



Robot Module
1303-D05A

Tool Module
1304-D57A

Tool Changer Safety Control Circuit
Manual 95575 Rev 05

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Revision

Revision	Date	Author	Description
00	2-17-2012	NS	Release
01	4-25-2013	JD	Editorial Changes
02	5-13-2013	SC	Label Changes on Pg. 11 RS Module Figure
03	5-21-2013	NS	Updated to include Latching Operation Descriptions
04	5-29-2013	NS	Updated Logic table and Programming Operation
05	6-28-2013	NS	Changed Size Specifications, Removed Schematic

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1 Precautions



READ MANUAL

Do not start, operate or service machine until you read and understand operator's manual. Failure to do so could result in serious injury.



HAND CRUSH NOTICE

Indicates the possibility for a crush force between components during coupling of the Robot and Tool adaptor.



Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.



Indicates a situation which, if not avoided, could result in equipment damage and voiding the manufacturer's equipment warranty.

IGNORING INFORMATION ABOUT POTENTIAL HAZARDS CAN LEAD TO SERIOUS HARM TO PERSONNEL AND/OR DAMAGE TO THE EQUIPMENT, AND MAY RESULT IN THE NULLIFICATION OF THE MANUFACTURERS' EQUIPMENT WARRANTY.

HEED ALL PRECAUTION NOTICES

2 System Description

Definitions

Tool – A device that may be attached to a tool changer to perform a specific function

Tool Changer – A device consisting of two adapters, one attached to a robot and one attached to a tool, that mechanically couple a robot to a tool, allowing a robot to use multiple tools. As a result, a single robot can perform multiple functions.

Tool Stand – A device that holds a tool mounted to a tool adapter for later use, as the robot performs other tasks. A Tool Stand is the safe area for the tool changer to drop off and pick up tools.

Couple – The action of moving the cams outward on the robot adaptor so the tool adaptor will connect.

Uncouple – The action of moving the cams inward on the robot adaptor so the tool adaptor will disconnect.

Safety Function

The reason for a Tool Changer Safety Circuit is to ensure an uncouple signal cannot be applied to the tool changer while it is not in a safe condition. A safe condition is defined as a tool changer engaged in a tool stand or in movement without a tool attached to the tool changer. To uncouple, a piston retracts three cams in the tool changer. It's this action, if not performed under safe conditions, which can cause injury to a person.

Functional Description

With air on, the tool changer not in a tool stand, and with a tool present, the robot may be moved to perform tasks. If air is lost to the valves, the tool will remain coupled, as mechanical safety mechanisms in the robot adaptor prevent uncoupling. The Tool Changer should never be operated without air supplied and, it is the customer's responsibility to make sure the correct air pressure is always being supplied during operation.

When the tool changer needs to be uncoupled, a signal must be sent through two sets of contacts driven by a force guided relay. The solenoid of the two sets of relays are driven by the tool stand present switch and tool present switch. When the tool stand present switch is actuated, it is safe to couple and uncouple, because this indicates that the tool has been docked in, and supported by the tool stand. The tool present switch is to indicate if a tool adapter is coupled to the robot adaptor. A tool changer is free to couple and uncouple at any point if a tool is not present.

After the two uncouple signals are applied and allowed to pass through the safety logic (see Section 3 Stage Diagram). The coils of two independent valves will be powered, causing the tool changer to uncouple. Both valves are pneumatically interlocked, this means both valves have to be actuated in order to achieve an uncoupled state.

Once a channel has allowed a valve solenoid to be powered, the channel will be latched in the uncoupled state, and as long as an uncouple signal is being applied, that channel will remain latched. This is to prevent any recoupling action while the robot side is separated from the tool side.

Diagnostic Coverage

The diagnostic coverage monitors the status of the Tool Stand Present, Tool Present, and the Output Valve Spool Position through a set of normally open and normally closed contacts. In order for proper operation of the system, all dual channel devices need to operate simultaneously. A resistor/capacitor combination is included, such that the uncouple signal to the valve shall remain present approximately (1) second after initial loss of valve signal. This is to ensure there are no “nuisance trips” while the switches and relays change state. A customer is given a single point to monitor and may supply a monitoring signal. This signal is applied across all diagnostic coverage contacts and should not be lost during normal operation. If any single channel fails to operate within (1) seconds of its complimentary channel, a loss of monitoring signal will occur. The customer also has the option of monitoring the signal directly and can determine what defines a nuisance trip.

3 State Diagram

The State Diagram below shows the status of each individual sensor/switch that makes up the Safety Function and Diagnostic Coverage. The Tool Present Status Switch is normally closed and will show a “1” when *NO* tool is present. The Tool Stand Present Status Switch is normally open and will show a “1” when there is a tool present. The Output Valve Prox is normally open and detects spool position, which shows a “1” when the valve spool is not actuated. The LEDs show in section 8 of this manual will correspond to this diagram by being ON when the listed condition shows a “1”.

Condition of Tool Changer	Tool Present Status	Tool Stand Present Status	Output Valve Prox Status	Uncouple Ability	Operation Condition, Safety Action
Tool Changer Coupled, No Stand, No Tool Present Signal	1	0	1	Yes	Abnormal Operation [†] , Uncouple Allowed
Tool Changer Coupled, No Stand, Tool Present Signal	0	0	1	No	Normal Operation, Forced Couple
Tool Changer Coupled, In Stand, No Tool Present Signal	1	1	1	Yes	Abnormal Operation, Forced Couple
Tool Changer Coupled, In Stand, Tool Present Signal	0	1	1	Yes	Normal Operation, Uncouple Allowed
Tool Changer Uncoupled, No Stand, No Tool Present Signal	1	0	0	Yes	Normal Operation, Uncouple Allowed
Tool Changer Uncoupled, No Stand, Tool Present Signal	0	0	0	No	Abnormal Operation, Forced Couple
Tool Changer Uncoupled, In Stand, No Tool Present Signal	1	1	0	No	Abnormal Operation, Forced Couple
Tool Changer Uncoupled, In Stand, Tool Present Signal	0	1	0	Yes	Normal Operation, Uncouple Allowed

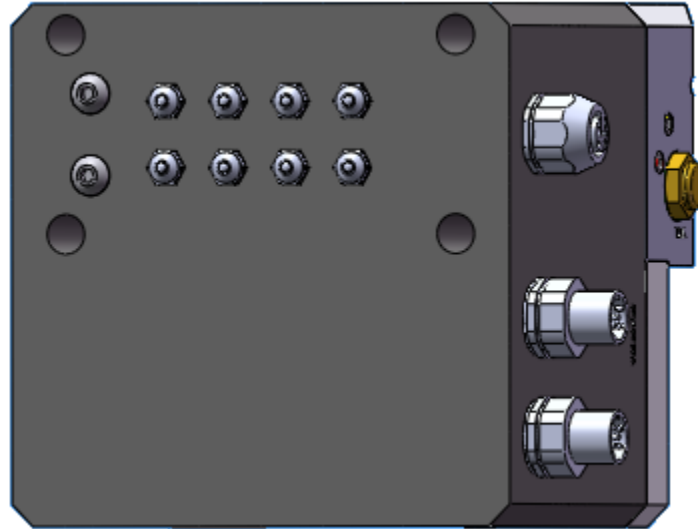
[†]Abnormal Operation - describes a condition not expected during Normal Operation, The result is always a safe condition being met.

4 Technical Specifications

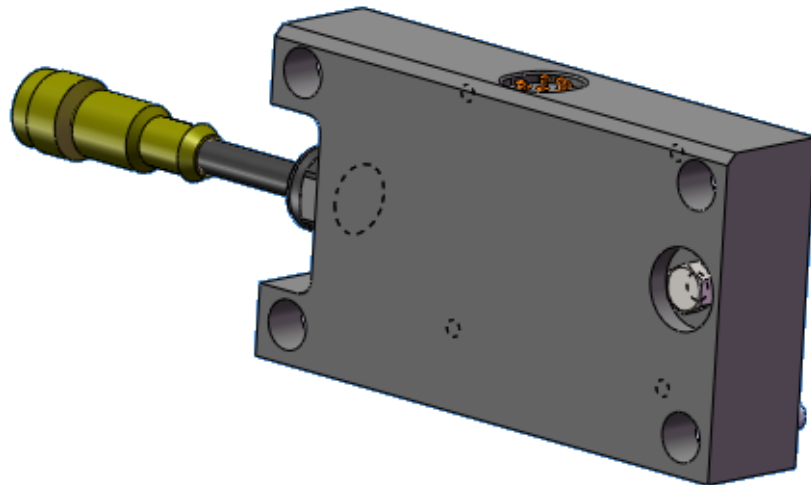
Minimum Safety Classification	Cat. 3 PLd EN ISO 13849-1
MTTFd	68 Years
Mission Time	20a (20 years)
Robot Side Dimensions	120mm x 118mm x 128mm
Tool Side Dimensions	108mm x 59mm x 22mm
Enclosure Rating	IP 65 (When Coupled)
Connection Type	3 x M12 (Robot Side) 1 x M12 (Tool Side)
Robot Side Weight	1.75 Kg
Tool Side Weight	0.16 Kg
Power Consumption	400mA Max
Max Voltage DC	30VDC
Operating Temperature	5 - 60 °C
Supply Pressure	16 Bar Max
Tool Stand Sensing	Safety Interlock Switch (Approved Safety Rated Switch)
Tool Present Sensing	Dual Output Safety Prox Switch
Air Valves	Dual valves with interlocking manifold and direct spool monitoring

5 Modules

1303-D05A
S.1-EM-R-V-ISO 13849-SCM



1304-D57A
S.1-EM-T-V-ISO 13849-SCM

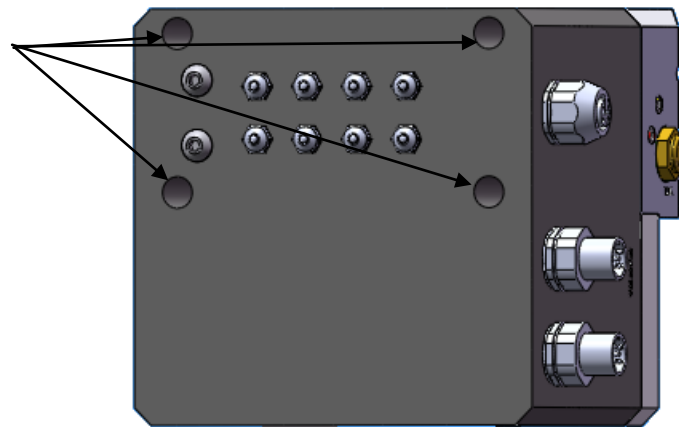


6 Installation

6.1 Attachment to Tool Changer

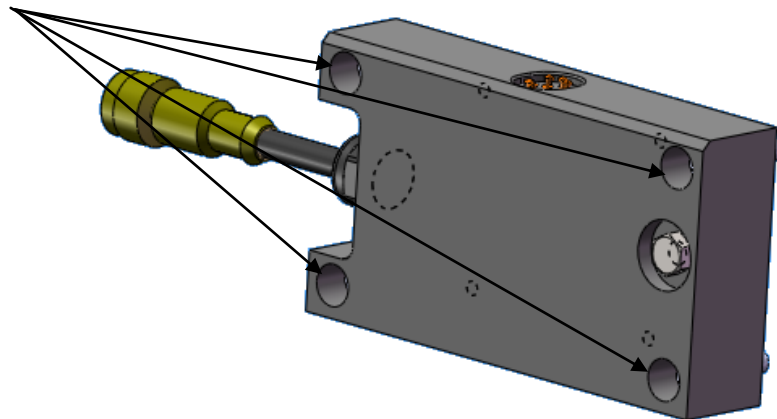
With the Robot and Tool Adapter uncoupled and apart, install both the robot and tool side module on side one of the tool changer.

4 x ARI # 49798 SCR, SOC
HD CAP M5 X 100 SS



Robot Module

4 x ARI # 48028 SCR, SOC
HD CAP M5 X 16 (SS)



Tool Module

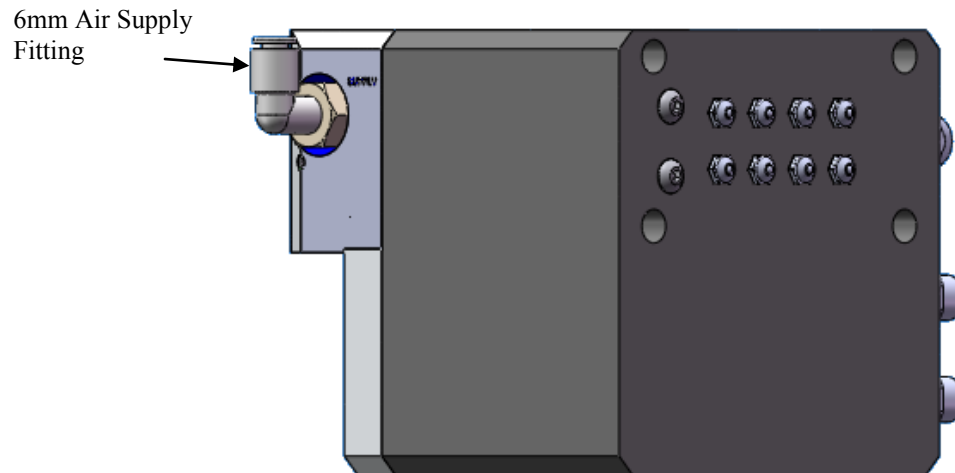
6.2 Air Supply

Connect the Air Supply to the 6mm air fitting show below:



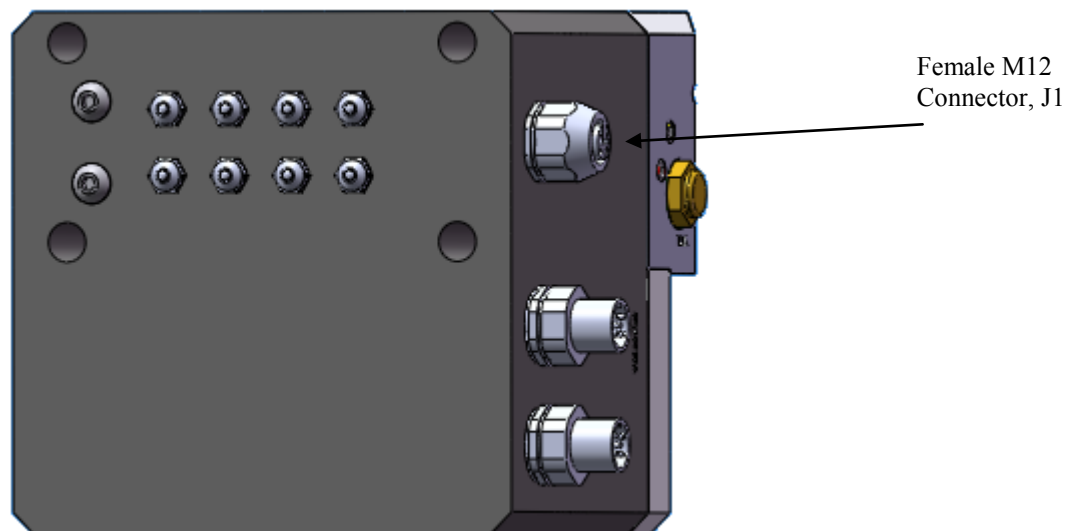
WARNING

Upon supplying air to the Safety Control Module, the robot adaptor will be forced coupled. Make sure the tool adaptor is not within range of the robot side cams to cause an undesired couple. Make sure all objects and fingers are clear of the cams and mating surfaces when air is supplied.



6.3 Electrical Connections

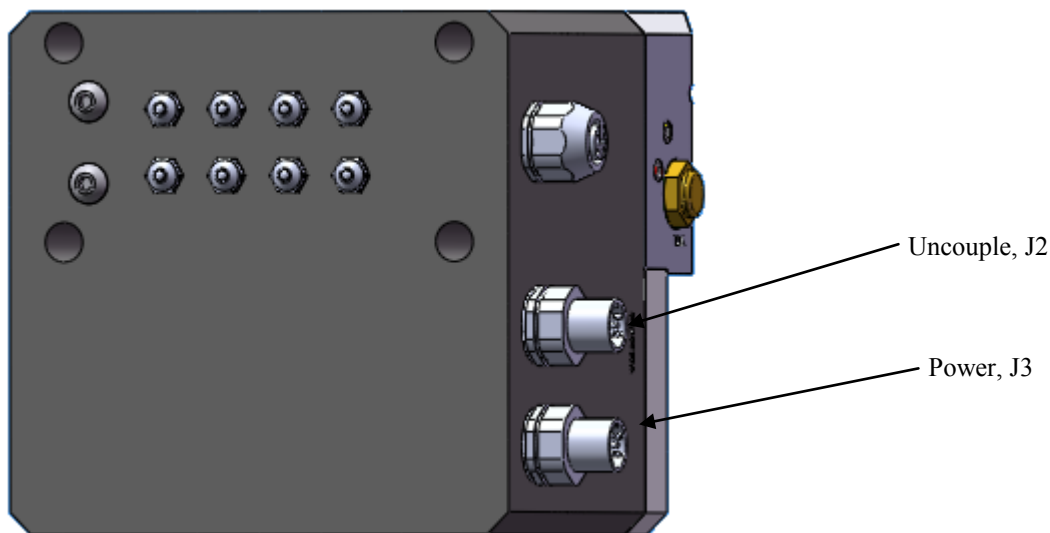
Connect the customer “Monitor Point” to the M12 connector, J1. This connection will provide feedback to show all channels are working correctly in the Safety Control Module.



Power and Uncouple are supplied on two separate M12 connections J3 and J2, respectively. Connect the appropriate cables to the connectors J3 and J2 as shown below:

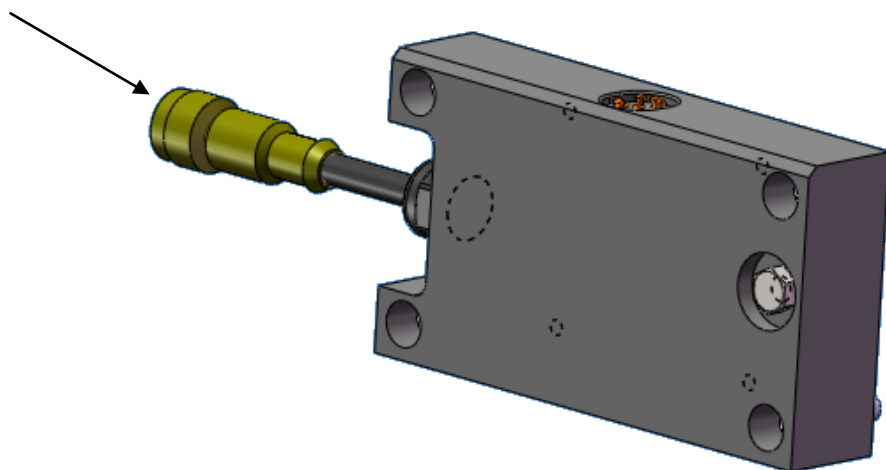
**WARNING**

Make sure an uncouple signal is not being supplied by the cable you care connecting to J2. This could cause the robot side to couple. Make sure all objects and fingers are clear of the cams when connecting J2.



Connect the tool side module connector T1 to an approved tool stand present safety switch. Refer to your manufacturer's tool stand connection manual for how the tool stand present switch should be installed.

Tool Stand Safety
Switch, T1



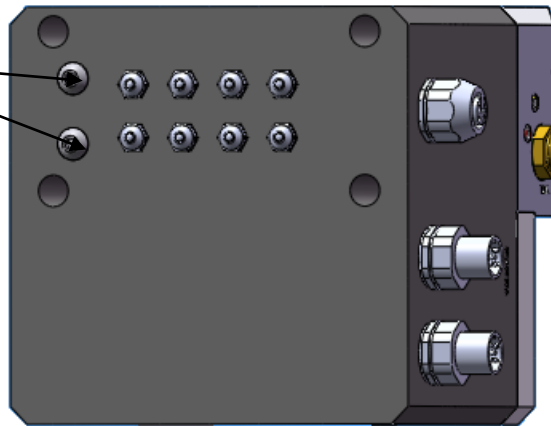
7 Manual Uncouple

With all cables and air fittings properly installed the Safety Module is ready for operation. Please refer to the system description on Page 5 and State Diagram on page 6 for how the module functions. During initial programming or if an undesired or abnormal state is achieved, the two M5 screws may be removed from the face of the cover to manually actuate the valves to uncouple. To do this, air will need to be supplied to the valves and both valves will need to be actuated with a small flat head screwdriver (approx. 3.5mm). This is done by inserting the flat head screw driver into the slot and turning it 90 degrees clockwise, locking it in position.



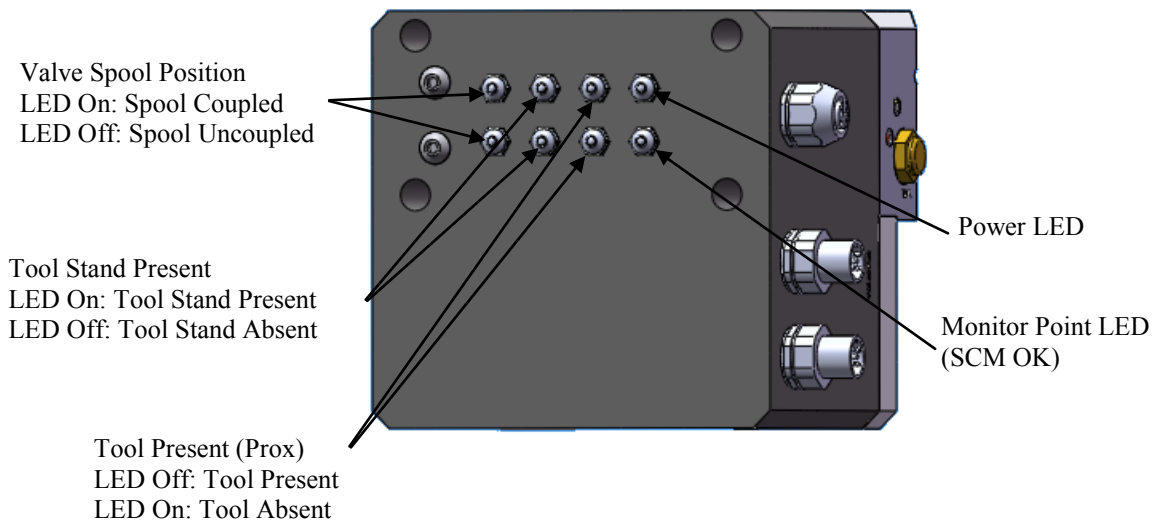
This operation should never be performed while a tool is present. Operation of the manual uncouple with a tool present may result in death or serious injury.

ARI # 49335 SCR, BUT
HD SOC CAP M5 X 6 STL
Valve Access Holes



8 LED Status Indicators

Eight LEDs show the function of each individual channel in the Safety Module along with the Power, and Monitor Point Status. In order to function properly, an LED's on/off status should match between row 1 and row 2. If there is a mismatch between corresponding rows, the customer monitor signal will be lost. The LEDs and their corresponding function are shown in the diagram below:



8.1 Operational Guidelines

Review the guidelines below to understand how the Safety Control Module operates.

- Manual uncouple may be used in a case where a new tool is being installed and there is no tool stand present signal to interface with the Safety Control Module. Please see section 7 for how manual uncouple operates.
- The Customer Monitor point supplied with the Safety Control Module should be constantly monitored to ensure that the Safety Control Module is operating properly. A loss of this signal is an indication of failure within the safety system. Should the Customer Monitor point still provide a signal, and the tool changer will not uncouple, check the LED status lights for diagnosis (see section 8).
- Monitoring of the couple and uncouple status is required as the Safety Control Module will force coupled if any unsafe state is reached. The Safety Control Module only internally incorporates tool present and tool stand present. Monitoring status of the couple and uncouple state prior to docking or undocking a tool is the responsibility of the end user. Failure to monitor this state may cause damage to the tool changer.