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<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>December 2019</td>
<td>Original release</td>
</tr>
<tr>
<td>02</td>
<td>January 2020</td>
<td>Updated Appendix A</td>
</tr>
<tr>
<td>03</td>
<td>April 2020</td>
<td>Updated Chapter 4.1.2</td>
</tr>
<tr>
<td>04</td>
<td>June 2020</td>
<td>Updated info on Safety System 3.3 and Appendix A</td>
</tr>
<tr>
<td>05</td>
<td>October 2021</td>
<td>Minor details revised</td>
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</table>
1. Comprehensive Information

1.1 Overview

This chapter describes the comprehensive important safety information of TM Robot. The user and system integrator of TM Robot must read and fully understand this chapter before using this robot.

1.2 Applicable Product Version

This document is only applicable to the combination of the following software and hardware versions of TM Robot. Users can check the hardware version and software version on “Techman Robot Product Brief Information” sheet in the control box carton, or through these methods: checking the hardware version on the product label on the control box and checking the software version from the software information button in the UI of TMflow. If the software version of the robot has been upgraded and is different from the original out-of-the-box one, users should only check the software version from the UI of TMflow.

<table>
<thead>
<tr>
<th>Safety System version: TECHMAN ROBOT Safety System 3.3*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware version</td>
<td>HW 3.2</td>
</tr>
<tr>
<td>Software version</td>
<td>SW 1.84</td>
</tr>
</tbody>
</table>

*Within the scope of hardware and software combination above, the safety system version remains the same as TECHMAN ROBOT Safety System 3.3

Table 1: Safety System Version

Users shall confirm whether the software and hardware version of the TM Robot is consistent with the applicable product version of this Safety Manual. The Corporation is not responsible for any safety issues caused by referring to the safety instruction of an incorrect version.

1.3 Safety Warning Symbols

The following table defines the levels of the safety warning symbols that are marked in each paragraph in this Manual. Read carefully and comply with each paragraph to avoid harm to people or equipment.

<table>
<thead>
<tr>
<th>![Safety Symbol]</th>
<th>DANGER:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Identifies an imminently hazardous situation which, if not avoided, is likely to result in serious injury, and might result in death or severe property damage.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>![Safety Symbol]</th>
<th>WARNING:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Identifies a potentially hazardous situation which, if not avoided, will result in minor or moderate injury, and might result in serious injury, death, or significant property damage.</td>
</tr>
</tbody>
</table>
Table 2: Safety Warning Symbols

1.4 Safety Precautions

- All personnel who install, operate, teach, program, or maintain the system must read the *Hardware Installation Manual*, *Software Manual*, and *Safety Manual* according to the software and hardware version of this product, and complete a training course for their responsibilities concerning the robot.

- All personnel who design the robot system must read the *Hardware Installation Manual*, *Software Manual*, and *Safety Manual* according to the software and hardware version of this product, and must comply with all local and national safety regulations of the location where the robot is installed.

- Observe the “Intended Use” section in *Safety Manual*.

- If the installation and application does not observe human-robot collaboration regulations of the safety regulations, the user is responsible for providing safety barriers around the robot to prevent anyone from accidentally coming into contact with the robot when it is in motion.

- If any local or national electrical regulation requires, power to the robot and its power supply must be locked out and tagged out, or have means to control hazardous energy or implement energy isolation before any maintenance is performed.

- Dispose of the product in accordance with the relevant rules and regulations of the country or area where the product is used.
1.5 Validation and Responsibility

The information provided in this Manual does not include how to design, install and operate a complete arm application, nor does it include the peripheral devices that will affect the overall system safety. The design and installation of the complete system must comply with the standards and regulations for safety requirements in the country located. The robot integrator needs to understand safety laws and safety regulations in the local countries, in order to avoid major risks existing in the entire system.

This includes but is not limited to:

- Performing a risk assessment of the whole system
- Adding other machines and additional risk reduction measures based on the results of the risk assessment
- Using appropriate software safety features
- Ensuring the user will not modify any safety measures
- Ensuring all systems are correctly designed and installed
- Specifying instructions for use
- Clearly marking the contact information of the integrator that installed the robot
- Making relevant documents accessible, including the risk assessment, and this manual

**CAUTION:**

This product is partly completed machinery. The design and installation of the complete system must comply with the safety standards and regulations in the country of use. The user and integrators of the robot should understand the safety laws and regulations in their countries and prevent major hazards from occurring in the complete system.

1.6 Limitation of Liability

Even if the safety instructions are followed, any safety-related information in the manual shall not be considered as a guarantee that the product will not cause any personal injury or damage.

1.7 Overall Safety Warning

These safety warnings are relevant for the entire manual.

**DANGER:**

1. Before transporting, installing, operating, maintaining and repairing this product, make sure to read the product specification and operation manual in detail. Confirm that all the conditions comply with the requirements of the specification and the Manual, to avoid unintended accidents (for example:
improper operation or conditions of use that exceed the product specification) that may result in injury to personnel.

2. Before installing and using this product, the integrator must perform a risk assessment and implement risk reduction measures.

3. Users shall create procedures for emergency and abnormal situations.

4. Before using this product, make sure that the emergency stop device functions correctly.

**WARNING:**

1. Before disassembling or repairing this product, make sure that the power has been turned off and disconnected before proceeding to avoid injury to people or damage to machinery caused by inadvertent short circuit or electric shock.

2. When operating this product, the operator shall avoid wearing loose clothing or wearing other accessories (such as: necklaces, ties, bracelets, etc.) to avoid injury caused by clothing or accessories becoming entangled in the machine during operation.

3. If the product malfunctions, follow the established procedures of your organization to obtain repair of the product. Do not attempt to repair the product yourself to avoid damage to the machinery.

4. Before the robot is in operation, make sure that each part has been completely mounted to avoid any possibility of accidents.

5. Before starting the operation of the robot, confirm that there are no persons or obstacles that may intrude into the operating area during operation. If the operating environment uses human-robot cooperative operation, be sure to complete the due risk assessment before starting the operation.

6. It is forbidden for any unauthorized person to operate this product in order to avoid any possibility of injury to personnel or damage to the machinery.

7. Do not install or operate this product in a hazardous area (for example: strong magnetic field, hazardous gas, fire source, or flammable product) in order to prevent the machinery from causing danger during operation because of external conditions.

**CAUTION:**

1. Before operating the robot, confirm the status of the machinery warning light.

2. After editing the task flow, operate the robot in the Manual Mode first, and confirm that all the movements in the task flow are correct before switching the operation mode to Auto Mode.
3. During the operation of machinery, do not turn off the power supply to prevent possible damage to the system.

4. For the robot noise levels and related environmental conditions, refer to the Hardware Installation Manual for the corresponding hardware version.

1.8 Intended Use

The TM Robot is designed so the hazards can be reduced to tolerable levels when installed as specified and operated under normal and intended use. TM Robots have been designed and constructed in accordance with relevant safety standards. TM Robots are intended for use in parts assembly and material handling for payloads (including end-effector and workpiece) up to the “Maximum Payload” specification of each model.

The TM Robot focuses on the safety of human-robot cooperative operation by design, but the cooperative operation is only for application procedures that have undergone a risk assessment including robots, related peripheral equipment and working environment.

Any use or application should consider the risk assessment. If the use is different from the intended application, The Corporation will not bear any responsibility. The Corporation clearly specifies that the following uses are not suitable for the TM Robot. This is not a complete list.

- Use in a potentially hazardous environment
- Use in any applications that may threaten human lives
- Use in any application that may cause personal injuries
- Use before completion of the risk assessment and implementation of risk reduction measures
- Use for life support
- Use when the rated performance cannot be reached
- Use when the reaction time of safety functions is insufficient
- Use without appropriate parameters in operations
- Use in applications which may cause damage to the robot itself
- Restricted movement of persons
- Use without proper mounting of the robot
- Use involving excessive oscillations when moving
- Use without proper design of earthquake-prevention mounting when installed in earthquake zones
- Use without safe access to (or at/from) the work station
- Use in the presence of exhaust gases/lack of oxygen at the work position
- Use in the presence of flame (flammability of the cabinet, lack of extinguishing means)
- Use with mechanical hazards at the work position: a) rollover; b) fall of objects, penetration by
objects; c) break-up of parts moving at high speed; d) contact of persons with machine parts or tools (non-collaborative machines)

- Use with insufficient visibility from the work positions
- Use with inadequate lighting
- Use with inadequate seating
- Use with insufficient means for escape or entrapment avoidance
- Use with inadequate location of manual controls
- Use with inadequate design of manual controls and their mode of operation

1.9 Risk Assessment

Before installing and using this product, the user must first perform a risk assessments based on the conditions of use. Risk assessments can be in reference to the specifications of ISO 10218-2, ISO 12100 and ISO/TS 15066 documentations. The purpose of a risk assessment is to anticipate any accidents that may occur during the operation process and by means of appropriate protective measures to reduce the occurrence of accidents or to reduce the severity of injury to persons in the event of an accident. Therefore, the risk assessment needs to include any operational actions of the machinery within the scope of the assessment. After the risk assessment is completed, the user can use external related components (i.e. sensing components, emergency stop devices, fences or railings, etc.) as well as the parameter settings of safety functions in the operating system, to reduce possible occurrence of accidents. Additional safety-related components must be installed in accordance with the manufacturer’s specifications for the required risk reduction. For operating system safety settings and other safety components usage, read and understand this manual, the Software Manual and the Hardware Installation Manual of corresponding versions.

Potential hazards requiring additional risk reduction measures may include but are not limited to:
1. Finger(s) (especially in the case of hand guiding) caught between the rear end of the camera module and the joint module(s).
2. The palm or finger injured by the motion of the robot or the hand guide teaching, if caught between the robot end-effector (including the workpiece) and the robot body.
3. Being hit by a robot and injured.
4. Entrapment between a robot and a fixed surface.
5. Incorrect human-robot collaborative workspace setup, parameter settings or project operation.
6. TCP force may be estimated incorrectly when robot is passing the area near singularity point in space, due to the nature of singularity.
WARNING:
Ensure compliance with all local and national safety and electrical codes for the installation and operation of the robot system.

WARNING:
Provide appropriately sized Branch Circuit Protection and Lockout/Tagout Capability in accordance with the National Electrical Code and any local codes.

WARNING: ELECTROCUTION RISK
It is necessary for a skilled and instructed person to perform AC power installation. During installation, it is mandatory to prevent unauthorized third parties from turning on power with the use of lockout/tagout measures. Failure to use appropriate power can lead to malfunction or failures of the robot or hazardous situations.
2. Safety Function

2.1 Overview

TM Robot incorporates multiple safety functions, and provides interfaces for additional external protective devices.

2.2 General Information

The following describes common information of the TM Robot system safety functions:

2.2.1 Safety Function Definitions

Safety Function Definitions of TM Robot System are listed in the following table:

<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Robot Stopping Function</th>
<th>Structure Category</th>
<th>PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF0</td>
<td>Robot Stick ESTOP</td>
<td>Emergency Stop</td>
<td>Cat. 3</td>
<td>d</td>
</tr>
<tr>
<td>SF1</td>
<td>User Connected ESTOP Input</td>
<td>Emergency Stop</td>
<td>Cat. 3</td>
<td>d</td>
</tr>
<tr>
<td>SF2</td>
<td>Encoder Standstill</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF3</td>
<td>User Connected External Safeguard Input</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF4</td>
<td>Joint Torque Monitoring</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF5</td>
<td>Joint Position Limit</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF6</td>
<td>Joint Speed Limit</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF7</td>
<td>TCP Speed Limit</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF8</td>
<td>TCP Force Limit</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF9</td>
<td>User Connected External Safeguard Input</td>
<td>--</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF10</td>
<td>Robot ESTOP Output</td>
<td>--</td>
<td>Cat. 3</td>
<td>d</td>
</tr>
<tr>
<td>SF11</td>
<td>User Connected External Safeguard Output</td>
<td>--</td>
<td>Cat. 3</td>
<td>d</td>
</tr>
<tr>
<td>SF12</td>
<td>User Connected External Safeguard Output for Human-Machine Safety Settings</td>
<td>--</td>
<td>Cat. 3</td>
<td>d</td>
</tr>
<tr>
<td>SF13</td>
<td>Robot Internal Protective Stop Output</td>
<td>--</td>
<td>Cat. 3</td>
<td>d</td>
</tr>
<tr>
<td>SF14</td>
<td>Robot Moving Output</td>
<td>--</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF15</td>
<td>User Connected Enabling Device Input</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF16</td>
<td>User Connected ESTOP Input without Robot ESTOP Output</td>
<td>Emergency Stop</td>
<td>Cat. 3</td>
<td>d</td>
</tr>
<tr>
<td>SF17</td>
<td>Cartesian Limit A</td>
<td>Protective Stop</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
<tr>
<td>SF18</td>
<td>Cartesian Limit B</td>
<td>--</td>
<td>Cat. 2</td>
<td>d</td>
</tr>
</tbody>
</table>

Table 3: Safety Function Definitions

Note:
1. The structure category according to ISO 13849-1:2015.
2. PL (Performance Level) in accordance with ISO 13849-1:2015.
4. Stop categories in accordance with IEC 60204-1.
2.2.2 Stopping Time and Stopping Distance in the Safety System

Safe stopping time is the time required from when an emergency stop or protective device (i.e. internal or external) is activated and motion stops. In this system, activating the emergency stop button will apply Cat. 1 safety stop. Activation of a safety function or external safety protective device will be a Cat. 2 stop. It may be necessary for the user or the system integrator to take these stop times into consideration when implementing risk reduction measures. The robot continues moving during this time, which can transmit energy and present additional risk. Refer to Appendix C for stopping time and stopping distance.

2.2.3 Software Safety Setting Permissions

A change management process should be in place listing known acceptable settings and potential hazards. Changes are made in the permissions management function. The authorized user must log in with administrator’s privilege to set all levels of permissions appropriately. Cybersecurity measure should take place when using a network connection. The Corporation is not liable for the possible harm caused by malicious attacks or intrusion of the users’ network to modify the permissions management system or safety setup.

2.3 Explanation of Safety Functions

2.3.1 SF0 Robot Stick ESTOP and SF1 User Connected ESTOP Input

The SF0 Robot Stick ESTOP refers to the built-in Emergency Switch on the Robot Stick of the TM Robot control box, and the SF1 User Connected ESTOP Input refers to the Emergency Stop Port on the control box, which is applicable to connect additional emergency switches.

Refer to the table below for the stop category and the reaction of the fault detection of the safety functions. The functions come with discrepancy detection to maintain safety when detecting conflicting signals from the dual channel input. When a discrepancy occurs, the system will enter and lock in a safety status. To resume from the safety status, first check the input wiring, correct it, and let the dual inputs open and close again, to enable the robot to the resume status of the safety function. When any fault other than discrepancy in the safety functions is detected, the system performs a Cat. 0 stop. When Cat. 0 stop occurs, reboot the robot system to recover from Cat.0 stop status.
<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Stop Category</th>
<th>Action of Fault Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF0</td>
<td>Robot Stick ESTOP</td>
<td>Cat. 1 stop</td>
<td>Discrepancy: Cat.1 Stop Others: Cat. 0 stop</td>
</tr>
<tr>
<td>SF1</td>
<td>User Connected ESTOP Input</td>
<td>Cat. 1 stop</td>
<td>Discrepancy: Cat.1 Stop Others: Cat. 0 stop</td>
</tr>
</tbody>
</table>

Note: Stop categories in accordance with IEC 60204-1.

Table 4: Stop Category and Action of Fault Detection of SF0 and SF1

The user can stop movement by pressing the Emergency Stop button. After the movement of the robot has ceased, the user must confirm that no hazardous conditions are present before manually releasing the Emergency Stop button to allow reactivation of the robot. The Emergency Stop should be used only when a critical condition occurs. To stop the movement of the robot under normal operation, use the Stop Button on the Robot Stick.

If the risk assessment requires additional Emergency Stop devices, the selected device must comply with the requirements of the IEC 60204-1. Any additional Emergency Stop Devices must be connected to the User Connected ESTOP Input port (SF1), so they do not diminish the overall performance level of the Emergency Stop.

Activation of an emergency stop initiates a Cat. 1 stop. The Indication Light Ring of the robot will not display light and the three lights on the Robot Stick will be constantly blinking. The steps to reset the emergency stop are as follows:

1. Rotate the Emergency Switch to the pop-up state. At this time, the robot arm will be re-powered. The Indication Light Ring will have the light blue light on to indicate the Safe Start up Mode.
2. Press the Stop Button on the Robot Stick for about three seconds. The robot will perform the calibration action of the start-up process and return to the previous operating mode.

**WARNING:**
The power of the robot arm will be cut and the joint brake will be activated, if the Emergency Stop is triggered. The Indication Light Ring of robot’s end module will not show light and the three lights from the robot stick will be constantly blinking. In this case, although each of the joints will be automatically locked by their brakes, the robot body will still drop slightly, before it completely stops. Pay attention to the risk that the end part of the robot may pinch the operator or collide with other objects.
WARNING:
During an Emergency Stop, power to the end effector will be cut. If the system was integrated with a power I/O enabled end effector, the emergency stop condition may cause the workpiece to be dropped.

This should be taken into consideration when the user integrates the system and perform appropriate design in compliance with risk assessment. To prevent the unexpected dropping of workpiece, user can choose an end-effector with self-maintaining function, using pneumatic logic configuration of reverse logic, using the power supply I/O of control box, or connecting extra power supply. The user should be responsible for a correct integration.

CAUTION:
Personnel should be outside of the robot’s operational space (areas that robot can reach) when recovering from the emergency stop. Clear off the loading at the tool end before recovering from the emergency stop.

CAUTION:
During the Joint Position Calibration period, each joint of the robot will perform a calibration motion. Make sure the robot pose is in a clear space of at least 5 degrees per joint to perform the calibration motion before starting the calibration. At the same time, make sure the TCP, which may have a long distance to the robot flange, will not causing harm during the calibration motion.

2.3.2 SF2 Encoder Standstill
This safety function is automatically activated after every Cat. 2 Stop. Encoders of each joint are monitored continuously to check if there is any unintended motion until the user acknowledges and manually resets the robot from the state of Cat. 2 Stop. If there is any unintended motion, this safety function will trigger a Cat. 0 Stop. When any fault other than discrepancy is detected in the safety function, the system performs a Cat. 0 stop. When a Cat. 0 stop occurs, reboot the robot system to recover from Cat. 0 stop status.

2.3.3 SF3 User Connected External Safeguard Input and SF9 User Connected External Safeguard Input for Human-Machine Safety Settings
These two safety inputs are present on the Safeguard Port of the robot control box. For the related connection and usage, refer to the Hardware Installation Manual. Resuming from the SF3 User Connected External Safeguard Input protective stop and SF9 User Connected External Safeguard Input for Human-Machine Safety Settings can be manual or auto. If manual resume is configured, press the PLAY button to resume the original status. For the setting for manual or automatic resume, refer to the relevant contents in the Software Manual.

Refer to the table below for the stop category and the reaction of fault detection of the safety
functions. The functions come with discrepancy detection to maintain the safety status when detecting conflicting signals from a dual channel input. When a discrepancy occurs, the system will enter and lock in a safety status of Cat. 1 stop. To resume from the safety status, first check the input wiring, correct it, and follow the steps below to resume.

1. Let the dual inputs open and close again. At this time, the robot arm will be re-powered. The Indication Light Ring will have the light blue light on to indicate the Safe Start up mode.
2. Press the Stop Button on the stick for about three seconds. The robot will perform the calibration action of the start-up process and return to the previous operating mode.

When any fault other than discrepancy detected in the safety functions, the system performs a Cat. 0 stop. When Cat. 0 stop occurs, reboot the robot system to recover from Cat.0 stop status.

<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Stop Category</th>
<th>Reaction of Fault Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF3</td>
<td>User Connected External Safeguard Input</td>
<td>Cat. 2 stop</td>
<td>Discrepancy: Cat. 1 Stop Others: Cat. 0 stop</td>
</tr>
<tr>
<td>SF9</td>
<td>User Connected External Safeguard Input</td>
<td>--</td>
<td>Discrepancy: Cat. 1 Stop Others: Cat. 0 stop</td>
</tr>
<tr>
<td></td>
<td>for Human-Machine Safety Settings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Stop categories in accordance with IEC 60204-1.

Table 5: Stop Category and Action of Fault Detection of SF3 and SF9

SF9 is a function to decrease the robot speed to which is set in Human-Machine Safety Settings and comes with a deceleration time parameter that users can configure to prevent force/torque related safety functions from triggering by the dramatic slowdown from high speed. The upper limit of the deceleration time is 800 milliseconds. Note that there is a fixed time delay of 1122 milliseconds after the trigger of Human-Machine Safety Settings to start to monitor the TCP speed to let the robot decrease to speed from Human-Machine Safety Settings. Users should take these timings into considerations for the risk assessment of applications and set the distance of the safeguard properly.

2.3.4 SF4~SF8 Defined Safety Functions

The name and description of SF4 to SF8 safety functions are listed in the following table:

<table>
<thead>
<tr>
<th>Safety Function</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF4</td>
<td>Joint Torque Monitoring</td>
<td>The additional torque that joint received after compensating the weight of tool in TCP setting, weight of workpiece in payload</td>
</tr>
</tbody>
</table>
setting in programming, and the weight of the robot body. Each joint’s torque limit condition can be set. When the robot exceeds a set value, it will trigger a protective stop.

<table>
<thead>
<tr>
<th>SF5</th>
<th>Joint Position Limit</th>
<th>Each joint’s motion angle limit can be set. When the robot exceeds a set value, it will trigger a protective stop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF6</td>
<td>Joint Speed Limit</td>
<td>Each joint’s motion speed range can be set. When the robot exceeds a set value, it will trigger a protective stop.</td>
</tr>
<tr>
<td>SF7</td>
<td>TCP Speed Limit</td>
<td>The speed limit of the tool center point can be set. When the robot exceeds a set value, it will trigger a protective stop.</td>
</tr>
<tr>
<td>SF8</td>
<td>TCP Force Limit</td>
<td>The additional force that TCP received after compensating the weight of tool in TCP setting and weight of workpiece in payload setting in the programming. The force limit of the tool center point can be set. When the robot exceeds a set value, it will trigger a protective stop. The force of the tool center point is the external force at the tool center point estimated through the model by the robot system. It is not the protection value of applied external force at the tool center point by the robot system.</td>
</tr>
</tbody>
</table>

Table 6: SF4~SF8 Defined Safety Functions

Refer to the table below for the stop category and the action of fault detection for the safety functions.

When any fault other than discrepancy is detected in the safety functions, the system performs a Cat. 0 stop. When Cat. 0 stop occurs, reboot the robot system to recover from Cat. 0 stop status.

<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Stop Category</th>
<th>Reaction of Fault Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF4</td>
<td>Joint Torque Monitoring</td>
<td>Cat. 2 stop</td>
<td>Cat. 0 stop</td>
</tr>
<tr>
<td>SF5</td>
<td>Joint Position Limit</td>
<td>Cat. 2 stop</td>
<td>Cat. 0 stop</td>
</tr>
<tr>
<td>SF6</td>
<td>Joint Speed Limit</td>
<td>Cat. 2 stop</td>
<td>Cat. 0 stop</td>
</tr>
<tr>
<td>SF7</td>
<td>TCP Speed Limit</td>
<td>Cat. 2 stop</td>
<td>Cat. 0 stop</td>
</tr>
<tr>
<td>SF8</td>
<td>TCP Force Limit</td>
<td>Cat. 2 stop</td>
<td>Cat. 0 stop</td>
</tr>
</tbody>
</table>

Note: Stop categories in accordance with IEC 60204-1.

Table 7: Stop Category and Reaction of Fault Detection of SF4~SF8

Refer to the relevant contents in the Software Manual for the setting of each item. Users can use any method listed below to recover the robot from protective stop manually from SF4 to SF8:

- Triggering the STOP or PLAY functions
- Any operation on the icons in the left sidebar of the TMflow (except Shutdown)
- Pressing the FREE button in the end module of TM Robot
- Switching the mode on the robot stick
- Jogging the robot in UI Controller
- Changing digital/analog output value in UI Controller
- Entering Step Run in UI
- Pressing “Test” in UI to move the robot
- Pressing “Move (+)” in UI to move the robot (except Posture Setting, Vision Job, the interruption while moving in Path node and Path Generator)
- Executing the project.

**DANGER:**
Pay attention that the “TCP Force” (Tool Center Point Force) is the external force at the tool center point estimated through the model by the robot system, not the protection value of the external force at the tool center point on the robot system. When the robot system exceeds the external force value at the tool center point, the robot will perform a category 2 stop. In this condition, applied forces will exceed this value. Therefore, clearly understand the amount of the external force applied before the robot comes to a complete stop. The extent this value will be exceeded will increase as the robot speed increases. This cannot be the primary risk mitigation for human-robot collision.

**DANGER:**
When the motion of TM Robot is passing the area near singular space, due to the nature of singularity, the TCP force may be estimated incorrectly. Users can set the robot's motion properly, e.g. do not set the motion too close to the singularity point in space, to avoid this situation. This is a residual risk and users should apply risk assessment for the detection of SF8 TCP force near the singularity case. SF8 TCP force should not be solely applied as the only safety protection measure in human-robot collision case. It’s always recommended to include SF4 Joint Torque Monitoring in the human-robot collision safety protection measure.

**DANGER:**
The speed, power and force limiting according to different body region in Human-Machine Safety Settings are designed for user to quickly set up an initial robot application in collaborative workspace following the biomechanical limits of each body region listed in ISO/TS 15066. The initial parameters are tested* based on the conditions state in the same UI, for details please refer to the software manual. User should still perform risk assessment on real application before deployment, if any parameter needed to be modified, user can enter More Limit Setting page to modify. User shall take responsibility for human body region which is not listed in this graph, and ensure the robot does not have any chance to be in contact with any vulnerable body region such as spine and hindbrain.

*The default speed limit on each body region is derived from the test based on the following criteria:

- 100mm long and 0.67kg weight tool for X and Y axes impact test is installed on the robot TCP. The weight of tool is compensated in TCP setting.
- 100mm long and 0.12kg weight tool for Z axes impact test is installed on the
robot TCP. The weight of tool is compensated in TCP setting.

- The impact force of the robot at the half reach collided with the sensor matches the biomechanical limits of each body region defined in ISO/TS 15066.
- The sensor used in the impact test is selected from which is described in document of DGUV:FB HM 080 (August 2017).

Note that the default speed limit when selecting Hand & Finger had been modified to a lower speed to match the test with sensor described in document of DGUV:FB HM 080 (August 2017). If you upgrade your Robot from previous version of Safety System to Safety System 3.3 by software update, the speed limit value of Hand & Finger will still keep the original setting. Re-select the body region or click the default button under Human-Machine Safety Setting page to update the speed limit value of Hand & Finger to align with the speed limit value of Hand & Finger in Safety System 3.3.

2.3.5 SF10~SF14 Safety Output Functions

SF10~SF14 provides the safety output functions connecting to other devices for system integration. Refer to the table below for the stop category, the definition of the triggered status, the action of the output signal, and the action of the fault detection. When any fault other than discrepancy is detected in the safety functions, the system performs a Cat. 0 stop. When Cat. 0 stop occurs, reboot the robot system to recover from Cat. 0 stop status. For the related connections and usages, refer to the Hardware Installation Manual of the respective hardware version. The definition of triggered status is when the connected device should stop or enter the safety status. These safety outputs will be LOW when triggered. For SF10 Robot ESTOP Output, note that it only reflects the emergence stop resulting from SF0 and SF1. The emergency stop resulting from SF16 User Connected ESTOP Input without Robot Output will not reflect on SF10.

For integration with safety output functions, it is necessary to add the corresponded safety input functions’ PFHd values for calculation. For example, when using SF10 Robot ESTOP Output to stop other machine when emergency situation. It is necessary to put SF0 Robot Stick ESTOP into...
calculation, or to put both external ESTOP button PFHd value and SF1 User Connected ESTOP Input into calculation. For those outputs to stop other machine when internal safety functions triggered like SF13 Robot Internal Protective Stop Output, it is needed to consider the corresponded input function, for example, SF7 TCP Speed Limit’s value into calculation.

One exception of safety output functions integration in Safety System 3.3* is SF14 Robot Moving Output, it does not need to add with the corresponding input function. SF14 is the combination of encoder monitoring mechanism and output function, and all related PFHd has been taken into consideration.

*In Safety System 3.2, SF14 is marked with Cat. 3, as the output of encoder standstill function, and needed to add with the structure and PFHd of SF2, which is a Cat.2 structure. In Safety System 3.3, they are all considered in SF14.
<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Output Signal in Regular Status</th>
<th>Definition of Triggered Status</th>
<th>Output signal of Triggered Status</th>
<th>Action of Output when Discrepancy Detected from Safety IO Input Ports</th>
<th>Action of Output when System Cat. 0 Stop Occurs</th>
<th>Action of Output when System Cat. 1 Stop Occurs</th>
<th>Action of Fault Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF10</td>
<td>Robot ESTOP Output</td>
<td>HIGH</td>
<td>ESTOP result from SF0 and SF1</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
<td>Cat. 0 stop</td>
</tr>
<tr>
<td>SF11</td>
<td>User Connected External Safeguard Output</td>
<td>HIGH</td>
<td>Protective Stop result from SF3</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
<td>Cat. 0 stop</td>
</tr>
<tr>
<td>SF12</td>
<td>User Connected External Safeguard Output for Human–Machine Safety Settings</td>
<td>HIGH</td>
<td>External Safeguard Input result from SF9</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
<td>HIGH</td>
<td>Cat. 0 stop</td>
</tr>
<tr>
<td>SF13</td>
<td>Robot Internal Protective Stop Output</td>
<td>HIGH</td>
<td>Protective Stop result from SF4,5,6,7,8,15,17</td>
<td>LOW</td>
<td>For SF 15 LOW</td>
<td>LOW</td>
<td>HIGH</td>
<td>Cat. 0 stop</td>
</tr>
<tr>
<td>SF14</td>
<td>Robot Moving Output</td>
<td>HIGH</td>
<td>Any joint speed moves no less than 0.3˚/s (Robot is moving)</td>
<td>LOW</td>
<td>--</td>
<td>LOW</td>
<td>LOW</td>
<td>Cat. 0 stop</td>
</tr>
</tbody>
</table>

Table 8: Output Signal and Action of Fault Detection of SF10~SF14
Refer to the table below for indication of the example of application using the safety functions.

<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Example of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF10</td>
<td>Robot ESTOP Output</td>
<td>Stop other devices when emergency stop button connected to the robot triggered.</td>
</tr>
<tr>
<td>SF11</td>
<td>User Connected External Safeguard Output</td>
<td>Stop other devices when safeguard connected to SF3 of the robot triggered.</td>
</tr>
<tr>
<td>SF12</td>
<td>User Connected External Safeguard Output</td>
<td>Stop other devices or let it change to Human–Machine Safety Settings when safeguard connected to SF9 of the robot triggered.</td>
</tr>
<tr>
<td>SF13</td>
<td>Robot Internal Protective Stop Output</td>
<td>Stop other devices when robot is stopped for SF4,5,6,7, or 8. Stop other devices when the robot is stopped for SF15 Enabling Device. Stop other devices when the robot is stopped for SF17 Cartesian Limit A.</td>
</tr>
<tr>
<td>SF14</td>
<td>Robot Moving Output</td>
<td>Prevent other devices from moving when the robot moves, e.g. application for robot mounted on an AGV or motional axis. (One should stand still while the other one is moving)</td>
</tr>
</tbody>
</table>

Table 9: Application example of Safety Output Function

**WARNING:**
SF14 Robot Moving Output is designed for stopping the other machine when the robot is moving. When the robot is not moving, the output is HIGH, and this signal is provided to allow other machine’s movement, not be used to stop the other machine. To stop the other machine while the robot is standstill, use other measures such as the safeguard output of the robot or use the safety device to stop both the robot and other machine at the same time.

### 2.3.6 SF15 and SF16 Safety Input Functions
SF15 and SF16 provides more safety input functions for system integration.

SF15 User Connected Enabling Device Input provides the dual channel input ports for user to connect to a three-position enabling device when risk assessment indicates. Enable this safety function in the Safety Setting in the software to use it by referring to the *Software Manual* of the respective software version. Note that the Open or Close status of this safety input will not affect the operation in Auto Mode. When this function is enabled and connected to the enabling switch, in Manual Mode, all manual control operations are enabled only when users press the three position enabling device in the middle position. If the Enabling Device is released or fully pressed, the robot performs a protective stop. When starting a manual trial run of the project pressing the PLAY button, the Enabling Device should be pressed in the middle position. When Enabling Device is released or fully pressed during the Manual Trial Run mode, the Project Speed will...
always automatically return to 5%. Connect this safety function only to the three-position enabling device compliant with IEC60204-1. Note that the input of this safety function has two input statuses only, so the Enabling Device should not have an enabled output during the procedure from the fully pressed status to the fully released status.

SF16 User Connected ESTOP Input without Robot ESTOP Output provides an emergency input function without triggering SF10 Robot ESTOP Output. This safety function provides the possibility to prevent the deadlock of the emergency stop between the robot and other devices/machines in different system integration design.

Refer to the table below for the stop category and the reaction of fault detection of the safety functions. The functions come with discrepancy detection to maintain the safety status when detecting conflicting signals from a dual channel input. When discrepancy occurs, the system will enter lock in a safety status of Cat.1 stop. To resume from the safety status, first check the input wiring, correct it, and follow the steps below to resume.

1. Let the dual inputs open and close again. At this time, the robot arm will be re-powered. The Indication Light Ring will have the light blue light on to indicate the Safe Start up Mode.
2. Press the Stop Button on the Robot Stick for about three seconds. The robot will perform the calibration action of the start-up process and return to the previous operating mode.

When any fault other than discrepancy is detected in the safety functions, the system performs a Cat. 0 stop. When Cat. 0 stop occurs, reboot the robot system to recover from Cat. 0 stop status.

<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Stop Category</th>
<th>Reaction of Fault Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF15</td>
<td>User Connected Enabling Device Input</td>
<td>Cat. 2 stop</td>
<td>Discrepancy: Cat.1 Stop Others: Cat. 0 stop</td>
</tr>
<tr>
<td>SF16</td>
<td>User Connected ESTOP Input without Robot ESTOP Output</td>
<td>Cat. 1 stop</td>
<td>Discrepancy: Cat.1 Stop Others: Cat. 0 stop</td>
</tr>
</tbody>
</table>

Note: Stop categories in accordance with IEC 60204-1.

Table 10: Stop Category and Reaction of Fault Detection of SF15 and SF16

**DANGER:**
Enabling Devices only stop the robot in Manual Mode and will not stop the robot in Auto Mode.

2.3.7 SF17 Cartesian Limit A
SF17 provides a safety function for users to set Cartesian limit on the robot. Cubical and cylindrical limits can be set, and both TCP and elbow are monitored. Refer to the table below for the stop category and the reaction of fault detection and the Software Manual of the respective software version for the parameters and procedure of setting.

To resume from this safety function, following the steps below:
1. Switch to the Manual Control Mode.
2. Press the FREE button on the end module of the robot to hand guide the robot to leave the limited space.

<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Stop Category</th>
<th>Reaction of Fault Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF17</td>
<td>Cartesian Limit A</td>
<td>Cat. 2 stop</td>
<td>Others: Cat. 0 stop</td>
</tr>
</tbody>
</table>

Note: Stop categories in accordance with IEC 60204-1.

Table 11: Stop Category and Reaction of Fault Detection of SF17

**WARNING:**
SF17 Cartesian Limit A is designed for the robot to monitor once the robot’s movement goes beyond the set limit and the robot performs a protective stop. It does not mean the spot to monitor will not exceed the limit due to the stopping time and the stopping distance. Take the stopping time and the stopping distance into consideration when using this safety function for setting the restricted space and the safeguarded space in system integration.

2.3.8 SF18 Cartesian Limit B

SF18 provides a safety function for users to set Cartesian limit on the robot. Cubical and cylindrical limits can be set, and both TCP and elbow are monitored. When the robot exceeds this Cartesian limit, the robot decreases the speed to which is set in Human-Machine Safety Settings. Refer to the table below for the stop category and the reaction of fault detection and the Software Manual of the respective software version for the parameters and procedure of setting.

To resume from this safety function, following the steps below:
1. Switch to the Manual Control Mode,
   (1) Press the FREE button on the end module of the robot to hand guide the robot to leave the limited space. Or,
   (2) Use the controller in the software to jog the robot to leave the limited space.
2. Under any other Mode, let robot leave the limited space by programming.
### Table 12: Stop Category and Reaction of Fault Detection of SF18

<table>
<thead>
<tr>
<th>Safety Function Number</th>
<th>Name</th>
<th>Stop Category</th>
<th>Reaction of Fault Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF18</td>
<td>Cartesian Limit B</td>
<td>--</td>
<td>Others: Cat. 0 stop</td>
</tr>
</tbody>
</table>

Note: Stop categories in accordance with IEC 60204-1.

**DANGER:**
Cartesian Limit cannot be used as the only safety measure for preventing collisions between human and the robot. When this safety function is used, other means should be provided to prevent human or the limb enters the limited space or detect the entering of the limited space with a protective measure.

**2.3.9 Safety Checksum**

This function is intended for generating a "Checksum" from the safety settings and showing on the UI for users to quickly check the safety settings when user modified or type-in safety parameters to other robots. The Safety Checksum indication displayed on the upper bar shows the applied safety settings and can be read from left to right. For example: FE55. Different indication, including text or numbers, indicates for different safety setting configuration.

![Checksum](FE55)

**WARNING:**
The Safety Checksum changes only when the limits or settings in safety setting been changed and saved.
3. Safety Related Operation

These are the operating instructions for Safety-related robot functions and designs.

3.1 Joint Movement without Drive Power

The conditions of robot without driving force are emergency stop, start up from the packing pose, and loss of power. The first two can enter Safe Start up Mode when the emergency switch resets, and the latter is the situation when the robot loses external power entirely. The following describes how to operate it:

3.1.1 During an Emergency Stop Procedure

The brake of each joint axis will automatically lock the joint, to avoid unlimited sagging of the robot's joints due to gravity. If you need to move the robot to resolve the condition, follow the steps listed below:
1. Releasing the Emergency Switch energizes the power to the robot.
2. Wait 10 seconds to enter the Safe Start Up Mode. The Indication Light Ring will turn light blue.
3. Press the FREE button continuously to release the joint axis brake and move the robot.
4. After the situation is resolved, press the stop button on the Robot Stick for about three seconds, the robot will perform the calibration startup process and return to the original operating mode.

**CAUTION:**
All personnel should be outside of the robot’s operational space (areas that robot can reach) when recovering from the emergency stop.

3.1.2 Extending the Robot from the Packing Pose

Refer to the Software Manual for the operation of extending the robot from the Packing Pose. The emergency stop reset method is in Section 2.3.1.

**DANGER:**
When using the FREE button to release brakes without motor power, the robot may sag due to gravity. Be prepared to support the robot system. If it not possible to support the robot system, release the FREE button immediately, which will lock the robot joint brakes.

3.1.3 Power Loss

If power loss to an end-effector can result in a hazardous condition (e.g. dropping of a workpiece), possible methods to reduce the risk may include but are not limited to:
• Use the 24V electrical output provided by the control box to supply the power to end effector instead of using the End Module of robot to supply power.

• Install an independent power supply for the end effector.

• If the end effector is a pneumatic control, use a low potential actuation design.

• Select the end effector with self-maintaining function / mechanical design.

If it is necessary to manually move the arm joint:
1. Remove the joint module protective cover screw and the joint module protective cover
2. Press the brake solenoid valve to release the brake
Refer to the brake release illustration in the Hardware Installation Manual.

3.2 Operation Mode and Mode Switching

TM Robot has two operation modes: Manual Mode (reduced speed and high speed) and Auto Mode. The modes are visually distinguishable by the color of the mode indicator on the Robot Stick and the Indication Light Ring on the robot’s end module. The robot is in Auto Mode when starting up.

3.2.1 Auto Mode

In Auto Mode the Indication Light Ring on the end module displays blue light and the Mode Indicator on the Robot Stick is in Auto position. The user can press the Robot Stick Play/Pause button to play/pause the robot program. The robot speed plays according to the project speed. In Auto Mode, the FREE button on the end module does not actuate, and cannot perform Hand Guiding operation.

Auto Remote Mode is a mode that can only be accessed from Auto Mode when user gets control permission and no project running. It is intended to let user implement remote control from remote side, e.g. Fieldbus command, while these remote control commands are forbidden in the other modes. For switching to Auto Remote Mode, click the Auto Remote Mode icon on the upper bar to permit remote control commands under this mode.

3.2.2 Manual Mode

In Manual Mode the Indication Light Ring on the end module displays in green and the Mode Indicator on Robot Stick is in Manual position. In Manual Mode, it can be divided into Manual Control Mode (Manual Reduced Speed), Manual Trial Run Mode (Manual High Speed), and Hand Guide Mode. When the protective stop occurs, the manual control operation in Manual Control Mode and Hand Guide Mode are prohibited by the system.
3.2.2.1 Manual Control Mode (Manual Reduced Speed)

In Manual Control Mode, the user can jog the robot with controller UI in TMflow or the Robot Stick. If the robot speed exceeds 250 mm/sec, it will enter an error stop state.

3.2.2.2 Hand Guide Mode

Hand Guide Mode can be activated in Manual Control Mode only. Press and hold the FREE button on the End Module to enter Hand Guide Mode, and release the FREE button to return to Manual Control Mode.

3.2.2.3 Manual Trial Run Mode (Manual High Speed)

In Manual Trial Run Mode, users can test the robot program by navigating to the TMflow project editing page and pressing the Play/Pause button on the Robot Stick. The initial project speed will reduce to 5% during each trial run, forcing the path motion of the robot lower than 250 mm/s. The +/- buttons on the Robot Stick are for the adjustment of the project run speed. Each button press increases or decreases project run speed by 5%.

WARNING:
The person should be outside of the safeguarded space when using Manual Trial Run Mode.

3.2.3 Switch Between Modes

For how to switch between modes, refer to the latest Software Manual of the respective software version of the robot system.

DANGER:
Prior to selecting automatic operation, any suspended safeguards shall be set back to full functionality.

3.3 Hold to Run

When the TM Robot is in Manual Control Mode, the functions include:

- joint angle movement
- robot base end movement
- tool base end movement
- self-defined base end movement
• move to visual initial position
• visual servo action
• step run
• move to point
• hand guiding
• others

Hold to Run has two categories:
• Jog the robot by continuously pressing the + / - Button of the Robot Stick.
• Jog the robot by continuously pressing the + / - Button in TMflow software.

Once the + / - Button is released, the robot will stop operation immediately and will continue operation when pressed again. If TMflow connects to the robot through Ethernet or Wi-Fi, the robot will automatically issue a protective stop when releasing the + / - Button or the connection is broken. Depending on the quality of connection, there may be a maximum detection delay of 800ms for loss of communication. Using the physical button to perform Hold to Run function, the detection time of releasing the button is up to 30ms.

3.4 Singularity Point
The motion of an articulated robot is often limited by the kinematic design, and cannot perform Cartesian motion control under all joint positions. The joint position that will cause the robot to be unable to perform Cartesian control is a singularity point. When the robot encounters a singularity point, it will stop motion and initiate a warning.

Three types of singularity point for TM Robot:
• Internal Singularity Point in Space
• Extensible Singularity Point in Space.
• Wrist Singularity Point in Space.

Internal Singularity Point in Space:
The distance from the intersection of the rotational axes of the fifth joint and the sixth joint to the extended line of the rotational axis of the first joint is defined as $R_{\text{offset}}$. The cylindrical space that is formed by $R_{\text{offset}}$ as the radius and centered on the extended line of the rotational axis of the first joint is the Internal Singularity Point in Space. As soon as the robotic arm approaches the Internal Singularity Point in Space, the arm will stop and issue a warning. The $R_{\text{offset}}$ values of each product series are shown in the following table:
<table>
<thead>
<tr>
<th>Main model</th>
<th>$R_{\text{offset}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM5 Series</td>
<td>122.3 mm</td>
</tr>
<tr>
<td>TM12/14 Series</td>
<td>156.3 mm</td>
</tr>
</tbody>
</table>

Table 13: The $R_{\text{offset}}$ values of each product series

**Extensible Singularity Point in Space:**

When the third joint is almost at its zero degree, which means the robot is almost at the maximum working radius. The space exceeding this radius is the Extensible Singularity Point in Space. In this space, the robot will stop and report a warning due to exceeding the motion range of the robot.
The maximum working range can be achieved when the third joint is almost at zero degrees.

**Figure 4: Extensible Singularity Point in Space**

**Wrist Singularity Point in Space:**

When the rotational axes of the fourth and the sixth joints are parallel, the robot will enter the Wrist Singularity Point in Space. At this time, the motion of the arm will cause a large-angle displacement of the fourth joint, but it will be stopped due to stop criteria of motion speed. Once the robot enters the Wrist Singularity Point in Space, it will stop and report an error.

**Figure 5: Wrist Singularity Point in Space**

When the fourth and sixth joint are nearly parallel, the robot is about to enter the Wrist Singularity Point in Space.
The Solution when Encountering Singularity Point in Space:
When the robot reports singularity, confirm the posture of the robot. If the tool end path crosses the internal cylinder as shown in the figure below, check the first point description. If the rotational axes of the fourth and sixth joints of the robot are parallel, check the second point description below.

1. When the arm reports a warning due to the Internal Singularity Point in Space, press the FREE button to release it from the posture. Change the point position or change the motion type to PTP between the points to avoid the arm path between the points crossing the Internal Singularity Point in Space, as shown in the figure below.

![Figure 6: The Solution when Encountering Singularity Point in Space (1/2)](image)

When the path crosses the Internal Singularity Point in Space, singularity will be triggered. Adjust the path and confirm that it will not cross the Internal Singularity Point in Space.

2. When the robot reports a warning because of entering the Wrist Singularity Point in Space, press the FREE button to release it. When the rotational axes of the fourth and the sixth joint are in parallel, if users still try to perform Cartesian motion, the Wrist Singularity Point in Space will be encountered. At this time, the method in the following figure can be used to avoid the rotational axes of the fourth and the sixth joints being parallel.
This example demonstrates how to avoid the rotational axes of the fourth and sixth joint being parallel, when the user needs to move the robot according to tool Z-axis.

3.5 Replacing the Robot Stick in Local Control

When users use other means to replace the local control function of the Robot Stick, the Robot Stick should not be accessed and used in local control at the same time. For example,

- Do not use devices like teach pendants when using the Robot Stick at the same time in local control.
- Do not enable and use the teach pendant function* on a keyboard when using the Robot Stick at the same time in local control.

* Supported by the software version newer than SW1.72 with the Keyboard Hot Key functions.

For initiation of robot motion under local control, the table below summarized executing project using PLAY function, hold to run or speed adjustment using +/- functions according to different control method in respective mode. The “X” means the user is allowed to use the function.
<table>
<thead>
<tr>
<th>Operation Mode</th>
<th>The user can Play Using</th>
<th>The user can +/- Using</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Robot Stick</td>
<td>Configure IO</td>
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<td>Manual Trial Run Mode</td>
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<td>Auto Mode</td>
<td>Y X X X X X X X</td>
<td>X*</td>
</tr>
<tr>
<td>Auto Remote Mode</td>
<td>Y X X X X X X X</td>
<td>X*</td>
</tr>
</tbody>
</table>

Table 14: Control Methods in Respective Modes Summary

* Needs to enable speed adjustment under Auto Mode
4. Compliance of Safety Regulations

This section describes the compliance and certification of this product to international safety regulations.

This product complies with the following international safety regulations:

ISO 10218-1:2011
ISO/TS 15066
ISO 13849-1:2015

Certification: Third-party certification (refer to the certificate in Appendix A)

4.1 Compliance

This product complies with the combined scope of ISO 10218-1:2011 and ISO/TS-15066. The relevant design and corresponding provisions in safety regulations of this part are listed in the following sections.

4.1.1 Requirement of Enabling Device

- The power and force limiting functions provide the alternative measures for the requirement of an enabling device per ISO/TS 15066:2016.
- Means are provided for connection of an Enabling device when required by the risk assessment.

4.1.2 Access of Safety Setting

- TM Robot's safety setting has been integrated with the user's permission system of the entire product.
5. Declaration of Incorporation

The following is based on the Declaration of Incorporation in application of 2006/42/EG, Annex II, No. 1 B

The robot product of the Corporation is a partly completed machinery. When it is put into automation applications, it needs to be integrated with other equipment, and appropriately installed with the safety related measures and design before it can be used. When the semi-finished products are to put on the market, the following requirements according to 2006/42/EC Annex I need to be achieved. It must be noted that since the TM Robot product is easy to use, the “system integrator” here refers to the end user who uses the product directly through simple installation.

A: Not related
B: Satisfied by machinery equipment provider
C: Responsibility of the system integrator

Attention: in the following tables:

- Items marked as A: The scope of use of this product has been exceeded, and is not included into the consideration, or it is not directly related to this product.

- Items marked as B solely: The items that are to be satisfied by the machinery equipment provider, meaning the machinery provider has satisfied or has specified in each of the Software and Hardware / Safety Manual. In the latter case, the system integrator is still responsible for the full compliance with specification of machinery equipment provider. In addition, in the entire system, the satisfaction of machinery equipment belonging to the system but not belonging to this product is not included here, and the system integrator must be responsible for it.

- Items marked as C solely: The item cannot be satisfied by this product. The system integrator must implement additional measures.

- Items marked as both B and C:
  1. When the item can be satisfied in using this product itself, the machinery equipment provider of this product shall satisfy it.
  2. When the system integrator replaces the related functions of this product through system integration, the system integrator shall satisfy it. For example:
     - Replacing the emergency switch of the Robot Stick with an external emergency switch
connected to the Emergency Switch Port

- Replacing the Play/Stop Button of the Robot Stick with user-defined IO or the functions of equivalent functions.

When this type of design replaces the original function of this product, the system integrator shall be responsible for the equivalence of the replacement.

3. The machinery equipment provider satisfies this item in normal conditions, but in extraordinary conditions, the satisfying of this item is the responsibility of the system integrator. For example:

- The product will not break in normal operation, without a collision. However, the product can break in the event of a strong collision due to incorrect programming setup and safety setting during operation.

*A – Scope Exceeded, B – Manufacturer Provided, C – May Require Additional Risk Reduction Measures

<table>
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<th>Number</th>
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<th>B*</th>
<th>C*</th>
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</table>

Table 15: Declaration of Incorporation
Appendix A. Certificate of Compliance and Declaration of Incorporation

The "manufacturer" in the article above should be deemed to be "original equipment manufacturer."
The "manufacturer" in the article above should be deemed to be "original equipment manufacturer."
The "manufacturer" in the article above should be deemed to be "original equipment manufacturer."
CERTIFICATE OF CONFORMITY
MD/CoC/20/HEL/006

Product: Industrial Robot

Certificate holder / Manufacturer: TECHMAN ROBOT Inc.
4F, No. 188, Wenhua 2nd Rd., Guishan Dist., Taoyuan City, Taiwan

Manufacturing site: TECHMAN ROBOT Inc.
7F, No. 58, Huaya 2nd Rd., Guishan Dist., Taoyuan City, Taiwan

Model(s): TM-series (see page 2)

Trade mark (if any): Techman Robot Inc.

Technical details / ratings: see page 2


This Certificate of Conformity is based on documentation of the product. Above mentioned Documentation of the product has been evaluated. Based on documentation the product has been found to be in conformity with the above-mentioned standard(s) and applicable parts of the Annex I of the Machinery Directive (2006/42/EC).

This certificate can be used to demonstrate product compliance until 11 September 2025 with the presumption that standards mentioned remains valid. Surveillance activities are not part of this certificate.

It is the obligation of the certification holder to demonstrate upon request that the product produced is identical to the certified product. Use of the CE marking requires actions set in Article 5 clause 1 of Machinery Directive (2006/42/EC), completion of an EU Declaration of Conformity, internal production control (Annex VIII, item 3) and compliance with all relevant EU Directives.

Date of issue: 11 September 2020

Signature: Markus Arnesus
Certification Manager
### Models in TM-series:

<table>
<thead>
<tr>
<th>Type</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC100-240V</td>
<td>TM5-700, TM5X-700, TM5-900, TM5X-900, TM12, TM12X, TM14, TM14X, TM5-700 SEMI, TM5X-700 SEMI, TM5-900 SEMI, TM5X-900 SEMI, TM12 SEMI, TM12X SEMI, TM14 SEMI, TM14X SEMI</td>
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<td>DC22V-60V</td>
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</tr>
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### Additional information about safety system:

TECHMAN ROBOT Safety System 3.3, Hardware 3.2, Hardware 3.2a, Software 1.80

This certificate is based on Certificate of Conformity certificates MDC 2522, MDC 2523 and MDC 2524 issued by SGS United Kingdom Limited.
DECLARATION OF INCORPORATION

We, TECHMAN ROBOT Inc.,
4F, No. 188, Wenhua 2nd Rd. Guishan Dist., Taoyuan City, Taiwan

Declare that the
Product name: Industrial Robot
Series Model Number:
TM5-700; TM5M-700; TM5X-700; TM5MX-700; TM5-900; TM5M-900; TM5X-900; TM5MX-900;
TM5-700 SEMI; TM5M-700 SEMI; TM5X-700 SEMI; TM5MX-700 SEMI; TM5-900 SEMI;
TM5M-900 SEMI; TM5X-900 SEMI; TM5MX-900 SEMI;
TM12; TM12L; TM12X; TM12MX; TM14; TM14M; TM14X; TM14MX;
TM12 SEMI; TM12M SEMI; TM12X SEMI; TM12MX SEMI; TM14 SEMI; TM14M SEMI; TM14X SEMI; TM14MX SEMI;

Conform to the essential safety requirements of the relevant European Directive:
- Machinery Directive 2006/42/EC
- EMC Directive 2014/30/EU

The following essential requirements of EC Machinery Directive 2006/42/EC have been applied:
Clause 1.1.2, 1.1.3, 1.1.5, 1.1.6, 1.1.7, 1.2.1, 1.2.2, 1.2.3, 1.2.4.1, 1.2.4.2, 1.2.4.3, 1.2.4.4, 1.2.5, 1.2.6, 1.3.1, 1.3.2,
1.3.4, 1.3.6, 1.3.7, 1.3.8.1, 1.3.8.2, 1.3.9, 1.4.1, 1.4.2.1, 1.4.3, 1.5.1, 1.5.2, 1.5.3, 1.5.4, 1.5.13, 1.5.14, 1.6.1,
1.6.2, 1.6.3, 1.6.4, 1.6.5, 1.7.1.1, 1.7.1.2, 1.7.2, 1.7.3, 1.7.4, 1.7.4.1, 1.7.4.2, 1.7.4.3

The person who compile technical file established within the EU:
Name: TECHMAN ROBOT Inc.
Address: Staalindustrieweg 21 NL-2952 AT Alblasserdam, Netherlands

Mounting and connecting instructions defined in catalogues and technical construction files must be respected by
the user.

They are based on the following standards:
- EN ISO 60204-1:2018 / Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- EN ISO 13849-1:2015 / Safety of machinery - Safety-related parts of control systems Part 1: General principles for
design
- ISO TS 15066-2016 / Robots and robotic devices — Collaborative robots
- EN IEC 61000-6-2:2005 / Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for
industrial environments
standard for industrial environments

The relevant technical documentation has been compiled in accordance with Annex VII, Part B of EC Machinery
Directive 2006/42/EC. We undertake, in response to a reasoned request, to supply it to the market surveillance
authorities within a reasonable period.

The partly completed machinery must not be put into service until the final machinery into which it is to be incorporated
has been declared in conformity with the provisions of the Machinery Directive.

Authorized Signature: [Signature]
Name: Hau Chen
Responsibility: CEO
Date: May 29, 2020
Place: Taiwan

Safety Manual TECHMAN ROBOT Safety System 3.3
Appendix B. Verifications of EMC Compliance

VERIFICATION OF EMC COMPLIANCE

Verification No. : MH/2018/50140C
Representative Model No. : TM14M
Added Module(s) :
- TM5M-700, TM5MX-700, TM5M-900, TM5MX-900,
- TM5M-700 SEMI, TM5MX-700 SEMI, TM5M-900 SEMI,
- TM5M-900 SEMI, TM12M, TM12MX, TM14M, TM14MX,
- TM12M SEMI, TM12MX SEMI, TM14M SEMI, TM14MX SEMI

Product Name : Industrial Robot
Brand Name : Techman Robot
Applicant : Techman Robot
Address of Applicant : 4F, No. 188, Wenhu 2nd Rd, Gushan Dist., Taoyuan City, Taiwan
Test Report Number : MH/2018/50140
Date of Issue : Aug. 06, 2018

Applicable Standards :
- EN 61000-6-2 : 2017
- IEC 61000-4-4 : 2012, IEC 61000-4-5 : 2014
- IEC 61000-4-6 : 2013, IEC 61000-4-8 : 2008

Conclusion
The apparatus meets the requirements of the above standards. In addition, this verification is only valid for the equipment and configuration described and in conjunction with the test report as detailed above.

Authorized Signatory:
Eddy Cheng
SGS TAIWAN LTD.
Technical Asst. Supervisor
SGS Reference No: MH/2018/30017/C

VERIFICATION OF EMC COMPLIANCE

Verification No. : MH/2019/30017C
Representative Model No. : TM12
Added Model(s) : TMS-700, TMSX-700, TMS-900, TMSX-900, TMS-700 SEMI, TMSX-700 SEMI;
SEM1, TMS-900 SEMI, TMSX-900 SEMI; TM12, TM12X, TM14, TM14X;
TM12 SEMI, TM12X SEMI, TM14 SEMI, TM14X SEMI

Product Name : Industrial Robot
Brand Name : TECHMAN ROBOT INC
Applicant : Techman Robot Inc.
Address of Applicant : 4F, No. 188, Wenhua 2nd Rd. Guishan Dist., Taoyuan City, Taiwan
Test Report Number : MH/2019/30017
Date of Issue : May 02, 2018
EN 61000-6-2 : 2005+A1:2005
IEC 61000-4-4 : 2012, IEC 61000-4-5 : 2014
IEC 61000-4-6 : 2013, IEC 61000-4-8 : 2005, IEC 61000-4-11 : 2004

Conclusion
The apparatus meets the requirements of the above standards. In addition, this verification is only valid for the equipment and configuration described and in conjunction with the test report as detailed above.

Authorized Signatory:

[Signature]
SGS TAIWAN LTD.
Eddy Cheng
Technical Asst. Supervisor
Appendix C. TM Robot Stopping Time and Distance for all Series Product Models

The stopping time and stopping distance of the Cat.1 stop functions of this product at different speeds and with different payloads are shown below.

WARNING:
Any moving robot requires some distance to stop. When stopping a robot, make sure that there is no interference with other equipment. This requires more distance at high operating speeds or with heavier payloads.

### TM5-700 Series

#### Stop Time and Stop Distance Table

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Table 17: Stopping Time and Distance for TM5-900 Series
### TM14 Series

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Table 18: Stopping Time and Distance for TM14 Series
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Table 19: Stopping Time and Distance for TM12 Series