KL6904-FB

Documentation for TwinCAT function blocks of the TwinSAFE KL6904 Logic Terminal

Version: 1.1.1
Date: 26.07.2006

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1 Foreword

1.1 Notes on the manual

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards. It is essential that the following notes and explanations are followed when installing and commissioning these components.

1.1.1 Liability conditions

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

The documentation has been prepared with care. The products described are, however, constantly under development. For this reason, the documentation may not always be have been fully checked for consistency with the performance data, standards or other characteristics described. None of the statements in this manual represent a guarantee for as set out in § 443 of the German Civil Code or a statement about the assumed use according to the contract as set out in § 434 para. 1 clause 1 no. 1 of the German Civil Code. In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

1.1.2 Delivery conditions

In addition, the general delivery conditions of the company Beckhoff Automation GmbH apply.

1.1.3 Copyright

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1.2 Safety instructions

1.2.1 State at delivery

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH.

1.2.2 Operator's obligation to exercise diligence

The operator must ensure that

- the TwinSAFE products are only used as intended (see product description chapter);

- the TwinSAFE products are only operated in sound condition and in working order.

- the TwinSAFE products are operated only by suitably qualified and authorised personnel.

- the personnel is instructed regularly about relevant occupational safety and environmental protection aspects, and is familiar with the operating manual and in particular the safety notes contained herein.

- the instruction manual is in good condition and complete, and always available for reference at the location where the TwinSAFE products are used.

- none of the safety and warning notes attached to the TwinSAFE products are removed, and all notes remain legible.

1.3 Documentation issue status

Version	Comment
1.1.1	Corrections during translation into English language
1.1	Application examples update
1.0	First official version
0.2	Addition to the block descriptions
	Creation of further examples and systems description
	Screenshots of the updated blocks
0.1	First preliminary version

2 Description of the system

The TwinSAFE system consists of safe inputs (KL1904), safe outputs (KL2904) and logic modules (KL6904). The TwinSAFE Logic Terminal (KL6904) contains function blocks, which can be parameterised and connected to each other and form the safety-related logic. Free programming is not possible. A Fieldbus configurator is required in addition to the non-safety related logic configuration, which deals with the mapping of the TwinSAFE data packets. These functions are realised via the TwinCAT System Manager. The safety-related TwinSAFE Verifier, which is available at the moment as a separate installation, deals with the loading and testing of the TwinSAFE project onto the KL6904.

The TwinSAFE Logic Terminal can communicate, via the fieldbus-independent and certified TwinSAFE-protocol with safe input and output terminals, and also with further logic terminals.

3 TwinSAFE KL6904 Logic Terminal

The configuration of the TwinSAFE Logic Terminal consists of function blocks, which can be consolidated into one or more TwinSAFE groups. TwinSAFE groups can be started and stopped independently of each other.

The execution sequence of the function blocks corresponds to the TwinCAT System Managers project structure sequence illustrated. This sequence can be changed in the System Manager by Drag'n Drop.

The function blocks have parameters which must be configured by the user.

By the user the inputs and outputs of the function blocks are assigned to inputs and outputs of TwinSAFE terminals, to other function blocks or to input or output variables of the standard PLC.

A TwinSAFE connection is the unambiguous assignment of a TwinSAFE device (KL1904, KL2904, KL6904) to a TwinSAFE group. Only function blocks which belong to this TwinSAFE group can be linked with the input and outputs of an assigned TwinSAFE connection. The DECOUPLE block can be used if it is necessary for other groups to access the inputs and outputs (see chapter 0).

Errors of the TwinSAFE communication within the TwinSAFE group and errors within a function block affect the complete TwinSAFE group. The TwinSAFE group then stops all associated function blocks, which then switch their outputs into a safe state.

Errors in the TwinSAFE Logic result in it switching off completely.

3.1 TwinSAFE group

The function blocks are assigned to TwinSAFE groups. These have a characteristic that results in the return of all group outputs to a safe state (a safe state is always a wattless state at the output, corresponding to a logical 0) such as, in case of a communication error of an assigned TwinSAFE connection, in case of an error in assigned function blocks (e.g. excessive discrepancy time) or an error in the local assigned outputs. I.e. the TwinSAFE connection data and thus TwinSAFE input or output terminal are always exactly assigned to a TwinSAFE group. This is why the local outputs are always assigned to only one TwinSAFE group.

A communication error is displayed on the output (COM ERR) and acknowledged on the input (ERR ACK) of the TwinSAFE group. A function block error is displayed on the output (FB ERR) and acknowledged on the same input (ERR ACK) as the communication error. An error on the local outputs is displayed on the third output (OUT ERR) and once again acknowledged (ERR_ACK) on the same input. The safe state of the TwinSAFE group outputs is removed once the error is no longer present and has been acknowledged.

The error acknowledgement is not carried out automatically, i.e. the "ERR ACK" input must always be - linked.

Apart from this the TwinSAFE group has an input (RUN), with which the processing of the assigned function blocks can be stopped and started. All TwinSAFE group assigned outputs are in a safe state when stopped.

3.1.1 TwinSAFE group inputs

Table 3-1: TwinSAFE group inputs

Name	Permitted type	Description
RUN	FB-Out Standard-In	TRUE: The function blocks assigned to the TwinSAFE group are executed FALSE: All of the TwinSAFE group assigned function blocks are at a STOP state and thus all associated outputs are in a safe state When the input is not linked it is in the TRUE state
ERR ACK	FB-Out Standard-In	All pending errors in the assigned function blocks and in the TwinSAFE connections are acknowledged by the FALSE->TRUE->FALSE signal sequence.

3.1.2 TwinSAFE group outputs

Table 3-2: TwinSAFE group outputs

Name	Permitted type	Description
FB ERR	TwinSAFE-Out FB-In Standard-Out	TRUE: At least one assigned function block has an error FALSE: All assigned function blocks have no errors
COM ERR	TwinSAFE-Out FB-In Standard-Out	TRUE: At least one TwinSAFE connection of TwinSAFE group has an error FALSE: All TwinSAFE connections of the TwinSAFE group have no errors
OUT ERR	TwinSAFE-Out FB-In Standard-Out	TRUE: At least one locally assigned output of the TwinSAFE group has an error FALSE: All of the locally assigned outputs of the TwinSAFE group have no errors

3.2 TwinSAFE connection

Each safe communication path between the TwinSAFE logic and TwinSAFE inputs, outputs or other TwinSAFE logic terminals are referred to as TwinSAFE connection.

A communication partner is thus always the TwinSAFE master, the other the TwinSAFE slave. The TwinSAFE logic is in a TwinSAFE connection to a TwinSAFE input or TwinSAFE output always TwinSAFE master. The TwinSAFE connection to another TwinSAFE logic can be TwinSAFE slave on the other hand, whereby the TwinCAT System Manager automatically defines this assignment.
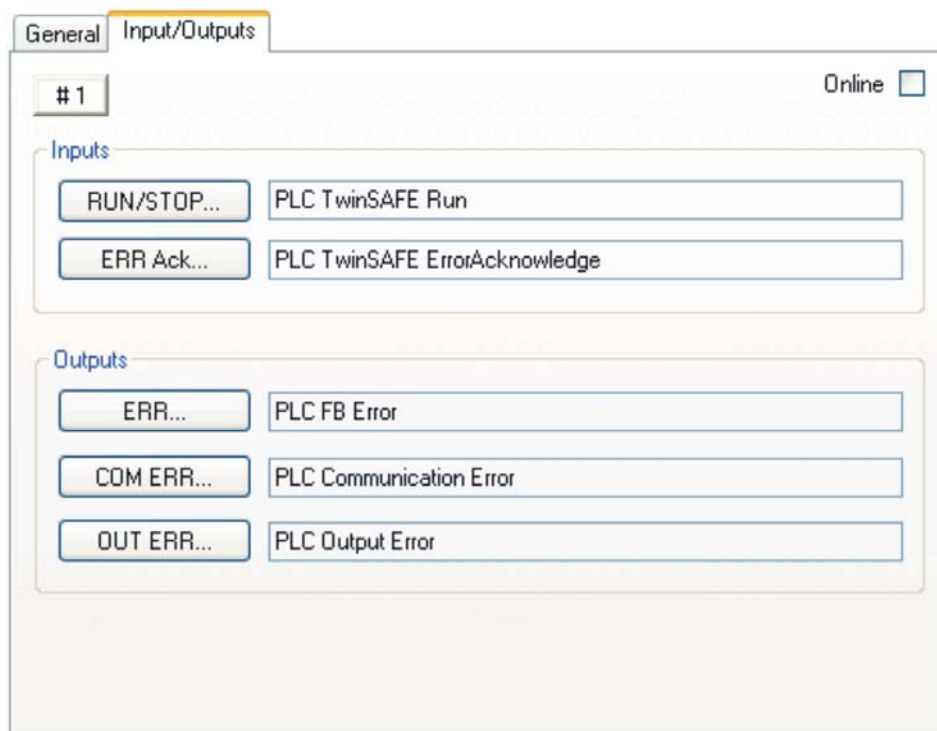
Both the TwinSAFE master and TwinSAFE slave have a TwinSAFE address, which can be adjusted via a DIP switch on the TwinSAFE terminal, so that an permutation of the TwinSAFE data packets will always be detected. These TwinSAFE addresses are checked within the TwinSAFE communication and must be unique in the control system. The TwinSAFE Verifier for each TwinSAFE logic terminal checks that. The user must ensure that the TwinSAFE addresses, which are present in the whole TwinSAFE logic control system and mostly in the TwinSAFE logic terminals cannot be chosen more than once, since the TwinSAFE Verifier can only check one TwinSAFE logic terminal at a time.

A watchdog time and corresponding S address of the communicating device can be set for the TwinSAFE connection. In addition there is a possibility to adjust the SIL level, however this setting is not supported at the moment and has no effects on the safety behaviour of the system.

3.3 System diagnosis

The states of the TwinSAFE groups, FBs and connections can be checked in the System Manager.

TwinSAFE groups have inputs and outputs of associated Screenshots assigned offline and which can be considered online. Furthermore these signals are also available for the standard PLC.

| General | Input/Outputs |

| #1 | Status: | RUN | | Online ☑ |

Inputs
| RUN/STOP... | 1 |
| ERR Ack... | 0 |

Outputs
ERR...	0
COM ERR...	0
OUT ERR...	0

The status of TwinSAFE FBs is displayed on online summary. The current status data can be read off the KL6904 using a manual refresh.

| General | Function Block List |

#	Type	State	Diagnosis
1	Machine Monitoring	RUN	0000 0000
2	AND	RUN	0000 0000
3	AND	RUN	0000 0000
4	AND	SAFE	0000 0000
5	AND	RUN	0000 0000
6	AND	RUN	0000 0000
7	AND	SAFE	0000 0000
8	AND	RUN	0000 0000
9	AND	SAFE	0000 0000

Refresh

The diagnostic bits are set in addition to the status in case of an error. These have the following meaning. The display begins from the right with index 0.

Emergency stop diagnostic bits:
Index 0-3: Discrepancy error (index 0 means input group 1, index 3 means input group 4)

Index 4-5: EDM error (index 4 means EDM1, index 5 means EDM2)

Machine monitor diagnostic bits:
Index 0-1: Discrepancy error MonIn (index 0 means input group 1, index 1 means input group 2)

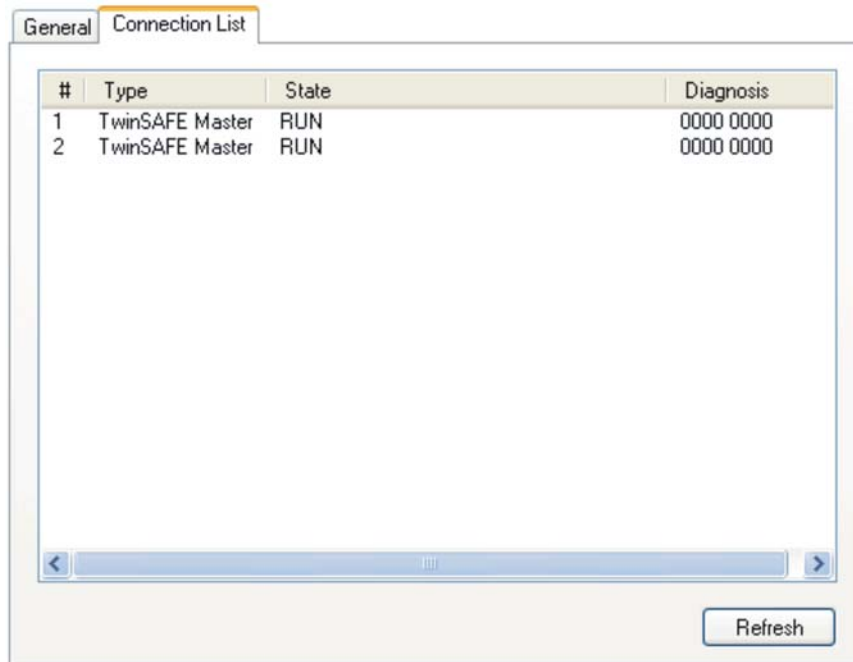Index 2: Discrepancy error of secure inputs

Index 4-5: EDM error (index 4 means EDM1, index 5 means EDM2)

Diagnostic bits operation mode:
Index 0: Discrepancy error

No further diagnostic bits are defined for all other FBs (AND, OR, DECOUPLE).

The TwinSAFE connections states are displayed on the TwinSAFE connection list summary under the "Connection List" tab. Diagnostics bits are also set in addition to the status.

The diagnostic bits have the following meaning. The display begins with index 0 on the right edge of the diagnostic bytes.

Connection diagnostic bits:

Bit 0:   (unexpected) zero messages received (e.g. interruption of the K-Bus or Fieldbus)

Bit 1:   invalid K-Bus status

Bit 2:   Watchdog time elapsed

Bit 3:   CRC2 error

Bit 4:   Seq No. error

Bit 5:   Slave error (error bits (Comm_Fault, WD_Fault) in F_Status are set)

Bit 6:   F- and I-parameter are transmitted

Bit 7:   ActivateFV-Bit in F_Control is set

4 Function blocks

The function blocks have a specified functionality that still must be configured via parameters. The inputs or outputs of a function block can be inputs or outputs of a local process image, but function block outputs and inputs can be linked.

4.1 FB AND

4.1.1 Functional description

Several input signals can be linked with the FB AND to one output signal via AND. In addition each input can be still be set even if the input signal is a normally closed (Break contact) or normally open contact (Make contact). A normally open contact means that the corresponding input signal is negated, before it affects the AND.

The AndIn1 input differs from the AndIn2-AndIn8 inputs in such a way that it can also be linked with a standard input. This makes it possible to switch off a safe output using a standard signal. Outputs cannot be switched on but only released using a standard signal, since at least two inputs must always be linked for FB AND (and the second input is a safe one, which prevents switching on).

Figure 4-1: FB AND
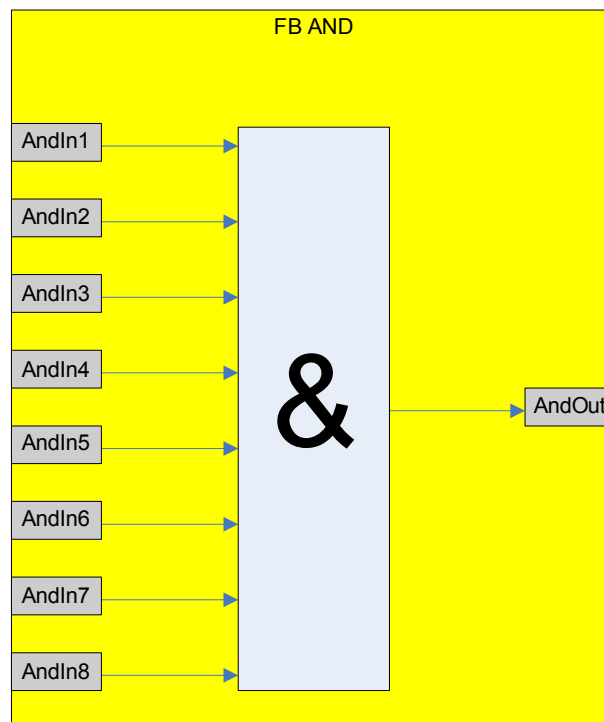
4.1.2 Signal description

4.1.2.1 Inputs

Table 4-1: FB inputs

Name	Permitted type	Description
AndIn1	TwinSAFE-In FB-Out Standard-In	1st input channel
AndIn2	TwinSAFE-In FB-Out	2nd input channel
AndIn3	TwinSAFE-In FB-Out	3rd input channel
AndIn4	TwinSAFE-In FB-Out	4th input channel
AndIn5	TwinSAFE-In FB-Out	5th input channel
AndIn6	TwinSAFE-In FB-Out	6th input channel
AndIn7	TwinSAFE-In FB-Out	7th input channel
AndIn8	TwinSAFE-In FB-Out	8th input channel

4.1.2.2 Outputs

Table 4-2: FB outputs

Name	Permitted type	Description
AndOut	TwinSAFE-Out FB-In Standard-Out Local-Out	Output channel

4.1.2.3 Type description

Table 4-3: Type of FB inputs and outputs

Type	Description
TwinSAFE-In	TwinSAFE input on a KL1904
Standard-In	Standard PLC variable (PLC output in %Q*)
FB-Out	TwinSAFE FB output
TwinSAFE-Out	TwinSAFE output on a KL2904
Standard-Out	Standard PLC variable (PLC input in %Q*)
FB-In	TwinSAFE FB input
Local-Out	TwinSAFE output on KL6904

4.1.3 FB AND configuration in the TwinCAT System Manager

Figure 4-2: FB AND configuration
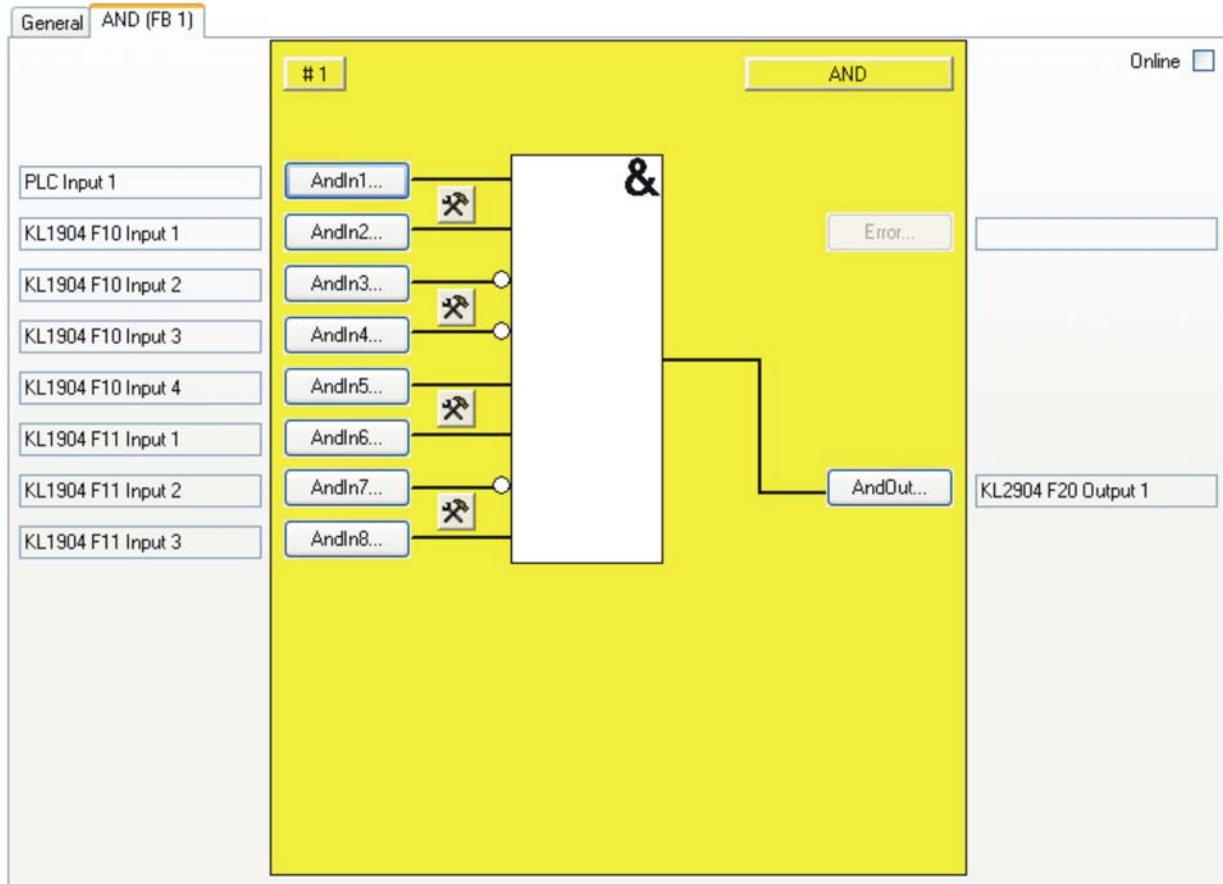
Their characteristics are configured with the setting buttons on the right near the two AndIn inputs, whereby the inputs are always single-channel ones. A discrepancy monitoring cannot be used for the AND.

The 'AndIn(x)' buttons can only be selected when the corresponding input has been activated. All inputs are deactivated in the default setting.

The FB AND input variables are linked using the 'AndIn(x)' buttons.

The output variable of the FB AND are linked using the 'AndOut' button.

The FB AND does not supply any error information and therefore the error button is basically deactivated.

4.2 FB OR

4.2.1 Functional description

Several input signals can be linked with the FB OR to one output signal via OR. In addition each input can be still be set even if the input signal is a normally closed (Break contact) or normally open contact (Make contact). A normally open contact means that the corresponding input signal is negated, before it affects the OR.

Figure 4-3: FB OR
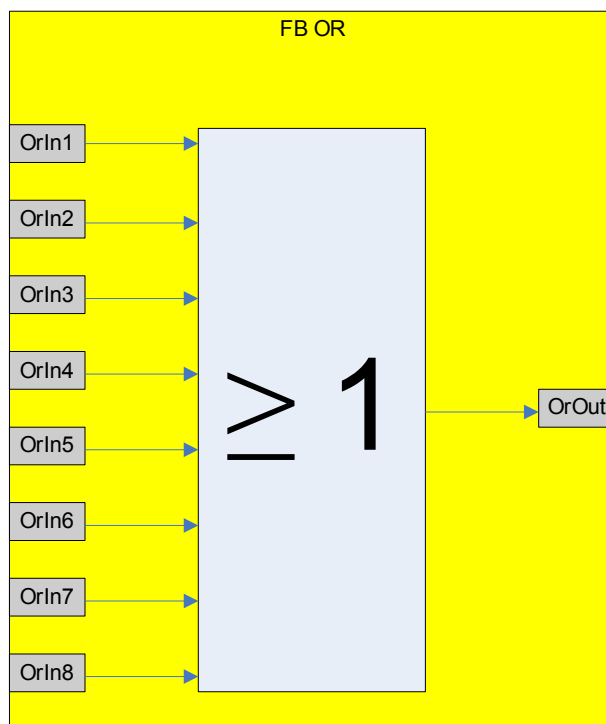
4.2.2 Signal description

4.2.2.1 Inputs

Table 4-4: FB inputs

Name	Permitted type	Description
OrIn1	TwinSAFE-In FB-Out	1st input channel
OrIn2	TwinSAFE-In FB-Out	2nd input channel
OrIn3	TwinSAFE-In FB-Out	3rd input channel
OrIn4	TwinSAFE-In FB-Out	4th input channel
OrIn5	TwinSAFE-In FB-Out	5th input channel
OrIn6	TwinSAFE-In FB-Out	6th input channel
OrIn7	TwinSAFE-In FB-Out	7th input channel
OrIn8	TwinSAFE-In FB-Out	8th input channel

4.2.2.2 Outputs

Table 4-5: FB outputs

Name	Permitted type	Description
OrOut	TwinSAFE-Out FB-In Standard-Out Local-Out	Output channel

4.2.2.3 Type description

Table 4-6: Type of FB inputs and outputs

Type	Description
TwinSAFE-In	TwinSAFE input on a KL1904
Standard-In	Standard PLC variable (PLC output in %Q*)
FB-Out	TwinSAFE FB output
TwinSAFE-Out	TwinSAFE output on a KL2904
Standard-Out	Standard PLC variable (PLC input in %Q*)
FB-In	TwinSAFE FB input
Local-Out	TwinSAFE output on KL6904

4.2.3 FB OR configuration in the TwinCAT System Manager

Figure 4-4: FB OR configuration
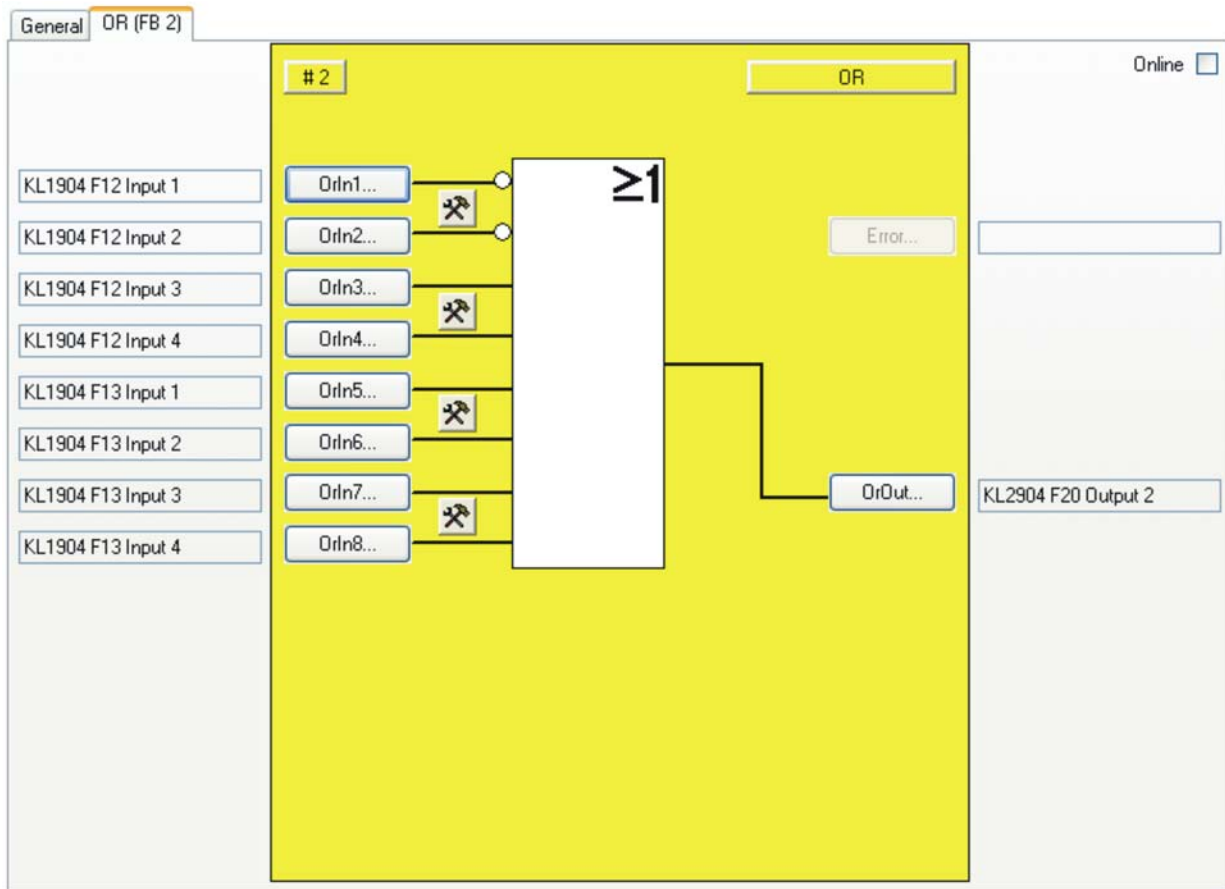
Their characteristics are configured with the setting buttons on the right near the two OrIn inputs, whereby the inputs are always single-channel ones. A discrepancy monitoring cannot be used for the OR.

The 'OrIn(x)' buttons can only be selected when the corresponding input has been activated. All inputs are deactivated in the default setting.

The FB OR input variables are linked using the 'OrIn(x)' buttons.

The output variable of the FB OR are linked using the 'OrOut' button.

The FB OR does not supply any error information and therefore the error button is basically deactivated.

4.3 FB OPMODE

4.3.1 Functional description

Operating mode selectors can be realised with the FB OPMODE. The function block has 8 inputs and 8 outputs, which are looped through one-to-one, whereby up to 8 different operating modes can be selected. The FB OPMODE sets the corresponding output, only when an input is precisely set ("1"), whereby the other outputs remain in a safe („0") state. All outputs are in a safe state if there is none or more than one input is set. The output safe state can only be exited during start and change of operating modes using a 0->1->0 signal sequence on the restart input, once the restart input is activated. In addition a discrepancy time can be given, with which the change of operating mode can be monitored.

Figure 4-5: FB OPMODE
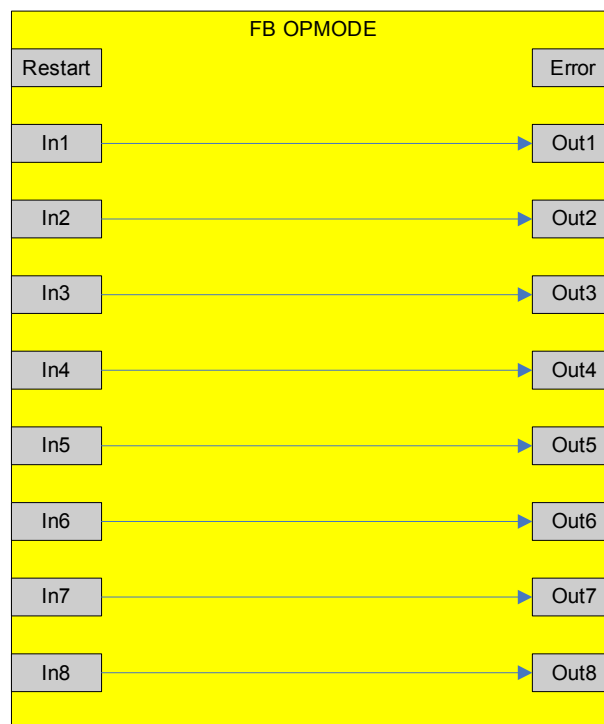
4.3.2 Signal description

4.3.2.1 Inputs

Table 4-7: FB inputs

Name	Permitted type	Description
Restart	TwinSAFE-In FB-Out Standard-In	The 0->1->0 signal sequence must be detected on the restart input, before the safe state of the outputs can be removed, when starting the FB or when all outputs are switched to the safe state
OpIn1	TwinSAFE-In FB-Out	1st input channel
OpIn2	TwinSAFE-In FB-Out	2nd input channel
OpIn3	TwinSAFE-In FB-Out	3rd input channel
OpIn4	TwinSAFE-In FB-Out	4th input channel
OpIn5	TwinSAFE-In FB-Out	5th input channel
OpIn6	TwinSAFE-In FB-Out	6th input channel
OpIn7	TwinSAFE-In FB-Out	7th input channel
OpIn8	TwinSAFE-In FB-Out	8th input channel

4.3.2.2   Outputs

Table 4-8: FB outputs

| Name	Permitted type	Description
Error	TwinSAFE-Out FB-In Standard-Out Local-Out	TRUE: The discrepancy time monitoring or the input monitoring has found an error. The acknowledgement of the error must be carried out via the ERR_ACK input of the related TwinSAFE group FALSE: No error was found.
OpOut1	TwinSAFE-Out FB-In Standard-Out Local-Out	1st output channel
OpOut2	TwinSAFE-Out FB-In Standard-Out Local-Out	2nd output channel
OpOut3	TwinSAFE-Out FB-In Standard-Out Local-Out	3rd output channel
OpOut4	TwinSAFE-Out FB-In Standard-Out Local-Out	4th output channel
OpOut5	TwinSAFE-Out FB-In Standard-Out Local-Out	5th output channel
OpOut6	TwinSAFE-Out FB-In Standard-Out Local-Out	6th output channel
OpOut7	TwinSAFE-Out FB-In Standard-Out Local-Out	7th output channel
OpOut8	TwinSAFE-Out FB-In Standard-Out Local-Out	8th output channel

4.3.2.3 Type description

Table 4-9: Type of FB inputs and outputs

Type	Description
TwinSAFE-In	TwinSAFE input on a KL1904
Standard-In	Standard PLC variable (PLC output in %Q*)
FB-Out	TwinSAFE FB output
TwinSAFE-Out	TwinSAFE output on a KL2904
Standard-Out	Standard PLC variable (PLC input in %Q*)
FB-In	TwinSAFE FB input
Local-Out	TwinSAFE output on KL6904

4.3.3 FB OPMODE configuration in the TwinCAT System Manager

Figure 4-6: FB OPMODE configuration
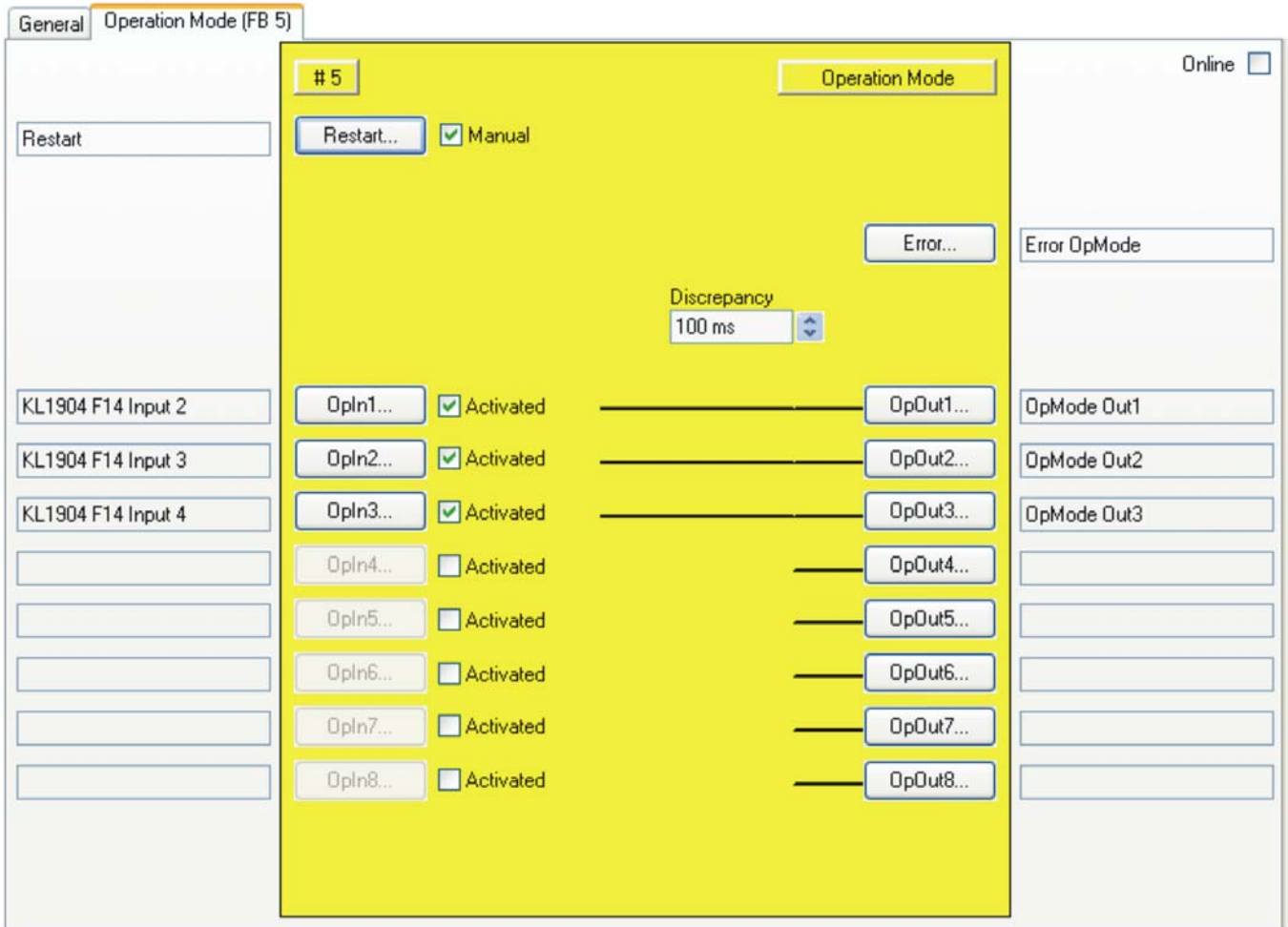
The manual restart or the corresponding input is activated using the 'Activated' check box on the right near the 'Restart' or 'OpIn(x)' buttons.

The 'Restart' or 'OpIn(x)' buttons can only be selected, once the corresponding check box has been selected.

The FB OPMODE input variables are linked using the 'Restart' and 'OrIn(x)' buttons.

The FB OPMODE output variables are linked using the 'Error' and 'OpOut(x)' buttons.

The discrepancy time is configured using the 'Discrepancy' selection box.

4.4 FB ESTOP

4.4.1 Functional description

An emergency stop circuit with up to eight emergency stop inputs (EStopIn1-EStopIn8) can be realised with the FB ESTOP. Each of the eight inputs can be used as normally closed (Break contact - 0 requests the safe state) or normally open contacts (Make contact - 1 request the safe state). The first output (EStopOut) goes immediately, and the second one (EStopDelOut) after a configurable time delay, into the safe state ("0"), once an input requests the safe state. Several immediate (EStopOut) or delayed switch-off (EStopDelOut) outputs can be realised with only one FB ESTOP, due to the multiple linking possibility of the FB output. The 0->1->0 signal sequence must be detected on the restart input, before the safe state of the outputs can be exited.

Figure 4-7: FB ESTOP
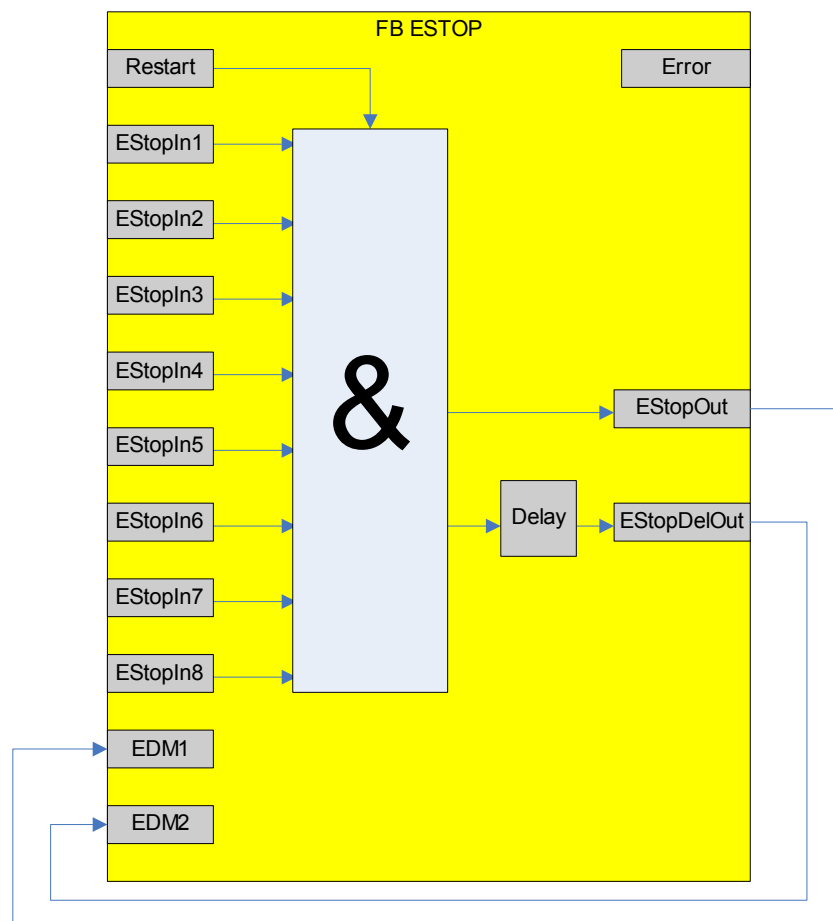
Apart from this a feedback loop can be activated for both outputs, whereby the EStopOut output is fed back to the EDM1 input and the EStopDelOut output is fed back to the EDM2 output, using an external circuit. The EDM inputs are tested as soon as the safe state on the restart input should be exited using the 0->1->0 signal sequence. If the EDM inputs don't have the "1" signal state, the FB ESTOP goes into error state and sets the output error to 1. The error state can only be exited again by a 0->1->0 signal sequence on the ERR_ACK-input of the related TwinSAFE group.

Furthermore each time 2 inputs (EStopIn1 and EStopIn2, EStopIn3 and EStopIn4, EStopIn5 and EStopIn6 and EStopIn7 and EStopIn8) can be consolidated as input pairs, whereby the signal states of both inputs can only deviate from each other within a configurable discrepancy time. If this discrepancy time is exceeded for an input pair, the FB ESTOP will also go into the error state. The outputs go into the safe state "0" if the FB is in error state.

4.4.2 Signal description

4.4.2.1 Inputs

Table 4-10: FB inputs

Name	Permitted type	Description
Restart	TwinSAFE-In FB-Out Standard-In	The 0->1->0 signal sequence must be detected on the restart input, during start (when the related TwinSAFE group is started), or restart (when one input has requested the safe state), before the safe state of the outputs can be removed.
EStopIn1	TwinSAFE-In FB-Out	1st input channel: The parameterisation determines, whether the input will be a normally closed contact (Break contact – safe state will be requested by logical 0) or normally open contact (Make contact – safe state will be requested by logical 1).
EStopIn2	TwinSAFE-In FB-Out	2nd Input channel, behaves like EStopIn1 If the discrepancy time is not equal to 0, the 1st and 2nd input channel are considered to be the 1st input pair and a discrepancy time monitoring is carried out between both channels.
EStopIn3	TwinSAFE-In FB-Out	3rd Input channel or 1st input channel of the 2nd input pairs, otherwise corresponds with EStopIn1
EStopIn4	TwinSAFE-In FB-Out	4th Input channel or 2nd input channel of the 2nd input pairs, otherwise corresponds with EstopIn2
EStopIn5	TwinSAFE-In FB-Out	5th Input channel or 1st input channel of the 3rd input pairs, otherwise corresponds with EStopIn1
EStopIn6	TwinSAFE-In FB-Out	6th Input channel or 2nd input channel of the 3rd input pairs, otherwise corresponds with EstopIn2
EStopIn7	TwinSAFE-In FB-Out	7th Input channel or 1st input channel of the 4th input pairs, otherwise corresponds with EStopIn1
EStopIn8	TwinSAFE-In FB-Out	8th Input channel or 2nd input channel of the 4th input pairs, otherwise corresponds with EstopIn2
EDM1	TwinSAFE-In FB-Out Standard-In	EDM1 is the feedback loop for the non-delayed output channel (EStopOut). If this input is parameterised as active, the safe state of the outputs will only be exited during restart, when the EDM1 supplies the "1" signal.
EDM2	TwinSAFE-In FB-Out Standard-In	EDM2 is the feedback loop for the delayed switching of the output channel (EStopDelOut). If this input is parameterised as active, the safe state of the outputs will only be exited during restart, when the EDM2 supplies the "1" signal.

4.4.2.2 Outputs

Table 4-11: FB outputs

| Name	Permitted type	Description
Error	TwinSAFE-Out FB-In Standard-Out Local-Out	TRUE: The discrepancy time monitoring of an input pair, or one of the feedback loops, has found an error. The error reset must be carried out via the ERR_ACK input of the related TwinSAFE group. FALSE: No error was found.
EStopOut	TwinSAFE-Out FB-In Standard-Out Local-Out	1st output channel, the safe state corresponds to a logical 0.
EStopDelOut	TwinSAFE-Out FB-In Standard-Out Local-Out	2nd output channel, the safe state corresponds to a logical 0. The safe state is output with a delay, which corresponds to the parameterised Delay Time.

4.4.2.3 Type description

Table 4-12: Type of FB inputs and outputs

Type	Description
TwinSAFE-In	TwinSAFE input on a KL1904
Standard-In	Standard PLC variable (PLC output in %Q*)
FB-Out	TwinSAFE FB output
TwinSAFE-Out	TwinSAFE output on a KL2904
Standard-Out	Standard PLC variable (PLC input in %Q*)
FB-In	TwinSAFE FB input
Local-Out	TwinSAFE output on KL6904

4.4.3 FB ESTOP configuration in the TwinCAT System Manager

Figure 4-8: FB ESTOP configuration
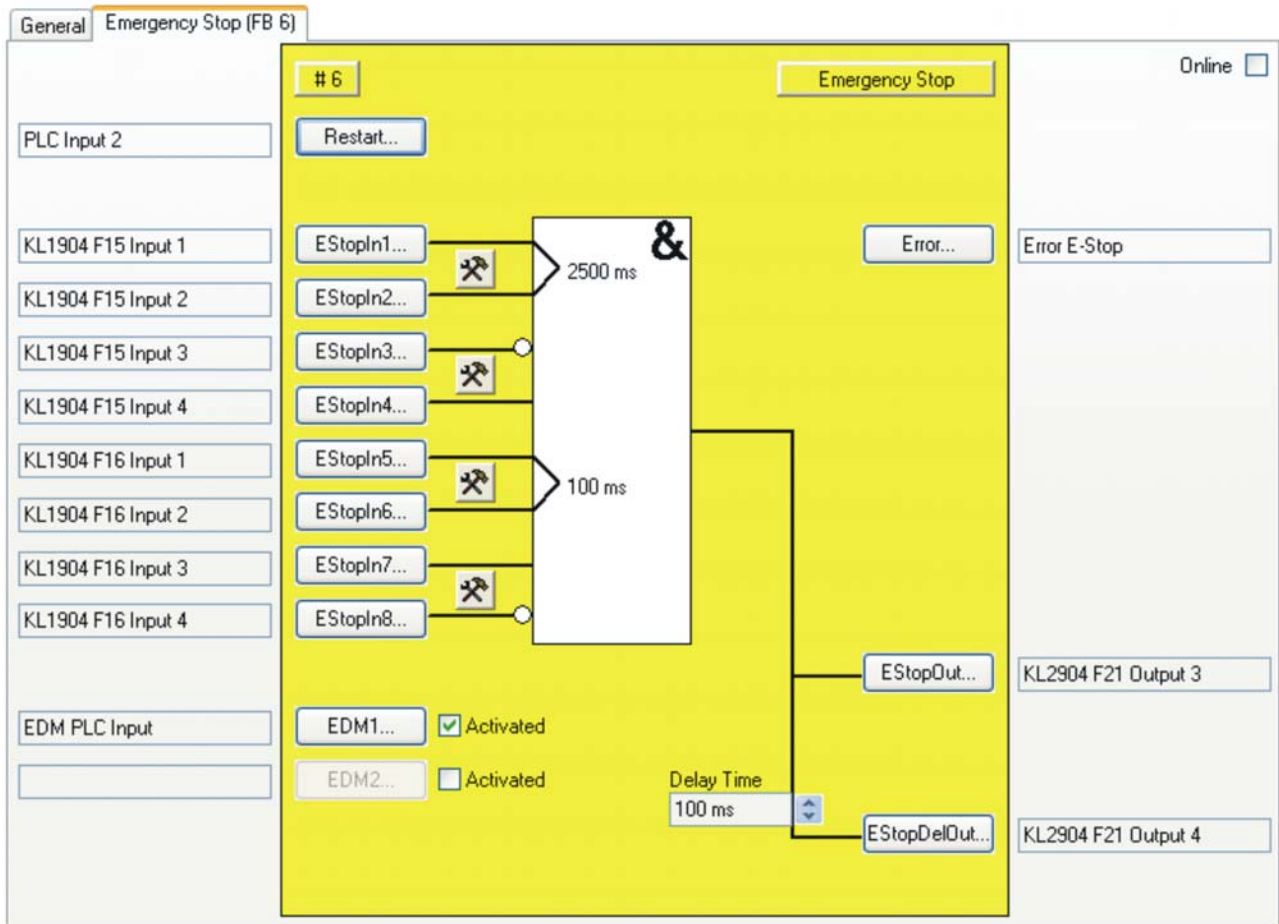
The characteristics of the input pair are configured with the setting buttons on the right near the two EStopIn inputs of an input pair.

The 'EStopIn(x)' buttons can only be selected when the associated input has been activated. All inputs are deactivated in the default state.

The FB ESTOP input variables are linked using the 'Restart', 'EStopIn(x)' and 'EDM(x)' buttons.

The corresponding feedback loop is activated using the 'Activated' check box on the right near the 'EDM(x)' buttons. The 'EDM(x)' button can only be selected, if the associated feedback loop is activated.

The FB ESTOP output variables are linked using the 'Error', 'EStopOut' and 'EStopDelOut' buttons.

The delay time of the 'EStopDelOut' output is configured via the selection box 'Delay-Time'.

4.5 FB MON

4.5.1 Functional description

A safety door circuit with up to four inputs (MonIn(x)) can be realised with the FB MON for example. Each of the four inputs can be used as normally closed (Break contact - 0 requests the safe state) or normally open contacts (Make contact - 1 request the safe state). The first output (MonOut) goes immediately, and the second one (MonDelOut) after a configurable time delay, into the safe state "0", once an input requests the safe state. Several immediate (MonOut) or delayed switch-off (MonDelOut) outputs can be realised with only one FB MON, due to the multiple linking possibility of the FB output.

In addition there are two Secure inputs, with which the request of the safe state can be bypassed through the MonIn inputs. The Secure inputs can also be realised as normally closed (Break contact) or normally open (Make contact) contacts.

The FB restart input can be activated. The 0->1->0 signal sequence must be detected on the restart input, in case of an active restart, before the safe state of the outputs is exited. In case of an inactive restart the safe state is exited once the MonIn or Secure inputs no longer request the safe state.

Figure 4-9: FB MON
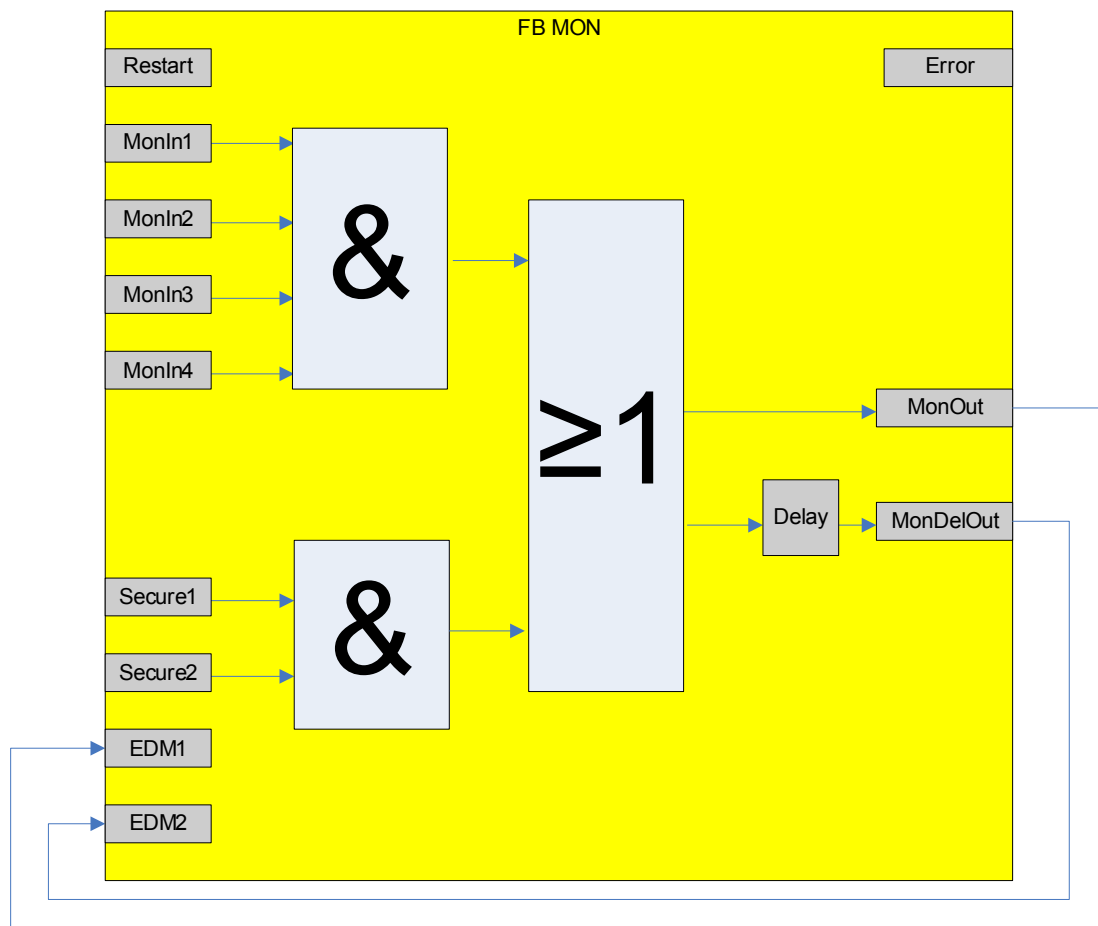
Apart from this a feedback loop can be activated for both outputs, whereby the MonOut output is fed back to the EDM1 input and the MonDelOut output is fed back to the EDM2 output, using an external circuit. Die EDM-inputs are tested once the safe state should be exited. The FB MON goes into error state in the case of activated restart and sets the output error to 1, when the EDM inputs don't have the "1" signal state. The FB MON remains in the safe state in the case of deactivated restart, when the EDM inputs don't have the "1" signal state at the restart moment. An EDM error can therefore only be detected, when the manual restart is

active. The error state can only be exited again by a 0->1->0 signal sequence on the ERR_ACK-input of the related TwinSAFE group.

Furthermore each time 2 inputs (MonIn1 and MonIn2, MonIn3 and MonIn4 and Secure1 and Secure2) can be consolidated as input pairs, whereby the signal states of both inputs can only deviate from each other within a configurable discrepancy time. If this discrepancy time is exceeded for an input pair, the FB MON will also go into the error state.

The safe state must have been requested at least once on each active MonIn input after starting the FB MON if the manual function test is active, before the edge of a restart input reacts.

4.5.2 Signal description

4.5.2.1 Inputs

Table 4-13: FB inputs

Name	Permitted type	Description
Restart	TwinSAFE-In FB-Out Standard-In	The 0->1->0 signal sequence must be detected at the restart input, during the start of the FB, in case a manual restart is active or when an input request the safe state, before the safe state of the outputs is exited. This input is not used if the manual restart is inactive. Both starting and exiting the safe state is carried out automatically, as long as no input of the safe state is requested any longer.
MonIn1	TwinSAFE-In FB-Out	1st input channel: The parameterisation determines, whether the input will be linked to a normally closed contact (Break contact – safe state will be requested by logical 0) or normally open contact (Make contact – safe state will be requested by logical 1).
MonIn2	TwinSAFE-In FB-Out	2nd Input channel, behaves like MonIn1 If the discrepancy time is activated or used, the 1st and 2nd input channel are considered to be the 1st input pair and a discrepancy time monitoring is carried out between both channels.
MonIn3	TwinSAFE-In FB-Out	3rd Input channel or 1st input channel of the 2nd input pairs, otherwise corresponds with MonIn1
MonIn4	TwinSAFE-In FB-Out	4th Input channel or 2nd input channel of the 2nd input pairs, otherwise corresponds with MonIn2
Secure1	TwinSAFE-In FB-Out	If the Secure 1 or Secure 2 are parameterised as active, the evaluation of the MonIn(x) inputs can be switched off. If Secure1 or Secure2 are parameterised as normally closed (Break contact), the MonIn(x) inputs are ignored if Secure1 and/or Secure2 are "1". If Secure1 or Secure2 are parameterised as normally open (Break contact), the MonIn(x) inputs are ignored if Secure1 and/or Secure2 are "0". If the discrepancy time is activated or used, Secure1 and Secure2 are considered as an input pair and a discrepancy time monitoring is carried out between both channels.
Secure2	TwinSAFE-In FB-Out	Secure2 is the 2nd channel of the input pair and otherwise corresponds to Secure1.
EDM1	TwinSAFE-In FB-Out Standard-In	EDM1 is the feedback loop for the non-delayed output channel (MonOut). If this input is parameterised as active, the safe state of the outputs will only be exited, when the EDM1 supplies the "1" signal.
EDM2	TwinSAFE-In FB-Out Standard-In	EDM2 is the feedback loop for the delayed switching of the output channel (MonDelOut). If this input is parameterised as active, the safe state of the outputs will only be exited, when the EDM2 supplies the "1" signal.

4.5.2.2 Outputs

Table 4-14: FB outputs

| Name	Permitted type	Description
Error	TwinSAFE-Out FB-In Standard-Out Local-Out	TRUE: The discrepancy time monitoring of an input pair, or one of the feedback loops, has found an error. The error reset must be carried out via the ERR_ACK input of the related TwinSAFE group. FALSE: No error was found.
MonOut	TwinSAFE-Out FB-In Standard-Out Local-Out	1st output channel, the safe state corresponds to a logical 0.
MonDelOut	TwinSAFE-Out FB-In Standard-Out Local-Out	2nd output channel, the safe state corresponds to a logical 0. The safe state is output with a delay, which corresponds to the parameterised Delay Time.

4.5.2.3 Type description

Table 4-15: Type of FB inputs and outputs

Type	Description
TwinSAFE-In	TwinSAFE input on a KL1904
Standard-In	Standard PLC variable (PLC output in %Q*)
FB-Out	TwinSAFE FB output
TwinSAFE-Out	TwinSAFE output on a KL2904
Standard-Out	Standard PLC variable (PLC input in %Q*)
FB-In	TwinSAFE FB input
Local-Out	TwinSAFE output on KL6904

4.5.3 FB MON configuration in the TwinCAT System Manager

Figure 4-10: FB MON configuration
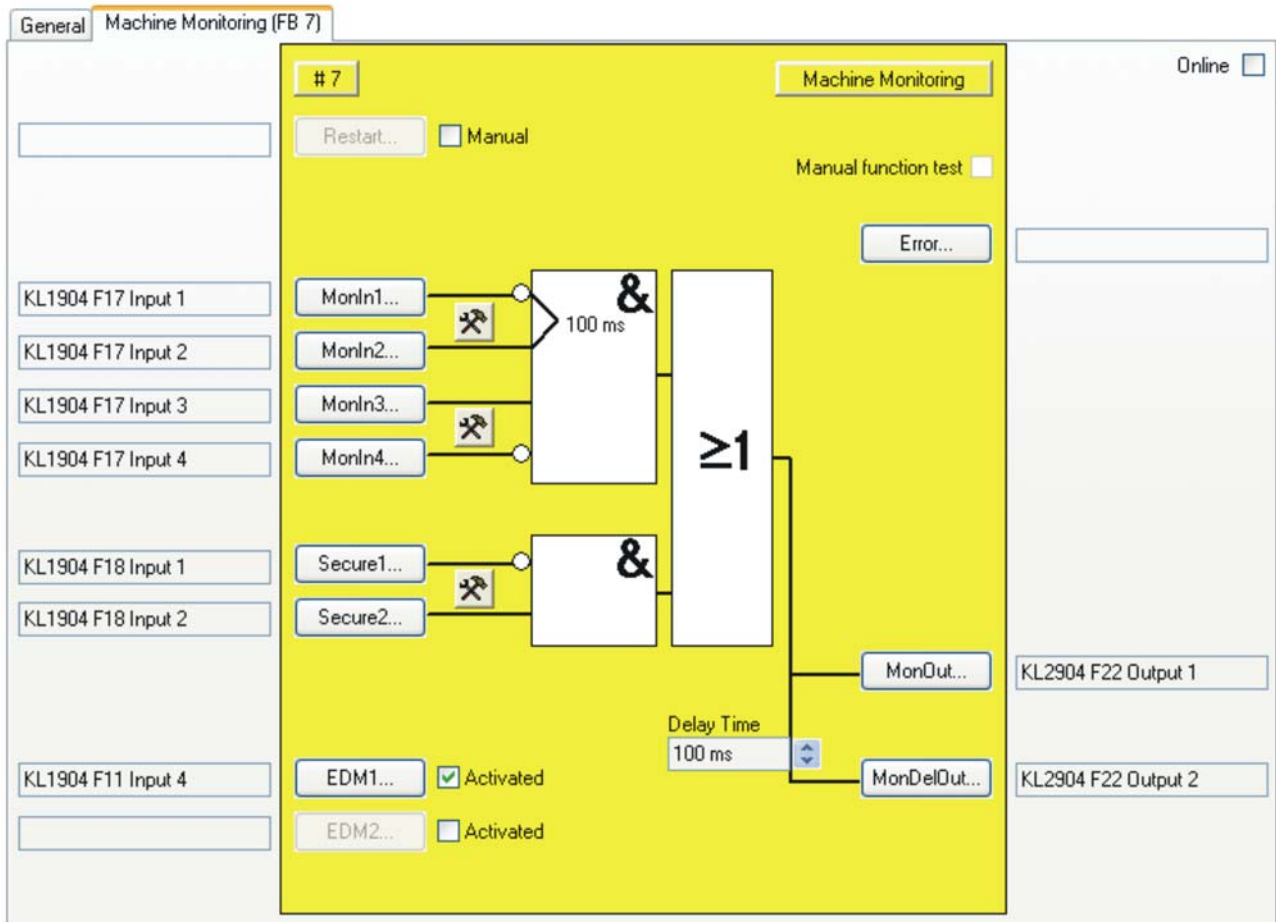
The manual restart is activated using the "Manual" check box on the right near the 'Restart' button. The 'Restart' button can only be selected, if the manual restart is activated.

The characteristics of the input pair are configured with the setting buttons on the right near the two MonIn or Secure inputs of an input pair. The 'MonIn(x)' or 'Secure(x)' buttons can only be selected when the associated input has been activated. All inputs are deactivated by default.

The corresponding feedback loop is activated using the 'Activated' check box on the right near the 'EDM(x)' buttons. The 'EDM(x)' button can only be selected, if the associated feedback loop is activated.

The FB MON input variables are linked using the 'Restart', 'MonIn(x)', 'Secure(x)' and 'EDM(x)' buttons.

The manual function test is activated using the 'Manual Function Test' check box.

The FB MON output variables are linked using the 'Error', 'MonOut' and 'MonDelOut' buttons.

The delay time of the 'MonDelOut' output is configured via the selection box 'Delay-Time'.

4.6 FB DECOUPLE

4.6.1 Functional description

The FB DECOUPLE is for uncoupling of signals from a TwinSAFE connection. The function block has 8 inputs and 8 outputs, whereby the outputs are looped one-to-one with the inputs. The associated output must be linked as soon as one of the block inputs is used. The converse is also valid.

Figure 4-11: FB DECOUPLE
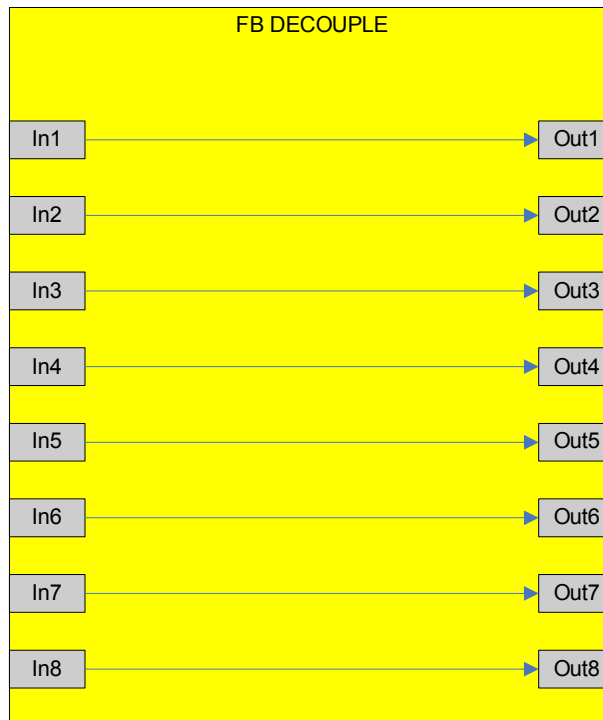
It is possible to subdivide and decouple the signals of a TwinSAFE connection into several TwinSAFE groups, using the FB DECOUPLE, since a TwinSAFE connection is always assigned to a TwinSAFE group. The block within an existing TwinSAFE group can be used to subdivide the signals. The block must be used in a separate TwinSAFE group in case the signals should be decoupled, since all used outputs of the TwinSAFE group can be switched off in case of a connection communication error. The input signals of a TwinSAFE connection can now be linked with the FB DECOUPLE inputs, and the outputs distributed over to different TwinSAFE groups. It operates the same way in the other directions, the outputs of a TwinSAFE connection are linked with the FB DECOUPLE outputs, the FB DECOUPLE inputs can once again come from various TwinSAFE groups.

4.6.2 Signal description

4.6.2.1   Inputs

Table 4-16: FB inputs

Name	Permitted type	Description
DecIn1	TwinSAFE-In FB-Out	1st input channel
DecIn2	TwinSAFE-In FB-Out	2nd input channel
DecIn3	TwinSAFE-In FB-Out	3rd input channel
DecIn4	TwinSAFE-In FB-Out	4th input channel
DecIn5	TwinSAFE-In FB-Out	5th input channel
DecIn6	TwinSAFE-In FB-Out	6th input channel
DecIn7	TwinSAFE-In FB-Out	7th input channel
DecIn8	TwinSAFE-In FB-Out	8th input channel

4.6.2.2 Outputs

Table 4-17: FB outputs

| Name	Permitted type	Description
DecOut1	TwinSAFE-Out FB-In Standard-Out Local-Out	1st output channel
DecOut2	TwinSAFE-Out FB-In Standard-Out Local-Out	2nd output channel
DecOut3	TwinSAFE-Out FB-In Standard-Out Local-Out	3rd output channel
DecOut4	TwinSAFE-Out FB-In Standard-Out Local-Out	4th output channel
DecOut5	TwinSAFE-Out FB-In Standard-Out Local-Out	5th output channel
DecOut6	TwinSAFE-Out FB-In Standard-Out Local-Out	6th output channel
DecOut7	TwinSAFE-Out FB-In Standard-Out Local-Out	7th output channel
DecOut8	TwinSAFE-Out FB-In Standard-Out Local-Out	8th output channel

4.6.2.3   Type description

Table 4-18: Type of FB inputs and outputs

Type	Description
TwinSAFE-In	TwinSAFE input on a KL1904
Standard-In	Standard PLC variable (PLC output in %Q*)
FB-Out	TwinSAFE FB output
TwinSAFE-Out	TwinSAFE output on a KL2904
Standard-Out	Standard PLC variable (PLC input in %Q*)
FB-In	TwinSAFE FB input
Local-Out	TwinSAFE output on KL6904

4.6.3   FB DECOUPLE configuration in the TwinCAT System Manager

Figure 4-12: FB DECOUPLE configuration
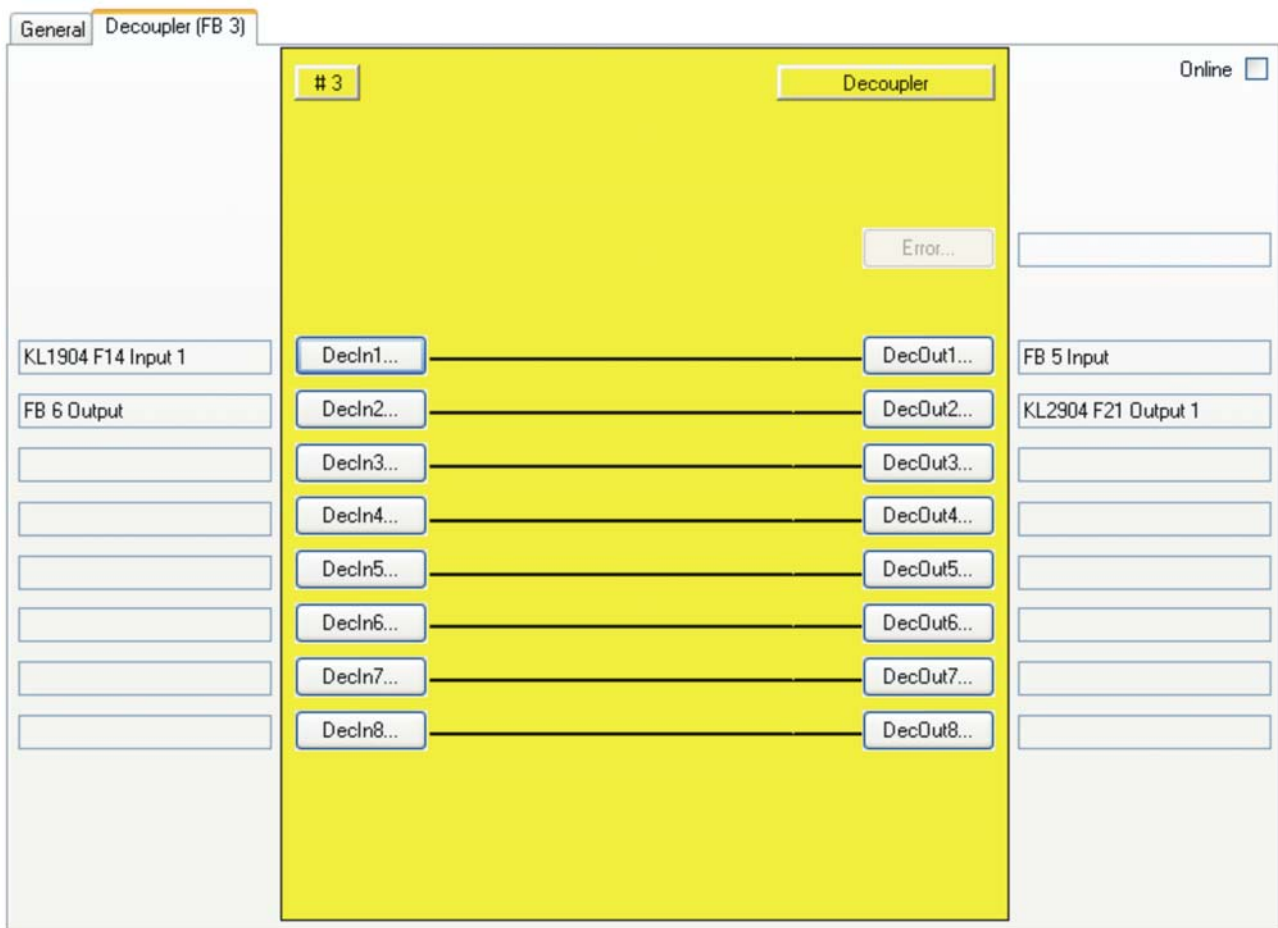
The FB DECOUPLE input variables are linked using the 'DecIn(x)' buttons.

The FB DECOUPLE output variables are linked using the 'DecOut(x)' buttons.

The FB DECOUPLE does not supply any error information and therefore the error button is basically deactivated.

5 Application examples

5.1 Machine with an emergency off switch

Necessary components:

2 x KL1904
1 x KL6904
2 x contactor with forced signal contact (e.g. Siemens Sirius)

1 x FB E_Stop

Function:

The EStopOut and EStopDelOut outputs are in "0" state after switching on. The EStopOut and EStopDELOut are set to "1", only when the EStopIn1, EStopIn2 and EDM1 inputs are at the "1" state (switch S1 closed) and the S2 switch is pressed (at first rising and then falling edges on the Restart input). The contactors K1 and K2 are activated. Pressing the S1 switch leads to a drop of the contactors K1 and K2.

The sticking of contacts on contactors K1 and K2 is detected at the EDM1 input and prevents switching on of the block again.

The block reports this error by setting the output error to TRUE

Figure 5-1: Machine with an emergency off switch
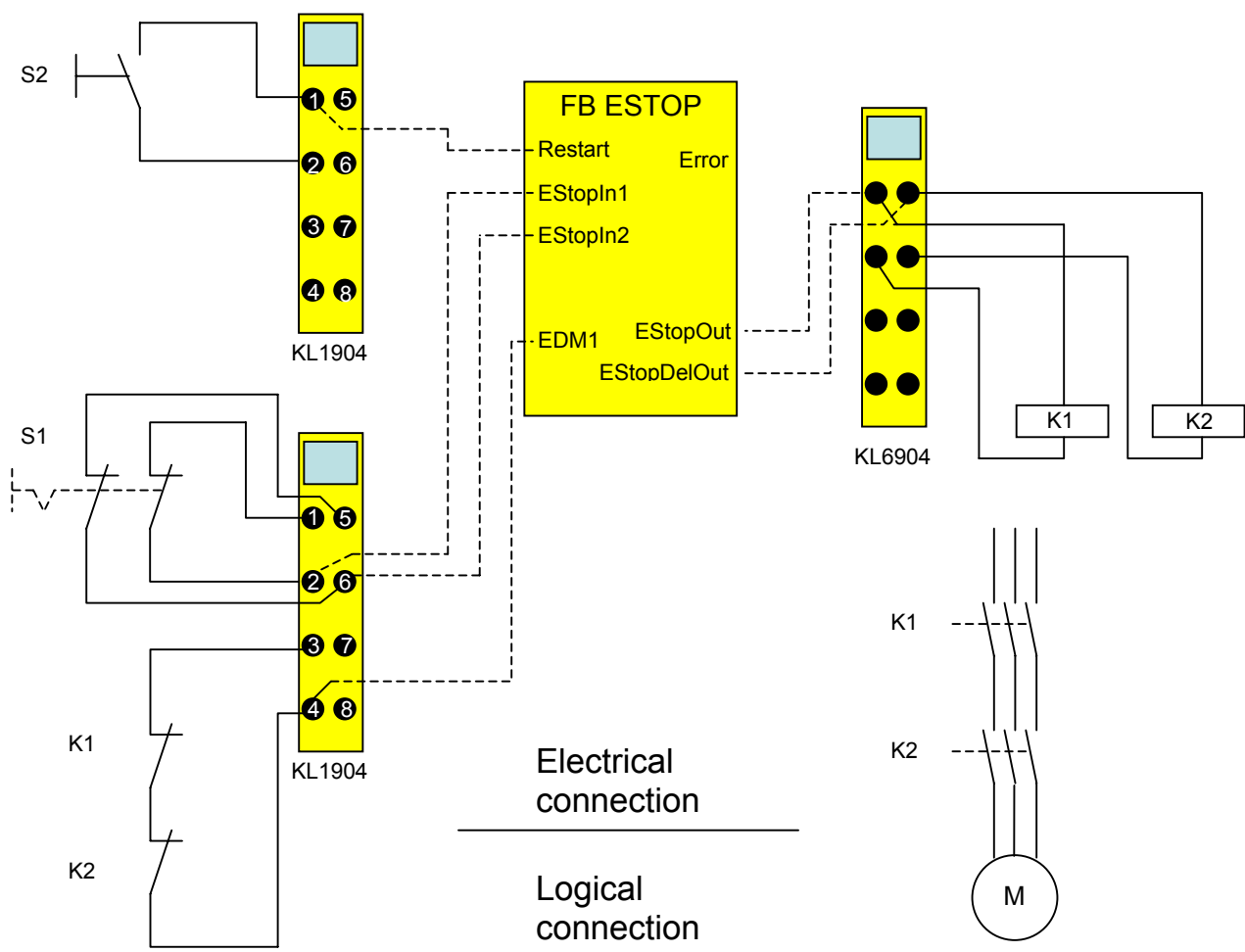
5.2 Machine with safety door monitoring

Necessary components:

1 x KL1904
1 x KL6904
1 x KL1404
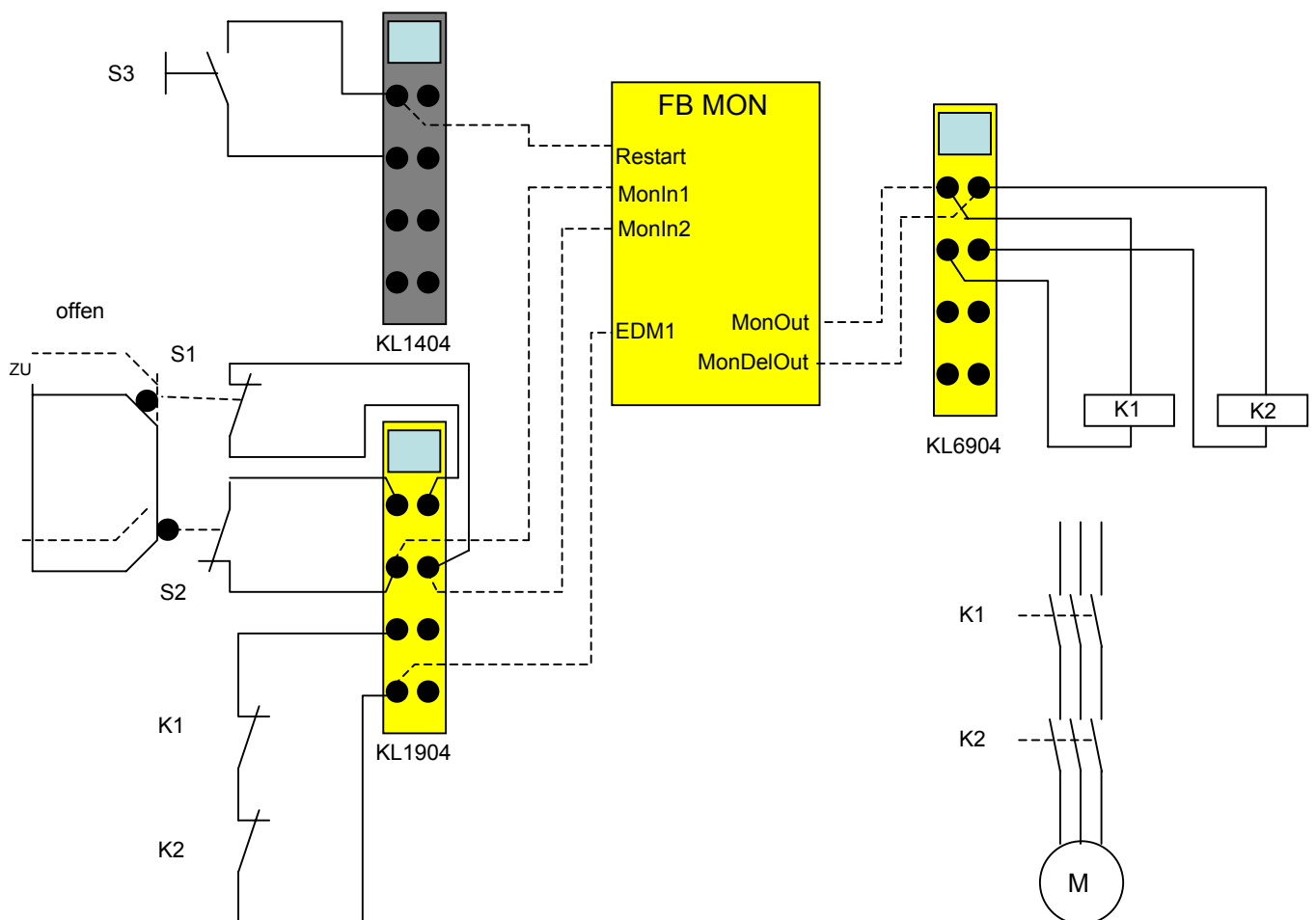2 x contactor with forced signal contact (e.g. Siemens Sirius)

1 x FB MON

Function:

The MonOut and MonDelOut outputs are in "0" state after switching on. The MonOut and MonDelOut are switched to "1", only when the MonIn1, MonIn2 and EDM1 inputs are at the "1" state (switches S1 and S2 closed) and the S3 switch is pressed (at first rising and then falling edges on the restart input). The contactors K1 and K2 are activated. Opening the S1 and/or S2 safety door switch leads to a drop of contactors K1 and K2.

The sticking of contacts on contactors K1 and K2 is detected at the EDM1 input and prevents switching on of the block again.

The block reports this error by setting the output error to TRUE.

Figure 5-2: Machine with safety door monitoring

5.3 Distributed systems

Necessary components:

2 x KL6904
2 x KL1904
2 x CX1000
2 x contactor with forced signal contact (e.g. Siemens Sirius)

2 x FB ESTOP
2 x FB DECOUPLE

Function:

The system consists of 2 independent systems similar to that described in application 1 (see chapter 5). Both systems should communicate over Ethernet in this case RT Ethernet and transfer the local emergency stop status. The safe output on both CX systems should be switched on, only when the safe state has not been requested by both systems. Both systems should switch off the output once the safe state has been requested on one of the systems.

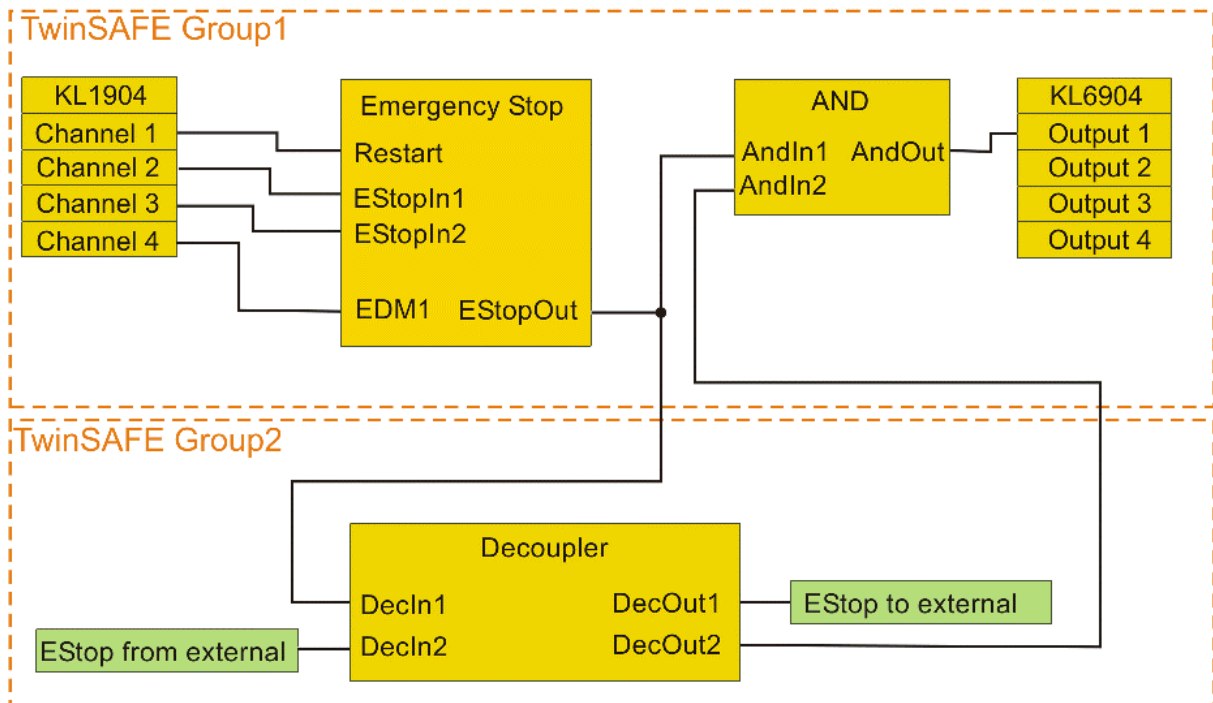Likewise the safe state should be taken up, in case of a communication error between the systems.

**Figure 5-3: Networked application**
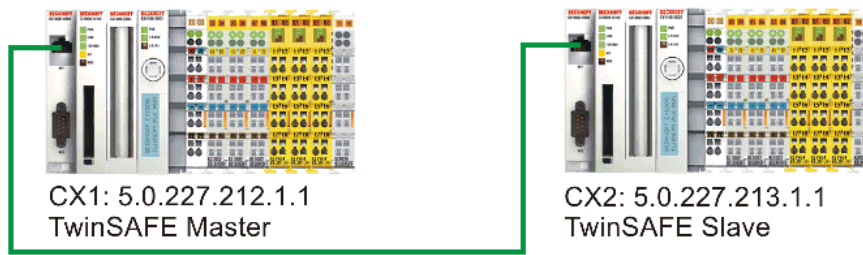
The configuration exchange of the necessary network variables between the TwinSAFE telegram between the CX systems is clearly shown in the following sample graph.

Once a publisher MASTER_MESSAGE and a subscriber SLAVE_MESSAGE network variable has been established on the CX, which will become a TwinSAFE Master, then it is possible to create a TwinSAFE connection, which uses the installed network variables to exchange the TwinSAFE telegram.

A network variable must be installed on both the publisher SLAVE_MESSAGE and subscriber MASTER_MESSAGE, on the CX that will become the TwinSAFE Slave. The "TwinSAFE Slave" option must be selected when creating the TwinSAFE connection and the installed network variables should be selectable.

**Figure 5-4: Creating a connection**
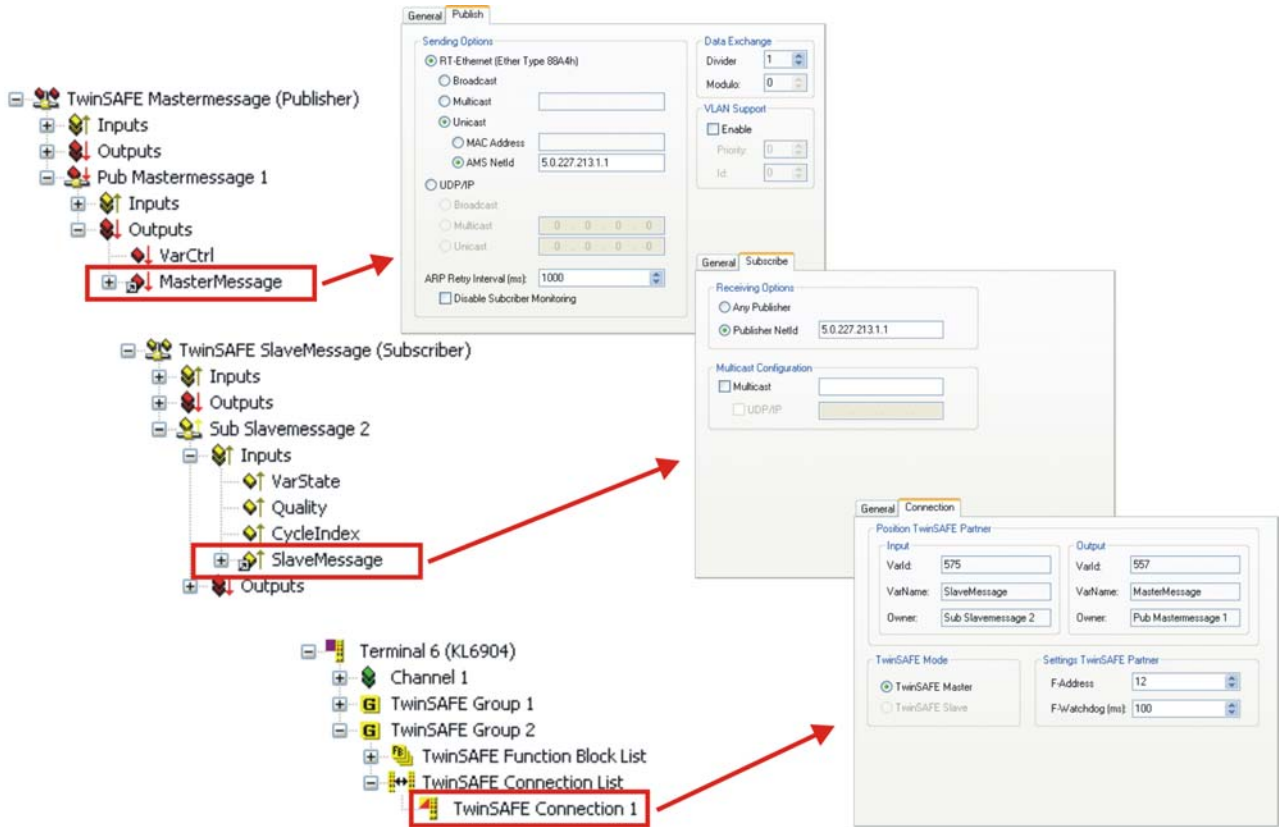
The 8 TwinSAFE channels available in each data direction can be accessed directly from the TwinSAFE configuration, once the connection is added. The signals are displayed as "TwinSAFE Input" or "TwinSAFE Output" in the selection diagram according to the following screen extract.

Figure 5-5: Use of TwinSAFE signals
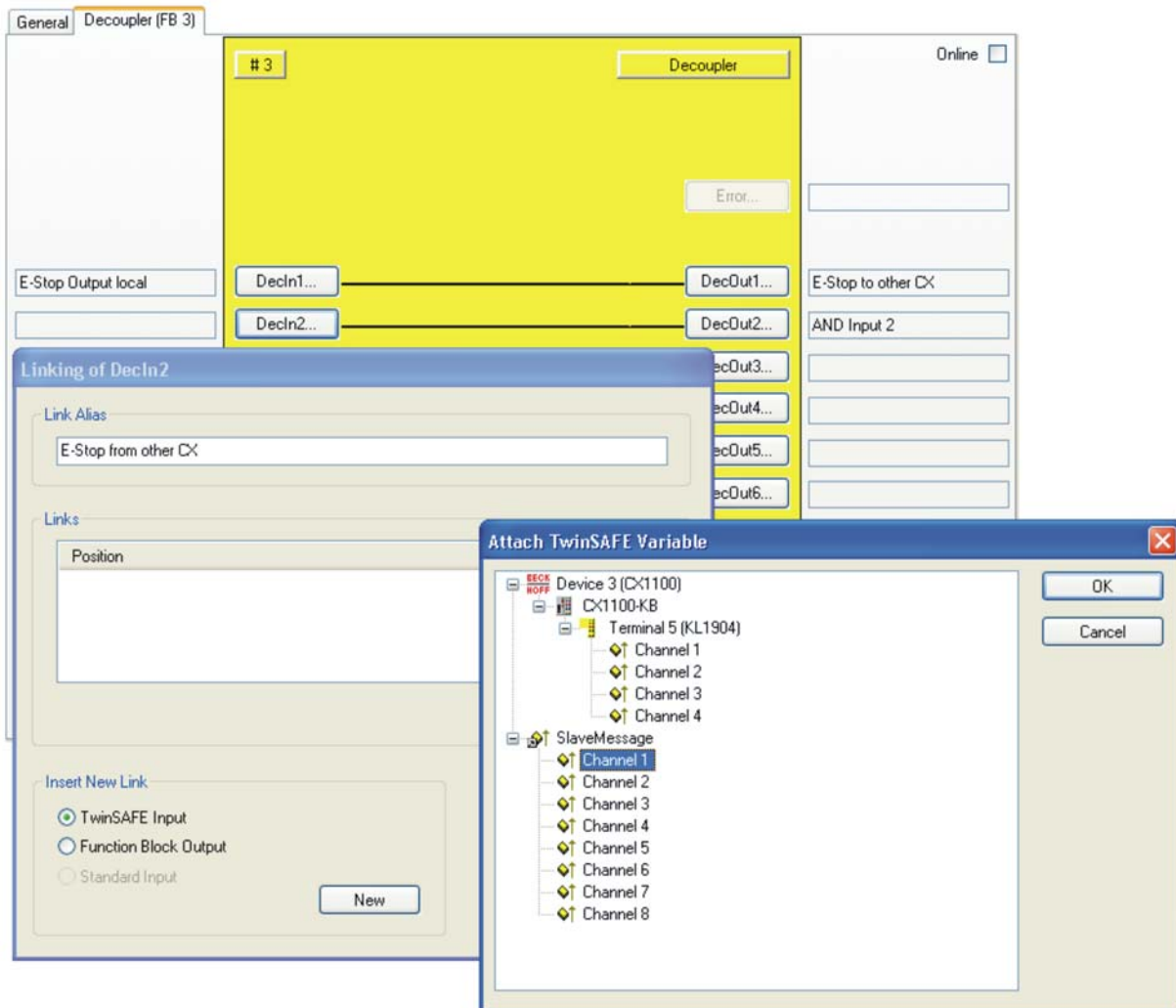
The connection state can be checked online, once the TwinSAFE configuration has been loaded on the logic terminal and the TwinCAT project has been started.

Figure 5-6: Connection online
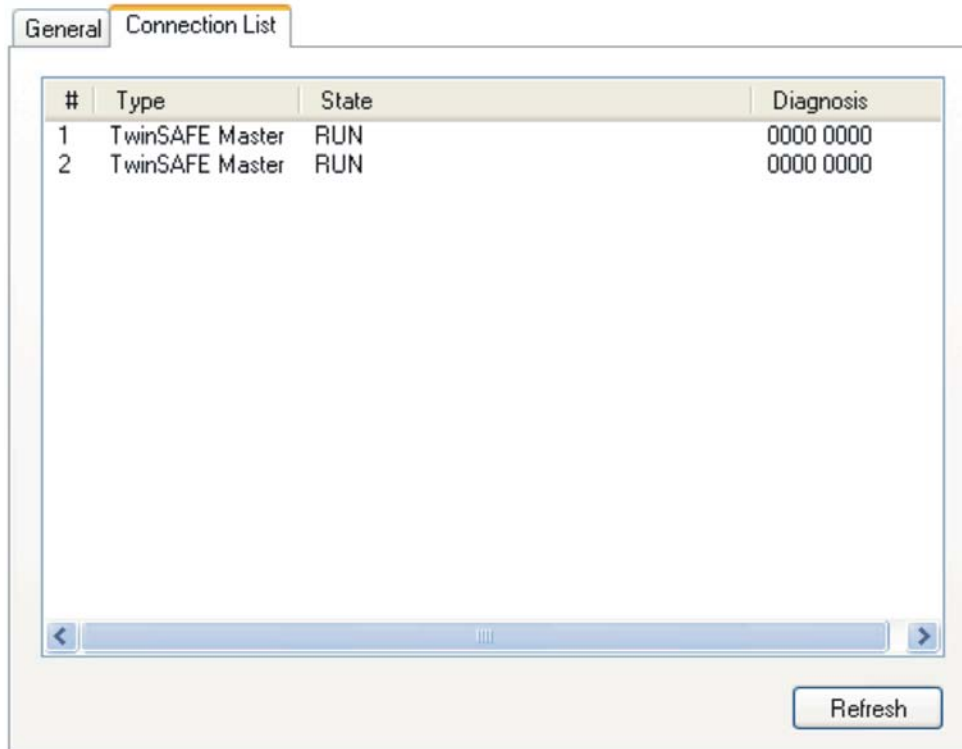
6 Appendix

6.1 Beckhoff Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

Beckhoff Support and Service is available to you wherever you are in the world, and can be reached by telephone, fax or e-mail. The contact addresses for your country may be found in the list of Beckhoff branches and partner firms.

6.1.1 Beckhoff Support

Support offers you comprehensive technical assistance, helping you no only with the application of individual Beckhoff products, but also with other, wide-ranging services:

- world-wide support
- design, programming and commissioning of complex automation systems
- and extensive training program for Beckhoff system components

Hotline: + 49 (0) 5246/963-157
Fax: + 49 (0) 5246/963-9157
e-mail: support@beckhoff.com

6.1.2 Beckhoff Service

The Beckhoff Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

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