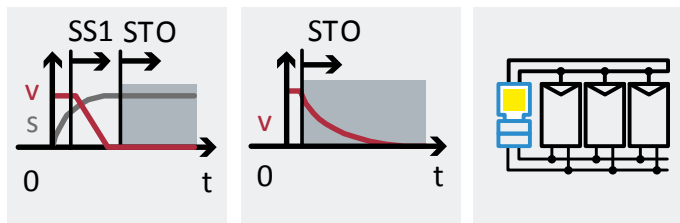


Safety Sub-Functions SS1-t, STO Servo Drive CMMT-ST-...-S0 Cross Wiring of Servo Drives



Application Note
CMMT-ST-...-S0,
SS1-t, STO, Cross
Wiring

TitleApplication Note CMMT-ST-....S0, SS1-t, STO, Cross Wiring
Version 1.0
Document number (TSHQ) 100245
Original German
Author Festo
Last date of saving 30/07/2019

Legal Notice

In the following, the “Festo AG & Co.KG” is designated as “Festo”.

This Example circuit is not binding. This example circuit outlines a possible solution for a sample application and makes no claim of completeness, especially with regard to configuration and equipment, as well as any eventualities for your actual application. The Example circuit is not a customised solution, it merely offers assistance with typical task assignments.

The values stated in the Example circuit are partly assumptions and assessments which do not replace a detailed examination based on EN ISO 13849 part 1 and 2.

The actual characteristic values that can be obtained (especially PL, PFH_D, category, DC, MTT_D, CCF) depend on the components used, as well as their conditions of use in the actual application.

The example circuit does not relieve you of the obligation to carry out a risk assessment and a validation of the specific application and to ensure the adherence to all specifications, especially the EC Machinery Directive 2006/42/EG. As the user, you are responsible for your specific application and for the correct operation of the described products.

Festo does not accept any liability for damages arising from the use of any incorrect or incomplete information contained in this documentation or any information missing therefrom. This equally applies to defects resulting from improper handling of devices and modules. In addition, all liability, with the exception of intent or gross negligence on the part of Festo, for damages arising due to non-adherence of the specifications of the EC Machinery Directive 2006/42/EG is also rejected.

The information in this document is in no way intended as a substitute for the operating instructions of the respective manufacturers or the design and testing of the application by the user. The operating instructions for products from Festo can be found at www.festo.com. Users of this document must themselves verify that all the functions described herein also work correctly in the application. Even after examining this document and using the specifications contained herein, users are nevertheless solely responsible for their own application.

Otherwise, all stipulations concerning liability included in the terms and conditions of delivery, payment and use of software from Festo, which can be found at www.festo.com and can be supplied on request, apply.

This document is only suitable for persons with sufficient expertise for machine safety based on EN ISO 12100 and EN ISO 13849. In addition, the following qualifications are required in the project team:

- Specialist in electrical engineering
- Specialist for the programming of control systems and safety switching devices

Copyright Notice

This documentation is the intellectual property of Festo, which also holds the exclusive copyright. Any modification of the content, duplication or reprinting of this documentation, as well as distribution to third parties, is only permissible with the express consent of Festo.

Festo reserves the right to make modifications to this document in whole or in part. All brand and product names are trademarks or registered trademarks of their respective owners.

© (Festo AG & Co.KG, D - 73734 Esslingen, 2019)

Internet: www.festo.com

E-Mail: service_international@festo.com

Table of Content

1	Example Circuits	4
1.1	Selection Guide for the Circuits	4
1.2	SS1-t, STO with CMMT-ST-...-S0, contact outputs, without STA evaluation	5
1.2.1	Circuit Diagram	5
1.2.2	Components.....	6
1.2.3	Description.....	6
1.2.4	Safety Considerations	7
1.3	SS1-t, STO with CMMT-ST-...-S0, contact outputs, with STA evaluation	8
1.3.1	Circuit Diagram	8
1.3.2	Components.....	9
1.3.3	Description.....	9
1.3.4	Safety Considerations	10
1.4	SS1-t, STO with CMMT-ST-...-S0, with electronic outputs, without STA evaluation	11
1.4.1	Circuit Diagram	11
1.4.2	Components.....	12
1.4.3	Description.....	12
1.4.4	Safety Considerations	13
1.5	SS1-t, STO with CMMT-ST-...-S0, electronic outputs, with STA evaluation	14
1.5.1	Circuit Diagram	14
1.5.2	Components.....	15
1.5.3	Description.....	15
1.5.4	Safety Considerations	16
2	Literature	16

1 Example Circuits

- The circuits specified in this document are principle circuits which cannot be complete due to their clarity and scope. Safety commanding device and safety switching device are not part of this document and are given for information only.
- The abbreviations used for the safety sub-functions refer to the definitions in EN 61800-5-2 [1] for electrical power drive systems:
 - SS1-t: Safe stop 1 time controlled
 - STO: Safe Torque Off
- Category and PL according EN ISO 13849-1 [2].
- To understand this application note, are following documents necessary:
 - Description “Servo drive CMMT-AS-C2/C4-3A-...”. This description is available on the Internet https://www.festo.com/net/en-gb_gb/SupportPortal/Downloads/466851/573769/CMMT-AS-C2_C4-3A_2018-10a_8095049g1.pdf
 - Description “Safety sub-function STO, SBC, SS1” for servo drive CMMT-ST-...-S0. This description is available on the Internet https://www.festo.com/net/en-gb_gb/SupportPortal/Downloads/466859/573777/CMMT-AS-S1_2018-10a_8096257g1.pdf
- The circuits and the procedure described are recommendations which do not exclude other possibilities.

1.1 Selection Guide for the Circuits

The circuits specified in this application note differ in the following points:

- Use of safe outputs of the safety switching device (T1) with contact outputs without short-circuit and cross-circuit detection or electronic outputs with short-circuit and cross-circuit detection
- With or without evaluation of the diagnostic signal of the servo drives (T3, T4, T5) by the safety switching device (T1).

Section	Safety Switching Device (T1)	Possible Category and PL	Remarks
1.2	Safety relay or safety PLC Contact outputs Without short-circuit and cross-circuit detection Without evaluation STA Suitable for PL e, category 3	Stepper motor: Category 3, up to PL e EC motor: Category 3, up to PL d	Fault exclusions for wiring in the control cabinet required
1.3	Safety relay or safety PLC Contact outputs Without short-circuit and cross-circuit detection With evaluation STA Suitable for PL e, category 3	Stepper motor: Category 3, up to PL e EC motor: Category 3, up to PL d	Fault exclusions for wiring in the control cabinet required
1.4	Safety relay or safety PLC Electronic outputs With short circuit and cross circuit detection Without evaluation STA Suitable for PL e, category 3	Stepper motor: Category 3, up to PL e EC motor: Category 3, up to PL d	
1.5	Safety relay or safety PLC Electronic outputs With short circuit and cross circuit detection With evaluation STA Suitable for PL e, category 3	Stepper motor: Category 3, up to PL e EC motor: Category 3, up to PL d	

- With stepper motors: SS1-t, STO, category 3, up to PL e
- With EC motors: SS1-t, STO, category 3, up to PL d
- Safety switching device with contact outputs
- Without evaluation STA
- Fault exclusion control cabinet necessary

Only relevant contacts are shown!

The diagram illustrates the safety circuit for the M20, M21, and M22 machines. It shows the connection of safety switches S1, S2, and S20 to terminal blocks T1, T2, and T5. The circuit is powered by 24V and 0V lines. The diagram is labeled "Only relevant contacts are shown!".

Terminal Blocks and Connections:

- T1:** 24V, 0V, and Pulse 1 are connected to pins 17, 16, and 15 respectively. Pins 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 are connected to pins 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 of T2.
- T2:** 24V, 0V, and Pulse 2 are connected to pins 17, 16, and 15 respectively. Pins 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 are connected to pins 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 of T5.
- T5:** 24V, 0V, and Pulse 1 are connected to pins 17, 16, and 15 respectively. Pins 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 are connected to pins 17, 16, 15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 of T4.

Safety Switches and Monitoring Relays:

- S1, S2, S20:** Safety switches connected to the 24V and 0V lines. S1 and S2 are connected to the 24V line, and S20 is connected to the 0V line.
- CMMT-ST-...:** Monitoring relays connected to the 24V and 0V lines. The relays are labeled -X1A, -X9A, and -X6A.

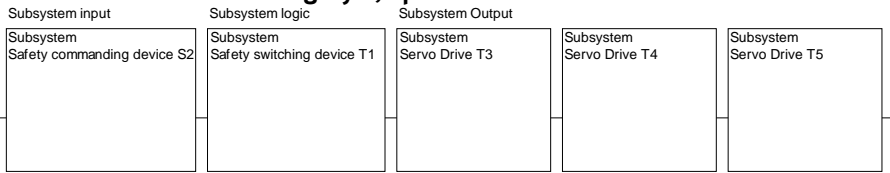
Machine Connections:

- M20:** Connected to the 24V line via a switch.
- M21:** Connected to the 24V line via a switch.
- M22:** Connected to the 24V line via a switch.

1.2.2 Components

Component	Type (Part Number)	Description / Remarks	Qty.	Mssr.
M20, M21, M22	EMM...-ST	Stepper motor (or EC motor)	3	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Start push button	1	
T1		Safety switching device	1	
T2		Functional PLC	1	
T3, T4, T5	CMMT-ST-...-S0	Servo drive	3	Festo

1.2.3 Description

Application	Servo drive with stepper motor or EC motor without external forces, e.g. horizontal axis
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety function)	<p>Stopping at safety request by using safety sub-function “safe stop 1 time controlled (SS1-t)” with the safe state “safe torque off (STO)”, With stepper motors: category 3, up to PL e With EC motors: category 3, up to PL d</p> 
Safe state	<p>The electric motors (M20, M21, M22) are functionally stopped and after an application-specific time no energy is supplied to the electric motors (M20, M21, M22) that can generate a force and a movement. It is presumed that this state of the electric motors (M20, M21, M22) is the safe state.</p> <p>Notes:</p> <ul style="list-style-type: none"> Stopping the electric motors (M20, M21, M22) is functional and is not safety-rated, i.e. if the movement is not stopped in the event of a fault, additional measures may be required, e.g. end position damping for linear axes. If external forces act on the electric motors, e.g. in the case of vertical axes, the request for the safety sub-function STO can result in a dangerous movement. Then additional measures may be necessary, e.g. a holding brake. For the wiring between safety switching device (T2) and servo drives (T3, T4, T5), fault exclusions on short circuits and cross circuits, e.g. according to ISO 13849-2 [4], Table D.4, are required. The precondition for this is that the safety switching device (T2) and the servo drives (T3, T4, T5) are located in the same control cabinet and that the control cabinet meets the requirements of EN 60204-1 [3].
Function of the circuit	<p>Due to the safety request (S2):</p> <ol style="list-style-type: none"> The input circuit of the safety switching device (T1) is interrupted. The output (Q5) of the safety switching device (T1) is then switched off. The input “output stage enable (CTRL-EN)” of the servo drives (T3, T4, T5) is no longer controlled. This causes the servo drives (T3, T4, T5) to functionally decelerate the motor with the braking ramp. This corresponds to a behaviour of stop category 1 according to EN 60204-1 [3]. After the end of the braking ramp, the output stage is functionally switched off. The outputs (Q6, Q7) of the safety switching device (T1) are then switched off with a time delay. The required time delay must be determined depending on the specific application. The inputs “Safe torque off, channel A and B (#STO-A, #STO-B)” of the servo drives (T3, T4, T5) are no longer controlled. This switch off the control of the output stage and requests the safety sub-function STO.

Manual reset function	<ol style="list-style-type: none"> 1. After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety gate, the start or restart can be made possible by actuating the acknowledgement button (S1). 2. The safety switching device (T1) controls via the outputs (Q6, Q7) the servo drives (T3, T4, T5). This makes it possible to control the power output stage again and the STO safety sub-function is no longer active. 3. The safety switching device (T1) permits the control of the “output stage enable (CRTL-EN)” via the functional control (T2) again via the output (Q5). Normal operation is then possible by pressing the start push button (S20).
Diagnosis	The diagnostic outputs (STA) must not be evaluated for the specified category and PL.

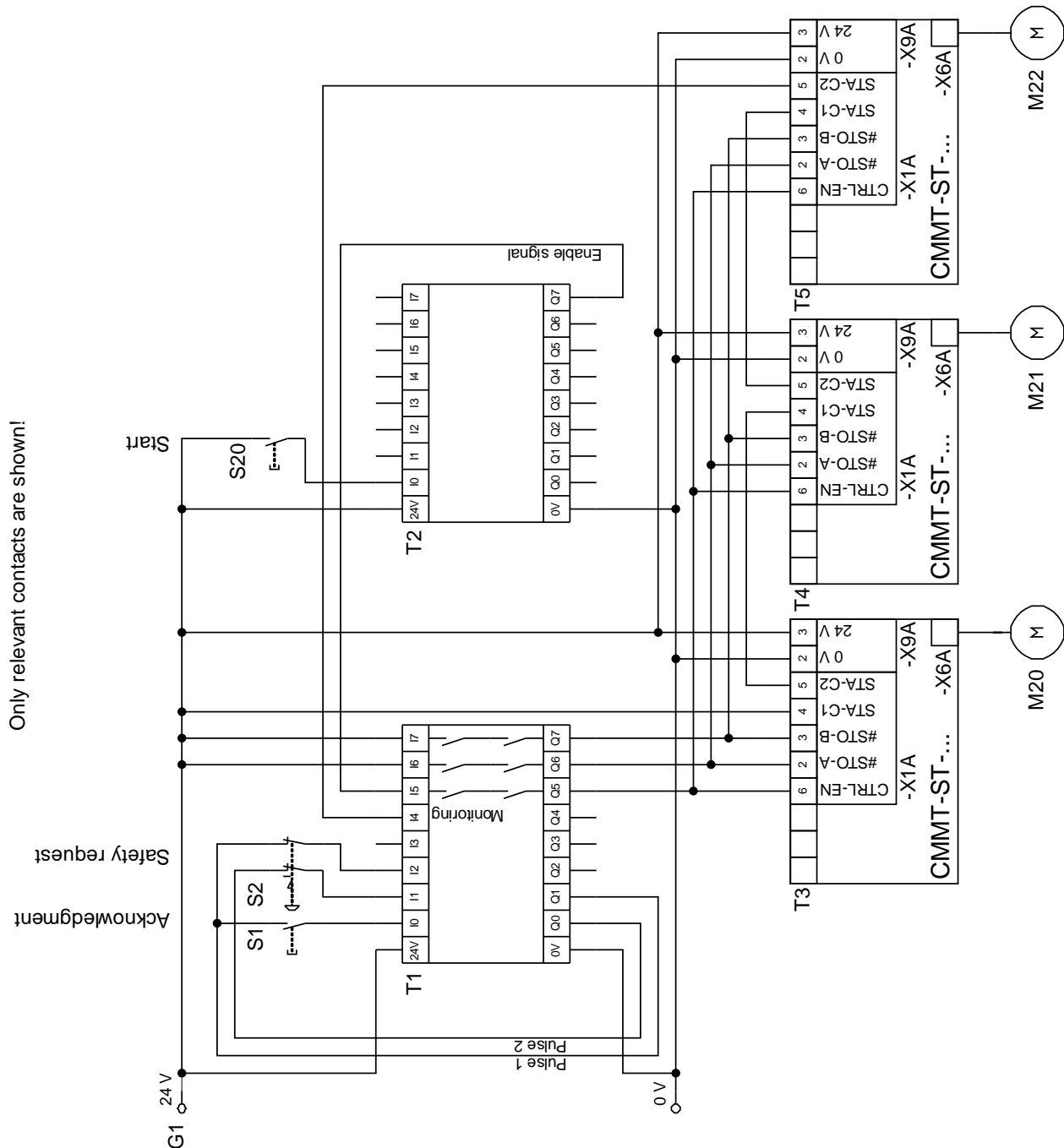
1.2.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	<p>Safety considerations must be carried out in accordance with the selected safety switching device (T1).</p> <p>Notes:</p> <ul style="list-style-type: none"> • The outputs (Q6, Q7) of the safety switching device (T1) for switching the signals for the inputs (#STO-A, #STO-B) of the servo drives (T3, T4, T5) are contact outputs without short-circuit and cross-circuit detection. • The outputs (Q6, Q7) of the safety switching device (T1) including the necessary time delay must be suitable for PL e, category 3 when using a stepper motor or PL d, category 3 when using an EC motor.
Output	<p>The intended use of the servo drives (T3, T4, T5) includes the safety sub-function STO with category 3, up to PL e when using a stepper motor or PL d, category 3 when using an EC motor. The PL, category and PFH_D values of the servo drives (T3, T4, T5) required to determine the reliability of the overall circuit must be available.</p> <p>Note:</p> <ul style="list-style-type: none"> • Depending on the electric motor used, the corresponding safety reference data of the servo drives (T3, T4, T5) must be selected: Either the safety reference data for “stepper motor” or “EC motors without evaluation of STA”.

1.3 SS1-t, STO with CMMT-ST-...-S0, contact outputs, with STA evaluation

- With stepper motors: SS1-t, STO, category 3, up to PL e
- With EC motors: SS1-t, STO, category 3, up to PL d
- Safety switching device with contact outputs
- With evaluation STA
- Fault exclusion control cabinet necessary

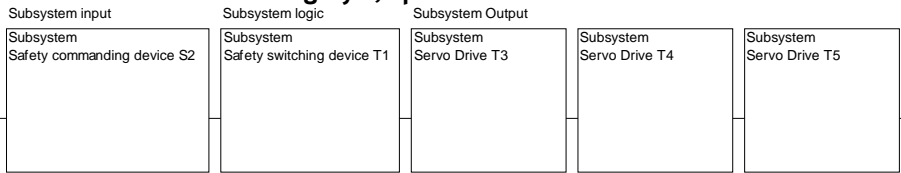
1.3.1 Circuit Diagram



1.3.2 Components

Component	Type (Part Number)	Description / Remarks	Qty.	Mssr.
M20, M21, M22	EMM...-ST	Stepper motor (or EC motor)	3	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Start push button	1	
T1		Safety switching device	1	
T2		Functional PLC	1	
T3, T4, T5	CMMT-ST-...-S0	Servo drive	3	Festo

1.3.3 Description

Application	Servo drive with stepper motor or EC motor without external forces, e.g. horizontal axis
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety function)	<p>Stopping at safety request by using safety sub-function “safe stop 1 time controlled (SS1-t)” with the safe state “safe torque off (STO)”, With stepper motors: category 3, up to PL e With EC motors: category 3, up to PL d</p> 
Safe state	<p>The electric motors (M20, M21, M22) are functionally stopped and after an application-specific time no energy is supplied to the electric motors (M20, M21, M22) that can generate a force and a movement. It is presumed that this state of the electric motors (M20, M21, M22) is the safe state.</p> <p>Notes:</p> <ul style="list-style-type: none"> Stopping the electric motors (M20, M21, M22) is functional and is not safety-rated, i.e. if the movement is not stopped in the event of a fault, additional measures may be required, e.g. end position damping for linear axes. If external forces act on the electric motors, e.g. in the case of vertical axes, the request for the safety sub-function STO can result in a dangerous movement. Then additional measures may be necessary, e.g. a holding brake. For the wiring between safety switching device (T2) and servo drives (T3, T4, T5), fault exclusions on short circuits and cross circuits, e.g. according to ISO 13849-2 [4], Table D.4, are required. The precondition for this is that the safety switching device (T2) and the servo drives (T3, T4, T5) are located in the same control cabinet and that the control cabinet meets the requirements of EN 60204-1 [3].
Function of the circuit	<p>Due to the safety request (S2):</p> <ol style="list-style-type: none"> The input circuit of the safety switching device (T1) is interrupted. The output (Q5) of the safety switching device (T1) is then switched off. The input “output stage enable (CTRL-EN)” of the servo drives (T3, T4, T5) is no longer controlled. This causes the servo drives (T3, T4, T5) to functionally deaccelerate the motor with the braking ramp. This corresponds to a behaviour of stop category 1 according to EN 60204-1 [3]. After the end of the braking ramp, the output stage is functionally switched off. The outputs (Q6, Q7) of the safety switching device (T1) are then switched off with a time delay. The required time delay must be determined depending on the specific application. The inputs “Safe torque off, channel A and B (#STO-A, #STO-B)” of the servo drive (T3) are no longer controlled. This switch off the control of the output stage and requests the safety sub-function STO.

Manual reset function	<ol style="list-style-type: none"> 1. After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety gate, the start or restart can be made possible by actuating the acknowledgement button (S1). 2. The safety switching device (T1) controls via the outputs (Q6, Q7) the servo drive (T3). This makes it possible to control the power output stage again and the STO safety sub-function is no longer active. 3. The safety switching device (T1) permits the control of the “output stage enable (CTRL-EN)” via the functional control (T2) again via the output (Q5). Normal operation is then possible by pressing the start push button (S20).
Diagnosis	<p>The diagnostic outputs STA reports the status of the safety sub-function STO to the safety switching device (T1). Diagnosis is performed via the safety switching device (T1):</p> <ul style="list-style-type: none"> • If the outputs (Q6, Q7) of the safety switching device (T1) are switched off with a time delay, the safety sub-function STO is requested via the inputs (#STO-A, #STO-B) of the servo drives (T3, T4, T5). After the typical time for the servo drive, the output (STA) is switched on. This diagnostic feedback delay can be monitored for a minimum permissible time and must be monitored for a maximum permissible time by the safety switching device (T1). • If the outputs (Q6, Q7) of the safety switching device (T1) are switched on, the safety sub-function STO is disabled via the inputs (#STO-A, #STO-B) of the servo drives (T3, T4, T5). After the typical time for the servo drive, the output (STA) is switched off. This diagnostic feedback delay can be monitored for a minimum permissible time and must be monitored for a maximum permissible time by the safety relay (T1). <p>If a fault is detected by the diagnosis, a suitable fault reaction must be carried out by the safety switching device (T1). It is common that the machine is brought into a safe state and further operation is prevented.</p>

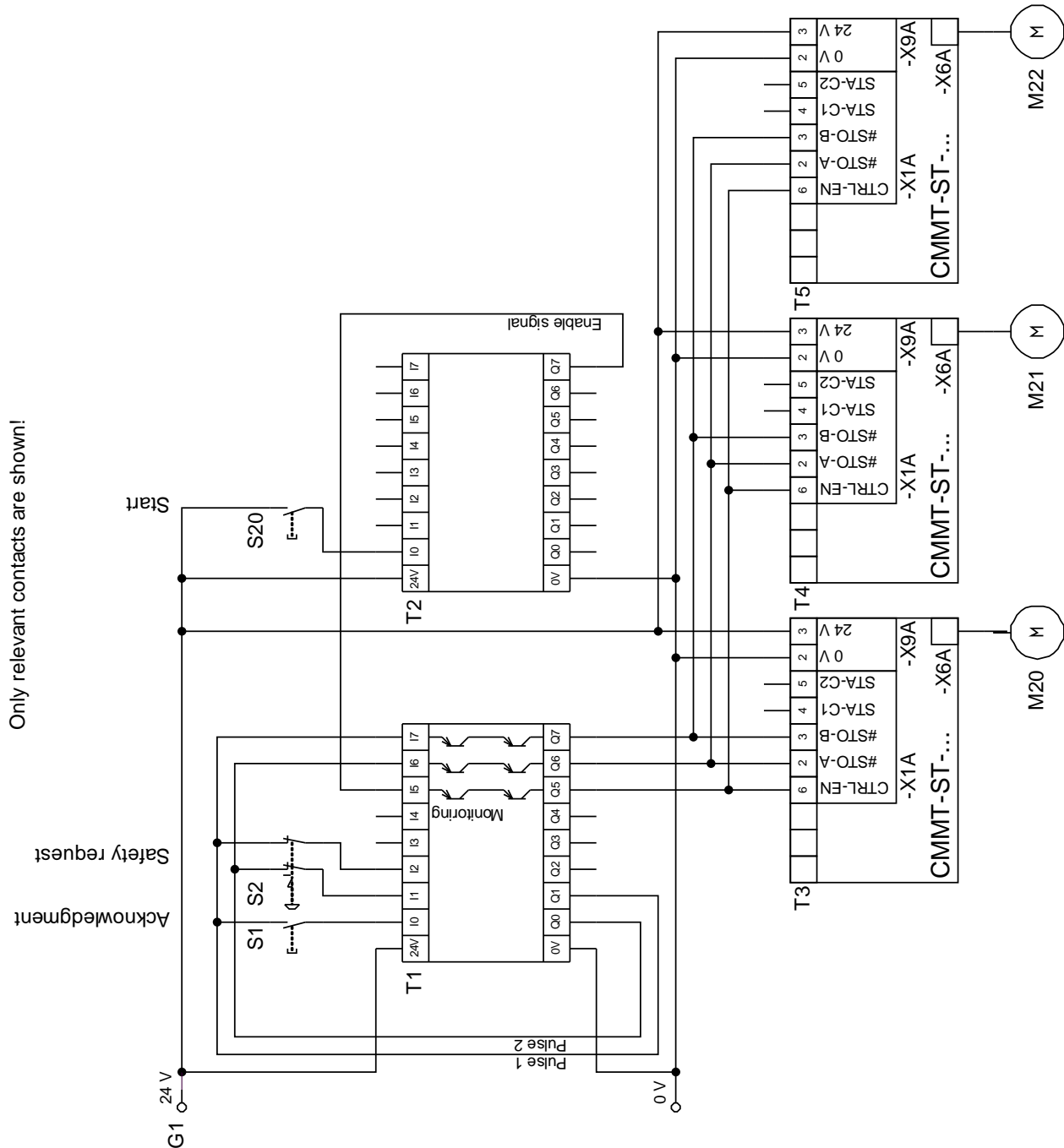
1.3.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	<p>Safety considerations must be carried out in accordance with the selected safety switching device (T1).</p> <p>Notes:</p> <ul style="list-style-type: none"> • The outputs (Q6, Q7) of the safety switching device (T1) for switching the signals for the inputs (#STO-A, #STO-B) of the servo drives (T3, T4, T5) are contact outputs without short-circuit and cross-circuit detection. • The outputs (Q6, Q7) of the safety switching device (T1) including the necessary time delay must be suitable for PL e, category 3 when using a stepper motor or PL d, category 3 when using an EC motor.
Output	<p>The intended use of the servo drives (T3, T4, T5) includes the safety sub-function STO with category 3, up to PL d, with cross wiring. The PL, category and PFH_D values of the servo drives (T3, T4, T5) required to determine the reliability of the overall circuit must be available.</p> <p>Note:</p> <ul style="list-style-type: none"> • Depending on the electric motor used, the corresponding safety reference data of the servo drives (T3, T4, T5) must be selected: Either the safety reference data for “stepper motor” or “EC motors with evaluation of STA”. • According to section 4.1.4 (Description “Safety function STO, SS1-t”) for the servo drive CMMT-ST-C8-1C-...-S0), only PL d can be reached with this wiring with EC motors.

1.4 SS1-t, STO with CMMT-ST-...-S0, with electronic outputs, without STA evaluation

- With stepper motors: SS1-t, STO, category 3, up to PL e
- With EC motors: SS1-t, STO, category 3, up to PL d
- Safety switching device with electronic outputs
- Without evaluation STA

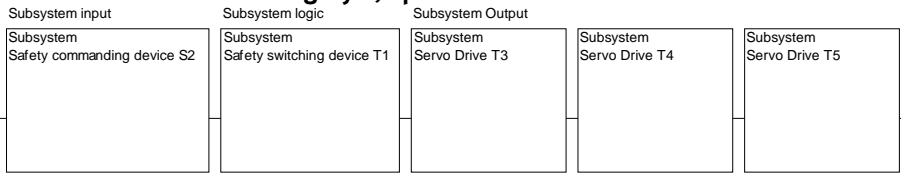
1.4.1 Circuit Diagram



1.4.2 Components

Component	Type (Part Number)	Description / Remarks	Qty.	Mssr.
M20, M21, M22	EMM...-ST	Stepper motor (or EC motor)	3	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Start push button	1	
T1		Safety switching device	1	
T2		Functional PLC	1	
T3, T4, T5	CMMT-ST-...-S0	Servo drive	3	Festo

1.4.3 Description

Application	Servo drive with stepper motor or EC motor without external forces, e.g. horizontal axis
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety function)	<p>Stopping at safety request by using safety sub-function “safe stop 1 time controlled (SS1-t)” with the safe state “safe torque off (STO)”, With stepper motors: category 3, up to PL e With EC motors: category 3, up to PL d</p>  <pre> graph LR S2[Subsystem Safety commanding device S2] --> T1[Subsystem Safety switching device T1] T1 --> T3[Subsystem Servo Drive T3] T1 --> T4[Subsystem Servo Drive T4] T1 --> T5[Subsystem Servo Drive T5] </pre>
Safe state	<p>The electric motors (M20, M21, M22) are functionally stopped and after an application-specific time no energy is supplied to the electric motors (M20, M21, M22) that can generate a force and a movement. It is presumed that this state of the electric motors (M20, M21, M22) is the safe state.</p> <p>Notes:</p> <ul style="list-style-type: none"> Stopping the electric motors (M20, M21, M22) is functional and is not safety-rated, i.e. if the movement is not stopped in the event of a fault, additional measures may be required, e.g. end position damping for linear axes. If external forces act on the electric motors, e.g. in the case of vertical axes, the request for the safety sub-function STO can result in a dangerous movement. Then additional measures may be necessary, e.g. a holding brake.
Function of the circuit	<p>Due to the safety request (S2):</p> <ol style="list-style-type: none"> The input circuit of the safety switching device (T1) is interrupted. The output (Q5) of the safety switching device (T1) is then switched off. The input “output stage enable (CTRL-EN)” of the servo drives (T3, T4, T5) is no longer controlled. This causes the servo drives (T3, T4, T5) to functionally decelerate the motor with the braking ramp. This corresponds to a behaviour of stop category 1 according to EN 60204-1 [3]. After the end of the braking ramp, the output stage is functionally switched off. The outputs (Q6, Q7) of the safety switching device (T1) are then switched off with a time delay. The required time delay must be determined depending on the specific application. The inputs “Safe torque off, channel A and B (#STO-A, #STO-B)” of the servo drives (T3, T4, T5) are no longer controlled. This switch off the control of the output stage and requests the safety sub-function STO.
Manual reset function	<ol style="list-style-type: none"> After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety gate, the start or restart can be made possible by actuating the acknowledgement button (S1).

	<ol style="list-style-type: none"> 2. The safety switching device (T1) controls via the outputs (Q6, Q7) the servo drives (T3, T4, T5). This makes it possible to control the power output stage again and the STO safety sub-function is no longer active. 3. The safety switching device (T1) permits the control of the “output stage enable (CRTL-EN)” via the functional control (T2) again via the output (Q5). Normal operation is then possible by pressing the start push button (S20).
Diagnosis	The diagnostic outputs (STA) do not have to be evaluated for the specified category and PL.

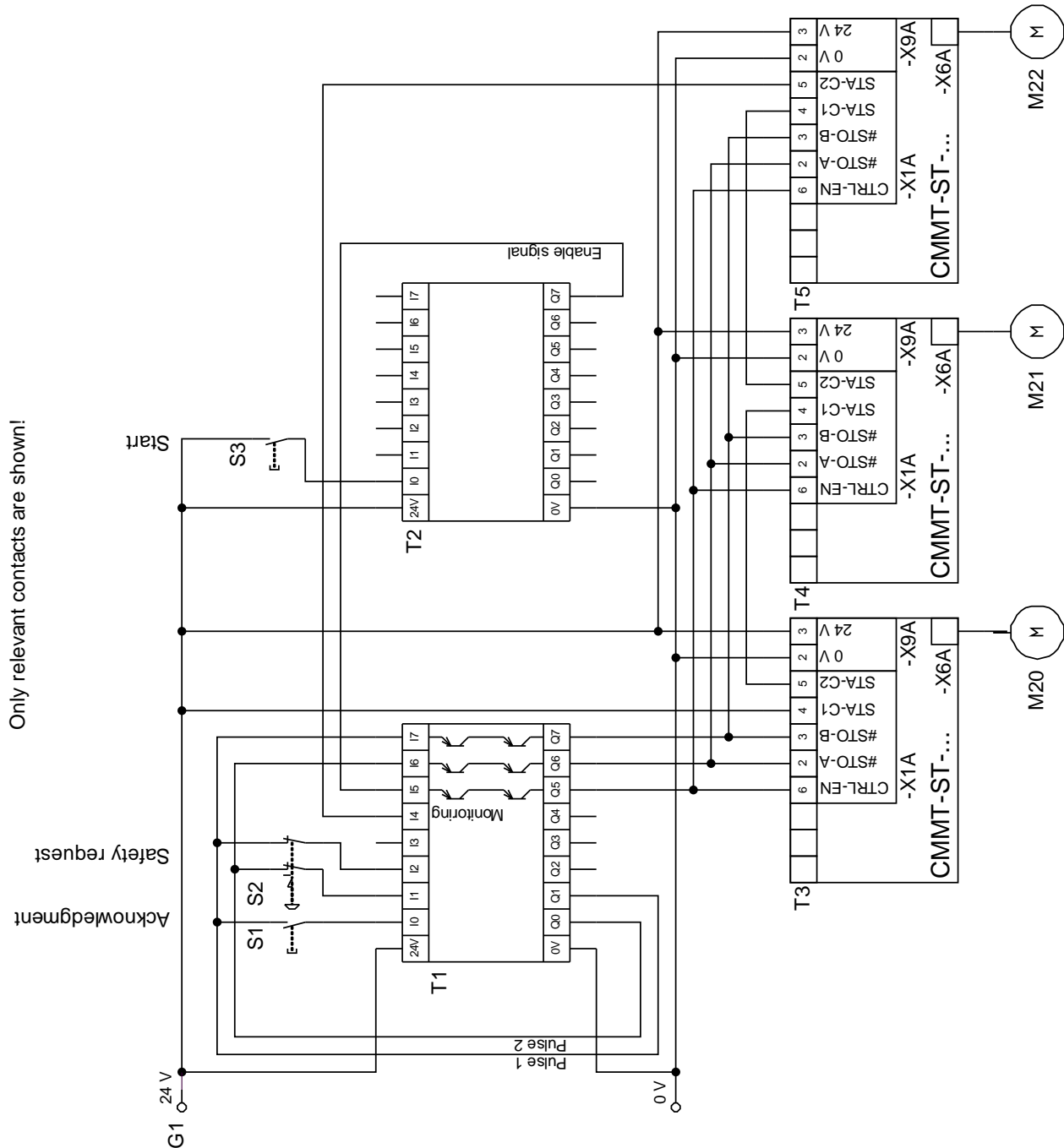
1.4.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	<p>Safety considerations must be carried out in accordance with the selected safety switching device (T1).</p> <p>Notes:</p> <ul style="list-style-type: none"> • The outputs (Q6, Q7) of the safety switching device (T1) for switching the signals for the inputs (#STO-A, #STO-B) of the servo drives (T3, T4, T5) are electronic outputs with short-circuit and cross-circuit detection. • The outputs (Q6, Q7) of the safety switching device (T1) including the necessary time delay must be suitable for PL e, category 3 when using a stepper motor or PL d, category 3 when using an EC motor.
Output	<p>The intended use of the servo drives (T3, T4, T5) includes the safety sub-function STO with category 3, up to PL e when using a stepper motor or PL d, category 3 when using an EC motor. The PL, category and PFH_D values of the servo drives (T3, T4, T5) required to determine the reliability of the overall circuit must be available.</p> <p>Note:</p> <ul style="list-style-type: none"> • Depending on the electric motors used, the corresponding safety reference data of the servo drives (T3, T4, T5) must be selected: Either the safety reference data for “stepper motor” or “EC motors without evaluation of STA”.

1.5 SS1-t, STO with CMMT-ST-...-S0, electronic outputs, with STA evaluation

- With stepper motors: SS1-t, STO, category 3, up to PL e
- With EC motors: SS1-t, STO, category 3, up to PL d
- Safety switching device with electronic outputs
- With evaluation STA

1.5.1 Circuit Diagram



1.5.2 Components

Component	Type (Part Number)	Description / Remarks	Qty.	Mssr.
M20, M21, M22	EMM...-AS	Servo motor (or EC motor)	3	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Start push button	1	
T1		Safety switching device	1	
T2		Functional PLC	1	
T3, T4, T5	CMMT-ST-...-S0	Servo drive	3	Festo

1.5.3 Description

Application	Servo drives with servo motors or EC motor without external forces, e.g. horizontal axis
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety function)	<p>Stopping at safety request by using safety sub-function “safe stop 1 time controlled (SS1-t)” with the safe state “safe torque off (STO)”, With stepper motors: category 3, up to PL e With EC motors: category 3, up to PL d</p> <pre> graph LR S2[Subsystem Safety commanding device S2] --> T1[Subsystem Safety switching device T1] T1 --> T3[Subsystem Servo Drive T3] T1 --> T4[Subsystem Servo Drive T4] T1 --> T5[Subsystem Servo Drive T5] </pre>
Safe state	<p>The electric motors (M20, M21, M22) are functionally stopped and after an application-specific time no energy is supplied to the electric motors (M20, M21, M22) that can generate a force and a movement. It is presumed that this state of the electric motors (M20, M21, M22) is the safe state.</p> <p>Notes:</p> <ul style="list-style-type: none"> Stopping the electric motors (M20, M21, M22) is functional and is not safety-rated, i.e. if the movement is not stopped in the event of a fault, additional measures may be required, e.g. end position damping for linear axes. If external forces act on the electric motors, e.g. in the case of vertical axes, the request for the safety sub-function STO can result in a dangerous movement. Then additional measures may be necessary, e.g. a holding brake.
Function of the circuit	<p>Due to the safety request (S2):</p> <ol style="list-style-type: none"> The input circuit of the safety switching device (T1) is interrupted. The output (Q5) of the safety switching device (T1) is then switched off. The input “output stage enable (CTRL-EN)” of the servo drives (T3, T4, T5) is no longer controlled. This causes the servo drives (T3, T4, T5) to functionally deaccelerate the motor with the braking ramp. This corresponds to a behaviour of stop category 1 according to EN 60204-1 [3]. After the end of the braking ramp, the output stage is functionally switched off. The outputs (Q6, Q7) of the safety switching device (T1) are then switched off with a time delay. The required time delay must be determined depending on the specific application. The inputs “Safe torque off, channel A and B (#STO-A, #STO-B)” of the servo drives (T3, T4, T5) are no longer controlled. This switch off the control of the output stage and requests the safety sub-function STO.
Manual reset function	<ol style="list-style-type: none"> After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety gate, the start or restart can be made possible by actuating the acknowledgement button (S1).

	<ol style="list-style-type: none"> The safety switching device (T1) controls via the outputs (Q6, Q7) the servo drives (T3, T4, T5). This makes it possible to control the power output stage again and the STO safety sub-function is no longer active. The safety switching device (T1) permits the control of the “output stage enable (CRTL-EN)” via the functional control (T2) again via the output (Q5). Normal operation is then possible by pressing the start push button (S20).
Diagnosis	<p>The diagnostic output STA reports the status of the safety sub-function STO to the safety switching device (T1). Diagnosis is performed via the safety switching device (T1):</p> <ul style="list-style-type: none"> If the outputs (Q6, Q7) of the safety switching device (T1) are switched off, the safety sub-function STO is requested via the inputs (#STO-A, #STO-B) of the servo drives (T3, T4, T5). After the typical time for the servo drive, the output (STA) is switched on. This diagnostic feedback delay can be monitored for a minimum permissible time and must be monitored for a maximum permissible time by the safety switching device (T1). If the outputs (Q6, Q7) of the safety switching device (T1) are switched on, the safety sub-function STO is disabled via the inputs (#STO-A, #STO-B) of the servo drives (T3, T4, T5). After the typical time for the servo drive, the output (STA) is switched off. This diagnostic feedback delay can be monitored for a minimum permissible time and must be monitored for a maximum permissible time by the safety switching device (T1). <p>If a fault is detected by the diagnosis, a suitable fault reaction must be carried out by the safety switching device (T1). It is common that the machine is brought into a safe state and further operation is prevented.</p>

1.5.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	<p>Safety considerations must be carried out in accordance with the selected safety switching device (T1).</p> <p>Notes:</p> <ul style="list-style-type: none"> The outputs (Q6, Q7) of the safety switching device (T1) for switching the signals for the inputs (#STO-A, #STO-B) of the servo drives (T3, T4, T5) are electronic outputs with short-circuit and cross-circuit detection. The outputs (Q6, Q7) of the safety switching device (T1) including the necessary time delay must be suitable for PL e, category 3 when using a stepper motor or PL d, category 3 when using an EC motor.
Output	<p>The intended use of the servo drives (T3, T4, T5) includes the safety sub-function STO for cross wiring with category 3, up to PL d. The PL, category and PFH_D values of the servo drives (T3, T4, T5) required to determine the reliability of the overall circuit must be available.</p> <p>Note:</p> <ul style="list-style-type: none"> Depending on the electric motor used, the corresponding safety reference data of the servo drive (T3) must be selected: Either the safety reference data for “stepper motor” or “EC motors with evaluation of STA”. According to section 4.1.4 (Description “Safety function STO, SS1-t”) for the servo drive CMMT-ST-C8-1C-...-S0, only PL d can be reached with this wiring with EC motors.

2 Literature

- [1] DIN EN 61800-5-2:2017-11 - Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional (IEC 61800-5-2:2016); German version EN 61800-5-2:2017
- [2] DIN EN ISO 13849-1:2016-06 - Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2015); German version EN ISO 13849-1:2015
- [3] DIN EN 60204-1:2007-06 - Safety of machinery - Electrical equipment of machines - Part 1: General requirements (IEC 60204-1:2005, modified); German version EN 60204-1:2006
- [4] DIN EN ISO 13849-2:2013-02 - Safety of machinery - Safety-related parts of control systems - Part 2: Validation (ISO 13849-2:2012); German version EN ISO 13849-2:2012

