Master module for support of an integrated double-solenoid valve (DC Voltage). The integrated valve is supplied as part of the valve adapter block, 9121-Jxx-M. Refer to the valve adapter block manual for more information (*9620-20-C-Air and Valve Adapters*). **Note: The design of the safety switch circuit in the VJ4 module requires the use of a double-solenoid valve.**

The VJ4 modules are designed with special features to afford the user the opportunity to operate the Tool Changer in the safest manner possible. In addition to providing the standard Locked, Unlocked, and Ready-to-Lock sensor inputs the VJ4 modules are outfitted with patented Tool Stand Interlock (TSI) technology. The TSI feature consists primarily of a physical break in the unlatch solenoid valve circuit. The TSI circuit is designed to allow Tool Changer release ONLY when the tool is in the stand or storage location. Refer to *Section 3.2—Tool-Side TSI* for more information.

Refer to *Section 8—Specifications* and *Section 9—Drawings* for specific connector details.

Figure 1.1—VJ4 Master and Tool Modules

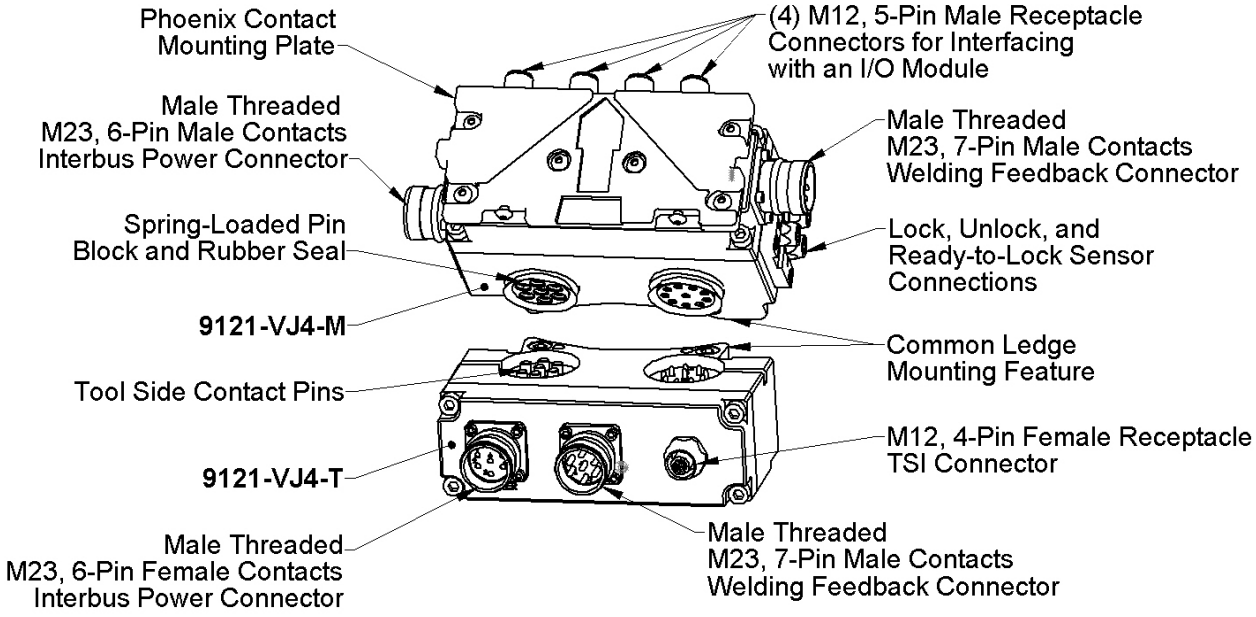
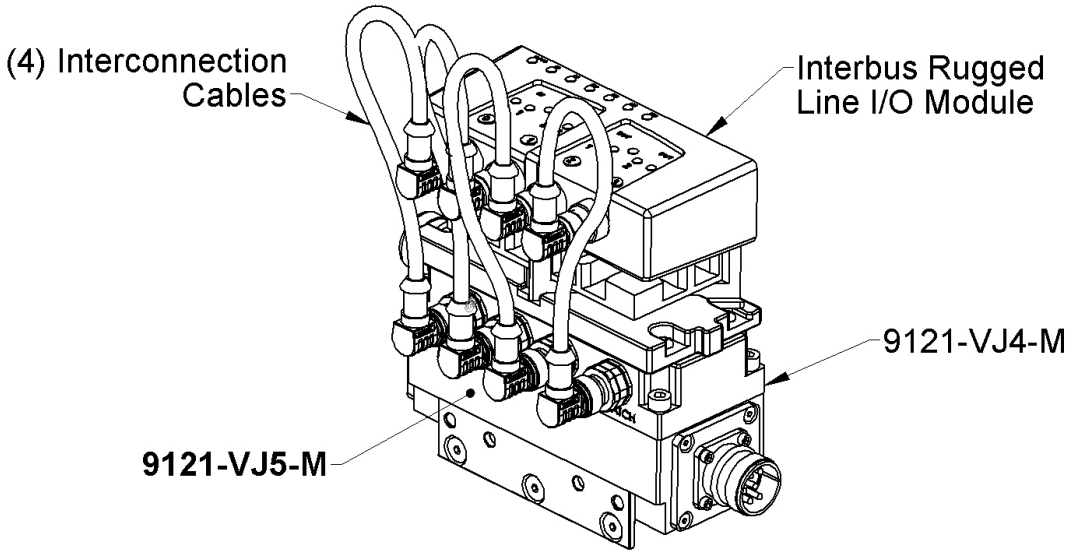


Figure 1.2—VJ5 Master Module



2. Installation

The control/signal modules are typically installed by ATI prior to shipment. The steps below outline the field installation or removal as required.

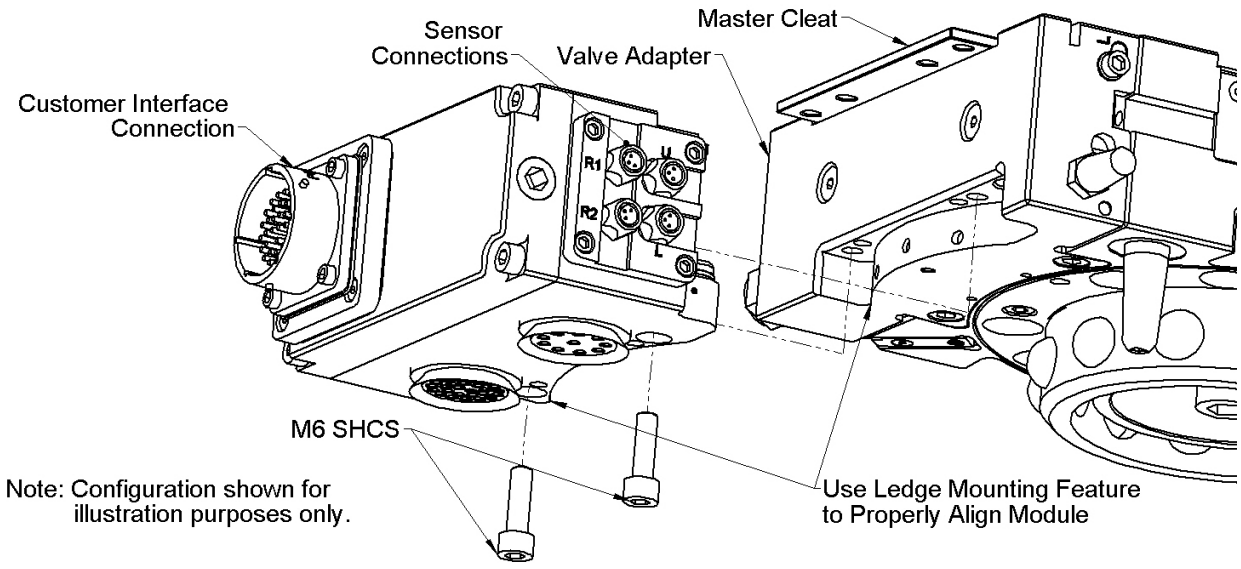
For wiring information refer to *Section 9—Drawings*.

> **WARNING:** Do not perform maintenance or repair on Tool Changer or modules with power or air on. Injury or equipment damage can occur with power or air on. Turn off power and air before performing maintenance or repair on Tool Changer or modules.

2.1 Installing

1. It may be necessary to clean the mounting surface on the Tool Changer prior to installing the module in order to remove any debris that may be present.
2. Using the ledge feature as a guide place the module into the appropriate location on the Tool Changer body. Align the module with the Tool Changer using the dowels in the bottom of the ledge feature. Refer to *Figure 2.1*.
3. If fasteners do not have pre-applied adhesive, apply Loctite 242® to the supplied M6 SHCS fasteners. Install the two (2) M6 socket head screws securing the module to the Tool Changer and tighten to 40–70 in-lbs.
4. Customer interface, switch, sensor, and valve cables can be connected to the module after attaching the module to the Tool Changer body. Ensure that the connectors are cleaned prior to being secured as appropriate.

Figure 2.1—Module Installation



2.2 Installing the Interbus I/O Block

1. It may be necessary to clean the top surface of the Master module, remove any debris that may be present prior to installing the Interbus I/O module.
2. Fasten the Interbus I/O module to the Mounting Plate using the (2) two included M4 screws. Apply Loctite 222 to the screws and torque to 15 in-lbs. Ensure that the orientation of the I/O module is as shown in *Figure 2.2*.
3. Connect the (4) cables between the Interbus I/O Module and the VJ4 Master module as indicated in *Figure 2.3*.

Figure 2.2—Mounting the Phoenix Contact I/O Module to the VJ4 Master

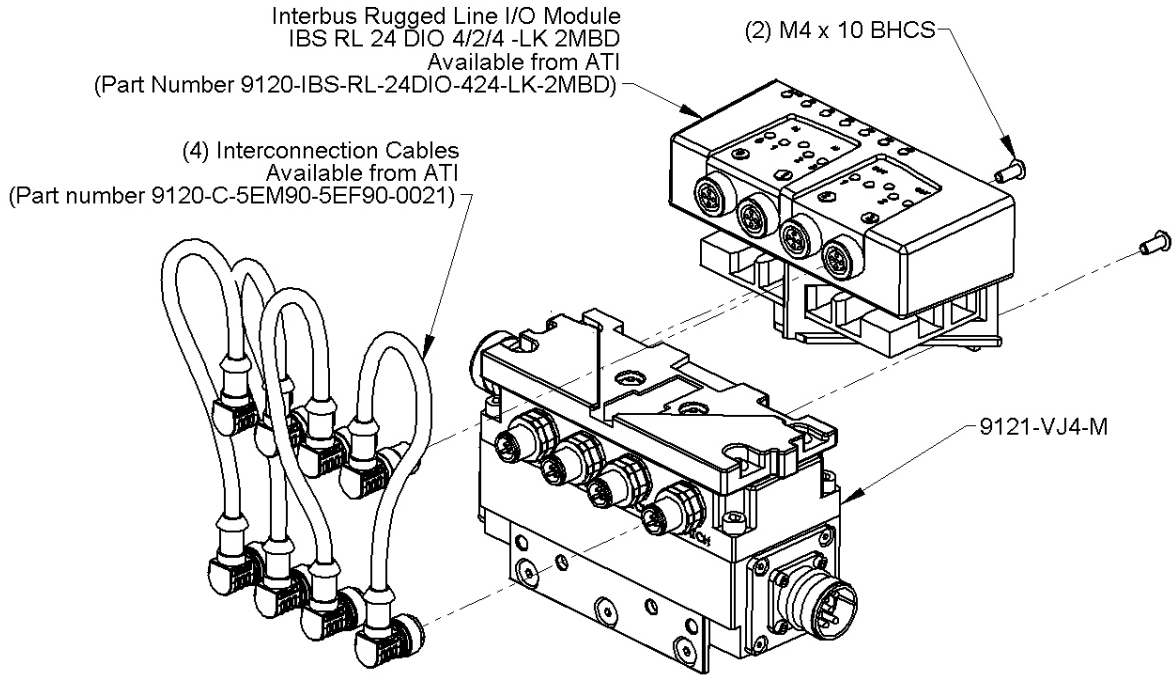
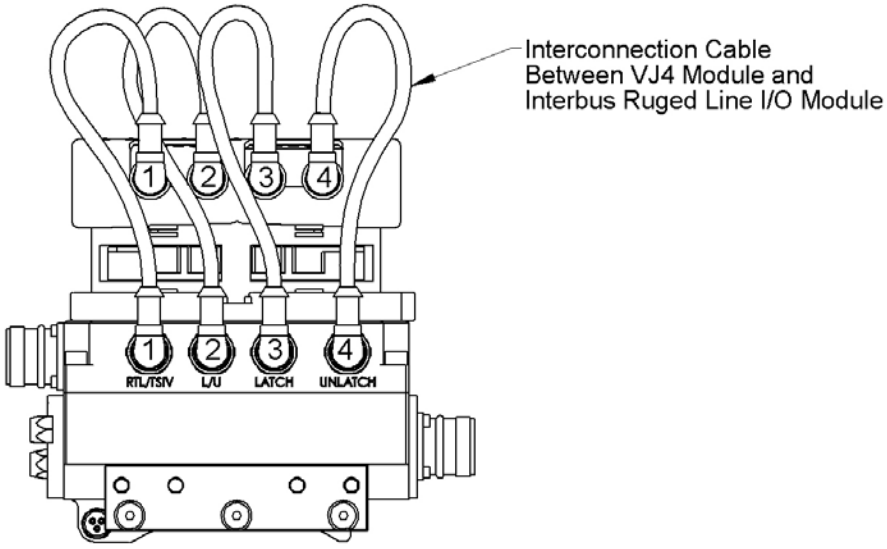


Figure 2.3—Cable Interconnections between Interbus Module and VJ4 Master Module



2.3 Removal

1. Prior to removing the module use a marker pen to scribe a line or indication between the Tool Changer and module body as a reminder where the module is to be re-installed.
2. Depending upon the service or repair being done, customer connections up to the module may or may not need to be disconnected. Also, proximity sensor and valve cables may or may not need to be disconnected.
3. Remove the socket head cap screws and lift the module from the Tool Changer.

> **CAUTION:** It is recommended, not to use fasteners with pre-applied adhesive more than three times. Fasteners used more than three times may come loose and cause equipment damage. Discard fasteners used more than three times and install new fasteners with pre-applied adhesive.

3. Product Information

Four M12, 5-Pin connectors on the Master module support an interface to Tool Changer Locked, Unlocked and Ready-to-Lock proximity sensor inputs as well as Latch and Unlatch valve outputs. These proximity sensor input connections are provided for confirmation of Tool Changer and locking mechanism positions.

Cables are provided in the overall Tool Changer package to connect these signals to the Interbus I/O module. Please refer to *Section 9—Drawings* for details. Refer to the specific Tool Changer manual for details on the operation of the Tool Changer and recommended procedure for coupling.

3.1 Arc Prevention Circuit

The VJ4 Module incorporates ATI's exclusive Arc Prevention Circuit. The Arc Prevention Circuit extends the life of all electrical power contacts by eliminating arcing caused by inductive loads and high inrush current during coupling/uncoupling. The Arc Prevention Circuit makes it possible to couple/uncouple without switching power off and prevents damage to the contacts. In the VJ4 Module, the Arc Prevention Circuit controls the ON/OFF status of the following two power signals:

1. US1 Power
2. US2 Power

The behavior of the Arc circuit is more fully described in the following sections.

3.1.1 Arc Prevention Circuit Behavior during Coupling

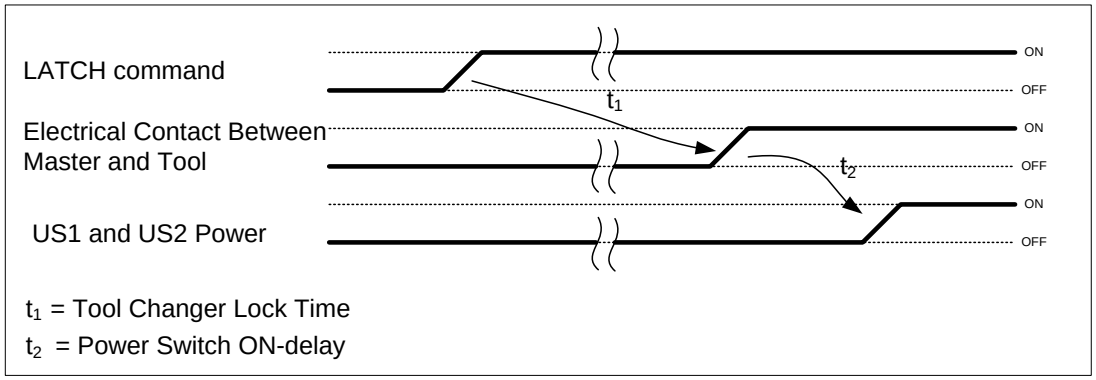
The behavior of the Arc Prevention circuit during coupling can be more clearly understood by referring to *Figure 3.1*, which shows the power-on timing diagram for the Arc Prevention circuit. Starting at the top of the diagram, the LATCH command is issued thus initiating locking of the Master and Tool.

Soon after locking is initiated, electrical contact between Master and Tool Pin Contacts occurs (this time is designated t_1 in the diagram). The magnitude of time t_1 is a function of many factors including the weight of the EOAT, the distance between the Master and Tool when the LATCH command is issued, how well the Master and Tool are aligned during pick-up, etc.

As soon as electrical contact is made and the LATCH command is issued, the Arc Prevention Circuit will turn on US1 and US2 power. The time delay between the electrical contacts becoming fully engaged and when power is actually available to the EOAT (time t_2 in the diagram) is less than 100ms.

Important: The Arc Prevention Circuit will only allow power to pass to the Tool after the LATCH command has been issued **and** the Master and Tool module's electrical contacts are fully engaged.

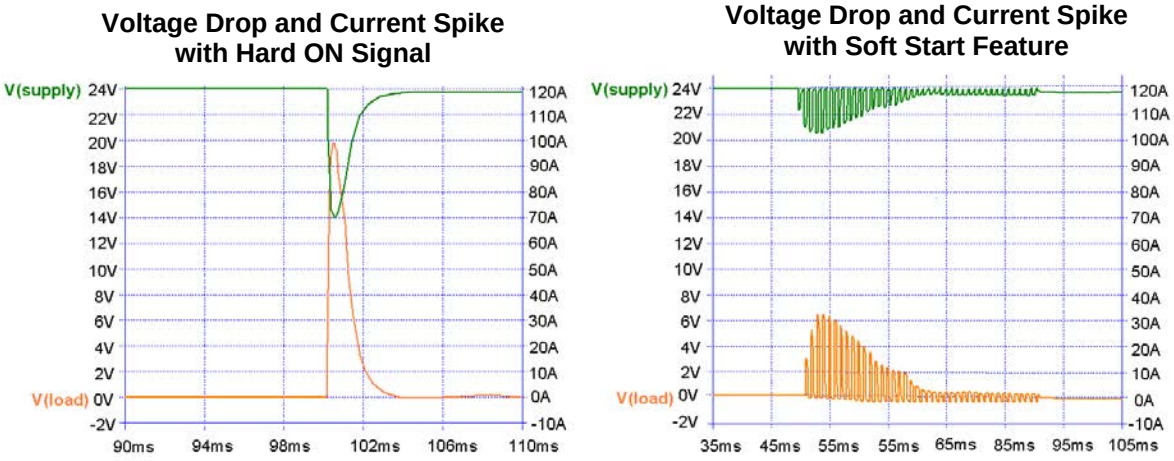
Figure 3.1—Arc Circuit Power-On Timing



3.1.1.1 Soft Start during Coupling

High current spikes can cause voltage drops on the power supply and potentially may lead to network faults. The Arc Prevention Circuit has an ATI exclusive Soft Start feature that pulses the power on gradually in the beginning, preventing the large current spike that would otherwise occur if there were only one hard on signal. This results in a series of much smaller current spikes and prevents significant voltage drops on the network power. *Figure 3.2* shows how the Soft Start feature effectively reduces the voltage drop on network power.

Figure 3.2—Soft Start Feature



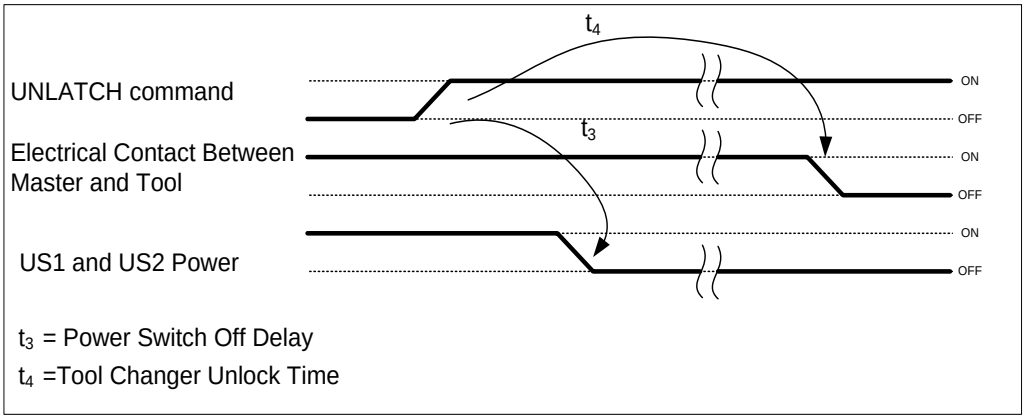
3.1.2 Arc Prevention Circuit Behavior during Uncoupling

The behavior of the Arc Prevention Circuit during uncoupling can be more clearly understood by referring to *Figure 3.3* which shows the power-off timing diagram for the Arc Prevention Circuit. Starting at the top of the diagram, the UNLATCH command is issued thus initiating uncoupling of the Master and Tool.

Immediately after the UNLATCH command is issued, the Arc Prevention Circuit will turn off US1 and US2 power. The power-off time delay between the UNLATCH command and the switching off of power (designated t_3 in the diagram) is less than 50ms.

Some time after power is turned off and the Master and Tool begin to separate, electrical contact between Master and Tool Pin Contacts will be lost. This occurs with a delay, designated t_4 in the diagram, after the UNLATCH command is issued. The magnitude of time t_4 is a function of many factors, including the weight of the EOAT, the friction between Master and Tool alignment pins, etc. but is usually not shorter than 100ms.

Figure 3.3— Arc Circuit Power-Off Timing



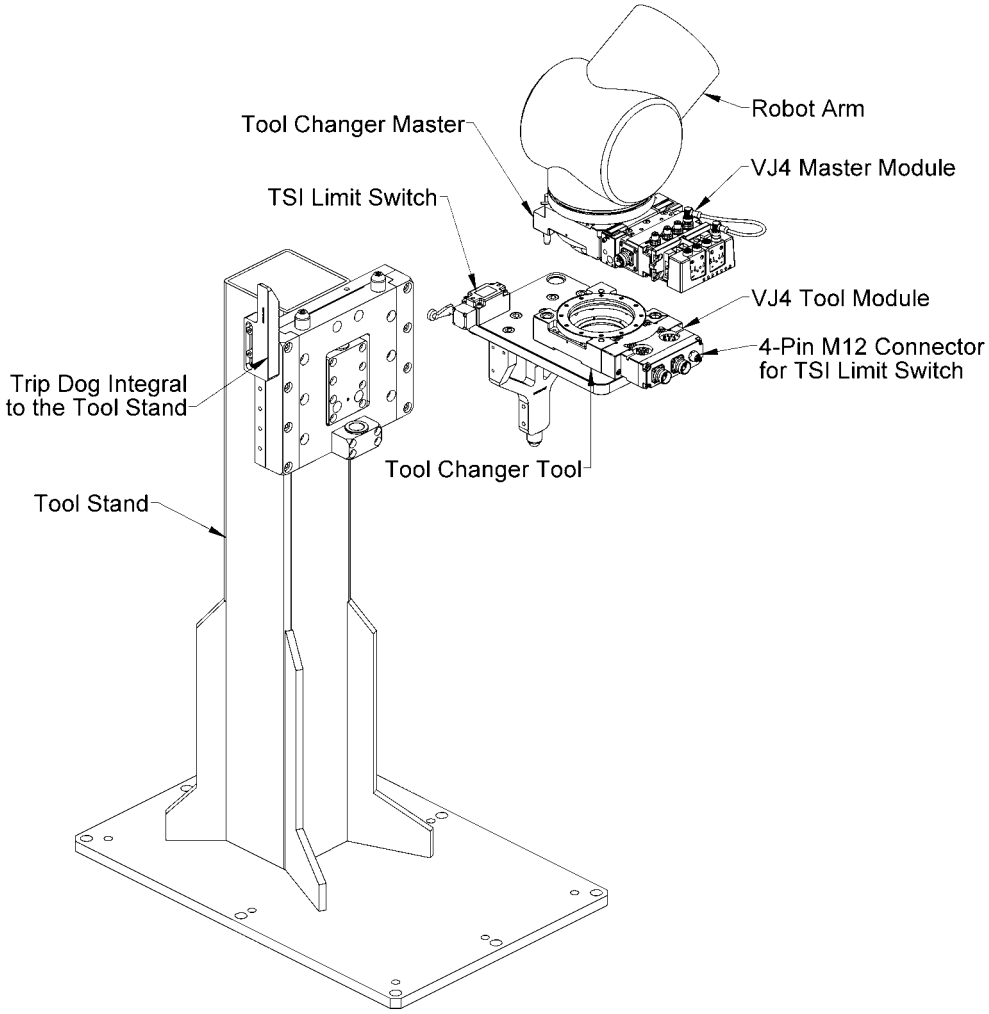
3.2 Tool-Side TSI

To prevent an unintended Tool release, the electrical power to the unlatch valve circuit is switched only when a Tool mounted Limit switch indicates that the Tool is nested safely in the Tool Stand. The Limit switch ensures that a Tool can only be released at the Tool Stand (refer to *Figure 3.4*).

A momentary action normally open, single-pole, single-throw mechanical limit switch is recommended to work with the TSI circuit. The limit switch must be mounted to the Tool in a manner that guarantees that the switch is closed only when the Tool is nested in the Tool Stand (see *Figure 3.5* and *Figure 3.6*). The Limit switch is connected to the VJ4 Tool module via a 5-Pin M12 female connector.

The function of the VJ4 safety circuitry can be more clearly understand by referencing the schematics shown in *Figure 3.5* and *Figure 3.6*.

Figure 3.4—Tool Stand Interlock (TSI)



CAUTION: The Master locking mechanism must be fully retracted prior to the Master entering the Tool. Failure to do so will cause ball bearings to damage the Tool Bearing Race. If Tool changer is locked, use solenoid valve manual override on the Tool changer to unlock before attempting to latch Master with Tool.

3.2.1 TSI Operational Function

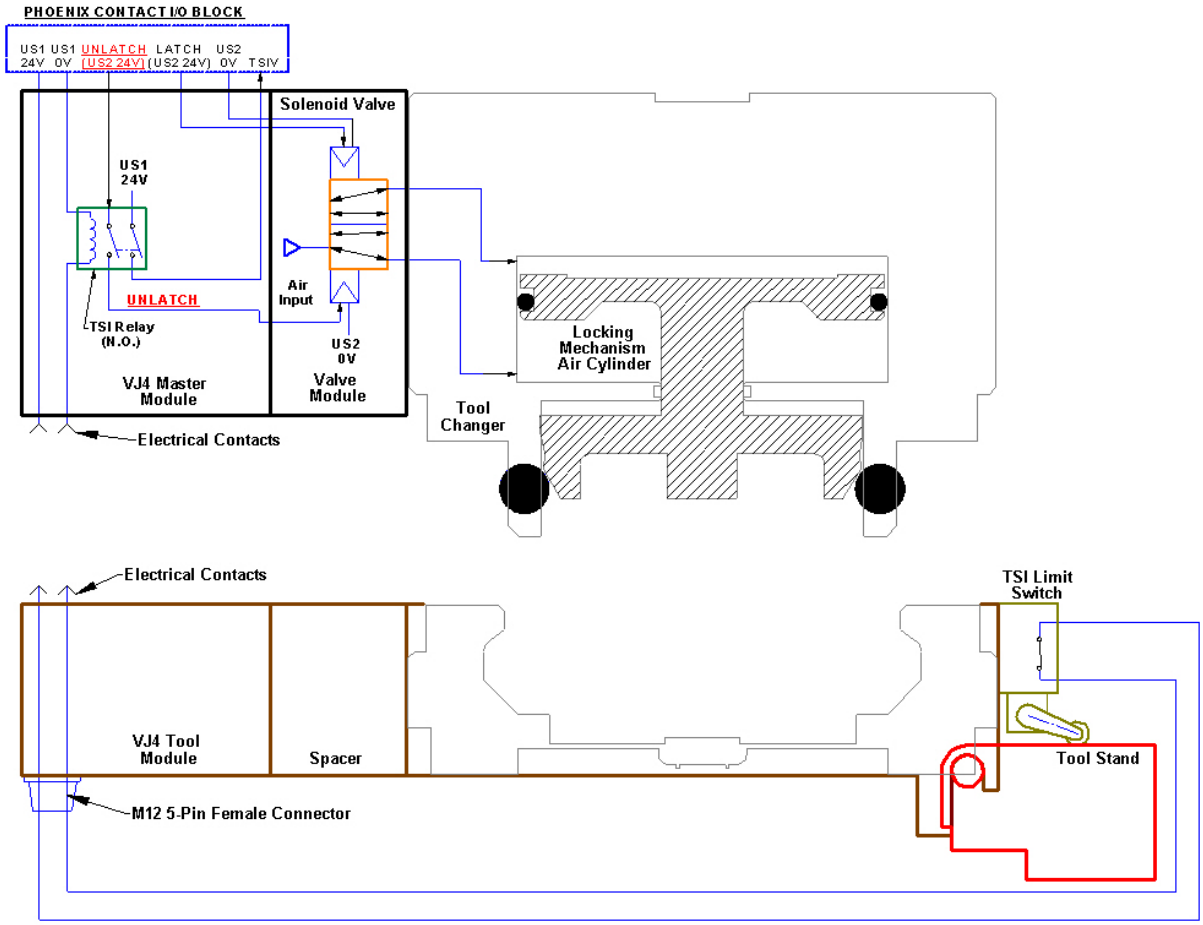
The Master is away from the Tool Stand and the Tool is nested safely in the Tool Stand. The TSI Relay, located in the Master Module, is driven by closure of the mechanical TSI Limit Switch located on the Tool. When closed, the relay passes the unlatch signal from the robot to the Solenoid Valve.

Since the Master and Tool are not coupled and the electrical contacts are not touching, it is not possible to close the TSI Relay and unlock the Tool Changer locking mechanism. Even if an unlatch command is provided by the robot, the Tool Changer will not unlock.

In the event that the Tool Changer is locked without a Tool, it must be unlocked using the manual override button on the valve (refer to *Section 3.2.2—Solenoid Valve Manual Override Procedure*).

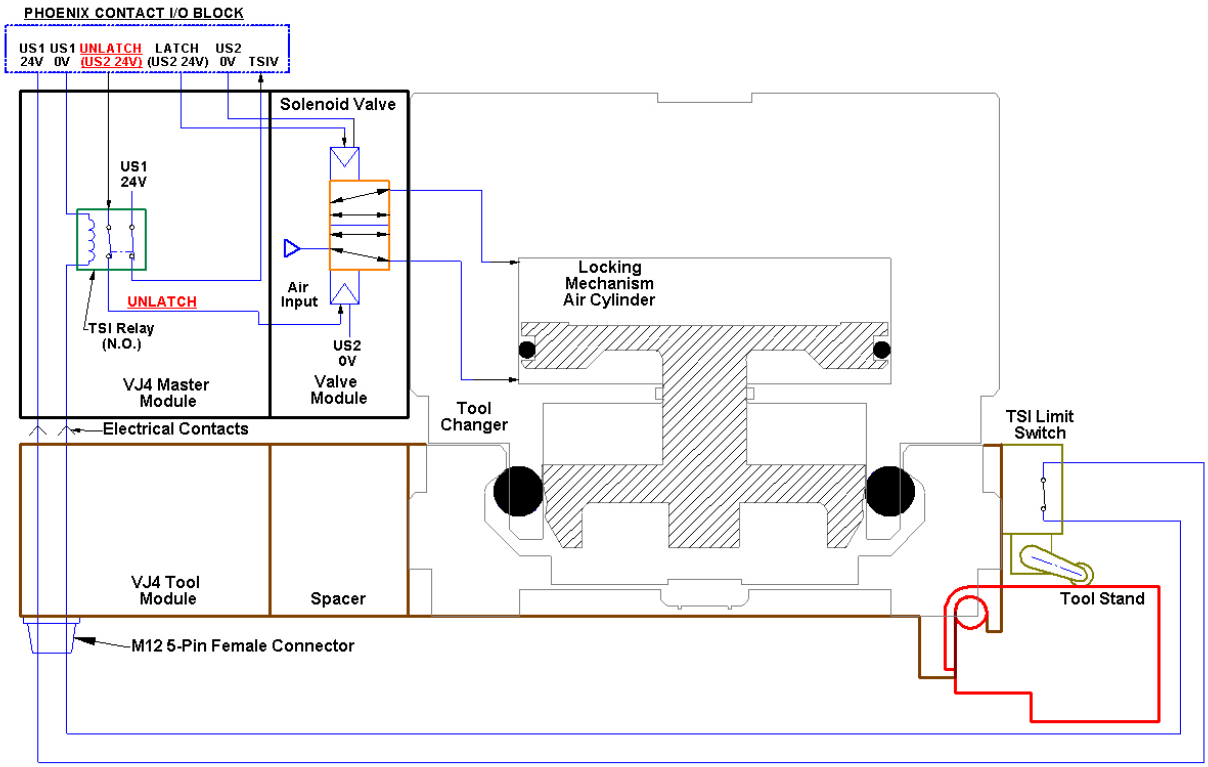
The second set of contacts on the TSI relay is used to provide the TSIV diagnostic signal (when the TSI Relay is open, the TSIV signal should be low). The TSIV signal can indicate if there is damage to the TSI relay, cable, or mechanical switch. For maximum safety, the status of the TSIV signal should be monitored in the manner described in *Section 4.1— Recommended Sequence of Operation*.

Figure 3.5—TSI Circuit with Master Free of Stand, Tool in the Stand



The Master and Tool are within coupling distance and the electrical contacts are touching. The TSI Relay closes because the TSI limit switch is actuated and the electrical contacts are touching. It is now possible for the TSI Relay to pass the unlatch signal from the robot to the Solenoid Valve.

Figure 3.6—TSI Circuit with Master and Tool Locked



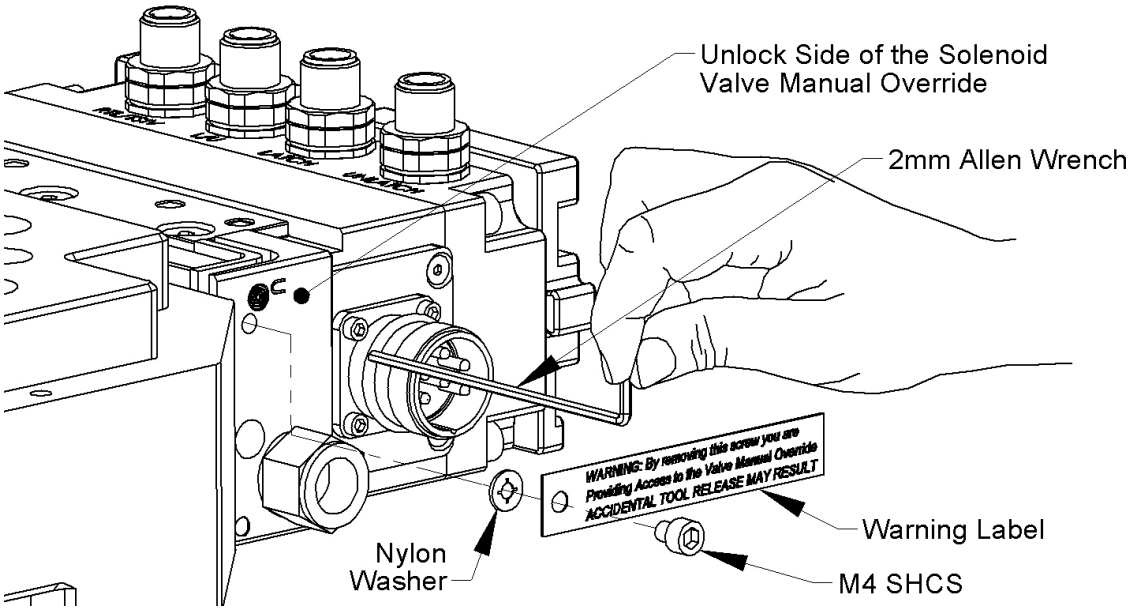
3.2.2 Solenoid Valve Manual Override Procedure

DANGER: : Do not use the solenoid valve manual override if the tool is locked to the Master. Using the manual override will release the Tool and may cause bodily injury or **damage to equipment. If the Tool is attached to the Master it must be secured in the tool** stand or in a location where the tool weight is supported before using the manual override.

CAUTION: The manual override is not intended for normal operations. Manual override is to be used in situation were no other alternative is available to unlock the Master. Do not execute the Latch command unless the Master and the Tool are ready to be coupled.

1. Remove the M4 SHCS, warning label, and nylon washer from the Unlock side of the solenoid valve. The Unlock side is marked with a "U".
2. Insert a 2mm ball end Allen wrench or similar blunt object in the Unlock valve screw hole and manually depress the valve override. Make sure locking mechanism is fully retracted.
3. Replace the M4 SHCS, warning label, and nylon washer and tighten the screw.

Figure 3.7—Solenoid Valve Manual Override



4. Operation

This recommended Sequence of Operations procedure is a general guide for programming a robot or PLC for use with a Tool Changer and VJ5-M/VJ4-M/VJ4-T control/signal modules. This procedure is intended for "automatic" modes used during normal processes.

4.1 Recommended Sequence of Operation

1. **Start→** 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 is fully retracted (unlocked condition). The Tool is by itself in the Tool Stand.
   a. The **RTL** input is false.
   b. The ATI Tool and any downstream device is offline.
   c. The **TSIV** input is false.

ATTENTION: In the event that the Tool Changer is locked without a Tool, it must be unlocked using the manual override button on the valve, refer to *Section 3.2.2—Solenoid Valve Manual Override Procedure.*

2. Ensure the Master is Unlocked. (The Master must be unlocked prior to entering the Tool to prevent the ball bearings from impinging on the Tool bearing race.)
   a. The **Latch** output command is false and the **Unlatch** output command is true.
   b. The **Unlocked** input is true, indicating that the Tool Changer locking mechanism is fully retracted.

ATTENTION: For maximum safety, ATI strongly recommends editing the robot program to verify that TSIV is OFF just before tool pick up.

3. Robot and Master move into the Tool are parallel and within 0.125" to 0.06" of the Tool (i.e., the module contact pins are touching, but the **RTL** sensors have not yet sensed the targets on the Tool).
   a.The **TSIV** input is true.

4. Robot and Master move within 0.06" of the Tool.
   a. The **RTL** input is true, indicating that it is okay to couple the Tool.

5. Couple the Tool Changer.
   a. The **Latch** output is made true.
   b. The **Unlatch** output is made false.
   c. The **Unlocked** input goes false a short time later, indicating piston travel. Subsequently, the **Locked** input goes true and remains true, indicating that the coupling operation is complete.
   d. Power becomes available on the Tool.

ATTENTION: For maximum safety, ATI strongly recommends editing the robot program to verify that TSIV is ON at tool pick up.

6. Robot moves away from the Tool Stand with the Tool Changer coupled.

ATTENTION: For maximum safety, ATI strongly recommends editing the robot program to verify that TSIV is OFF when the tool is above the stand immediately after tool

7. Normal operation
   a. The following inputs are true:
      i. **Locked**
      ii. **RTL**
   b. The following inputs are false:
      i. **Unlocked**
   c. The following output commands are false:
      i. **Unlatch**
      ii. **TSIV**

8. Robot moves into the Tool Stand with the Tool Changer coupled.

9. Uncouple the Tool Changer. **IMPORTANT: It is critical that the Tool be nested securely in the Tool Stand prior to Uncoupling the Tool Changer.**
   a. The **TSIV** input is true.
   b. The **Unlatch** output is made true.
   c. The **Latch** output is made false.
   d. Power on the Tool turns off.
   e. The **Locked** input goes false a short time later and subsequently the **Unlocked** input goes true and remains true, indicating that the uncoupling operation is complete.

10. Robot and Master move away from the Tool, are parallel and a distance 0.125” to 0.06” away from the Tool (i.e., the module contact pins are touching, but the **RTL** sensors are no longer sensing the Tool).
    a. The **RTL** input is false.
    b. The **TSIV** input is true.

11. Robot and Master move away from the Tool are parallel and > 0.125” from the Tool (the module contact pins are no longer touching).

12. Robot and Master in free space.
    a. The following inputs are true:
       i. **Unlocked**
    b. The following inputs are false:
       i. **Locked**
       ii. **RTL**
       iii. **TSIV**

5. Maintenance

Contact pins on the Tool module should be inspected and cleaned periodically to ensure electrical contact is maintained. A vacuum is recommended to remove and clear debris from the module mating surfaces. Care should be taken not to bend or pull out the contacts when cleaning.

> **CAUTION:** Do not use an abrasive media, cleaners, or solvents to clean the contact pins. Using abrasive media, cleaners, or solvents will cause erosion to the contact surface. Clean contact surfaces with non-abrasive media.

Cable connections should be inspected during maintenance periods to ensure they are secure. Loose connections should be cleaned and re-tightened as appropriate. Loose connections are not expected and may indicate improper routing and/or strain relieving.

If the Tool Changer is being used in dirty environments (e.g. welding or deburring applications) care should be taken to limit the exposure of the Tool Changer. Idle Tool assemblies should be covered to prevent debris from settling on the mating surface. Also, the Master assembly should be exposed for only a short period of time during tool change and down time.

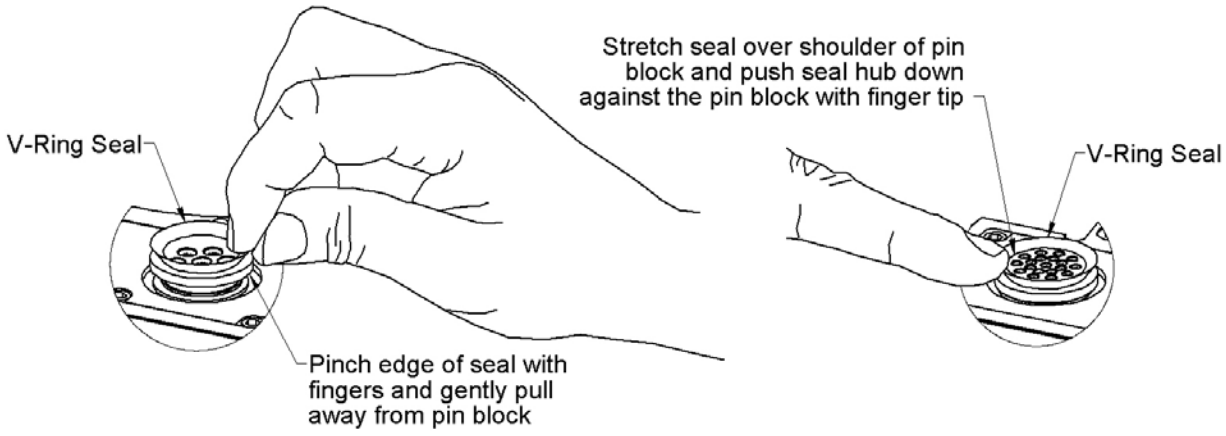
Assembly details are provided in *Section 9—Drawings.*

5.1 Seal Replacement

Replace the V-Ring seal:

1. To remove the existing seal, pinch edge of seal with fingers and gently pull the seal away from the pin block on the Master.
2. Pull the seal off the pin block.
3. To install a new seal, stretch the new seal over the shoulder of the pin block.
4. Push the seal's hub down against the pin block using finger tip.

Figure 5.1—V-Ring seal Replacement



6. Troubleshooting

Symptom	Possible Cause / Correction
Unit will not lock or unlock	Verify that ball bearings are moving freely. Clean and lubricate as needed. Check air supply. Check that exhaust port is properly vented (check muffler). Check valve for proper operation. Verify that discrete signals are mapped and are communicating properly. Verify that the Master and Tool are within the specified No-Touch zone when attempting to lock. Check TSI circuit for proper operation.
Sensors not operating properly	Verify that cables are connected correctly. Verify that the sensors are set correctly. Ensure that when the Latch signal is provided that the Tool Plate and Master Plate mate completely (i.e. there must be no visible gaps), that nothing is trapped between their surfaces, and that there is no air trapped in the Unlock (U) air port. Replace cables and/or sensors.
Loss of Weld Feedback Signal	Check/Replace signal cabling up- and down-stream of Tool Changer modules. Inspect the module's 10-Pin Block contact pins for debris/wear/damage. Check product up- and downstream of Tool Changer for failure.
Loss of Power to Downstream Devices	Verify that the LATCH command has been issued by the robot. Verify that the Master and Tool are fully coupled**.** Inspect the module's 7-Pin Block contact pins for debris/wear/damage.
Loss of Aux. Power on the Tool-side	Loss of US1 power on the Master-side will cause loss of US2 power to the Tool. The Arc Prevention Circuit relies on US1 power to operate. Restore US1 Power to the Master to restore Aux. Power to Tool.

7. Recommended Spare Parts

Description	Part Number
VJ4 Master Module Assembly	9121-VJ4-M
VJ5 Master Module Assembly	9121-VJ5-M
VJ4 Tool Module Assembly	9121-VJ4-T
TSI Teach Plug	9120-DC45-Plug
TSI Cable	9120-C-4EM-4EF-020
Interbus Rugged Line I/O Module IBS RL 24 DIO 4/2/4 -LK 2MBD	9120-IBS-RL-24DIO-424-LK-2MBD
Phoenix Contact Mounting Plate, IBS RL AP	3710-20-3376
Right Angle M12 Connectors, 5 Conductor Cordset, 0.21m	9120-C-5EM90-5EF90-0021
V-Ring Seals	4010-0000030-01
Master Cleat Sub-Assembly	9005-20-1198
Tool Cleat Sub-Assembly	9005-20-1199

8. Specifications

VJ4/VJ5-M Master Module	
Interface Connections	Interbus Power: M23 Male Thread, 6-Pin (male) connector. Weld Measure Line: M23 Male Thread, 7-Pin (male) connector. I/O Module Connections: (4) M12, 5-Pin (male) connectors. Integrated Tool Changer I/O: • 4X M8, 3-pin female connectors supporting Tool Changer Locked, Unlocked, and Ready-to-Lock proximity sensors (PNP type in series). • 1X Internal 3-Pin pin block to transmit latch and unlatch signal to the solenoid Valve.
Electrical Rating	Power Pass-Thru: • Input (US1) Power: 10A, 12-30 VDC *Note: Arc prevention is applied to Input power.* • Output (US2) Power: 10A, 21-26 VDC *Note: Arc prevention is applied to Output power.*
	Signal Pass-Thru: 3A, 250V maximum
	Tool Changer Control: • Lock, Unlock, and Ready-to-Lock sensors: 10-30 VDC operational voltage *Note: Input Power provides power to the L, U, and RTL sensors.* • Latch/Unlatch integrated solenoid valve: 21-26 VDC operational voltage *Note: Output Power provides power to the Latch/Unlatch solenoid valve.*
Weight	VJ4: 2.35 lbs (1.07 kg) VJ5: 2.75 lbs (1.25 kg)

VJ4-T Tool Module	
Interface Connections	Interbus Power: M23 Male Thread, 6-Socket (female) connector. Weld Measure Line: M23 Male Thread, 7-Pin (male) connector. TSI: M12, 4-Socket (female) connector.
Electrical Rating	Power Pass-Thru: • Input (US1) Power: 10A, 12-30 VDC *Note: Arc prevention is applied to Input power.* • Output (US2) Power: 10A, 21-26 VDC *Note: Arc prevention is applied to Output power.*
	Signal Pass-Thru: 3A, 250V maximum
Weight	VJ4: 1.40 lbs (0.64 kg)

9. Drawings

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