US Patent No.: 7,027,893 B2
US Patent No.: 6,840,895 B2

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Glossary of Terms

Term	Definition
Arc Prevention	Is an ATI exclusive feature that makes it possible to couple/uncouple without switching power OFF and preventing damage to the contacts. Arc Prevention extends the life of all electrical power contacts by eliminating arcing caused by inductive loads and high inrush current during coupling/uncoupling.
Coupling	The physical action of the locking the Master and Tool Plates together.
DeviceNetTM	A fieldbus communication network used mostly by devices in industrial settings, that communicates using CAN. DeviceNet is a trademark of ODVA.
EOAT	End-Of-Arm-Tool (end-effector).
Force Guided Relay	A Relay with linked contacts one normally open and one normally closed. A coil which when active will open the closed contact and close the open contact.
Input and Logic Power	DeviceNet Power.
Latch	The output supplied to the ATI Master DeviceNet node to couple the Tool Changer.
Locked	A proximity sensor input indicating that the coupling mechanism is in the Locked position.
RTL (Ready To Lock)	A proximity sensor that senses when ATI Master and Tool are close enough to couple. Used as a visual indicator for programming. Refer to *Section 4.1—Lock, Unlock, and RTL Sensor Cable LED Behavior*.
Safety Switch	A non-contact RFID switch is installed on the EOAT and is used to indicate that the EOAT is in the stand or storage location.
Soft Start	Is an ATI exclusive feature that pulses the power on gradually to prevent the large current spikes that would otherwise occur during the coupling of the master and tool. This results in a series of much smaller current spikes and prevents significant voltage drops on the network power.
Thermal 1	NPN input from the tool module.
Tool-ID	Inputs from the Master node reporting the values from the Tool-ID switch on Tool module.
Tool Stand Interlock (TSI)	The tool stand Interlock feature is a custom ATI circuit designed to enhance safety in Tool Changer applications by only allowing Tool release while tooling is in the stand or storage location. The TSI circuit consists of a TSI Switch and Relays.
Tool Stand Relay Verification (TSRV)	A duplicate of the TSI signal that is sent through force-guided relays as an additional verification that it is safe to unlatch a tool.
TSI1/TSI2 Relays Energized	Unlatch output connected to valve. NOTE: There are other preconditions that must be met before the Unlatch output is executed.
Uncoupling	The physical action of the unlocking the Master and Tool Plates.
Unlatch	The output supplied to the ATI Master DeviceNet node to uncouple the Tool Changer.
Unlocked	A proximity sensor input indicating that the coupling mechanism is in the Unlocked position.

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C. Control and Signal Modules

DU3—DeviceNet Modules

1. Product Overview

The DeviceNet modules are required to provide a means for the customer to communicate with and control the Tool Changer in a DeviceNet environment. Refer to *Section 2—Product Information* and *Section 4—Operation* for detailed DeviceNet programming information and a summary of module operational capabilities.

The DU3-M module supports the use of an integrated double solenoid valve adapter with air pressure switch which provides for Latch/Unlatch control of the Tool Changer. The user must provide a pneumatic supply source to the valve adapter. The DU3-M has a connector for an air pressure switch. The pressure switch will indicate if the supplied air pressure exceeds 63 psi +/- 3 psi. The pressure switch in this assembly is potted to achieve an IP65 rating which ensures that the pressure switch is not adjustable.

The DU3 modules are equipped with safety features such as redundant force guided relays controlling the Unlatch circuit activated by the TSI safety switch, air pressure monitoring, safety switch jumper plug detection, and a customer specified thermal connector. Refer to *Section 2.5—Safety System* for more details.

Standard mini connectors are provided on the Master and Tool modules for interfacing with auxiliary power (4-Pin) and DeviceNet (5-Pin) signals. When the Tool Changer couples, the Master and Tool modules pass signals through the spring-loaded pin block. When the modules are coupled, the V-ring seal forms a water resistant but not waterproof seal around the pin block.

Compliant spring pins are provided on the Master and fixed contact pins on the Tool. To avoid unintentional human contact, the Master spring pins are recessed below an insulated surface on both the power and signal circuits.

1.1 DU3 Master

The DU3 modules are designed with NPN Tool Changer input signals (Locked, Unlocked, and Ready-to-Lock proximity sensors). The Ready-to-Lock (R1 and R2) sensors are connected in series. Refer to *Section 2—Product Information* and *Section 4—Operation* for more information on these attributes. The Master module has an M8 4-pin female diagnostic connector for ATI use only. A Mini 5-Pin male connector supports the DeviceNet connection and a Mini 4-pin male connector provides a auxiliary power connection.

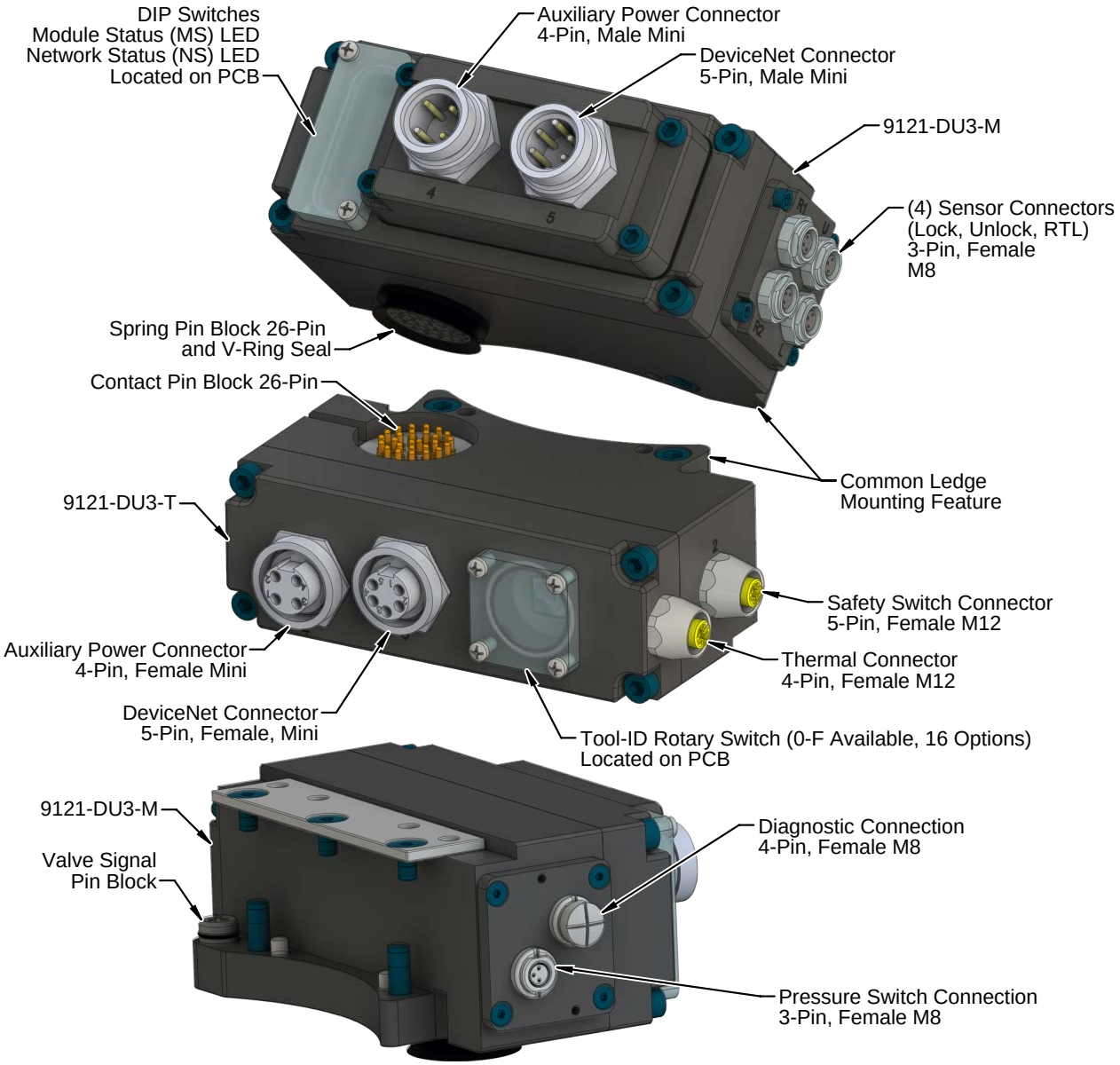
The DU3-M also incorporates ATI's exclusive Arc Prevention Circuit which extends the life of all electrical power contacts by eliminating arcing caused by inductive loads as well as high inrush current during coupling and uncoupling. Auxiliary power and DeviceNet power are protected through the Arc prevention circuits. Refer to *Section 2.2—Arc Prevention Circuit* and *Section 9—Drawings* for additional information.

1.2 DU3 Tool

The Tool module has a rotary switch for setting the Tool-ID input. This allows the customer to distinguish between the different Tools used in a robotic cell or on a production line. The Tool-ID is reported through the Master module bitmap. Refer to *Section 2.4—Software* for DeviceNet bitmap and detailed I/O information. A M12 4-Pin female connector supports Thermal 1 discrete NPN inputs. The Master module has an M8 4-pin female diagnostic connector for ATI use only. A Mini 5-Pin female connector supports the DeviceNet connection and a Mini 4-pin female connector provides a auxiliary power connection.

The DU3-T module is equipped with a M12 5-pin safety switch connector used to support a two channel PL e rated contactless Euchner safety switch , refer to *Section 2.5—Safety System* for more information. The module can support three or more safety switches when equipped. The use of more than two safety switches requires a TSI cable adapter kit (9120-DU3SWITCHKIT) which supplies enough power through the DeviceNet connector to support the additional switches. The module can support up to two safety switches in series using the 5-Pin M12 safety switch connector and a SICK 5325889 T-piece distributor both switches. Refer to *Section 9—Drawings* for more information.

Figure 1.1—DU3 Modules



2. Product Information

The DU3 modules enable the customer to control and communicate with the Tool Changer through a network using standard DeviceNet protocol (*www.odva.org*). A DeviceNet node is established on the Master module but not on the Tool. Control of the Tool Changer is realized through the Master Node along with the reporting of various Tool Changer I/O's. The Tool module supports Tool-ID reported through the Master and functions as a pass-through for DeviceNet and auxiliary power signals to downstream equipment.

The DU3 modules employ standard Mini 5-pin connector for DeviceNet communications and power. A Mini 4-pin connector for auxiliary power. Please refer to *Section 9—Drawings* for specific module wiring and connector interface information.

Prior to using the Tool Changer and the DeviceNet modules, various hardware settings must be configured. Communicating with the DeviceNet Modules requires knowledge of DeviceNet standards and operation.

2.1 Master Module Node

The Master Node operates as a Group 2-Only Server on the DeviceNet network. The Master Node supports Explicit Messaging, Polled, Strobe and Change of State/Cyclic communications for the predefined Master/Slave Connection set. The Master Node does not support the Unconnected Message Manager (UCMM).

MAC ID and Baud Rate settings for the Master Node are configured through a series of DIP switches. On board termination resistance is not supported and must be provided externally. LED's are integral to the module reporting network and module status.

2.1.1 Module and Network Status LED

The module status LED is identified on the module as "MS". It provides device status for power and proper operation. Refer to *Table 2.1* for an outline of this LED's operation. The network status LED is identified on the module as "NS". It provides network status for power and communication. Refer to *Table 2.2* for an outline of this LED's operation.

Table 2.1—Master Module Status LED

Color	State	Indication
None	OFF	No Power
Red	Solid	Unrecoverable Fault
	Flashing	Recoverable Fault (Tool Connected) • Serial Communication Errors • Invalid Tool-ID • Tool Module Returns an Error Message
Green	Solid	Normal Operation
	Flashing	No Tool Connected

Table 2.2—Master Network Status LED

Color	State	Indication
None	OFF	No Power
Red	Solid	Unrecoverable Fault
	Flashing	Output Error or Configuration Error
Green	Solid	Normal Runtime Operation
	Flashing	Device Is In Idle or Not Allocated to a Master

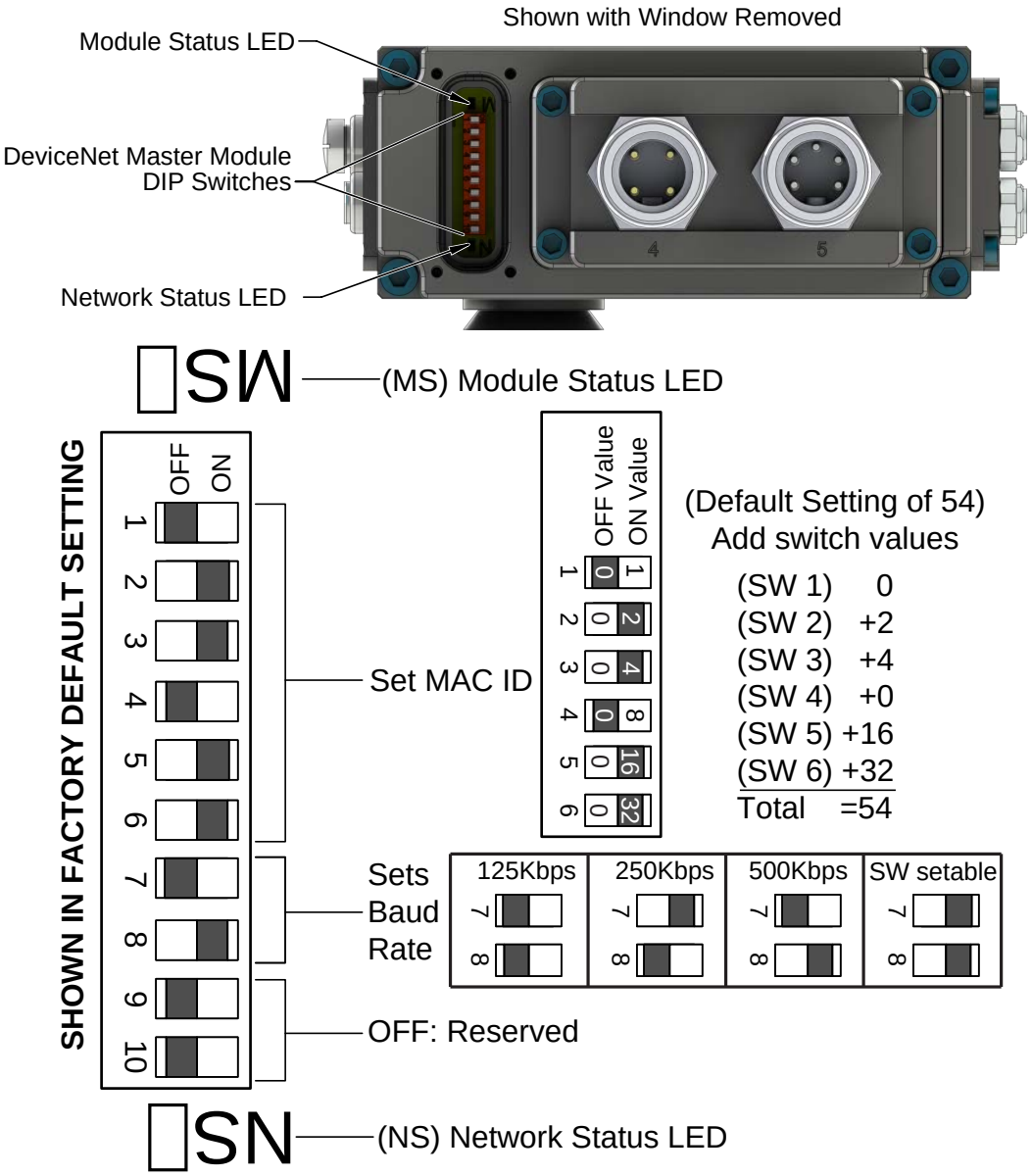
2.1.2 MAC ID

The MAC ID is set by either hardware or software configuration. The range is 0-63. In order for the MAC ID to be set by software, DIP switch positions 7 and 8 must be on. If the MAC ID is set by software, the Baud Rate must also be set by software. Refer to *Figure 2.1* for detailed information on DIP switch setup. The default MAC ID setting from the factory for the Master Node is 54.

2.1.3 Baud Rate

Baud Rate is set by either hardware or software configuration. The possible settings are 125, 250 Baud Rate is set by either hardware or software configuration. The possible settings are 125, 250 or 500Kbps. In order for the Baud Rate to be set by software, DIP switch positions 7 and 8 must be on. See *Figure 2.1* for DIP switch setup. The default Baud Rate setting from the factory for the Master Node is 500Kbps.

Figure 2.1— Master Module DIP Switches and LED's



2.1.4 Termination Resistor

Termination resistance is not supported with the Master Node. Required termination resistance must be provided external to the module.

2.1.5 Cable Drop Length Calculation

Subtract 1 foot from the DeviceNet total drop line budget for each Master node installed on the network (Note: the Master node can exceed the 24pF limit for the differential input capacitance between CAN_H and CAN_L by up to 12pF which is equivalent to 1 foot cable).

2.2 Arc Prevention Circuit

The DU3 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 DU3 Module, the Arc Prevention Circuit controls the ON/OFF status of the Device Net 24V power (CAN V+) and auxiliary power (P1, N1) and (P2, N2). The DU3 module provides an option for the Soft Start feature to prevent the large current spikes associated with a hard power on signal.

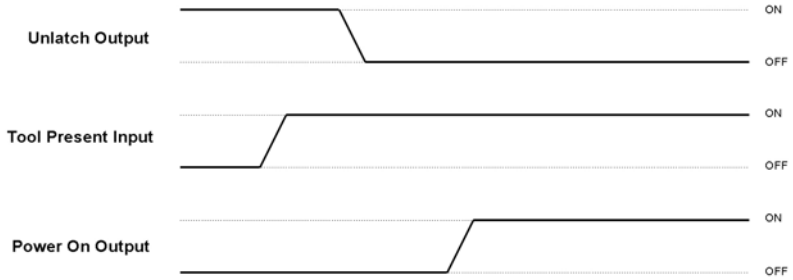
2.2.1 Arc Prevention Circuit Behavior During Coupling

The behavior of the Arc Prevention circuit during coupling can be more clearly understood by referring to *Figure 2.2*, which shows the power-on timing diagram for the Arc Circuit. The Power On Output will be OFF until the Tool Present Input turns on and the Unlatch Output is turned OFF.

NOTICE: The Tool Present Input is an internal input and not reported in the I/O bitmap.

NOTICE: The Arc Prevention Circuit will only allow power to pass to the Tool after the Unlatch Output has been turned OFF and the Tool Present Input has been turned ON.

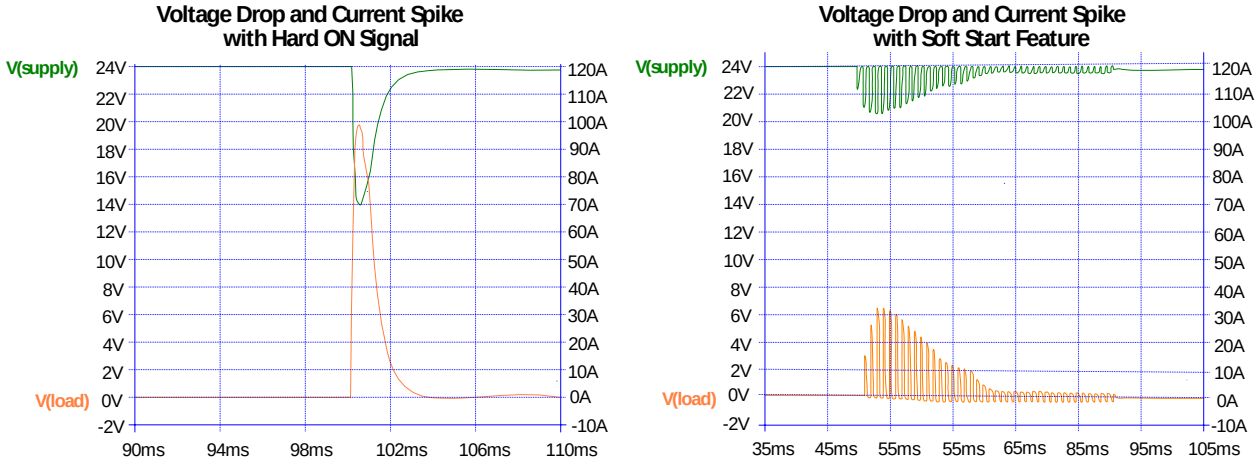
Figure 2.2—Arc Prevention Circuit Power-On Timing



2.2.2 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 2.3* shows how the Soft Start feature effectively reduces the voltage drop on network power. To implement the Soft Start feature, the Soft_Start_Enable bit (Bit 4) must be turned on, Refer to *Table 2.4*.

Figure 2.3—Soft Start Feature

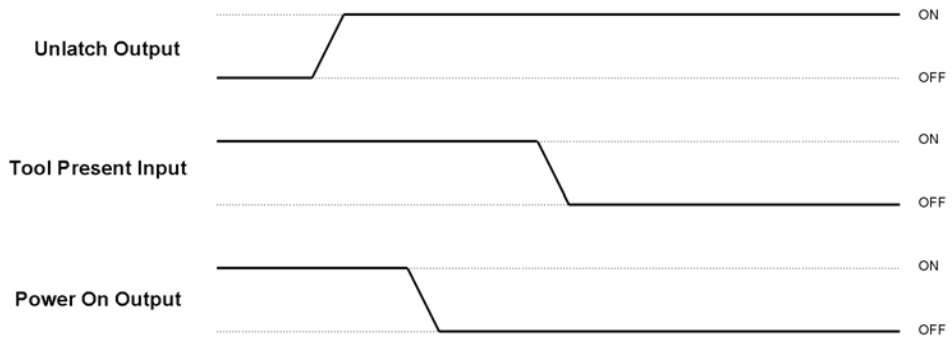


2.2.3 Arc Prevention Circuit Behavior during Uncoupling

The behavior of the Arc Prevention Circuit during uncoupling can be more clearly understood by referring to *Figure 2.4* which shows the power-OFF timing diagram for the Arc Prevention Circuit. Starting from right to left of the diagram, the Unlatch Output command is issued thus initiating uncoupling of the Master and Tool.

Immediately after the Unlatch Output is turned on, the Arc Prevention Circuit will turn OFF the Power On Output. Sometime after power is turned OFF and the Master and Tool begin to separate, electrical contact between Master and Tool Pin Contacts will be lost and the Tool Present Input will go OFF.

Figure 2.4—Arc Prevention Circuit Power-OFF Timing



2.3 Tool Module

In addition to providing Tool-ID, the Tool module also functions as a pass-through for DeviceNet and Auxiliary Power signals to downstream equipment, refer to *Section 9—Drawings*.

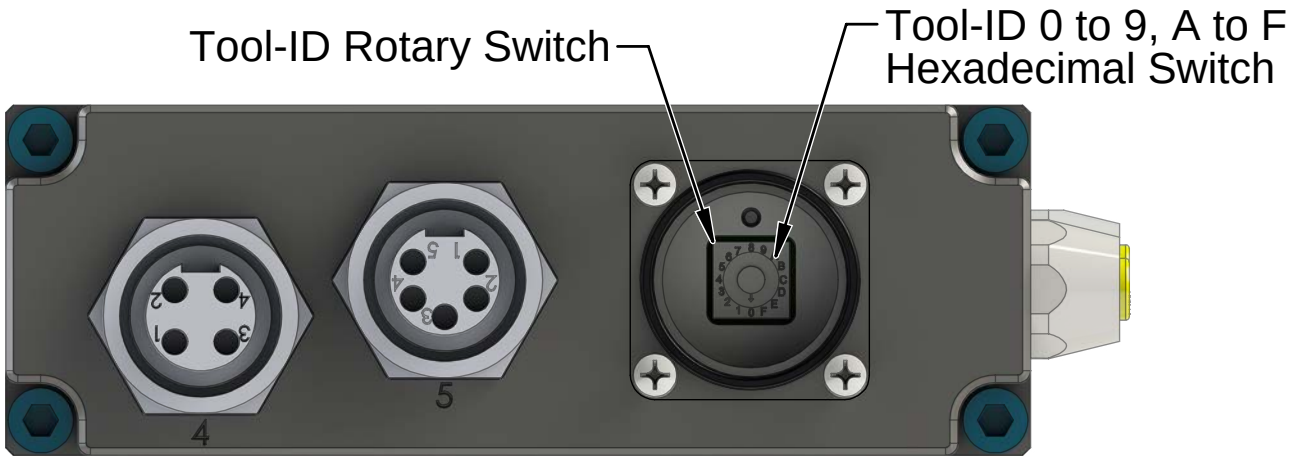
2.3.1 Tool-ID Switches

A rotary switch is provided on the Tool module for setting the Tool-ID number. There are 16 possible Tool-ID values available.

NOTICE: When there is no Tool mated to the Master, the Tool Presence bit will turn OFF and each Tool-ID bit will be assigned a value of 1, which translates to a Tool-ID of 15.

Figure 2.5 shows the location of the Tool-ID rotary switch. After adjustment is completed, ensure that the seal and window are re-positioned correctly to prevent a leakage path to inside the module

Figure 2.5—Tool Module Tool-ID Rotary Switch



2.4 Software

A working EDS file for the Master node is available from our website:

(www.ati-ia.com/download/edsfiles) or by e-mail, reference the following part number.

DU3-M Node EDS file 9031-20-1075

An I/O bitmap for the Master node is provided in the *Table 2.3* and *Table 2.4*.

Table 2.3—Robot Input From ATI Master, (Node 54)

Byte	Bit#	Name	Description/Function
1	0	Locked	Tool Changer Locked Proximity Sensor Input
	1	Unlocked	Tool Changer Unlocked Proximity Sensor Input
	2	Input and Logic Power Good	Input and Logic Power Present Input (11V to 26V)
	3	Valve Power Available	Valve Power Present Input (-19V to -26V)
	4	RTL	Ready-to-Lock Proximity Sensor Input (Series R1 and R2)
	5	Thermal 1	Thermal 1 Input
	6	No TSI or TSRV Discrepancy Present	No TSIx /TSRVx mismatch,TSRV1/TSRV2 mismatch, or TSI1/TSI2 mismatch present.
	7	Air Supply Pressure Available	Air Supply Pressure is greater than 60 psi IMPORTANT: The state of the “Air Pressure not Available” bit will not affect whether or not a Latch or Unlatch command is executed.
2	0	Tool-ID 1	Tool-ID1
	1	Tool-ID 2	Tool-ID2
	2	Tool-ID 4	Tool-ID4
	3	Tool-ID 8	Tool-ID8
	4	Tool in Stand	Indicates if TSI1 and TSI2 are ON. IMPORTANT: If the Euchner Safety Switch is not connected or shorted this bit will not go ON. IMPORTANT: “Tool in Stand” bit will only be reported ON when TSI1 and TSI2 are ON AND there are no mismatch errors.
	5	Unlatch Enabled	Indicates when the preconditions for unlatching the Tool Changer have been met.
	6	TSI1/TSI2 Relays Energized	Unlatch output connected to valve. NOTE: There are other preconditions that must be met before the Unlatch output is executed.
	7	Tool Power Is ON	Indicates that Arc Prevention Circuit is turned ON and power is provided to the Tool

Table 2.4—Robot Outputs to ATI Master, (Node 54)

Byte	Bit#	Name	Description/Function
1	0	Unlatch	Unlatch Solenoid Valve Output
	1	Latch	Latch Solenoid Valve Output
	2	--	(Reserved)
	3	Clear Errors	Reset errors, allow affected I/O to be reactivated
	4	Soft Start Enable	Enables the Arc Prevention soft start functionality.
	5	Arc Prevention Override	Bit employed to facilitate end-of-line testing. FOR ATI USE ONLY.
	6	-	(Reserved)
	7	-	(Reserved)

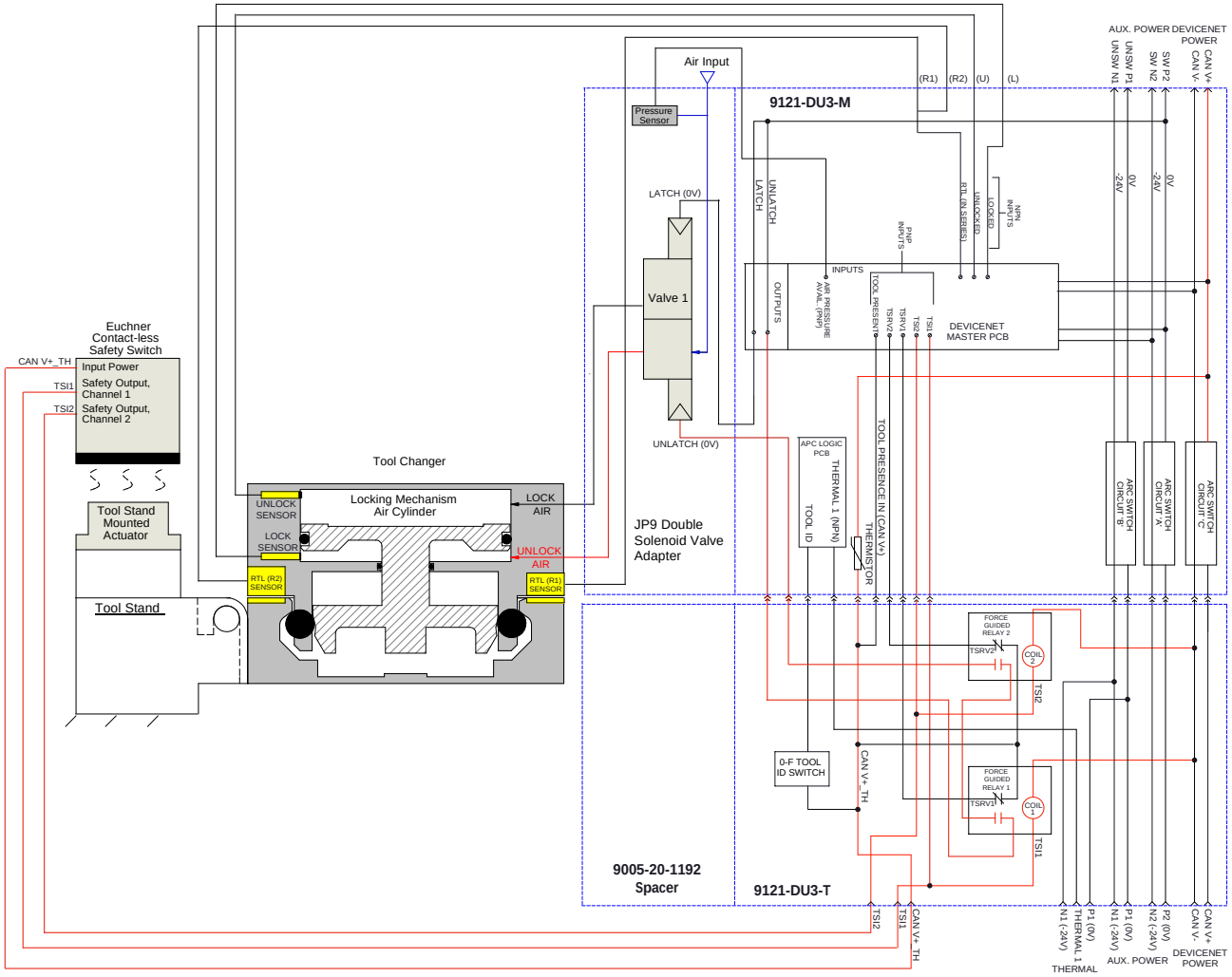
2.5 Safety System

The safety system is designed to avoid unintentional Tool release, by integrating a non-contact safety switch, double solenoid valve with air pressure switch, and redundant force guided relays.

The DU3 modules are equipped with an unlatch circuit that is routed through the normally open contacts of two force guided relays. Diagnostic monitoring of the force guided relays is achieved by evaluation of the TSRV1 and TSRV2 diagnostic signals that pass through the normally closed set of contacts.

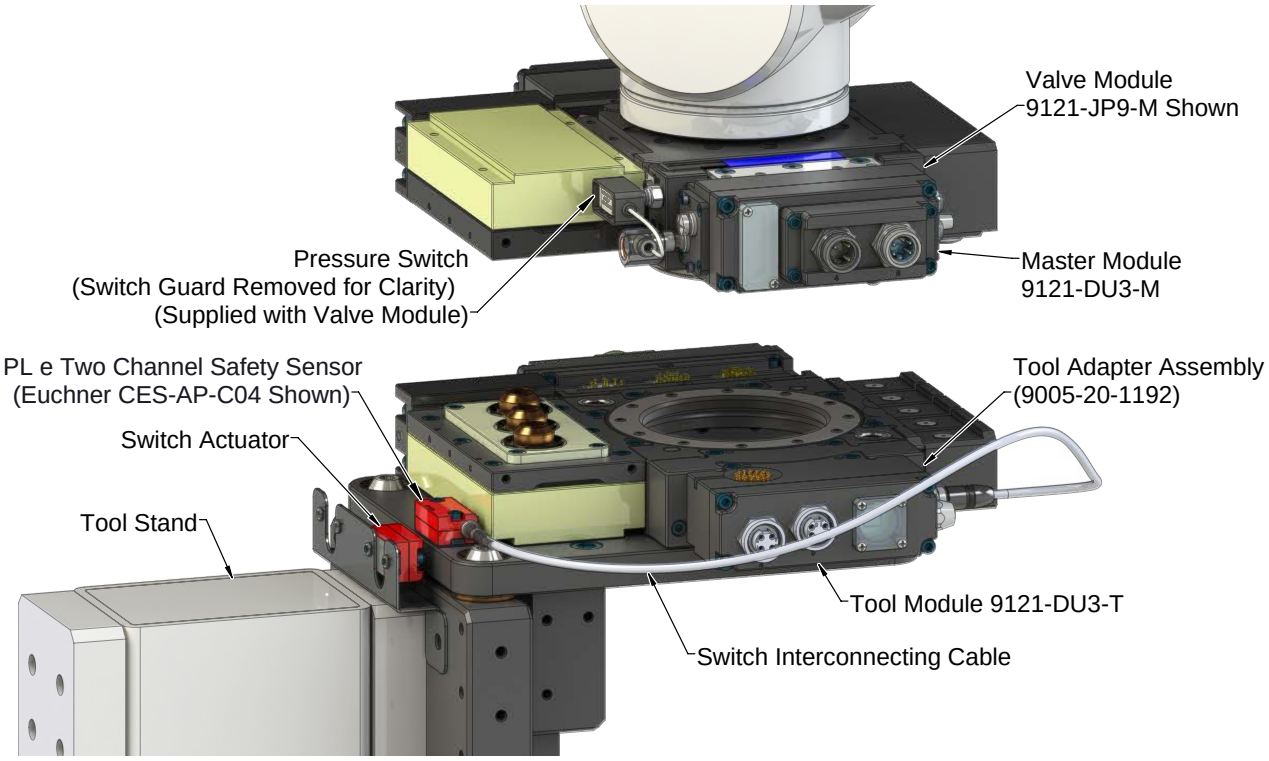
The redundant force guided relays are activated separately by a two channel safety switch. The DU3 modules require the use of a two channel PL e rated contactless safety sensor, specifically a Euchner CES-AP-C01-SB-106798 or CES-I-AP-M-C04-USB-117324. The safety switches and cable are not included with the DU3 modules but are available from ATI.

Figure 2.6—Safety Circuit Diagram



The TSI safety switch (not included with module) is connected to the DU3 Tool module by a five conductor M12 cable and the actuator is mounted to the tool stand. The air pressure switch is included with the valve module, refer to the valve adapter Manual (9620-20-C-Jxx Valve Adapters w Double Solenoid Valve Pass Through Pres Switch) for detailed information on the double solenoid valve functionality.

Figure 2.7—Safety System



The DU3-T module can support three or more safety switches when equipped. The use of more than two safety switches requires a TSI cable adapter kit (9120-DU3SWITCHKIT) which supplies enough power through the DeviceNet connector to support the additional switches. The module can support up to two safety switches in series using the 5-Pin M12 safety switch connector and a SICK 5325889 T-piece distributor both switches. Refer to *Section 9—Drawings* for more information.

2.5.1 Unlatch Circuit Behavior

The DU3 firmware evaluates the status of all of the safety critical inputs before executing an unlatch command. Only when the conditions required for safely unlatching the tool have been met will the DU3 firmware set the Unlatch Enabled bit. The conditions required for safely unlatching the tool are listed in *Table 2.5.*

The TSI1 and TSI2 channels of the safety switch are NO circuits until the Tool is placed in the tool stand closing the safety switch and activating the TSI1 and TSI2 channels. These channels activate the coils inside the redundant force guided relays closing the Unlatch circuit and opening the TSRV1 and TSRV2 NC contacts, allowing the Tool Changer to be Unlatched if all other conditions have been meet.

Although the firmware monitors the air pressure switch it will not preclude the Tool Changer from unlatching.

2.5.2 Fault Conditions

There are fault condition that the firmware monitors during operation that can prevent the Tool Changer from unlatching. Refer to *Section 6.1.1—Error Recovery Sequence* to recover from a fault condition.

2.5.2.1 No TSI or TSRV Discrepancy Present

The TSI1 and TSI2 safety switch inputs should both be in the same state (open or closed), otherwise the "No TSI or TSRV Discrepancy Present" bit will be OFF and the unlatch will be disabled. Similarly, the TSRV1 and TSRV2 diagnostic inputs should both be in the same state, otherwise the "No TSI or TSRV Discrepancy Present" error bit will become OFF and the unlatch will be disabled. A mismatch in the TSI1/2 and or TSRV1/2 inputs indicates the presence of a faulty safety switch, relay, or switch cable.

The TSIx safety switch inputs and the TSRVx relay diagnostic inputs should always be in the opposite state from each other, otherwise the "No TSI or TSRV Discrepancy Present" bit turn OFF and the tool changer will not unlatch.

2.5.2.2 Input and Logic Power Good / Valve Power Available

In addition to the safety switch and the force guided relays, the firmware will not allow the Tool Changer to be unlatched in the event the input or auxiliary power has been lost. The "Input and Logic Power Good" and "Valve Power Available" bits must be ON for the UNLATCH Enable bit to be ON and the Tool to be allowed to unlatch.

2.5.2.3 UNLATCH Enable

There are additional fault conditions that will prevent the Tool changer from unlatching and must be met for the UNLATCH Enable bit to be ON and the Tool to be allowed to unlatch:

1. The Euchner Safety switch generates a pulsed output. If the DU3 detects that this pulse output is missing (indicating a shorted cable or attempted override of the safety system via a jumper plug) then the unlatch will be disabled.
2. If the Locked and Unlocked sensor inputs are ON at the same time, then the DU3 will not execute an unlatch command.

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Table 2.5—UNLATCH Enable Logic and Truth Table

Tool Changer/Module Status	Safety Switch Inputs		Force Guided Relay Feedback Signals from NC Contacts		Bit Input State in Bitmap							
	TSI1	TSI2	TSRV1	TSRV2	TSI1/TSI2 Relays Energized Bit in Bitmap[1]	No TSI or TSRV Discrepancy Present	Input and Logic Power Good	Valve Power Available	Tool in Stand	Locked	Unlocked	UNLATCH Enabled
TSIx and TSRVx Mismatch	OP	OP	OP	OP	1	0	X	X	0	X	X	0
TSRV1/TSRV2 Mismatch	OP	OP	OP	CL	0	0	X	X	0	X	X	0
TSRV1/TSRV2 Mismatch	OP	OP	CL	OP	0	0	X	X	0	X	X	0
Tool is present, positioned in free air	OP	OP	CL	CL	0	1	X	X	0	X	X	0
TSI1/TSI2 Mismatch	OP	CL	OP	OP	1	0	X	X	0	X	X	0
TSIx and TSRVx Mismatch	OP	CL	OP	CL	0	0	X	X	0	X	X	0
TSIx and TSRVx Mismatch	OP	CL	CL	OP	0	0	X	X	0	X	X	0
TSI1/TSI2 Mismatch	OP	CL	CL	CL	0	0	X	X	0	X	X	0
TSI1/TSI2 Mismatch	CL	OP	OP	OP	1	0	X	X	0	X	X	0
TSIx and TSRVx Mismatch	CL	OP	OP	CL	0	0	X	X	0	X	X	0
TSIx and TSRVx Mismatch	CL	OP	CL	OP	0	0	X	X	0	X	X	0
TSIx and TSRVx Mismatch	CL	OP	CL	CL	0	0	X	X	0	X	X	0
Tool is present, positioned in Tool Stand	CL	CL	OP	OP	1	1	X	X	1	X	X	1
TSRV1/TSRV2 Mismatch	CL	CL	OP	CL	0	0	X	X	0	X	X	0
TSRV1/TSRV2 Mismatch	CL	CL	CL	OP	0	0	X	X	0	X	X	0
TSIx and TSRVx Mismatch	CL	CL	CL	CL	0	0	X	X	0	X	X	0
Input and Logic Power Failure	X	X	X	X	X	X	0	X	X	X	X	0
Valve Power Failure	X	X	X	X	X	X	X	0	X	X	X	0
Pulse not detected.	X	X	X	X	X	X	X	X	0	X	X	0
Locked/Unlocked Sensor Fault (on at same time).	X	X	X	X	X	X	X	X	X	1	1	0

Notes:

1. IMPORTANT: These values will only be reported if the Tool Present input is ON.
2. "X" indicates that the state/value of that input does not play a roll in the Tool Changer/Module Status.
3. "OP" means the circuit is open "CL" means the circuit is closed.
4. For Bit Input states: "0" Means the bit state is not active and "1" means the Bit state is active.
5. "Red text" indicates an error condition or incorrect state
6. "Green text" indicates the UNLATCH Enabled state is ON and the Tool Changer can be unlatched.

3. Installation

The control/signal modules are typically installed by ATI prior to shipment. The following steps outline the field installation or removal. For wiring information refer to *Section 9—Drawings*.

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 (e.g. electrical, air, water, etc.) are turned off, pressurized connections are purged and power is discharged from circuits in accordance with the customer's 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.

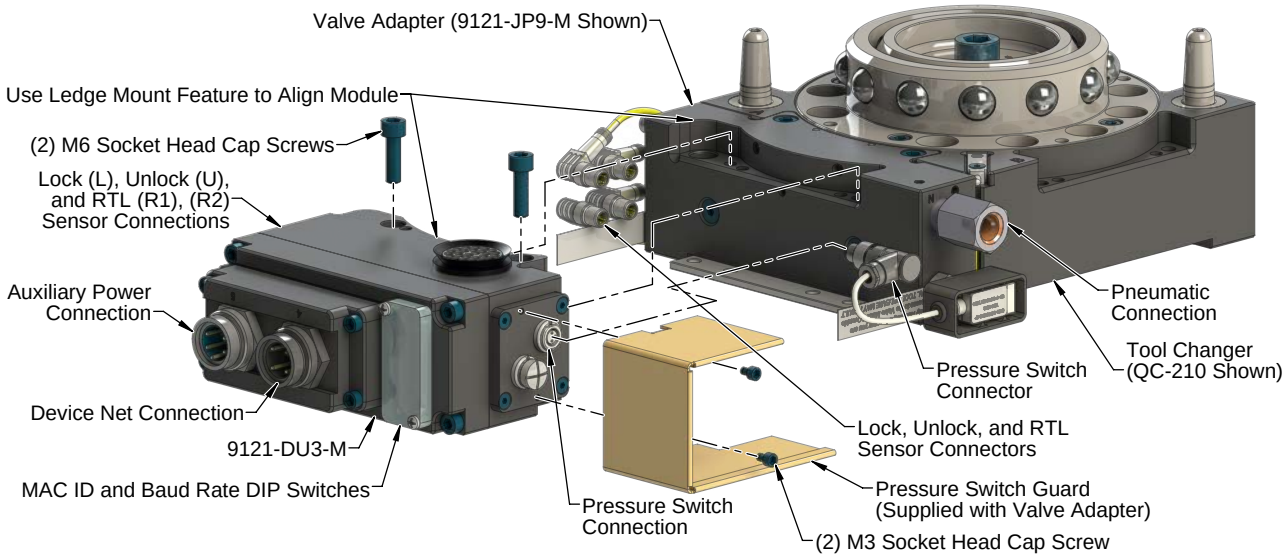
3.1 Master DU3-M Module Installation

Tools required: *2.5 mm and 5 mm Allen wrenches (hex key), torque wrench*

Supplies required: *clean rag, Loctite® 242 (if fasteners do not have pre-applied adhesive)*

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
4. Clean the mating surfaces.
5. Using the ledge feature, place the module into the appropriate location on the valve adapter. Align the module with the valve adapter using the dowels in the bottom of the ledge feature. Refer to *Figure 3.1*.
6. If fasteners do not have pre-applied adhesive, apply Loctite 242 to the supplied M6 socket head cap screws. Install the (2) M6 socket head cap screws securing the module to the valve adapter and tighten to 70 in-lbs (7.9 Nm).
7. Set the DIP switches for the MAC ID and Baud Rate desired. Refer to *Section 3.5—Setting the MAC ID and Baud Rate DIP Switches*.
8. Connect the (L) Lock, (U) Unlock, and (R1 and R2) RTL sensor cable connectors to the DU3-M module.
9. Connect the pressure switch from the valve adapter to the control/signal module.

Figure 3.1—Master Module Installation and Removal



10. Install the Pressure switch Guard to the contol/signal module. Secure the guard to the control/signal module with the (2) M3 socket head cap screws using a 2.5 mm Allen wrench. Tighten to 10 in-lbs (1.13 Nm)
11. Customer interface, auxiliary power and DeviceNet cables to the module. Ensure that the connectors are cleaned prior to being secured.
12. After the procedure is complete, resume normal operation.

3.2 Master DU3-M Module Removal

Tools required: *5 mm Allen wrench (hex key), torque wrench*

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
4. Disconnect the (L) Lock, (U) Unlock, and (R1 and R2) RTL sensor cable connectors from the DKR-M module.
5. Disconnect the auxiliary power and Device Net cables from the DU3-M module.
6. Disconnect the pressure switch cable from the DU3-M module.
7. Support the control/signal module and remove the (2) M6 socket head cap screws and lower the module until it clears the guide pin. Refer to o *Figure 3.1*.

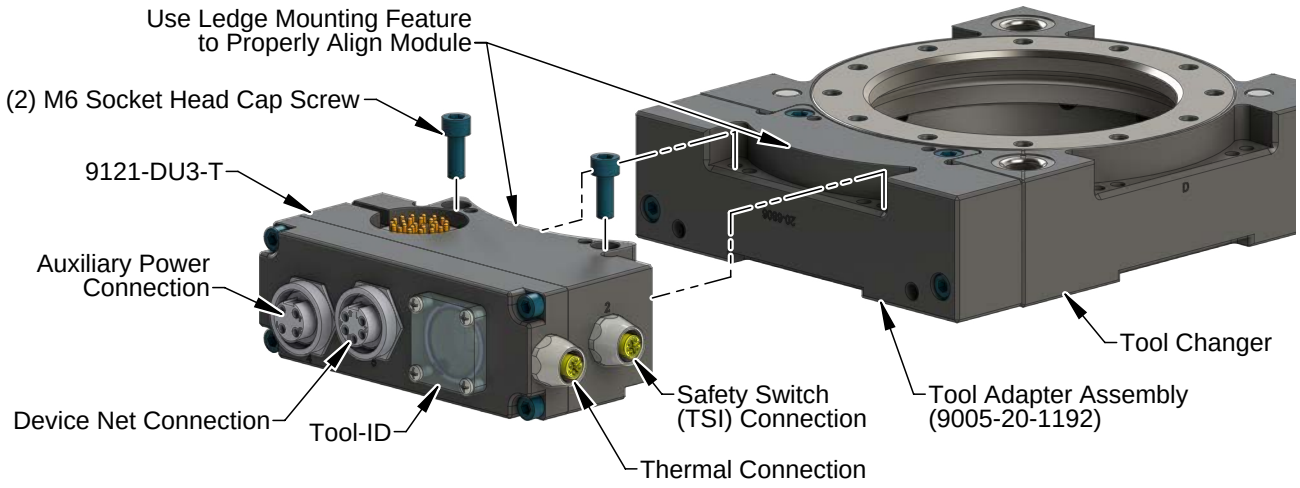
3.3 Tool DU3-T Module Installation

Tools required: *5 mm Allen wrench (hex key)*

Supplies required: *clean rag, Loctite® 242 (if fasteners do not have pre-applied adhesive)*

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
4. Clean the mating surfaces.
5. Using the ledge feature, place the module into the appropriate location on the valve adapter spacer. Align the module with the valve adapter spacer using the dowels in the bottom of the ledge feature. Refer to *Figure 3.2*.
6. Apply Loctite 242 to the supplied M6 socket head cap screws. Install the (2) M6 socket head cap screws securing the module to the valve adapter spacer and tighten to 70 in-lbs (7.9 Nm).
7. Connect the safety switch and thermal cables to the Tool module.
8. Connect the power cable and DeviceNet cable connectors to the Tool module.
9. Set the Tool-ID. Refer to *Section 3.6—Setting the Tool-ID.*
10. After the procedure is complete, resume normal operation..

Figure 3.2—Tool Module Installation and Removal



3.4 DU3-T Tool Module Removal

Tools required: *5 mm Allen wrench*

1. Place the Tool in a secure location.
2. Uncouple the Master and Tool plates.
3. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
4. Disconnect (e.g. power, signal, auxiliary, etc.) cables from the control/signal module.
5. Disconnect the cable from the control/signal module to the TSI limit switch.
6. Support the control/signal module, remove the (2) M6 socket head cap screws using a 5 mm Allen wrench, and lift the module from the valve adapter.

3.5 Setting the MAC ID and Baud Rate DIP Switches

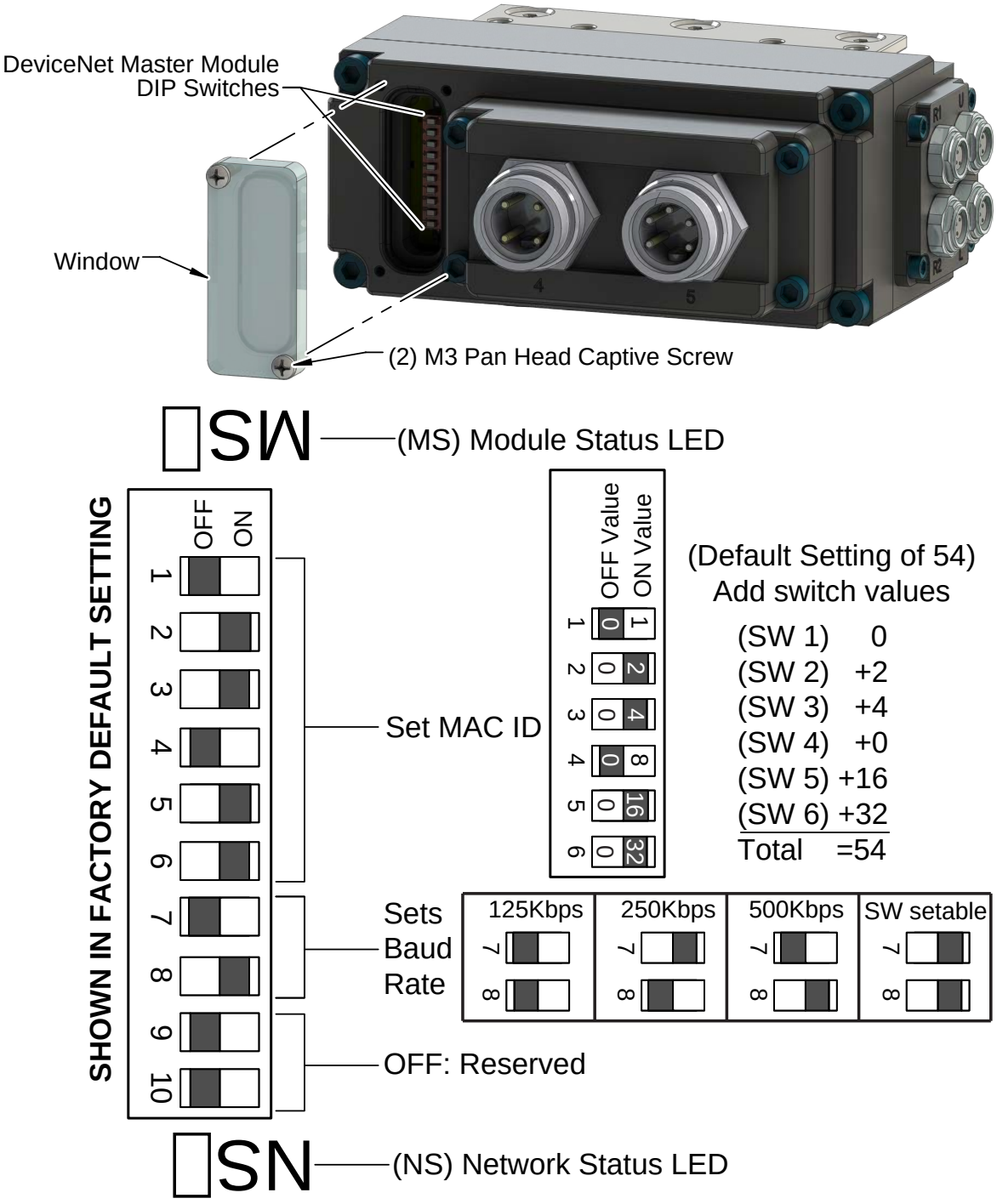
Tools required: *Phillips head screw driver*

1. Loosen the four M3 pan head captive screws and remove the window.
2. Set the DIP switches as needed, refer to *Figure 3.3* for details.

NOTICE: When replacing the window, ensure that the seal is positioned correctly to prevent fluid leakage into the module and damaging the electronics.

3. Install the window and tighten the M3 pan head captive screws.

Figure 3.3— Master Module DIP Switches and LED's



3.6 Setting the Tool-ID

The rotary switch is provided on the Tool module for setting of a Tool-ID number. Each Tool should be set to unique number from 0-F.

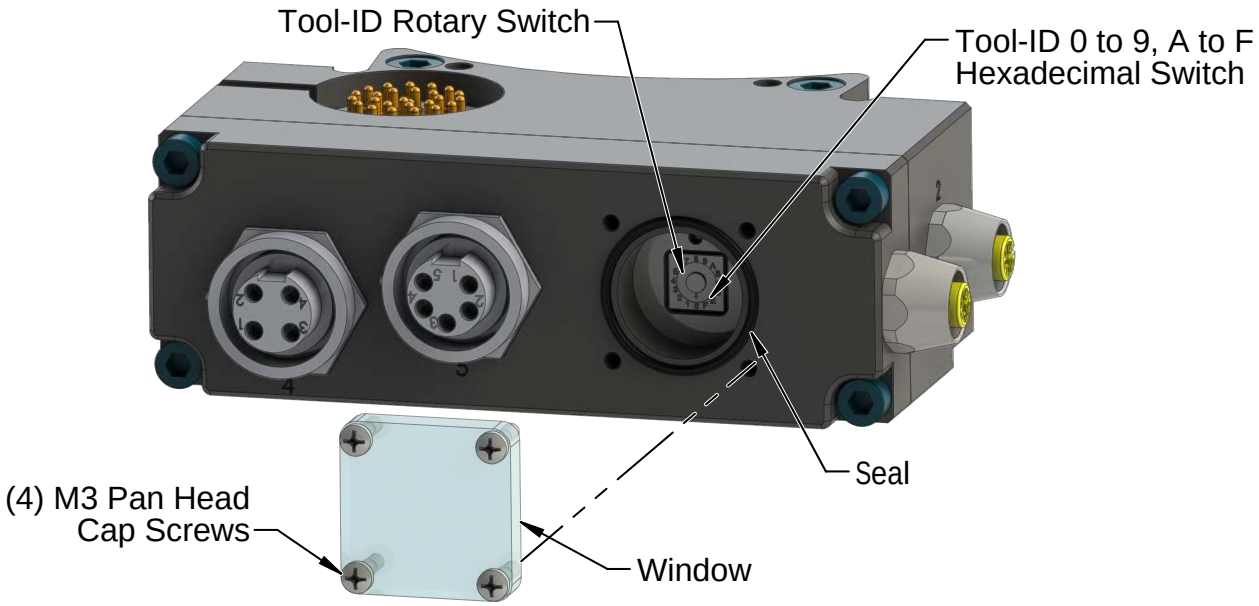
Tools required: *Phillips head screw driver, flat head screw driver*

1. Loosen the four M3 Pan head Captive Screws and remove the window.
2. Use a flat head screw driver to turn rotary switch to the digit value from 0 to F. Set the Tool-ID to the desired unique number each Tool.

NOTICE: When replacing the window, ensure that the seal is positioned correctly to prevent fluid leakage into the module and damaging the electronics.

3. Re-install the window and tighten the (4) M3 Pan Head Captive Screws.

Figure 3.4—Tool Module Tool-ID Rotary Switch



3.7 Utility Schematic

Refer to *Section 9—Drawings* of this manual for customer interface and wiring details for the DU3 modules.

WARNING: All pneumatic fittings and tubing must be capable of withstanding the repetitive motions of the application without failing. The routing of electrical and pneumatic lines must minimize the possibility of over stressing, pullout, or kinking the lines. Failure to do so can cause some critical electrical and/or pneumatic lines to malfunction and may result in injury to personnel or damage to equipment. Follow the robot manufacturer's guidelines and carefully route hoses and cables to avoid damage.

4. Operation

A procedure in *Section 4.3—Recommended Sequence of Operations* is to be used as a general guide when programming a robot or PLC for use with a Tool Changer and DU3 control/signal modules. This procedure is intended for "automatic" modes used during normal application processes.

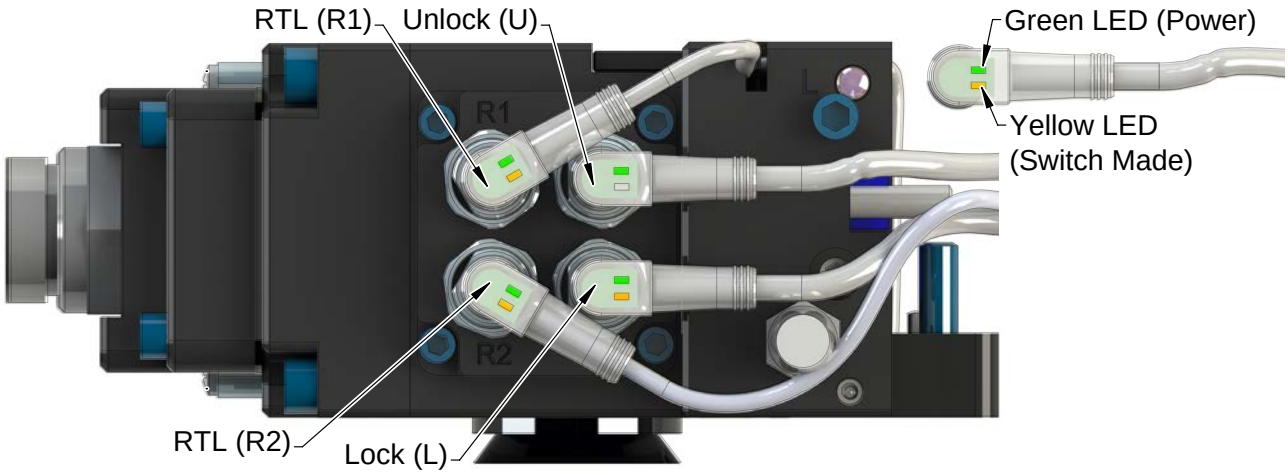
4.1 Lock, Unlock, and RTL Sensor Cable LED Behavior

The Lock, Unlock, and RTL sensor cables are equipped with (2) LEDs. The green LED indicates the sensor has power and the yellow LED indicates the switch has been made, The LED behavior is affected by the control/signal module. The behavior shown is specific for the Tool Changer with a control/signal module equipped with RTL sensors wired in series.

Table 4.1—Sensor Cable LED Behavior for Common Tool Changer Positions

Tool Changer Position	Sensor Cable LED Behavior			
Unlocked (Tool Changer Master plate free of stand with no Tool plate attached)	RTL (R1)	OFF OFF	ON ON	Unlock (U)
	RTL (R2)	ON OFF	ON OFF	Lock (L)
Ready to Lock (Tool Changer Master plate with Tool plate parallel and at a distance of 1.22 mm or less from each other)	RTL (R1)	ON ON	ON ON	Unlock (U)
	RTL (R2)	ON ON	ON OFF	Lock (L)
Locked (Tool Changer Master plate with Tool plate attached in fully locked position)	RTL (R1)	ON ON	ON OFF	Unlock (U)
	RTL (R2)	ON ON	ON ON	Lock (L)
Missed Tool (Tool Changer Master plate locked with no Tool plate attached)	RTL (R1)	OFF OFF	ON OFF	Unlock (U)
	RTL (R2)	ON OFF	ON OFF	Lock (L)

Figure 4.1—Lock, Unlock, and RTL Sensor Cable LED Behavior (Shown in Locked Position)



(Control module shown for reference only)

4.2 Inputs

The following describes the most critical inputs from the ATI Master module.

4.2.1 Locked

When the Locked input goes ON it indicates the Tool Changer locking mechanism has moved to the locked position turning on the Locked Proximity Sensor Input. When the Locked input goes OFF it indicates the locking mechanism has moved towards the Unlocked position out of the range of the Locked Proximity sensor.

4.2.2 Unlocked

When the Unlocked input goes ON it indicates the Tool Changer locking mechanism has moved to the unlocked position turning on the Unlocked Proximity Sensor Input. When the Unlocked input goes OFF it indicates the locking mechanism has moved towards the Locked position out of the range of the Unlocked Proximity sensor.

4.2.3 Input and Logic Power Good

The Input and Logic Power Good input will turn ON when the un-switched auxilary power is present (11V to 26V). The firmware will not allow the Tool Changer to be unlatched in the event the input or auxiliary power has been lost. The Input and Logic Power Good bits must be ON for the UNLATCH Enable bit to be ON and the Tool to be allowed to unlatch.

4.2.4 Valve Power Available

The Valve Power Available input will turn ON when the switched auxilary power is present (-19V to -26V).The firmware will not allow the Tool Changer to be unlatched in the event the input or auxiliary power has been lost. The Valve Power Available bits must be ON for the UNLATCH Enable bit to be ON and the Tool to be allowed to unlatch.

4.2.5 RTL

The (Ready-to-Lock) RTL input will turn ON when the Tool Changer Master and Tool Plates are in close enough proximity to each other to activate the RTL sensors (Series R1 and R2).

4.2.6 Thermal 1

If the Thermal 1 input is ON it indicates the NPN thermal input from the Tool module is activated.

4.2.7 No TSI or TSRV Discrepancy Present

For the No TSI or TSRV Discrepancy Present input to be ON the following conditions must exist:

1. The TSI1 and TSI2 safety switch inputs must both be in the same state (open or closed).
2. The TSRV1 and TSRV2 diagnostic inputs must both be in the same state (open or closed).
3. The TSI1/TSI2 and TSRV1/TSRV2 diagnostic inputs must always be in the opposite state from each other.

If any of the conditions are not meet the No TSI or TSRV Discrepancy Present input to be OFF and the tool changer will not unlatch.

4.2.8 Air Supply Pressure Available

The Air Supply Pressure Available input will turn ON when the air supply pressure is greater than 60 psi. The state of the “Air Pressure not Available” bit will not affect whether or not a Latch or Unlatch command is executed.

4.2.9 Tool-ID 1, 2, 4, and 8

The Tool module provides a rotary Tool-ID switch with 16 positions (hex 0 – F) that be used to set unique values for each tool. The Master uses the Tool-ID outputs to report this number in its binary form.

4.2.10 Tool in Stand

For the Tool in Stand input to turn ON the following condition must exist:

1. The TSI1 and TSI2 inputs close indicating the Euchner safety switch has been actuated.
2. The Euchner Safety Switch must be connected and not shorted.
3. The No TSI or TSRV Discrepancy Present input to be ON.

If any of the conditions are not meet the Tool in Stand input to be OFF.

4.2.11 Unlatch Enabled

The Unlatch Enabled input will turn ON when all the preconditions for unlatching the Tool Changer have been met. There are additional fault conditions that will prevent the Tool changer from unlatching and must be met for the Unlatch Enable bit to be ON and the Tool to be allowed to unlatch. Refer to *Section 2.5.2—Fault Conditions* for conditions affecting the Unlatch Enable input.

4.2.12 TSI1/TSI2 Relays Energized

When the TSI1/TSI2 Relays Energized input to turn ON, this indicates the Unlatch output connected to valve. The Euchner safety switch must be actuated, closing the TSI1 and TSI2 inputs in order for the relays to energize.

NOTICE: There are other preconditions that must be met before the Unlatch output is executed.

4.2.13 Tool Power Is ON

If the “Tool Power Is ON input” is turned ON, it indicates that Arc Prevention Circuit is turned ON and power is provided to the Tool.

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4.3 Recommended Sequence of Operations

1. 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, i.e.; **Locked** input is OFF). The tool is by itself in the Tool Stand.

   a. The following inputs are ON:
      i. **Unlocked**
      ii. **Input and Logic Power Good**
      iii. **Valve Power Available**
      iv. **Air Supply Pressure Available**
      v. **No TSI or TSRV Discrepancy Present**

   b. The following inputs are OFF:
      i. **Locked**
      ii. **RTL**
      iii. **Unlatch Enabled**
      iv. **Tool in Stand**
      v. TSI1/TSI2 Relays Energized
      vi. **Tool Power Is On**
      vii. **Tool-ID** is invalid (all bits are 1)

> **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 the Tool Changer is locked or in a missed tool condition, refer to *Section 6.1.2—Solenoid Valve Manual Override Procedure* to unlock the Tool Changer before attempting to latch Master with Tool.

2. Robot and Master move into the Tool, are parallel and within 0.15” 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)

3. Robot and Master move within 0.06” of the Tool.

   a. The **RTL** input is ON, indicating that it is okay to couple the Tool.
   b. The **Tool in Stand** turns ON, indicating that the safety switch actuator is within sensing range of the target.
   c. **Tool-ID** becomes available through DeviceNet communications within 100-150 ms.
   d. The **Unlatch Enabled, TSI1/TSI2 Relays Energized**, and **No TSI or TSRV Discrepancy Present** inputs turn ON.

4. Couple the Tool Changer.

   a. Turn the **Unlatch** output OFF (not required for pulsed outputs).
   a. Turn the **Latch** output ON.
   b. The **Unlocked** input turns OFF a short time later, indicating piston travel. Subsequently, the **Locked** input turns ON, indicating that the coupling operation is complete.
   c. The Arc Prevention circuit sends power to the end-of-arm tooling, turning ON **Tool Power Is On** input.
   d. Shortly thereafter, communications should be established with the downstream DeviceNet nodes.

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

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6. Normal operation
    a. The following inputs are ON:
        i. **Locked**
        ii. **Input and Logic Power Good**
        iii. **Valve Power Available**
        iv. **Air Supply Pressure Available**
        v. **RTL**
        vi. **No TSI or TSRV Discrepancy Present**
        vii. **Tool Power Is On**
    b. The following inputs are OFF:
        i. **Unlocked**
        ii. **Unlatch Enabled**
        iii. **Tool in Stand**
        iv. TSI1/TSI2 Relays Energized
    c. The following output is ON:
        i. **Latch** (for pulsed output **Latch** is OFF)
    d. The following output is OFF:
        i. **Unlatch**
7. Robot moves into the Tool Stand with the Tool Changer coupled. When tool is position correctly in stand the **Tool in Stand, TSI/TSI2 Relays Energized** and **Unlatch Enabled** go ON.
8. Uncouple the Tool Changer.
    a. Turn the **Latch** output OFF (not required for pulsed outputs).
    b. Turn the **Unlatch** output ON.
    c. The **Locked** input turns OFF a short time later, indicating piston travel. Subsequently the **Unlocked** input turns ON, indicating that the uncoupling operation is complete.
    d. Arc Prevention circuit turns power OFF to the end-of-arm tooling, **Tool Power Is On** turns OFF.
    e. Communication is lost with the ATI Tool and downstream nodes.
9. Robot and Master move away from the Tool, are parallel and a distance >0.125” from the Tool
    a. The **RTL** input becomes OFF.
    b. **Tool-ID** becomes invalid (all bits are 1)
10. Robot and Master in free space (>0.15” from the Tool).
    a. The following inputs are ON:
        i. **Unlocked**
        ii. **Input and Logic Power Good**
        iii. **Valve Power Available**
        iv. **Air Supply Pressure Available**
        v. **No TSI or TSRV Discrepancy Present**
    b. The following inputs are OFF:
        i. **Locked**
        ii. **RTL**
        iii. **Unlatch Enabled**
        iv. **Tool in Stand**
        v. TSI1/TSI2 Relays Energized
        vi. **Tool Power Is On**
        vii. **Tool-ID** invalid (all bits are 1)

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5. Maintenance

Once installed, the operation of the control modules is generally trouble free. The modules are not designed to be field serviced as all point-to-point wiring connections are soldered. Component replacement is limited to the V-ring seal on the Master.

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

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.

Under normal conditions, no special maintenance is necessary; however, it is recommended that periodic inspections be performed to assure long-lasting performance and verify that unexpected damage has not occurred. Perform the following visual inspection monthly:

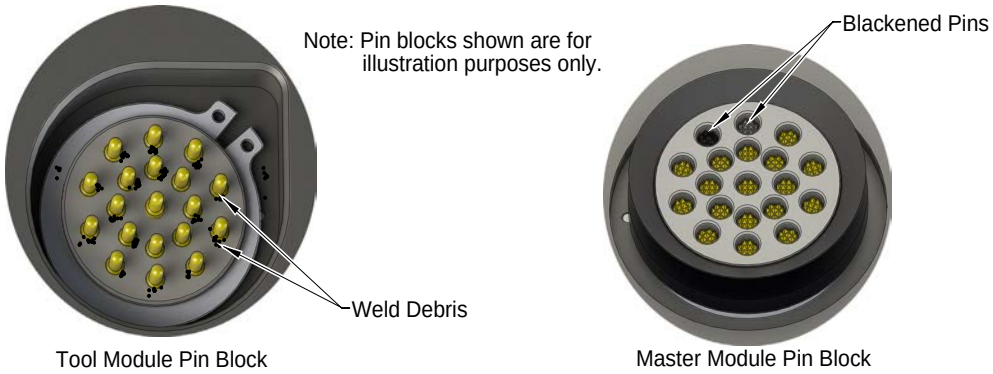
- Inspect mounting fasteners to verify they are tight and if loose, then tighten to the torque specified in *Section 3—Installation.*
- Cable connections should be inspected during maintenance periods to ensure they are secure. Loose connections should be cleaned and re-tightened. Inspect cable sheathing for damage, repair or replace damaged cabling. Loose connections or damaged cabling are not expected and may indicate improper routing and/or strain relieving.
- Inspect the Master and Tool pin blocks for any pin damage, debris or darkened pins. Refer to *Section 5.1—Pin Block Inspection and Cleaning.*
- Inspect V-Ring seals for wear, abrasion, and cuts. If worn or damaged, replace. Refer to *Section 6.2.1—V-ring Seal Replacement*.

5.1 Pin Block Inspection and Cleaning

Tools required: *Nylon Brush (ATI Part Number 3690-0000064-60)*

1. For a Tool Changer, if the Tool Changer is installed place the Tool safely in the tool stand. Uncouple the Tool Changer or Utility Coupler to allow clear access to the Master and Tool plates.
2. Turn off and de-energize all energized circuits (e.g. electrical, air, water, etc.).
3. Inspect the Master and Tool pin blocks for any debris or darkened pins.

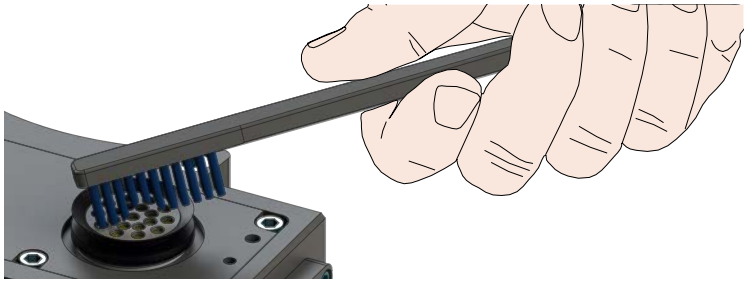
Figure 5.1—Inspect Master and Tool Pin Blocks



4. If debris or darkened pins exist, remove debris using a vacuum, and clean using a nylon brush (ATI Part Number 3690-0000064-60).

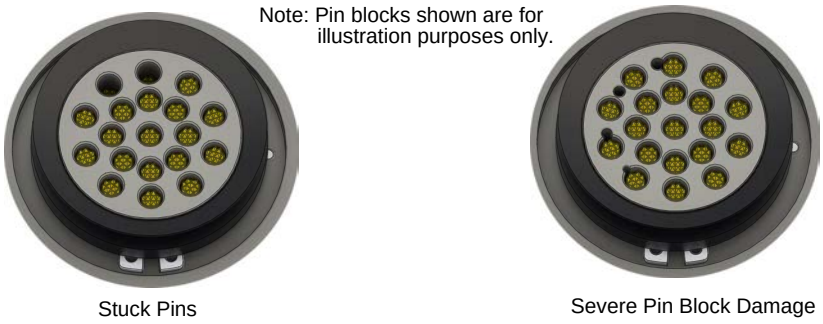
NOTICE: Do not use an abrasive media, cleaners, or solvents to clean the contact pins. Using abrasive media, cleaners, or solvents will cause erosion to the contact surface or pins to stick. Clean contact surfaces with a vacuum or non-abrasive media such as a nylon brush (ATI Part Number 3690-0000064-60)

Figure 5.2—Clean Pin Blocks with a Nylon Brush



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

Figure 5.3—Stuck Pin and Pin Block Damage



6. If stuck pins or severe pin block damage exists, contact ATI for possible pin replacement procedures or module replacement.
7. If repairs are complete, return circuits to normal operation.

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6. Troubleshooting and Service Procedures

The following section provides troubleshooting information to help diagnose conditions with the Tool Changer and service procedures to help resolve these conditions.

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 (e.g. electrical, air, water, etc.) are turned off, pressurized connections are purged and power is discharged from circuits in accordance with the customer's 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.

6.1 Troubleshooting

Refer to the following table for trouble shooting information.

Table 6.1—DU3 Troubleshooting

Symptom	Possible Cause	Correction
Unit will not lock or unlock.	Verify that ball bearings are moving freely. Clean and lubricate as needed.	Verify that ball bearings are moving freely. Clean and lubricate as needed. Refer to the Maintenance section of the Tool Changer manual for instructions.
	Air supply not to specifications.	Check air supply. Refer to the Installation section of the Tool Changer manual for specifications.
	Check that exhaust port is properly vented.	Check that exhaust port is properly vented. *Refer to Pneumatic Connection section of the Base Tool Changer Manual for valve requirements.*
	Incorrect valve operation.	Check valve for proper operation. *Refer to Pneumatic Connection section of the Base Tool Changer Manual for valve requirements.*
	Master and Tool are within the specified No-Touch zone.	Verify that the Master and Tool are within the specified No-Touch zone when attempting to lock. *Refer to the Installation – Tool Stand Design Section of the Tool Change manual for specifications.*
	Conditions for safe unlatch are not met (Unlatch Enabled inputs is OFF).	Make sure safety switch is not by passed, if so reconnect safety switch. *Verify the Unlatch Enabled bit input is OFF, if so refer to Section 2.5.2—Fault Conditions for possible error conditions.*
	Auxiliary Power not available (Auxiliary Power Available inputs is OFF).	*Verify the Auxiliary Power Available inputs is OFF, if so refer to Section 2.5.2—Fault Conditions for possible error conditions.*
	TSIx and/or TSRVx mismatch as indicated by "No TSI or TSRV Discrepancy" bit being OFF.	Possible causes for mismatch error can include: Damaged Safety Switch cable Faulty Safety Switch Spring probe contamination or damaged spring probes Faulty TSI Relays *After checking for damaged components, perform the error recovery sequence, refer to Section 6.1.1—Error Recovery Sequence.*
	Input and Logic Power not available.	In case of Logic Power failure condition the "Input and Logic Power Good" bit shall stay OFF until Logic power is restored, at which point it will return ON.
	Valve Power not available.	In case of Valve Power failure condition the "Valve Power Available" bit shall stay OFF until Valve Power is restored, at which point it will return ON.

Table 6.1—DU3 Troubleshooting		
Symptom	**Possible Cause**	**Correction**
Sensors Malfunctioning.	Sensor cables damaged or incorrectly connected.	Verify that cables are connected correctly and not damaged, replace if damaged. Refer to the Troubleshooting Section of the Tool Change manual.
	Sensors are set correctly.	Verify that the sensors are set correctly. Refer to the Troubleshooting Section of the Tool Changer manual.
	Tool Plate is not secured properly or debris is trapped between surfaces.	Ensure that the Tool Plate is securely held to the Master Plate, that nothing is trapped between their surfaces.
	Air trapped in the Unlock (U) air port.	Ensure that there is no air trapped in the Unlock (U) air port. Refer to Air and Valve adapter section for pneumatic specification and requirements.
Loss of DeviceNet Communication.	Damaged signal cabling or not tuned properly.	Check/Replace signal cabling up- and down-stream of Tool Changer modules.
		Verify DeviceNet network and cabling is properly tuned.
	Worn or damaged contact pins.	Inspect module contact pins for debris/wear/damage. Refer to *Section 5.1—Pin Block Inspection and Cleaning.*
	Product up- and downstream of Tool Changer failed or damaged.	Check nodes up- and downstream of Tool Changer for failures. These failures can “masquerade” as Tool Changer node faults.
No Power on the Tool-side.	Worn or damaged contact pins.	Inspect module contact pins for debris/wear/damage. Refer to *Section 5.1—Pin Block Inspection and Cleaning.*
	Latch output has not been turned **ON.**	Verify that the **Latch** output is **ON and the Unlatch** output is **OFF.** Verify that the **Tool Power IS ON** bit is **ON**.
	Arc Prevention circuit or module malfunctioning.	Contact ATI for service.
Loss of Aux. Power on the Tool-side.	Loss of DeviceNet power on the Master side will cause loss of Aux. Power to the Tool. The Arc Prevention Circuit relies on DeviceNet power to operate.	Restore DeviceNet Power to the Master to restore Aux. Power to Tool.

6.1.1 Error Recovery Sequence

If the Tool Changer is unable to be unlatched due to a fault condition it can be reset either by a power cycle or following the steps in the recovery sequence.

1. Turn OFF the Unlatch Output.
2. With the Master and Tool locked, move the Tool Changer away from the Tool stand.
3. Toggle the “Clear Errors” output.
4. The “No TSI or TSRV Discrepancy Present” error bit should now be ON.
5. Move the Tool Changer back into the Tool Stand.
6. Verify that the Unlatch Enabled bit is ON.
7. Attempt to Unlatch again.

6.1.2 Solenoid Valve Manual Override Procedure

Double solenoid valve adapters have manual override buttons on both lock and unlock side of the valve. The manual override should only be used for unlocking the Tool Changer.
The manual override procedure should be used when the Tool Changer is locked without the Tool plate attached. The control module safety circuit will not allow the Tool Changer to be unlatched without the Tool plate attached and the tool in the tool stand.

WARNING: 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.

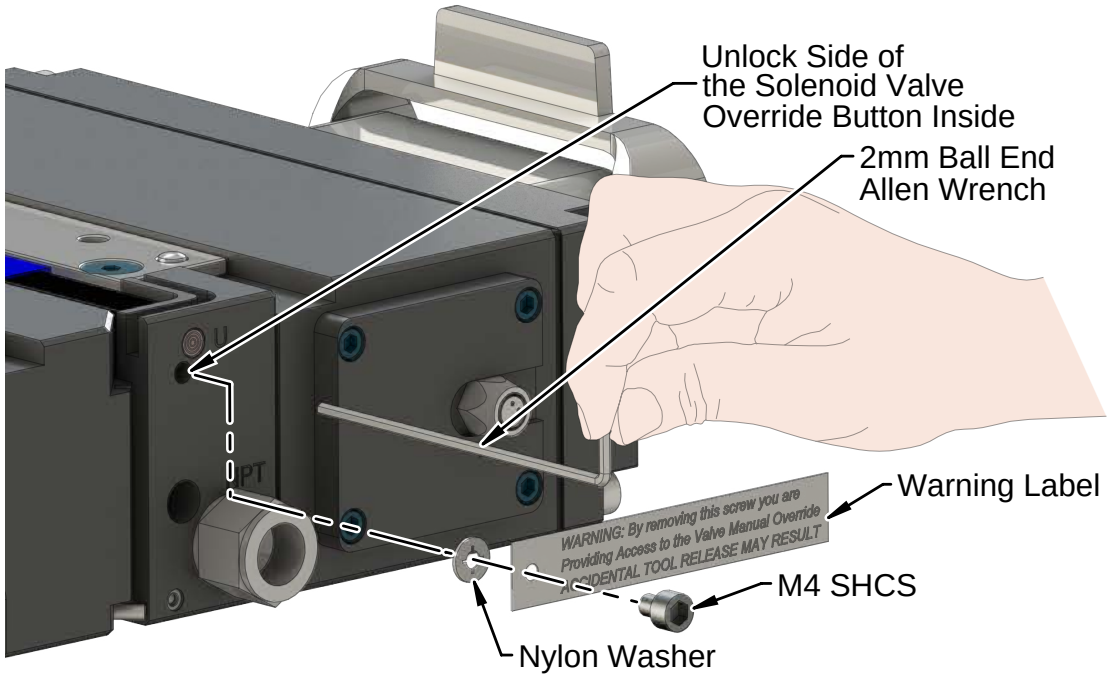
Tools required: *3 mm Allen Wrench, 2 mm ball end Allen wrench (hex key)*

1. Using a 3 mm Allen wrench, remove the M4 socket head cap screws, warning label, and nylon washer from the Unlock side of the solenoid valve. The Unlock side is marked with a “U”.

CAUTION: Applying excess force can damage the solenoid or cause override button to stick in one position. Actuation of valve override buttons requires very little travel (~1 mm) and only a small amount of force. Use non-sharp object, similar to ball nose 2 mm Allen key, to gently depress the override button; an air release should be heard when the solenoid is activated.

2. Insert a 2 mm ball end Allen Wrench in the unlock valve screw hole and gently depress the valve override button. An air release should be heard when the solenoid is actuated. Make sure locking mechanism is fully retracted.
3. Using a 3 mm Allen wrench, replace the M4 socket head cap screws, warning label, and nylon washer and tighten the screw.

Figure 6.1—Manual Override



6.2 Service Procedures

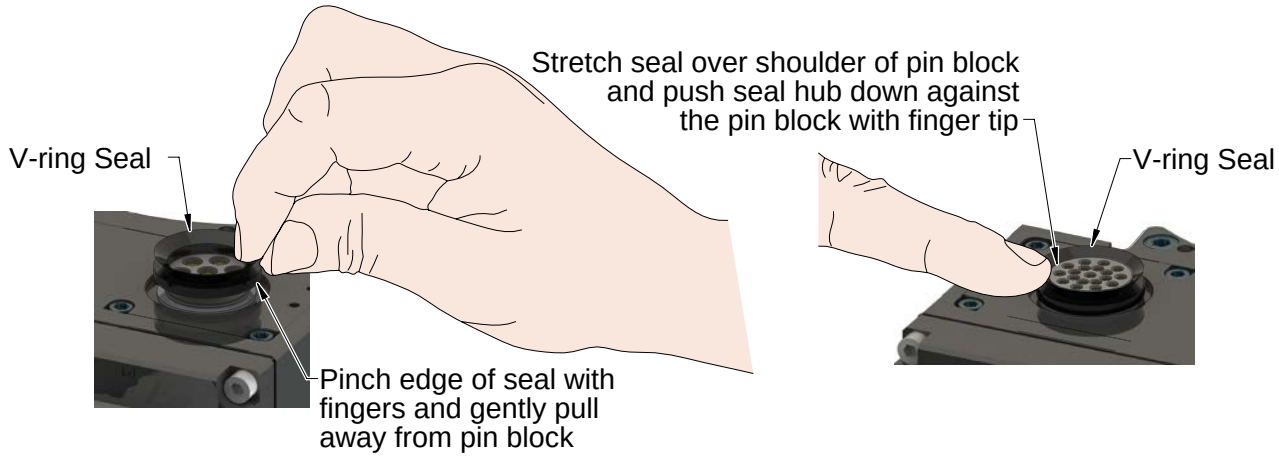
The following service procedures provide instructions for inspection, adjustment, test or replacement of components.

6.2.1 V-ring Seal Replacement

The seal protects the electrical connection between the Master and Tool module. If the seal becomes worn or damaged it needs to be replaced.

1. For a Tool Changer, place the Tool safely in the tool stand. Uncouple the Tool Changer or Utility Coupler to allow clear access to the Master and Tool plates.
2. Turn OFF and de-energize all energized circuits (e.g. electrical, air, water, etc.).
3. To remove the existing seal, pinch edge of seal with fingers and gently pull the seal away from the pin block on the Master.
4. Pull the seal OFF the pin block.
5. To install a new seal, stretch the new seal over the shoulder of the pin block.
6. Push the seal's hub down against the pin block using finger tip.
7. If repairs are complete, return circuits to normal operation.

Figure 6.2—V-ring Seal Replacement



US Patent No.: 7,027,893 B2
US Patent No.: 6,840,895 B2

7. Serviceable Parts

See *Section 9—Drawings* for spare parts directly associated with the DU3 modules

Table 7.1—Master module Mounting Fasteners	
Part Number	**Description**
3500-1066020-21A	M6 x 20 Socket Head Cap Screw, SS, ND Microspheres, 0-3 uncoated lead thds. 5-7 coated thds. IFI525

Table 7.2—Tool module Mounting Fasteners	
Part Number	**Description**
3500-1066016-21A	M6 x 16 Socket Head Cap Screw, DIN 912 A4 S/S (316) ND Ind. Microspheres Epoxy, Yellow. 0-3 uncoated lead thds. 5-7 coated thds.

Table 7.3—Accessories	
Part Number	**Description**
3690-0000064-60	Brush, Blue Nylon All Purpose (Contact Pin Cleaning)
3690-0000049-00	Closure Cap for Female Mini Receptacles

US Patent No.: 7,027,893 B2
US Patent No.: 6,840,895 B2

8. Specifications

DU3 DeviceNet Master Module	
Factory Default Configuration	MAC ID 54, Baud Rate 500 Kbps. The DU3 modules conform to the DeviceNet Specification Volume 3, Edition 1.2 (Reference Conformance Case #10423).
Interface Connectors	Auxiliary Power: Mini, 4-Pin Male supporting two Auxiliary Power Circuits DeviceNet: Mini, 5-Pin Male Pressure Switch connector: M8, 3-Pin Female Diagnostic Connector: M8, 4-Pin Female (ATI Diagnostics use only) Integrated Tool Changer I/O: • 4X M8, 3-pin female connectors supporting Tool Changer Locked, Unlocked, and Ready-to-Lock proximity sensors. RTL Sensors are NPN sensor in series.
Electrical Rating	Power Pass-Thru: • N1 and N2 Auxiliary Power: 5A, -19 to -26 V P1 and P2 Auxiliary Power: 0 V Note: Arc prevention is applied to P1 and P2 Auxiliary Power. • CAN V+ (DeviceNet) Power: 5A, 11-26 VDC Note: Arc prevention is applied to CANV+ power.
	Signal Pass-Thru: 3 Amp, 30V maximum.
	Tool Changer Control: • Lock, Unlock, and Ready-to-Lock sensors: 10-30 V operational voltage Note: CAN V- Power provides power to the L, U, and RTL sensors. • Latch/Unlatch integrated solenoid valve: -19 to -29 V operational voltage Note: N2 Power provides power to the Latch/Unlatch solenoid valve..
Current Draw[1]	220mA @ 24V, 250 mA @ 15 V: Master and Tool (Locked and RTL sensors “on”)
Weight	2.32 lbs (1.05 kg)

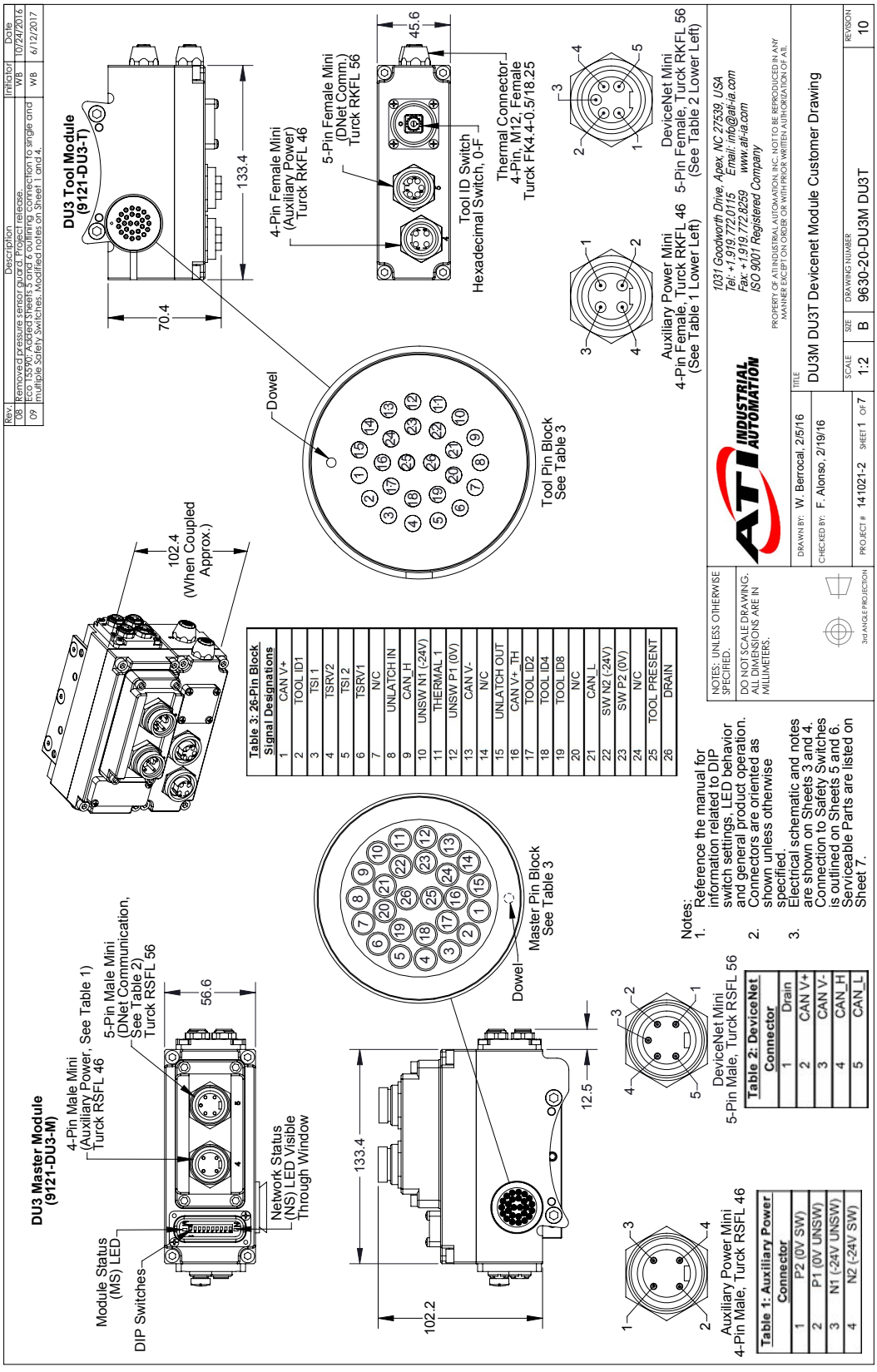
Note:

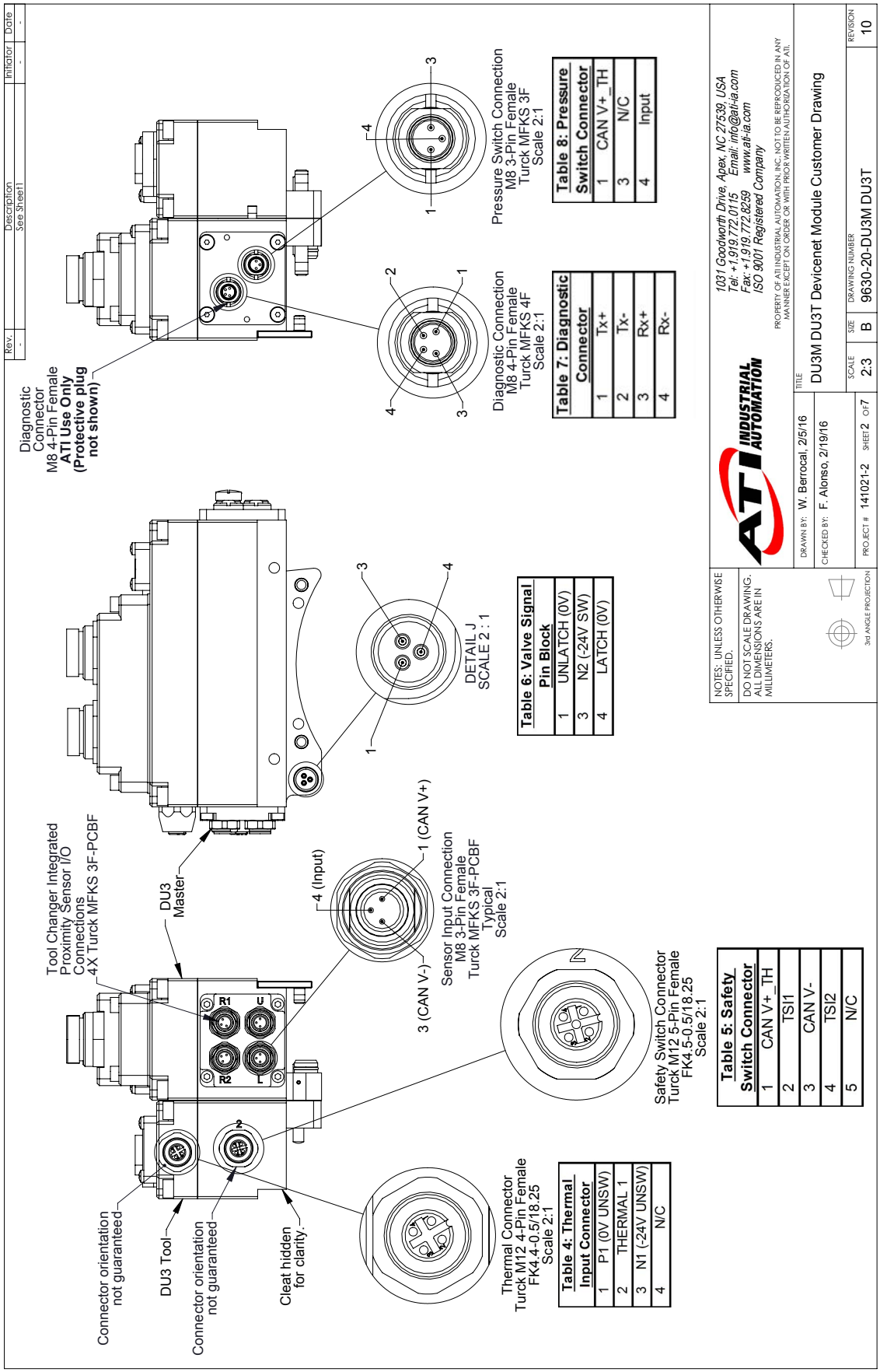
1. Current Draw totals for DeviceNet-powered circuits, not including downstream I/O devices and Auxiliary powered valves. Please refer to the module manufacturer for these specifications.

DU3 DeviceNet Tool Module	
Factory Default Configuration	(1) Independent Tool-ID switch, reading a (0 to F(15)) position (factory set to Tool Position 1)
Interface Connectors	Auxiliary Power: Mini, 4-Pin Female DeviceNet: Mini, 5-Pin Female Safety Switch (TSI) connector: M12, 5-Pin, Female Note: The DU3-T module TSI connector supports up to 2 safety switches, refer to *Section 9—Drawings* for additional information. Thermal connector: M12, 4-Pin, Female
Electrical Rating	Power Pass-Thru: • N1 and N2 Auxiliary Power: 5A, -19 to -26 V P1 and P2 Auxiliary Power: 0 V • CAN V+ (DeviceNet) Power: 5A, 11-26 VDC
	Signal Pass-Thru: 3 Amp, 30V maximum.
Weight	1.50 lbs (0.68 kg)

9. Drawings

9.1 DU3 DeviceNet Module




Rev. | Description | Initator | Date
- | See Sheet1 | - | -
Diagnostic Connector M8 4-Pin Female ATI Use Only (Protective plug not shown)
Pressure Switch Connection M8 3-Pin Female Turck MFKS 3F Scale 2:1
Diagnostic Connection M8 4-Pin Female Turck MFKS 4F Scale 2:1
Table 8: Pressure Switch Connector
1 CAN V+_TH
3 N/C
4 Input
Table 7: Diagnostic Connector
1 Tx+
2 Tx-
3 Rx+
4 Rx-
Tool Changer Integrated Proximity Sensor I/O Connections 4X Turck MFKS 3F-PCBF
DU3 Master
DETAIL J SCALE 2 : 1
Table 6: Valve Signal Pin Block
1 UNLATCH (0V)
3 N2 (-24V SW)
4 LATCH (0V)
4 (Input)
1 (CAN V+)
3 (CAN V-)
Sensor Input Connection M8 3-Pin Female Turck MFKS 3F-PCBF Typical Scale 2:1
Safety Switch Connector Turck M12 5-Pin Female FK4.5-0.5/18.25 Scale 2:1
Table 5: Safety Switch Connector
1 CAN V+_TH
2 TSI1
3 CAN V-
4 TSI2
5 N/C
Connector orientation not guaranteed
DU3 Tool
Connector orientation not guaranteed
Cleat hidden for clarity.
Thermal Connector Turck M12 4-Pin Female FK4.4-0.5/18.25 Scale 2:1
Table 4: Thermal Input Connector
1 P1 (0V UNSW)
2 THERMAL 1
3 N1 (-24V UNSW)
4 N/C
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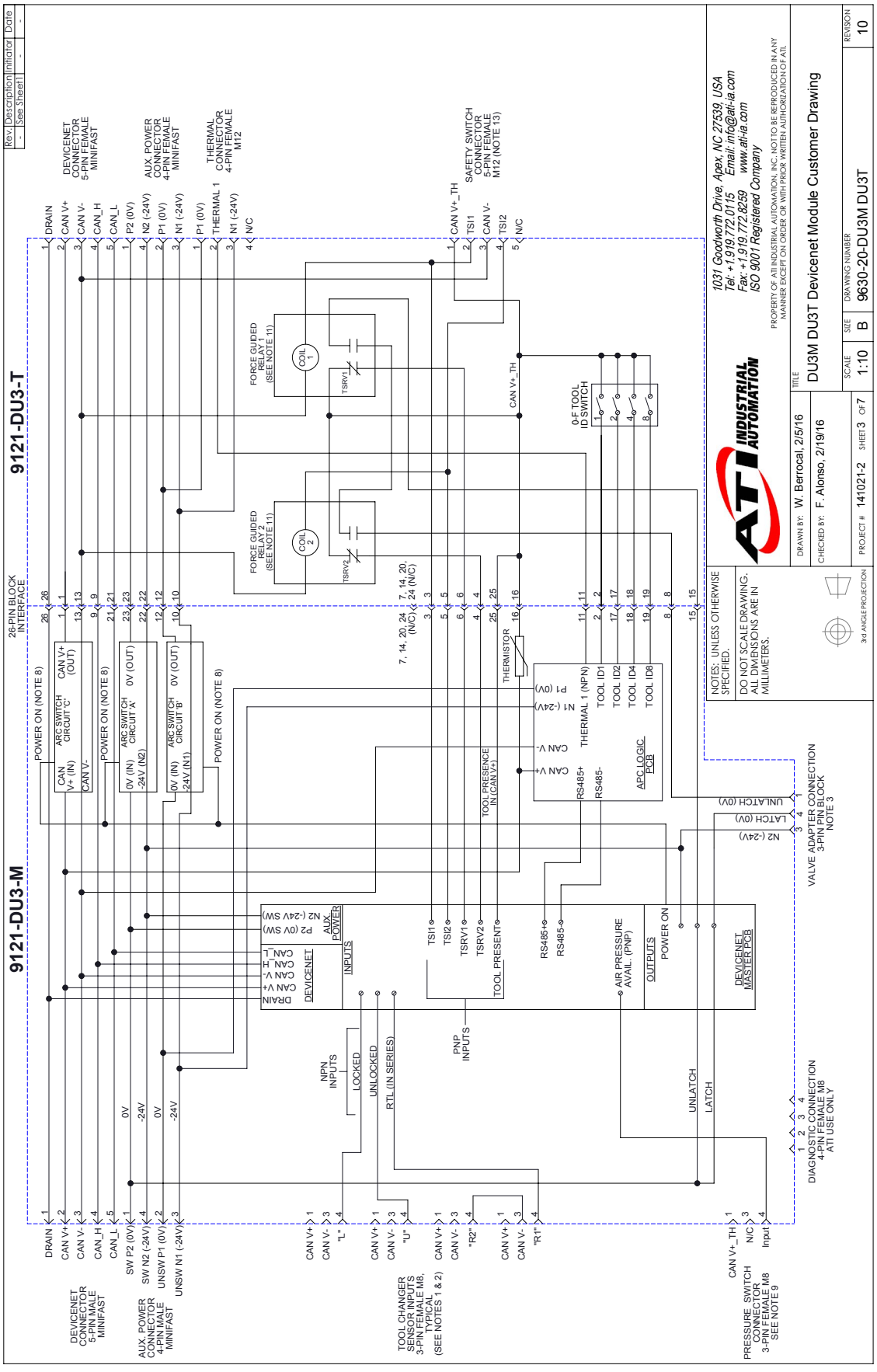
CHECKED BY: F. Alonso, 2/19/16
3rd ANGLE PROJECTION
TITLE: DU3M DU3T Devicenet Module Customer Drawing
PROJECT # 141021-2 SHEET 2 OF 7
SCALE 2:3 SIZE B DRAWING NUMBER 9630-20-DU3M DU3T REVISION 10


9121-DU3-M
9121-DU3-T
26-PIN BLOCK INTERFACE
DU3M DU3T Devicenet Module Customer Drawing
9630-20-DU3M DU3T
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PROJECT # 141021-2
SHEET 3 OF 7
SCALE 1:10
SIZE B
REVISION 10
DEVICENET CONNECTOR 5-PIN FEMALE MINIFAST
AUX. POWER CONNECTOR 4-PIN FEMALE MINIFAST
THERMAL CONNECTOR 4-PIN FEMALE M12
SAFETY SWITCH CONNECTOR 5-PIN FEMALE M12 (NOTE 13)
FORCE GUIDED RELAY 1 (SEE NOTE 11)
FORCE GUIDED RELAY 2 (SEE NOTE 11)
0-F TOOL ID SWITCH
THERMISTOR
THERMAL 1 (NPN)
APC LOGIC PCB
DEVICENET MASTER PCB
VALVE ADAPTER CONNECTION 3-PIN PIN BLOCK NOTE 3
DIAGNOSTIC CONNECTION 4-PIN FEMALE M8 ATI USE ONLY
TOOL CHANGER SENSOR INPUTS 3-PIN FEMALE M8, TYPICAL (SEE NOTES 1 & 2)
PRESSURE SWITCH CONNECTOR 3-PIN FEMALE M8 SEE NOTE 9
NPN INPUTS
PNP INPUTS
LOCKED
UNLOCKED
RTL (IN SERIES)
UNLATCH
LATCH
TOOL PRESENT
AIR PRESSURE AVAIL. (PNP)
POWER ON
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Rev.	Description	Initiator	Date
-	See Sheet1	-	-

Schematic Notes:

1. Note that the sensors are powered by DeviceNet power. The common V+ and V- connections are not shown here.
2. The complete tool changer package comes equipped with external cables that are connected to the sensors. The RTL, Locked, and Unlocked sensors are NPN.
3. The Latch and Unlatch signals are provided to a Double-Solenoid Valve Adapter via an internal 3-Pin Pin Block. Note: Only double-solenoid valves are supported.
4. In the event that a Tool Changer equipped with the tool changer is locked without a Tool, the only way to unlock the Tool Changer is to press the manual override button located on the control valve.
5. Cables for DeviceNet and Auxiliary Power to the DU3 Modules are supplied by the user.
6. The Tool ID I/O is reported in the DU3 Master Bitmap.
7. The Thermal 1 input from the Tool side M12 connector is NPN.
8. The Arc Prevention Circuits turn off DeviceNet and Auxiliary Power during coupling and uncoupling of the Master and Tool. The switching function is controlled by the "POWER ON" signal from the main PC Board. The TOOL PRESENT input is used to ensure that the spring/contact pins are touching when power is turned on. Refer to the product manual for additional information.
9. The Pressure Switch input indicates when the supply pressure is greater than 60 psi (PNP input). The CAN V+_TH connection is not shown here. Reference the customer drawing for the valve adapter for additional details.
10. The DU3 Tool is equipped with a 0-F rotary switch for setting the Tool ID. There are 16 unique tool IDs that can be selected.
11. The interlock relays in the DU3 Tool are Force Guided Relays. The 24V Unlatch is transmitted via the NO contacts. The relay diagnostic signals (i.e. TSRV1 and TSRV2) shall monitor the NC contacts (per EN50205, NO and NC contacts shall be used for Force Guided Relays). The relays are shown in the un-energized state, i.e. Tool not in the Tool Stand.
12. CAN V+_TH is current limited CAN V+ used to drive the TSI Relays and Safety Switch(es).
13. Connection to a single Safety Switch is shown on Sheet 5 (Figure 1). Series connection to two Safety Switches is shown on Sheet 5 (Figure 2). Series connection to more than two Safety Switches is shown on Sheet 6 (Figure 3).

NOTES: UNLESS OTHERWISE SPECIFIED.

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3rd ANGLE PROJECTION

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DRAWN BY: W. Berrocal, 2/5/16
CHECKED BY: F. Alonso, 2/19/16
PROJECT # 141021-2 SHEET 4 OF 7

TITLE: DU3M DU3T Devicenet Module Customer Drawing

SCALE	SIZE	DRAWING NUMBER	REVISION
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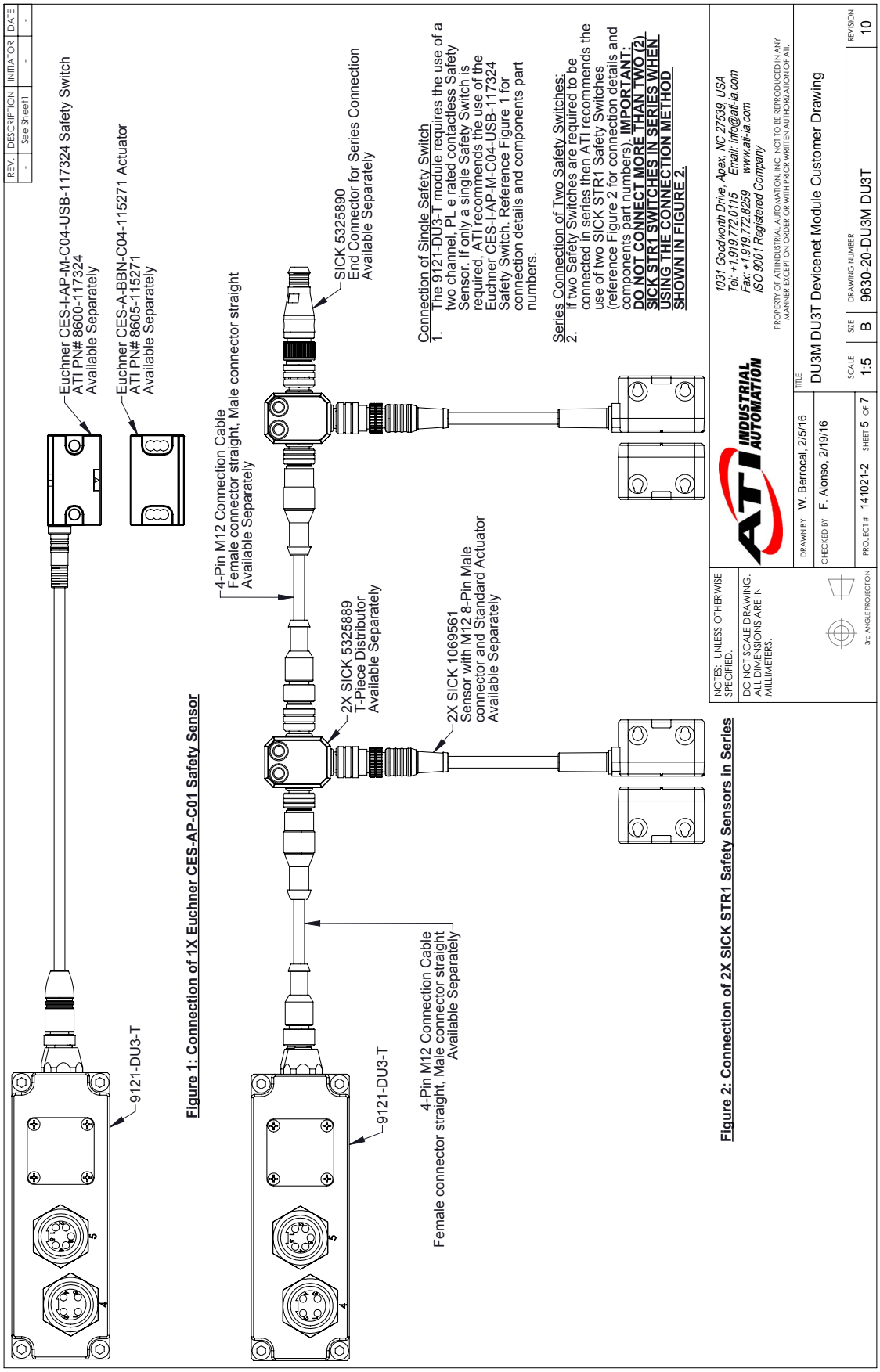
Euchner CES-I-AP-M-C04-USB-117324 Safety Switch
ATI PN# 8600-117324
Available Separately
Euchner CES-A-BBN-C04-115271 Actuator
ATI PN# 8605-115271
Available Separately
9121-DU3-T
Figure 1: Connection of 1X Euchner CES-AP-C01 Safety Sensor
4-Pin M12 Connection Cable
Female connector straight, Male connector straight
Available Separately
SICK 5325890
End Connector for Series Connection
Available Separately
2X SICK 5325889
T-Piece Distributor
Available Separately
2X SICK 1069561
Sensor with M12 8-Pin Male
connector and Standard Actuator
Available Separately
4-Pin M12 Connection Cable
Female connector straight, Male connector straight
Available Separately
9121-DU3-T
Figure 2: Connection of 2X SICK STR1 Safety Sensors in Series
Connection of Single Safety Switch
1. The 9121-DU3-T module requires the use of a two channel, PL e rated contactless Safety Sensor. If only a single Safety Switch is required, ATI recommends the use of the Euchner CES-I-AP-M-C04-USB-117324 Safety Switch. Reference Figure 1 for connection details and components part numbers.
Series Connection of Two Safety Switches:
2. If two Safety Switches are required to be connected in series then ATI recommends the use of two SICK STR1 Safety Switches (reference Figure 2 for connection details and components part numbers). IMPORTANT: DO NOT CONNECT MORE THAN TWO (2) SICK STR1 SWITCHES IN SERIES WHEN USING THE CONNECTION METHOD SHOWN IN FIGURE 2.
REV. | DESCRIPTION | INITIATOR | DATE
- | See Sheet1 | - | -
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PROJECT # 141021-2 SHEET 5 OF 7
TITLE
DU3M DU3T Devicenet Module Customer Drawing
SCALE 1:5
SIZE B
DRAWING NUMBER 9630-20-DU3M DU3T
REVISION 10

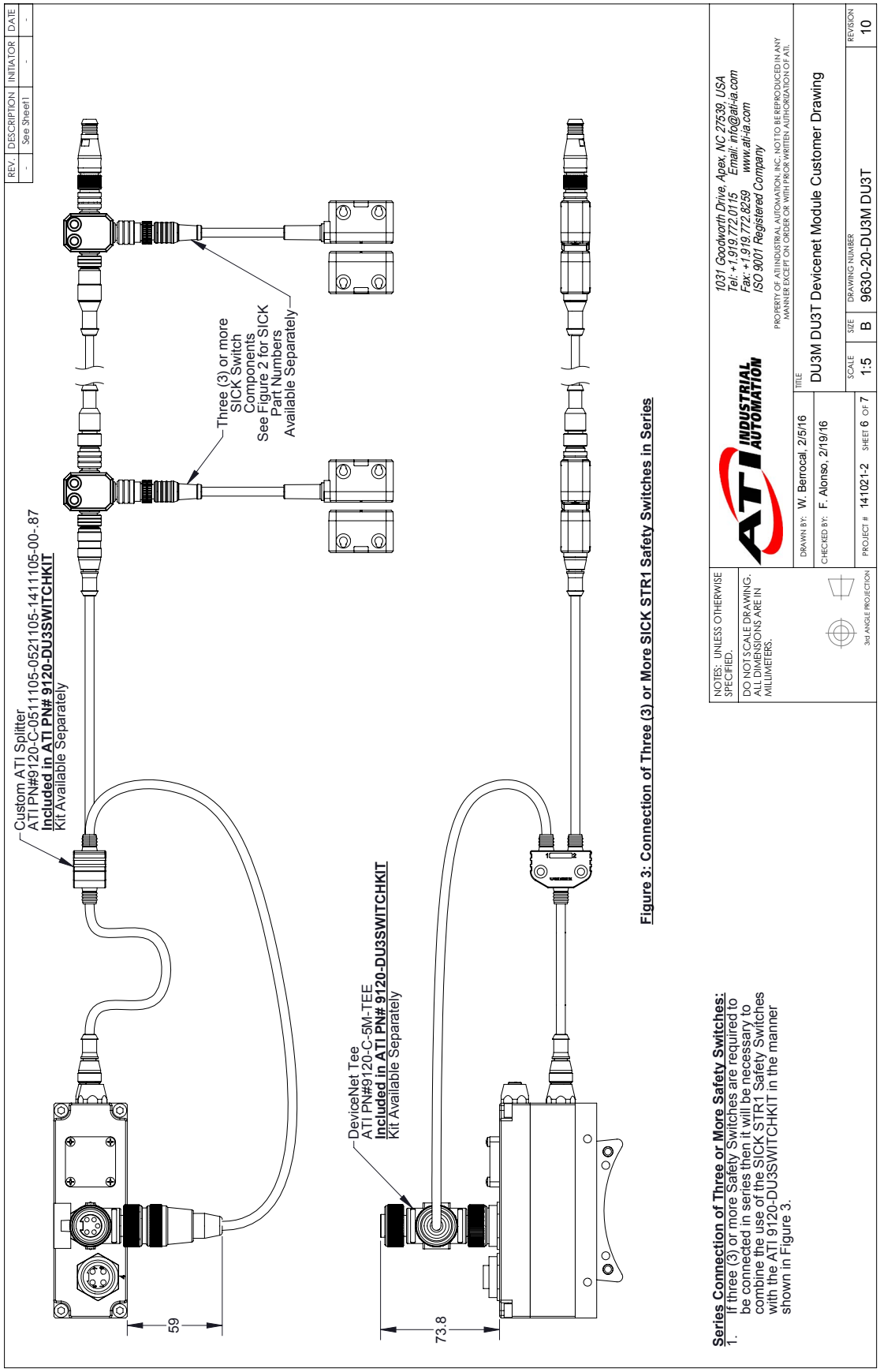


Figure 3: Connection of Three (3) or More SICK STR1 Safety Switches in Series

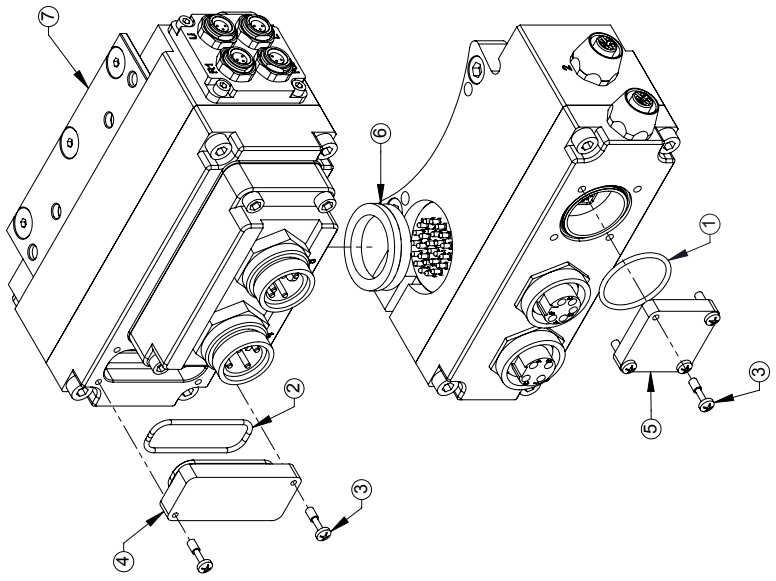
Series Connection of Three or More Safety Switches:

1. If three (3) or more Safety Switches are required to be connected in series then it will be necessary to combine the use of the SICK STR1 Safety Switches with the ATI 9120-DU3SWITCHKIT in the manner shown in Figure 3.

Rev.	Description	Initiator	Date
-	See Sheet1	-	-

9121-DU3-M/T SERVICEABLE PARTS

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	3410-0001008-01	Tool ID Window O-Ring
2	1	3410-0001201-01	O-Ring AS568-024
3	6	3500-9957012-21	Pan Head M3 Captive Screw M3 X 12
4	1	3700-20-2696	Device Net Master Window, Thick
5	1	3700-20-5844	Tool ID Window
6	1	4010-0000030-01	V-Ring Seal V-22A Nitrile
7	1	9005-20-1198	Master Cleat Sub-Assembly



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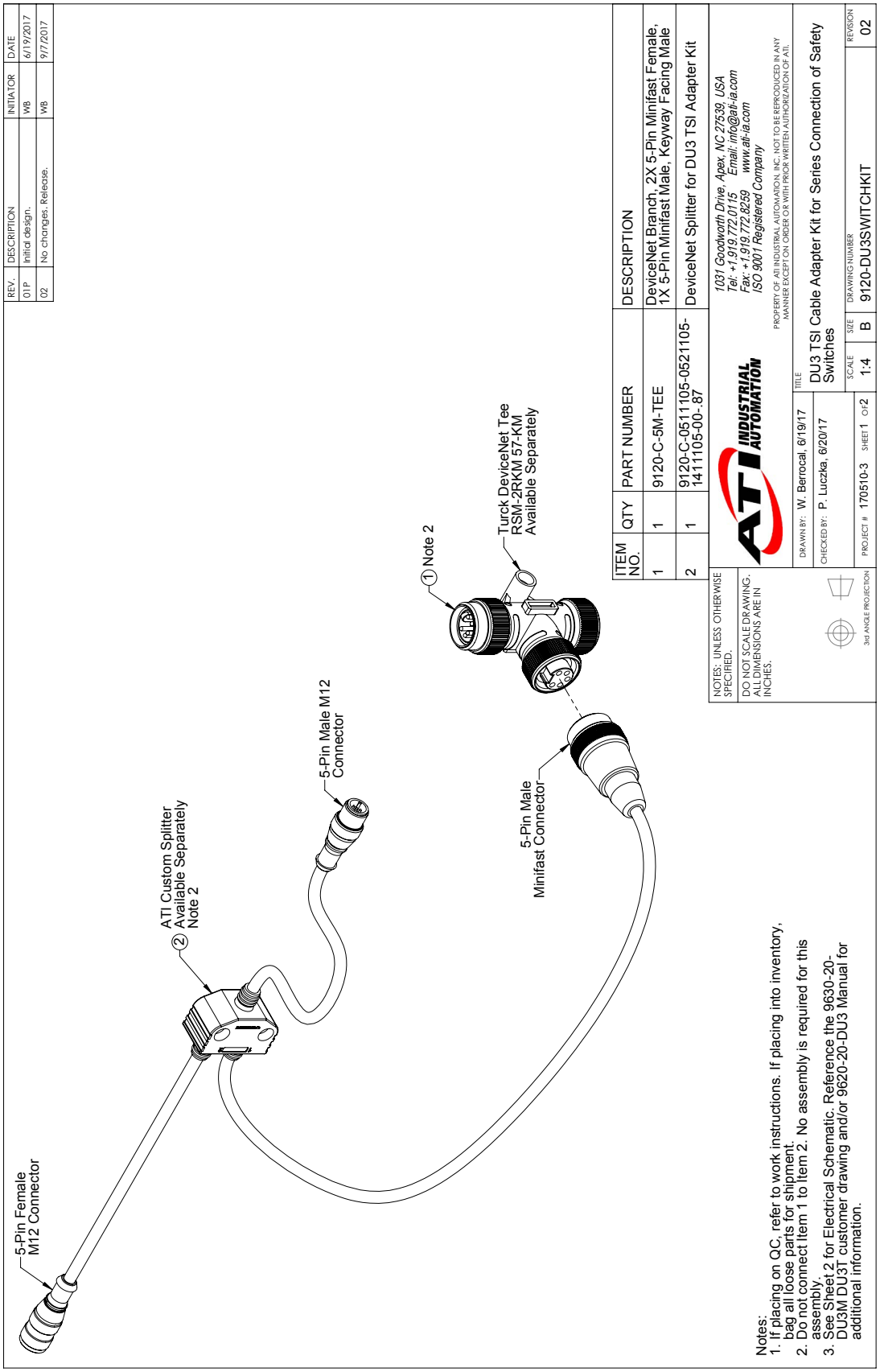
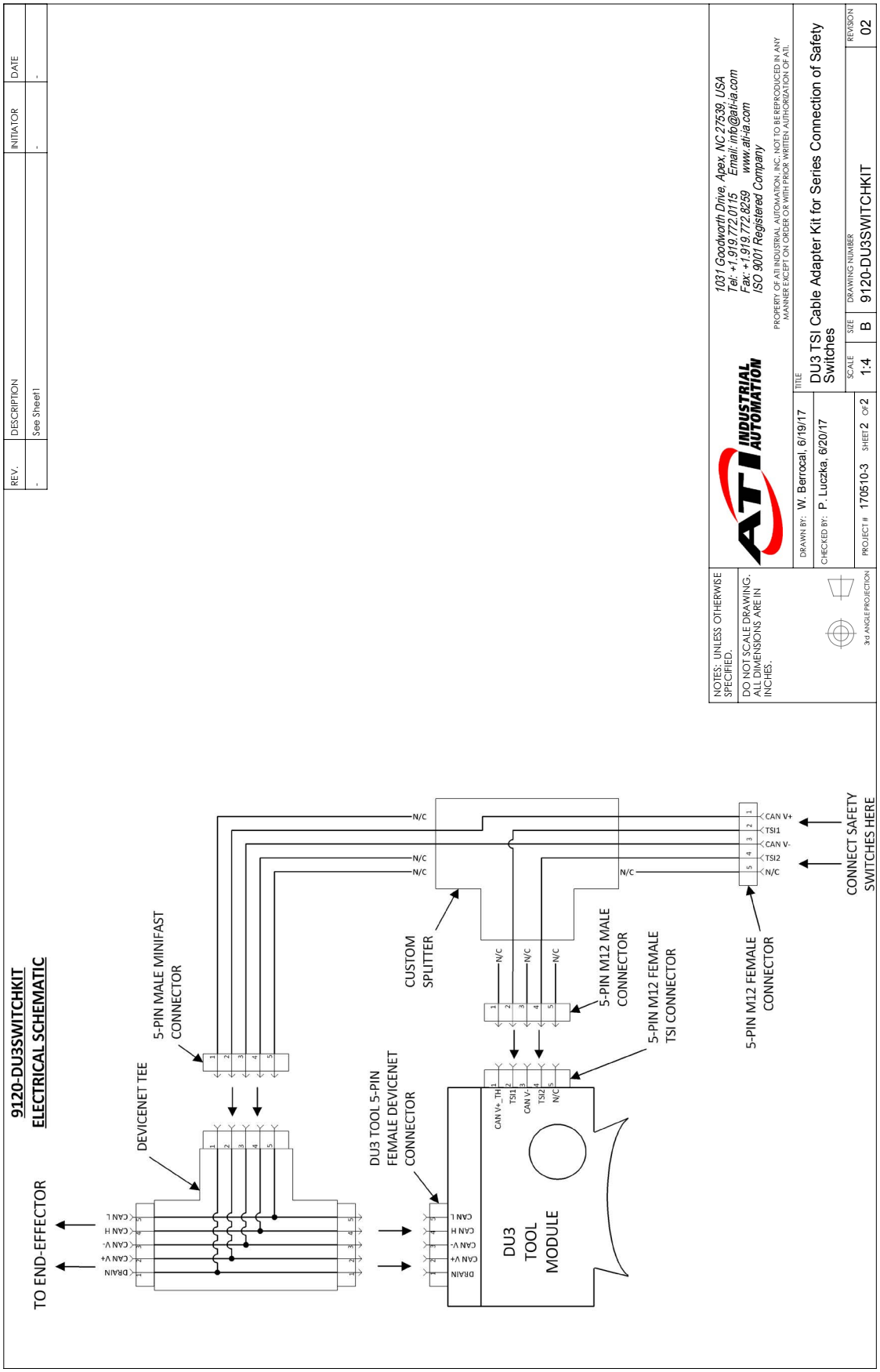
PROJECT # 141021-2 SHEET 7 OF 7

TITLE: DU3M DU3T Devicenet Module Customer Drawing

SCALE: 2:3
SIZE: B
DRAWING NUMBER: 9630-20-DU3M DU3T
REVISION: 10

9.2 DU3 TSI Cable Adapter Kit for Series Connection of Safety Switches




9120-DU3SWITCHKIT
ELECTRICAL SCHEMATIC
TO END-EFFECTOR
DEVICENET TEE
5-PIN MALE MINIFAST CONNECTOR
DU3 TOOL 5-PIN FEMALE DEVICENET CONNECTOR
DU3 TOOL MODULE
CUSTOM SPLITTER
5-PIN M12 MALE CONNECTOR
5-PIN M12 FEMALE TSI CONNECTOR
5-PIN M12 FEMALE CONNECTOR
CONNECT SAFETY SWITCHES HERE
N/C
CAN V+
TSI1
CAN V-
TSI2
DRAIN
CAN L
CAN H
CAN V-
CAN V+
REV.
DESCRIPTION
INITIATOR
DATE
See Sheet1
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CHECKED BY: P. Luczka, 6/20/17
PROJECT # 170510-3
SHEET 2 OF 2
3rd ANGLE PROJECTION
TITLE
DU3 TSI Cable Adapter Kit for Series Connection of Safety Switches
SCALE 1:4
SIZE B
DRAWING NUMBER 9120-DU3SWITCHKIT
REVISION 02