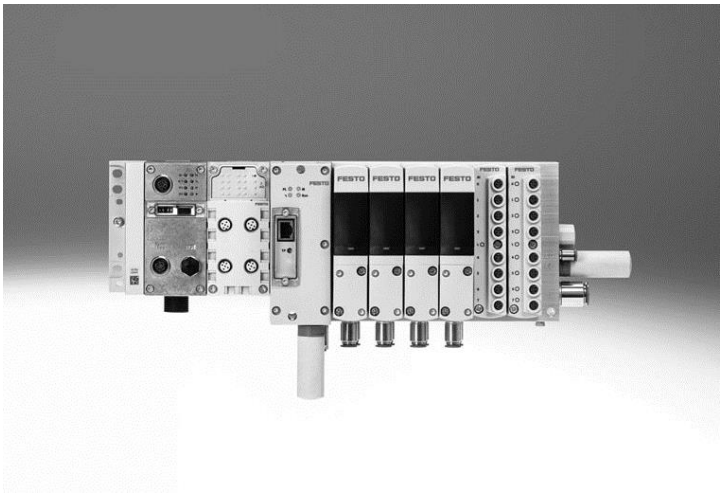
Application Note

Safety Sub-Functions in Connection with Motion Terminal VTEM



Application Note - Motion Terminal VTEM

100204

Title ..... Application Note - Motion Terminal VTEM
Version 1.33
Document number ..... (TSHQ) 100204
Original ..... German
Author ..... Festo
Last date of saving 22/11/2018

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

Copyright Notice

Internet: www.festo.com
E-Mail: service_international@festo.com

Table of Content

1 Example Circuits

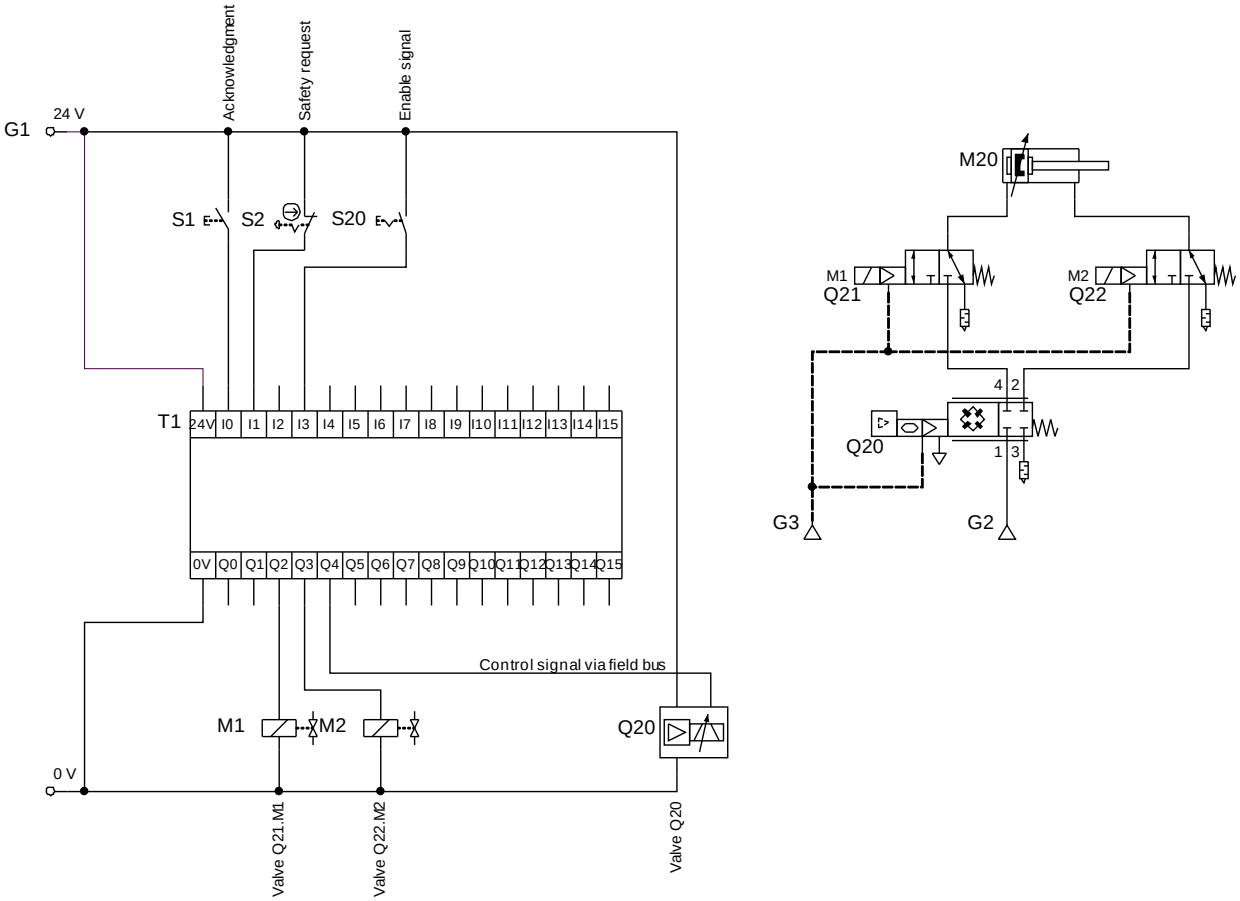
Notes

- The circuits specified in this document are principle circuits which cannot be complete due to their clarity and scope.
- The abbreviations used for the safety sub-functions refer to the definitions in VDMA 24584 [1] for pneumatics:
  - STO: Safe Torque Off
  - SS1-t: Safe Stop 1, time-controlled
  - SSC: Safe Stopping and Closing
  - SDI during stop: Safe Direction during stop
  - PUS: Prevention of unexpected start-up
- To understand this application note, the description of the function and parameterization of the Motion Terminal VTEM for Motion App #1 is required. This description are available on the Internet: https://www.festo.com/net/de_de/SupportPortal/Downloads/454990/505136/VTEM-Func-Par_2018-05a_8090102g1.pdf
  - Page 21: Description of the pressure build-up function
  - From page 35: 2.5 Description of Motion App #1: Directional control valve functions
  - Page 51: 2.7.3.6 Acknowledging errors
- If the pressure build-up function is available for the corresponding Motion App, it should not be deactivated.
- The circuits and the procedure described are recommendations which do not exclude other possibilities.
- The motion terminal and the associated motion apps are not involved in the mentioned safety sub-functions and cannot fail dangerously in relation to the mentioned safety sub-functions.

1.1 STO, Category 1, up to PL c

STO according VDMA 24584 [1] and category 1, up to PL c according EN ISO 13849-1 [2].

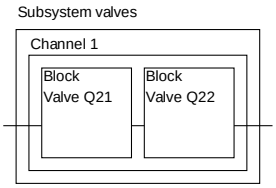
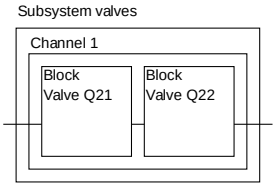
1.1.1 Circuit Diagram



1.1.2 Components

Component	Type (Part Number)	Description / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20	8047502	Motion Terminal VTEM	1	Festo
Q21, Q22	VUVS-L25-M32C-MZD-G14-F8-1C1 (575478) or VUVS-L25-M32C-MZD-G14-F8-1B2 (575482)	3/2 directional control valve nominal flow rate ≥600 l/min	2	Festo
		Silencer, if necessary	2	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch as a representative representation of all types of motion functions that can be requested by a functional PLC. Functional PLC with function block for the motion terminal (shown as switch for enable signal)	1	
T1		Safety switching device	1	

1.1.3 Description

Application	Double acting pneumatic drive, horizontal
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety sub-function)	**Safe torque off (STO), category 1, PL c**  **Prevention of unexpected start-up, category 1, PL c** 
Safe state	The pneumatic drive is exhausted and free of energy. It is presumed that the exhausted state of the drive is the safe state.
Function	The control of the valve (Q20) during a safety request and for the associated restart after the manual reset function must always be considered separately, depending on the application and the Motion App used. The procedure described here is a recommendation that does not exclude other possibilities. The safety request (S2): • Interrupts the input circuit of the safety switching device (T1). • For trouble-free operation, the Motion App #01: “directional control valve functions” should then be called up and valve type “4/3 E (normally exhausted)” set. This exhausts ports 2 and 4 of the valve (Q20) via port 3. This procedure is used to enable the restart without diagnostic message. • The safe outputs of the safety switching device (T1) are then switched off. • The solenoid of the valves (Q21, Q22) are no longer controlled. • Valves (Q21, Q22) move to their normal position, separate the supply of the operating pressure and exhausts both chambers of the pneumatic drive (M20). This exhausts the pneumatic drive (M20). Notes: • The valve (Q20) and the associated motion apps are not involved in the mentioned safety sub-functions and cannot fail dangerously in relation to the mentioned safety sub-functions. • Depending on the application and Motion App used, this functional exhausting function of the valve (Q20) may take too long. In this case, switching the valves (Q21, Q22) described may cause an diagnostic message which must be handled separately depending on the application and Motion App. Please refer to the troubleshooting information in the description of the Motion App used.
Manual reset function	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). Then the safety switching device (T1) can control the solenoids of the valves (Q21, Q22) and bring these valves into the switching position so that normal operation is possible. If an exhausting function of the valve (Q20) has been selected for both chambers of the pneumatic drive (M20) when the safety request (S2) is activated, the pressures in the pneumatic connecting lines between the valve outputs (Q20) and the pneumatic drive (M20) are identical upstream and downstream of the valves (Q21, Q22). This allows a restart without a diagnostic message of the valve (Q20). The required Motion App can then be called up with the pressure build-up function activated.

	Note: • If the pressure build-up function is available for the corresponding Motion App, it should not be deactivated. Please read the description of the respective Motion App.

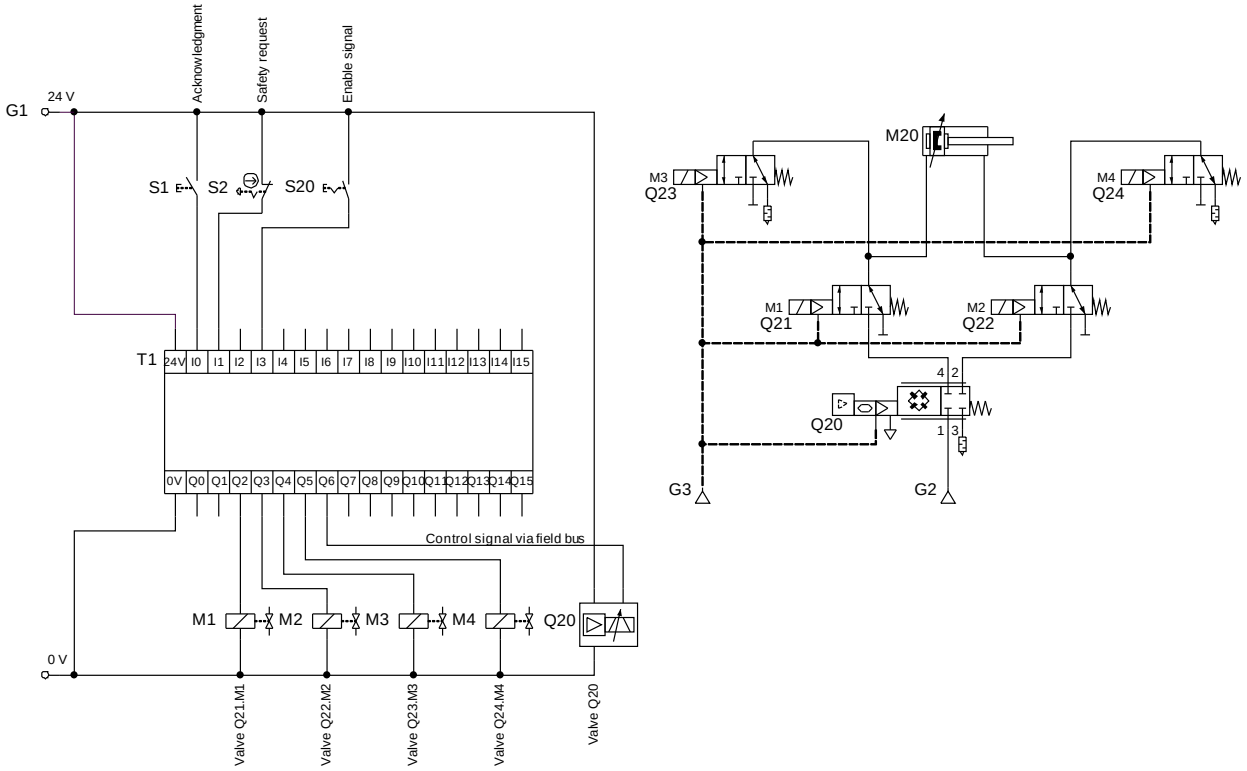
1.1.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	Safety considerations must be carried out in accordance with the selected safety switching device (T1).
Output	The valves (Q21, Q22) must be well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed. B10 values required for the calculation of the $MTTF_D$ must be available.

1.2 SS1-t, Category 1, up to PL c

SS1-t according VDMA 24584 [1] and category 1, up to PL c according EN ISO 13849-1 [2].

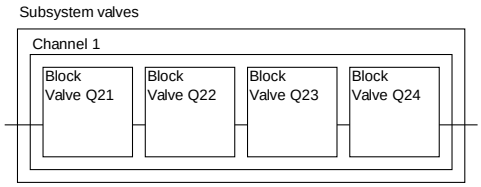
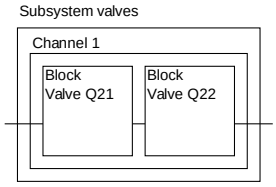
1.2.1 Circuit Diagram



1.2.2 Components

Component	Type (Part Number)	Description / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20	8047502	Motion Terminal VTEM	1	Festo
Q21, Q22, Q23, Q24	VUVS-L25-M32C-MZD-G14-F8-1C1 (575478) or VUVS-L25-M32C-MZD-G14-F8-1B2 (575482)	3/2 directional control valves nominal flow rate ≥600 l/min	4	Festo
		Blanking plug, suitable for port of selected valve	2	Festo
		Silencer, if required	2	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch as a representative representation of all types of motion functions that can be requested by a functional PLC. Functional PLC with function block for the motion terminal (shown as switch for enable signal)	1	
T1		Safety switching device	1	

1.2.3 Description

Application	Double acting pneumatic drive, horizontal
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety sub-function)	**Safe stop 1, time controlled (SS1-t), category 1, PL c**  **Prevention of unexpected start-up (PUS), category 1, PL c** 
Safe state	The pneumatic drive is stopped time controlled, exhausted and free of energy. It is presumed that the exhausted state of the drive is the safe state.
Function	The control of the valve (Q20) during a safety request and for the associated restart after the manual reset function must always be considered separately, depending on the application and the Motion App used. The procedure described here is a recommendation that does not exclude other possibilities. The safety request (S2): • Interrupts the input circuit of the safety switching device (T1). • Then Motion App #01: “directional control valve functions” should be called up and valve type “4/3 G (normally closed)” set. Ports 2 and 4 of the valve (Q20) are closed. • The safe outputs of the safety switching device (T1) for the valves (Q21, Q22) are then switched off so that they are no longer controlled and switch to the normal position. In the normal position, the pneumatic flow paths through the valves are blocked. The pneumatic drive (M20) is to be stopped in this way. • The safe outputs of the safety switching device (T1) for the valves (Q23, Q24) are switched off with a time delay so that they are no longer controlled and switch to the normal position. In the normal position of the valves, both chambers of the pneumatic drive (M20) are exhausted. Depending on the pressure conditions in the chambers of the pneumatic drive (M20), this exhausting can cause a movement. • After the valves (Q23, Q24) are in the normal position and the pneumatic drive (M20) has been stopped, the valve type “4/3 E (normally exhausted)” should be set. Ports 2 and 4 of the valve (Q20) are exhausted via port 3. This procedure is used to enable the restart without diagnostic message. Notes: • The valve (Q20) and the associated motion apps are not involved in the mentioned safety sub-functions and cannot fail dangerously in relation to the mentioned safety sub-functions. • Depending on the application and Motion App used, this functional closing function of the valve (Q20) may take too long. In this case, switching the valves (Q21, Q22) described below may cause an diagnostic message which must be handled separately depending on the application and Motion App. Please refer to the troubleshooting information in the description of the Motion App used.
Manual reset function	After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety guard, the start or restart can be made possible by pressing the acknowledgement button (S1).

	When starting or restarting, the safe outputs of the safety switching device (T1) for the valves (Q23, Q24) are switched on first, so that they move to their switching position and block the pneumatic flow paths. The safe outputs of the safety switching device (T1) for the valves (Q21, Q22) are switched on with a time delay so that the valves open the pneumatic flow paths in their switching position and normal operation is possible. If an exhausting function of the valve (Q20) has been selected for both chambers of the pneumatic drive (M20) when the safety request (S2) is activated, the pressures in the pneumatic connecting lines between the valve outputs (Q20) and the pneumatic drive (M20) are identical upstream and downstream of the valves (Q21, Q22). This allows a restart without a diagnostic message of the valve (Q20). The required Motion App can then be called up and used as intended. Note: • If the pressure build-up function is available for the corresponding Motion App, it should not be deactivated. Please read the description of the respective Motion App.

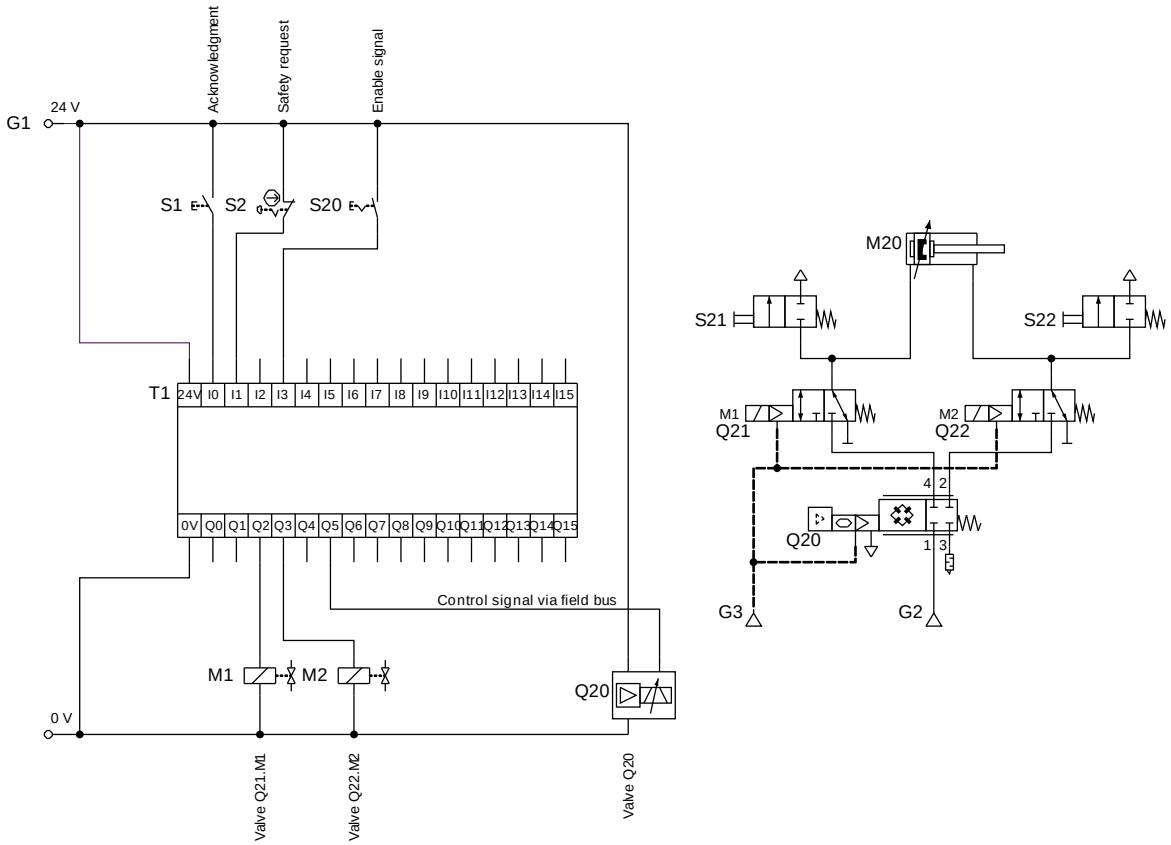
1.2.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	Safety considerations must be carried out in accordance with the selected safety switching device (T1).
Output	The valves (Q21, Q22, Q23, Q24) are well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed. B10 values required for the calculation of the $MTTF_D$ must be available.

1.3 SSC, Category 1, up to PL c SSC according VDMA 24584 [1] and category 1, up to PL c according EN ISO 13849-1 [2].

1.3.1 Circuit Diagram

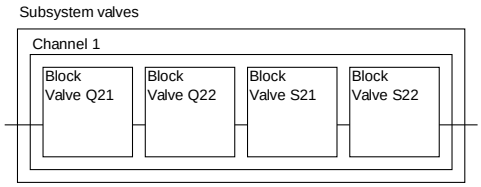
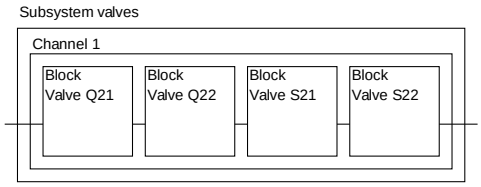
According to EN ISO 14118 enclosed pressurized air shall be marked and shall be provided with a possibility for manual pressure release. Leakage can cause movements that cannot be stopped.



1.3.2 Components

Component	Type	Description / Part Number / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20	8047502	Motion Terminal VTEM	1	Festo
Q21, Q22	VUVS-L25-M32C-MZD-G14-F8-1C1 (575478) or VUVS-L25-M32C-MZD-G14-F8-1B2 (575482)	3/2 directional control valves nominal flow rate ≥600 l/min	2	Festo
		Blanking plug, suitable for port of selected valve	2	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch as a representative representation of all types of motion functions that can be requested by a functional PLC. Functional PLC with function block for the motion terminal (shown as switch for enable signal)	1	
S21, S22	HAB-1/8 (184585)	2/2 directional control valves, manually actuated	2	Festo
T1		Safety switching device	1	

1.3.3 Description

Application	Double acting pneumatic drive
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety sub-function)	**Safe Stopping and Closing (SSC), category 1, PL c**  **Prevention of unexpected start-up (PUS), category 1, PL c** 
Safe state	In the pneumatic drive compressed air is enclosed to hold the last position. Slow movements are possible by leakage that cannot be stopped. It is presumed, that this can be a possible safe state. It must be evaluated whether this may cause a hazard. By actuating the valves (S21, S22), the exhausted state of the pneumatic drive can be possible.
Function	The control of the valve (Q20) during a safety request and for the associated restart after the manual reset function must always be considered separately, depending on the application and the Motion App used. The procedure described here is a recommendation that does not exclude other possibilities. The safety request (S1): • Interrupts the input circuit of the safety switching device (T1). • Then Motion App #01: “directional control valve functions” should be called up and valve type “4/3 G (normally closed)” set. Ports 2 and 4 of the Valve (Q20) are closed. This procedure is used to enable the restart without diagnostic message. • The safe outputs of the safety switching device (T1) are then switched off. • The solenoid of the valves (Q21, Q22) are no longer controlled. • Valves (Q21, Q22) move to their normal position, separate the supply of the operating pressure and closing the pneumatic flow paths to both chambers of the pneumatic drive (M20). This stops the pneumatic drive (M20). Notes: • The valve (Q20) and the associated motion apps are not involved in the mentioned safety sub-functions and cannot fail dangerously in relation to the mentioned safety sub-functions. • Depending on the application and Motion App used, this functional closing function may take too long. In this case, switching the valves (Q21, Q22) described may cause an diagnostic message which must be handled separately depending on the application and Motion App. Please refer to the troubleshooting information in the description of the Motion App used.
Manual reset function	Important note: • Depending on the leakage, pressure differences can occur which can trigger a movement during restart. After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety guard, the start or restart can be made possible by pressing the acknowledgement button (S1). Then the safety switching device (T1) can control the solenoids of the valves (Q21, Q22) and bring these valves into the switching position so that normal operation is possible. In normal operation, the manually actuated valves (S21, S22) do not exhaust the pneumatic drive (M20) and the following procedure should be used:

	• If a closing function of the pneumatic flow paths of the valve (Q20) has been selected for both chambers of the pneumatic drive (M20) after activation of the safety request (S2), the pressures in the pneumatic connecting lines between the valve outputs (Q20) and the pneumatic drive (M20) are almost identical before and after the valves (Q21, Q22) depending on leakage. This makes it possible to restart without a diagnostic message of the valve (Q20). If the pneumatic drive (M20) has been exhausted via the manually actuated valves (S21, S22), the following procedure should be used: • If the pneumatic drive (M20) has been exhausted during the safety request (S2), Motion App #01: “Directional control valve functions” should be called before resetting the safety request (S2) and valve type "4/3 E (normally exhausted) should be set. This means that the pressures in the pneumatic connecting lines between the valve outputs (Q20) and the pneumatic drive (M20) are identical upstream and downstream the valves (Q21, Q22). This makes it possible to restart the system without a diagnostic message of the valve (Q20). The required Motion App can then be called up with the pressure build-up function activated. Note: • If the pressure build-up function is available for the corresponding Motion App, it should not be deactivated. Please read the description of the respective Motion App.

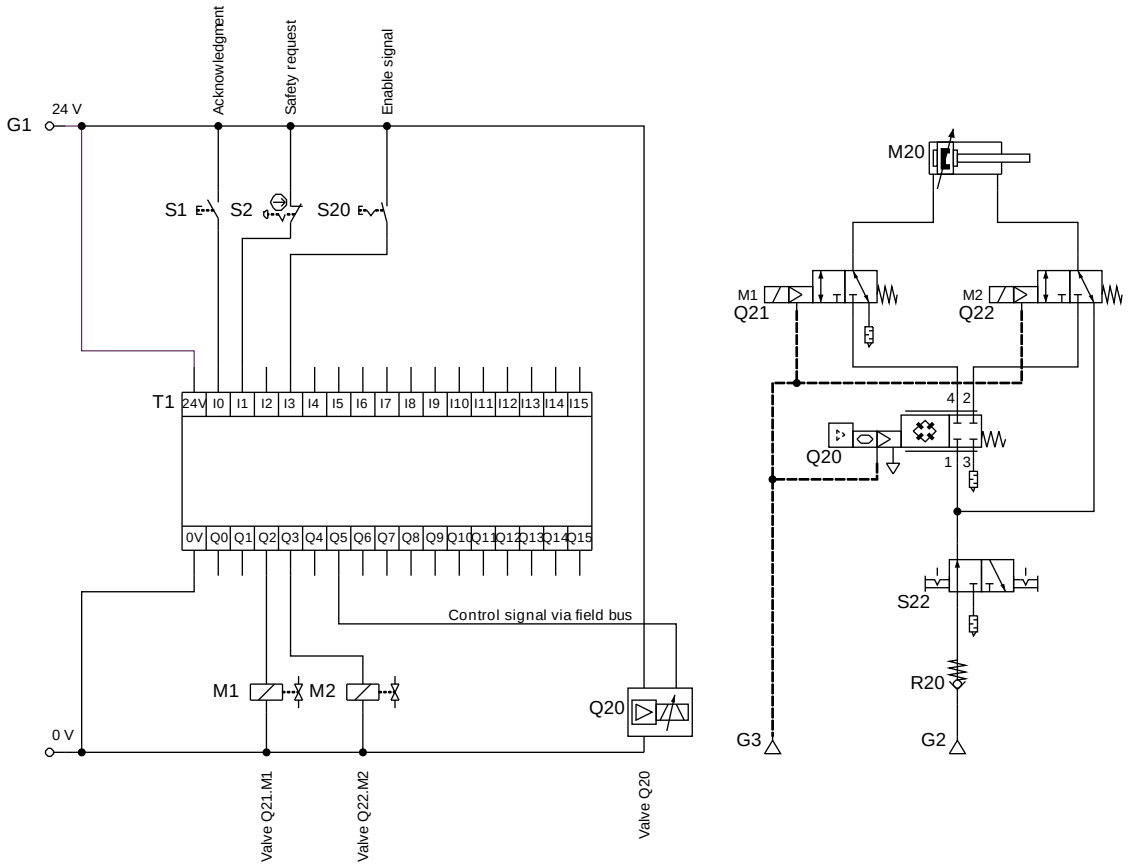
1.3.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	Safety considerations must be carried out in accordance with the selected safety switching device (T1).
Output	The valves (Q21, Q22, S21, S22) are well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed. B10 values required for the calculation of the $MTTF_D$ must be available.

1.4 SDI at Stopping, Category 1, up to PL c SDI according VDMA 24584 [1] and category 1, up to PL c according EN ISO 13849-1 [2].

1.4.1 Circuit Diagram

According to EN ISO 14118 enclosed pressurized air shall be marked
and shall be provided with a possibility for manual pressure release.
If exhausting takes place via S22, a dangerous movement of the pneumatic drive is possible.

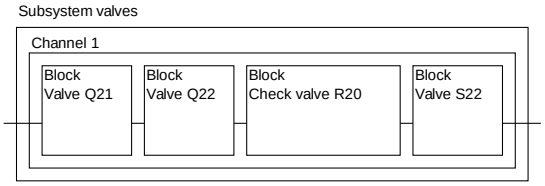
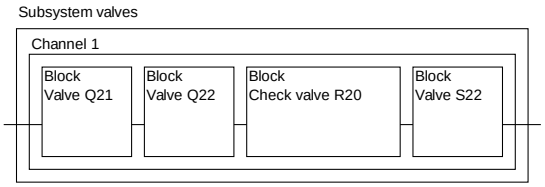


1.4.2 Components

Component	Type (Part Number)	Description / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20	8047502	Motion Terminal VTEM	1	Festo
Q21, Q22	VUVS-L25-M32C-MZD-G14-F8-1C1 (575478) or VUVS-L25-M32C-MZD-G14-F8-1B2 (575482)	3/2 directional control valves nominal flow rate ≥600 l/min	2	Festo
		Silencer, if necessary	1	Festo
R20		Check valve	1	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch as a representative representation of all types of motion functions that can be requested by a functional PLC. Functional PLC with function block for the motion terminal (shown as switch for enable signal)	1	

Component	Type (Part Number)	Description / Remarks	Qty.	Mssr.
S22	MS6-EM1-3/8 (541275)	3/2 directional control valve, bistable, manual actuated; nominal flow rate ≥600 l/min (The required flow rate of the entire valve terminal must be taken into account. This can be up to 4000 l/min).	1	Festo
T1		Safety switching device	1	

1.4.3 Description

Application	Double acting pneumatic drive
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety sub-function)	**Safe Direction (SDI) at stopping, category 1, PL c**  **Prevention of unexpected start-up (PUS), category 1, PL c** 
Safe state	One chamber of the pneumatic drive is supplied with compressed air and the other chamber is exhausted. This can cause a movement in the direction in which there is no additional risk. The pneumatic drive will come to a standstill in the corresponding end position. It is presumed that this may be a safe condition. The circuit diagram shows the safe direction of movement when stopping as retraction. This circuit must be checked for its applicability for the specific application and adapted if necessary. By actuating the valve (S22), the exhausted state of the pneumatic drive can be possible.
Function	The control of the valve (Q20) during a safety request and for the associated restart after the manual reset function must always be considered separately, depending on the application and the Motion App used. The procedure described here is a recommendation that does not exclude other possibilities. The safety request (S2): • Interrupts the input circuit of the safety switching device (T1). • Then Motion App #01: “directional control valve functions” should be called up and valve type “3/2 O + 3/2 G” (normal position: retracting) set. Ports 2 of the Valve (Q20) should be closed, the port 4 should be exhausted. This procedure is used to enable the restart without diagnostic messages or dangerous movements. • Switch off the safe outputs of the safety switching device (T1). • The solenoid of the valves (Q21, Q22) are no longer controlled. • Valve (Q21) move to its normal position, exhausts one chamber of the pneumatic drive (M20). Valve (Q22) move to its normal position, connects the other chamber of the pneumatic drive (M20) to the operation pressure. This controls the movement of the pneumatic drive (M20) in one direction. The pneumatic drive (M20) is thus to be controlled in one direction and stopped in the end position. Notes: • The valve (Q20) and the associated motion apps are not involved in the mentioned safety sub-functions and cannot fail dangerously in relation to the mentioned safety sub-functions.

	• Depending on the application and Motion App used, this functional exhausting function of the valve (Q20) may take too long. In this case, switching the valves (Q21, Q22) described below may cause a diagnostic message which must be handled separately depending on the application and Motion App. Please refer to the troubleshooting information in the description of the Motion App used.
Manual reset function	Notes: • If the pneumatic drive (M20) is exhausted by the manually actuated valve (S22) during the safety request, dangerous movement of the pneumatic drive (M20) is possible due to external forces. Depending on the application, measures must be taken to prevent hazards or damage to the machine and its components. • If the pressure supply has been disconnected from the pneumatic system and exhausted by the manually actuated valve (S22), the valve terminal of the valve (Q20) recognizes this and a diagnostic message is output. The valve terminal and thus also the valve goes into the error state and ports 2 and 4 of the valve (Q20) are closed. If the pneumatic system is pressurized again by the manually actuated valve (S22), this diagnostic message can be reset (see section “2.7.3.6 Acknowledging errors” in the operating instructions). Then Motion App #01: “directional control valve functions” should be called up and valve type “3/2 O + 3/2 G” (normal position: retracting) set. Ports 2 of the Valve (Q20) should be closed, the port 4 should be exhausted. This procedure is used to enable the restart without diagnostic message. • If the manually operated valve (S22) switches the pneumatic drive (M20) from the exhausted to the pressurized state during the safety request, it is possible to move the pneumatic drive (M20) in the direction in which there is no additional risk. After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety guard, the start or restart can be made possible by pressing the acknowledgement button (S1). Then the safety switching device (T1) can control the solenoids of the valves (Q21, Q22) and bring these valves into the switching position so that normal operation is possible. If after activating the safety request (S2), the “normal position: retracting” of the valve (Q20) for the pneumatic drive (M20) has been selected, the pressures in the pneumatic connecting lines between the valve outputs (Q20) and the pneumatic drive (M20) are identical upstream and downstream of the valves (Q21, Q22). This makes it possible to restart without an diagnostic message of the valve (Q20). The required Motion App can then be called up with the pressure build-up function activated. Note: • If the pressure build-up function is available for the corresponding Motion App, it should not be deactivated. Please read the description of the respective Motion App.

1.4.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	Safety considerations must be carried out in accordance with the selected safety switching device (T1).
Output	The valves (Q21, Q22) are well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed. B10 values required for the calculation of the $MTTF_D$ must be available.

Literature

[1] VDMA 24584:2016-08 - Safety functions of regulated and unregulated (fluid) mechanical systems (German edition)

[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] Motion Terminal VTEM, Description Function Parameterisation. German Edition 8092388, 2018-05a [8090101]