Virtual Commissioning

Transfer system TS2

Requirement Specification

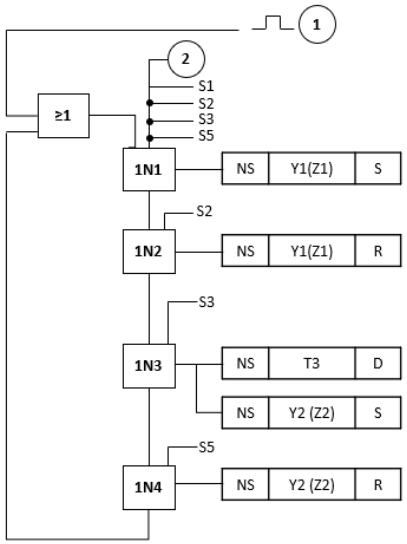
Development of TS2 Library

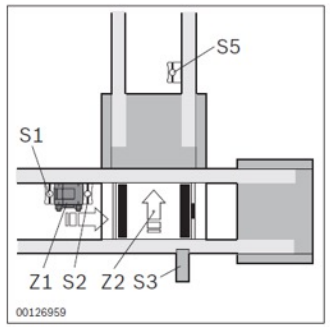
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU:

1. TFE1: Implementation in transverse section





S2 = WT after VE1 (Z1)
S3 = WT in position on HQ (Z2) (rocker WI/M)
T3 = Delaying time 100 ... 200 ms
S5 = Enable main section 1
Y1 = Main section VE (Z1)
Y2 = Lifting cylinder HQ (Z2)
See also explanation on page 10-7

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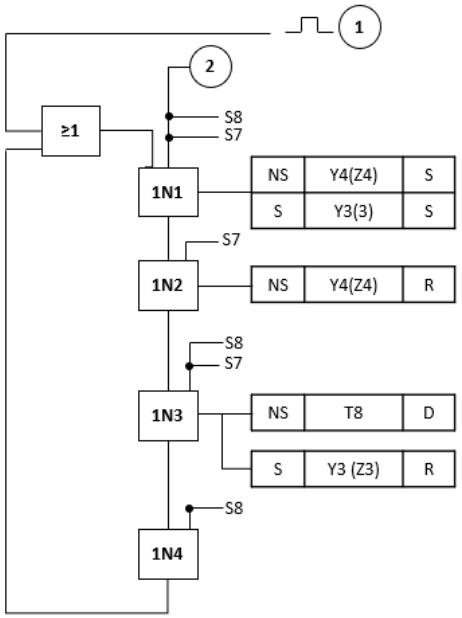
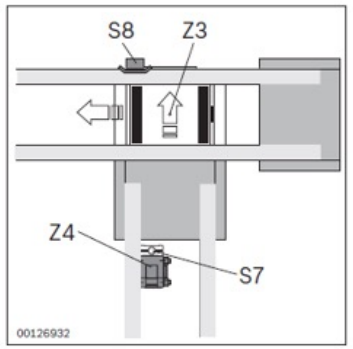
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU:

2. TFE2: Implementation in longitudinal section





S7 = WT after VE4 (Z4)
S8 = WT in position on HQ (rocker WI/M)
T8 = Delaying time 100 ... 200 ms
Y3 = EQ lifting cylinder (Z3)
Y4 = Secondary section VE (Z4)
See also explanation on page 10-7

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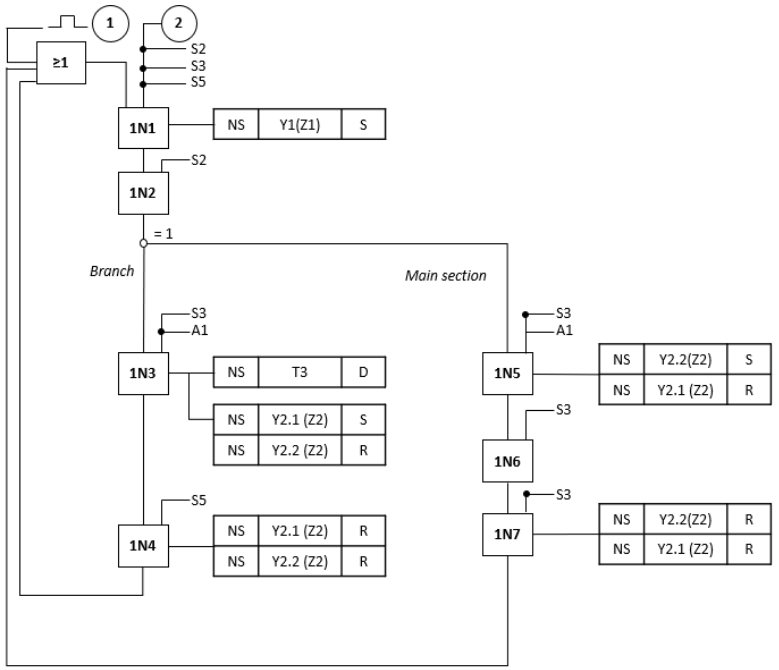
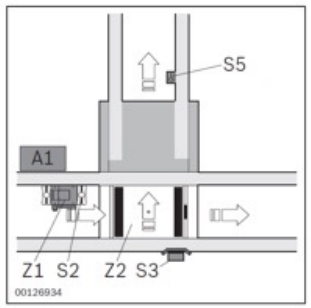
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU:

3. TFE3: Transverse conveyor (separating, outfeeding)





S2 = WT after VE1 (Z1)
S3 = WT in position on HQ
T3 = Delaying time 100 ... 200 ms
S5 = Enable secondary section
Y1 = Main section VE (Z1)
Y2 = Lifting cylinder HQ (Z2)
P10 = Priority main section
A1 = Identification system with straight-ahead signal
(0 = branch
1 = straight on)

Y2.1 S, Y2.2 R = Lift is UP
Y2.2 S, Y2.1 R = Lift is DOWN
Y2.1 AND Y2.2 Reset = Lift is in MIDDLE position

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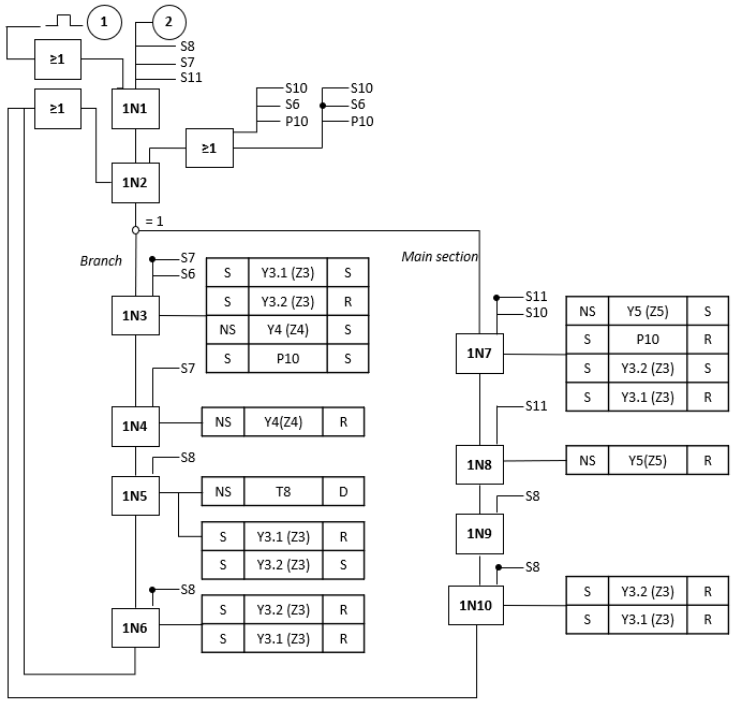
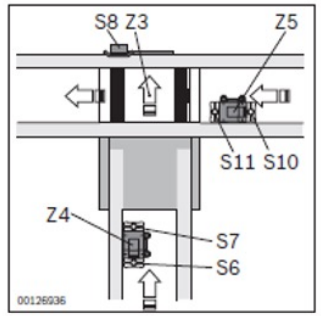
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU:

4. TFE4: Transverse conveyor (separating, infeeding)





T8 = Delaying time 100 ... 200 ms
S6 = WT before VE4 (Z4)
S7 = WT after VE4 (enable secondary section)
S8 = WT in position on HQ (rocker WI/M)
S10 = WT before VE5 (Z5)
S11 = WT after VE5 (Z5)
Y3 = Lifting cylinder HQ (Z3)
Y4 = Secondary section VE (Z4)
Y5 = Main section VE (Z5)
Y6 = VE in EQ (Z6)
P10 = Priority main section
See also explanation on page 10-7

Y3.1 S, Y3.2 R = Lift is UP
Y3.2 S, Y3.1 R = Lift is DOWN
Y3.1 AND Y3.2 Reset = Lift is in MIDDLE position

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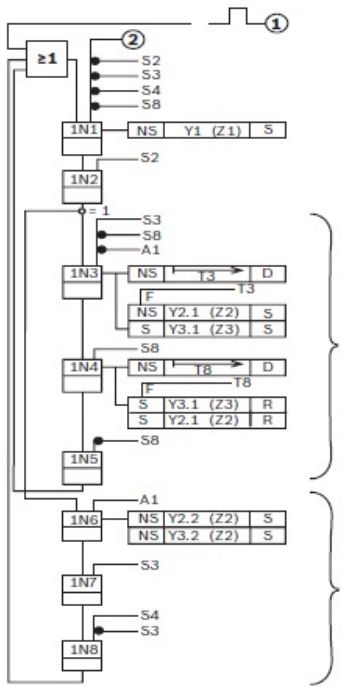
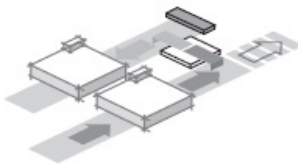
Requirement Specification

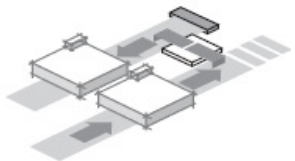
Evaluation TFE Product Catalogue > *Which TFEs exist?*

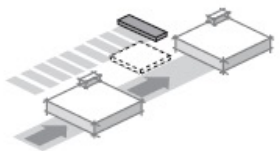
- Function Plans for TS2 LTU:

5. TFE5: Transverse conveyor EQ 2/TR (separating, outfeeding)

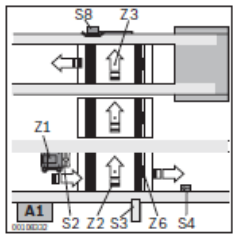








TFE2



TFE3

S1 = WT in position at VE1 (Z1)
S2 = WT after VE1 (Z1)
S3 = WT in position on EQ Part 1
T3 = Switch-on delay 100 ... 200 ms
T8 = Switch-on delay 100 ... 200 ms
S4 = Enable main section 1

S6 = WT before VE4 (Z4)
S7 = WT after VE4
S8 = WT on EQ Part 2 (rocker WI/M)
Y1 = Main section VE (Z1)
Y2.1/2.2 = Lifting cylinder EQ (Z2)
Y3.1/3.2 = EQ lifting cylinder (Z3)
A1 = Straight-ahead signal
(0 = branch
1 = straight on)

See also explanation on page 10-7

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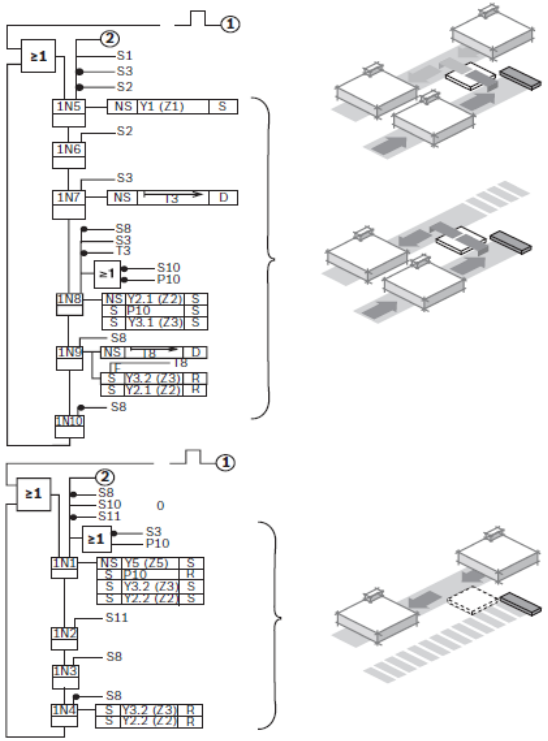
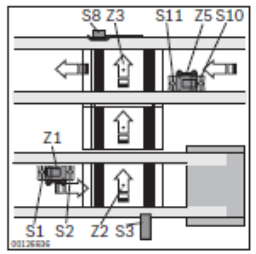
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU:

6. TFE6: Transverse conveyor EQ 2/TR (separating, infeeding)





TFE4

TFE1

S1	=	WT in position at VE1 (Z1)
S2	=	WT after VE1 (Z1)
S3	=	WT in position on EQ Part 1
T3	=	Switch-on delay 100 ... 200 ms
T8	=	Switch-on delay 100 ... 200 ms
S8	=	WT on EQ-part 2

See also explanation on page 10-7

S11=	WT after VE5 (Z5)
Y1=	Main section VE (Z1)
Y2.1/2.2=	Lifting cylinder EQ (Z2)
Y3.1/3.2=	EQ lifting cylinder (Z3)
Y5=	Main section VE (Z5)
P10=	Priority

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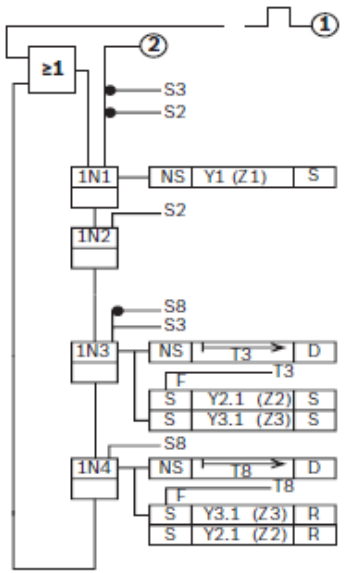
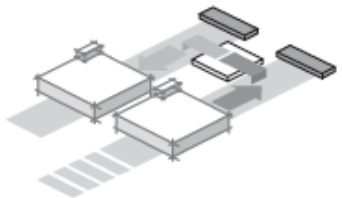
Requirement Specification

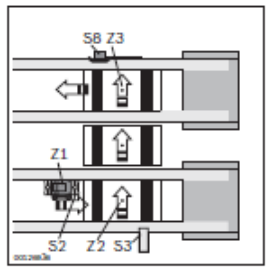
Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU:

7. TFE7: Transverse conveyor EQ 2/TR (transfer) (TFE 7)







S1 = WT in position at VE1 (Z1)
S2 = WT after VE1 (Z1)
S3 = WT in position on EQ Part 1
T3 = Switch-on delay 100 ... 200 ms
T8 = Switch-on delay 100 ... 200 ms
S8 = WT on EQ-part 2
Enable main section 1 (rocker WI/M)
Y1 = Main section VE (Z1)
Y2.1/2.2 = Lifting cylinder EQ (Z2)
Y3.1/3.2 = EQ lifting cylinder (Z3)
See also explanation on page 10-7

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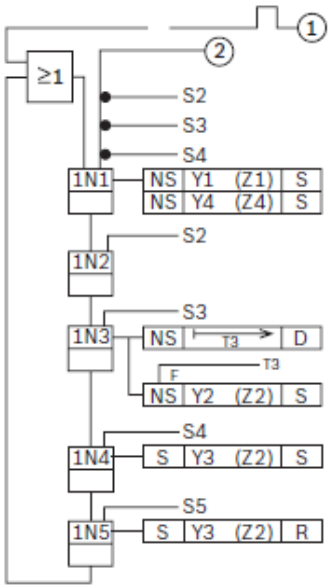
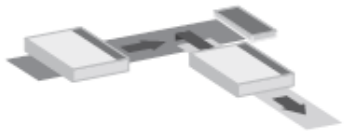
Requirement Specification

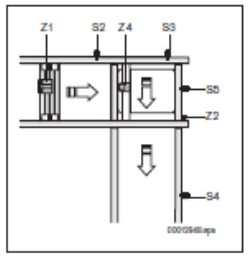
Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU (*HQ 2/C-H, HQ 2/G-H*):

1. TFE1: Implementation in transverse section







① = Start pulse after end of start-up
② = Enable cyclic travel
S2 = WT after VE2
S3 = WT in position on HQ 2
S4 = Enable secondary section, HQ 2 free
S5 = HQ 2 in the lower position
Y1 = Main section VE 2 (Z1)
Y2 = HQ 2 up (Z2)
Y3 = HQ 2 down (Z2)
Y4 = Extend damper DA 2 (Z4), stop position
Notice:
- Central position of HQ 2 is centered by springs (without pressurization)
- Distance Z1–Z3 IWT +200 mm

See also explanation on page 10-7

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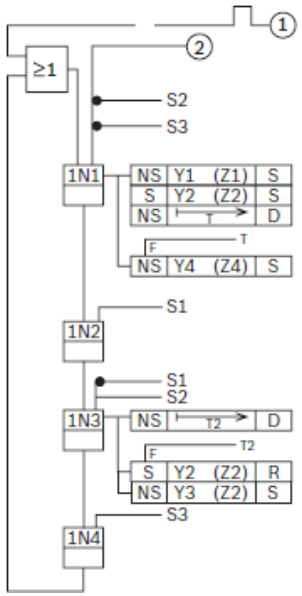
Development of TS2 Library

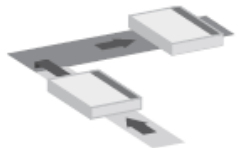
Requirement Specification

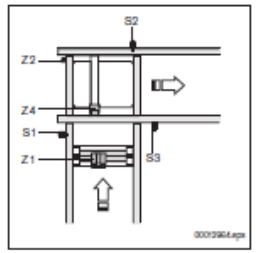
Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU (*HQ 2/C-H, HQ 2/G-H*):

2. TFE2: Implementation in longitudinal section







① = Start pulse
② = Enable cyclic travel
S1 = WT after VE 2
S2 = WT in position on HQ 2
S3 = Enable main section, HQ 2 free
Y1 = VE 2 secondary section (Z1)
Y2 = HQ 2 up (Z2)
Y3 = HQ 2 down
Y4 = Extend DA 2 damper
Notice: Distance Z1–Z3 bWT +200 mm
See also explanation on page 10-7

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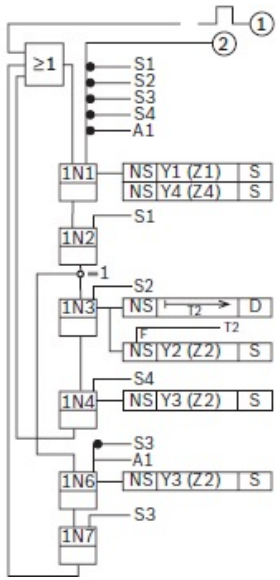
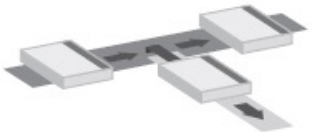
Requirement Specification

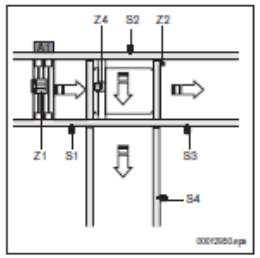
Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU (*HQ 2/C-H, HQ 2/G-H*):

3. TFE3: Outfeeding from longitudinal conveyor







①	=	Start pulse
②	=	Enable cyclic travel
S1	=	WT after VE4
S2	=	WT in position on HQ 2
S4	=	Enable secondary section, HQ 2 free
S3	=	Enable main section, HQ 2 free
Y1	=	Main section VE 2 (Z1)
Y2	=	HQ 2 up (Z2)
Y3	=	HQ 2 down (Z2)
Y4	=	Extend DA 2 damper
A1	=	Straight-ahead signal

Notice:
- Central position (WT 2 stop position) of HQ 2 is centered by springs (without pressurization)
- Distance Z1–Z3 IWT +200 mm
- Distance S2–S3 = min. 200 mm

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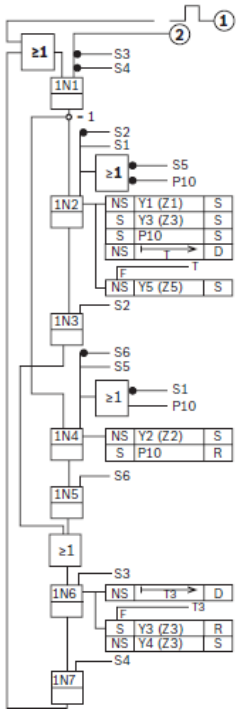
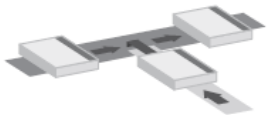
Requirement Specification

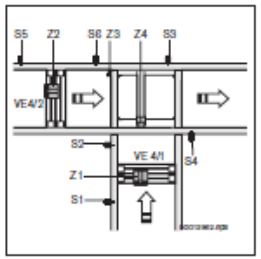
Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 LTU (*HQ 2/C-H, HQ 2/G-H*):

4. TFE4: Infeeding to longitudinal conveyor







①	=	Start pulse after end of start-up	S6	=	WT after VE 2
②	=	Enable cyclic travel	Y1	=	VE 2 secondary section (Z1)
S1	=	WT before VE 2	Y2	=	VE 2 secondary section (Z2)
S2	=	WT after VE 2	Y3	=	HQ 2 up (Z3)
S3	=	WT in position on HQ 4	Y4	=	HQ 2 down
S4	=	WT after HQ 4	Y5	=	Extend DA 2 damper (Z4)
S5	=	WT before VE 2	P10	=	Priority

See also explanation on page 10-7

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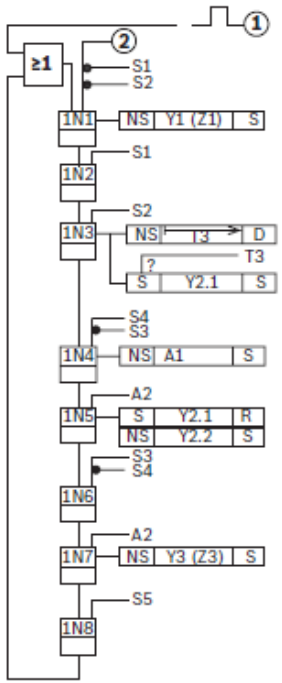
Development of TS2 Library

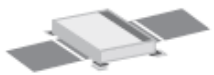
Requirement Specification

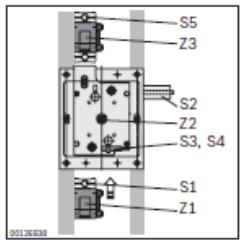
Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 Position Unit:

1. Conveyor function unit PE







S1 = WT after VE1
S2 = WT arrival
S3 = Bottom end position of lift
S4 = Top end position of lift
S5 = WT after VE2
Y1 = Open VE1 (Z1)
Y2 = WT lift
Y3 = Open VE (Z3)
A1 = Start process
A2 = Process ended

See also explanation on page 10-7

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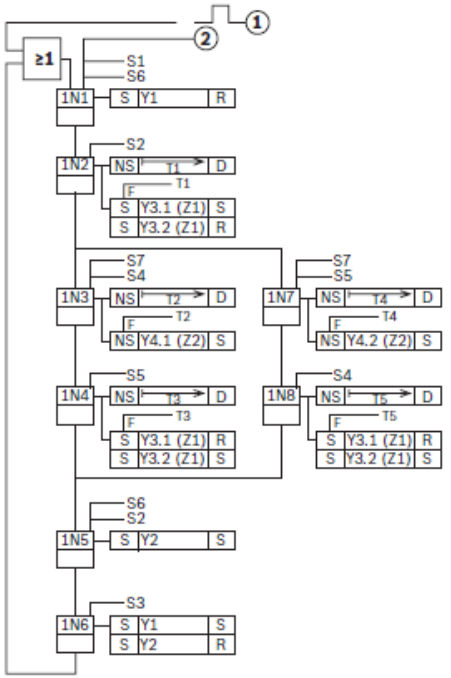
Development of TS2 Library

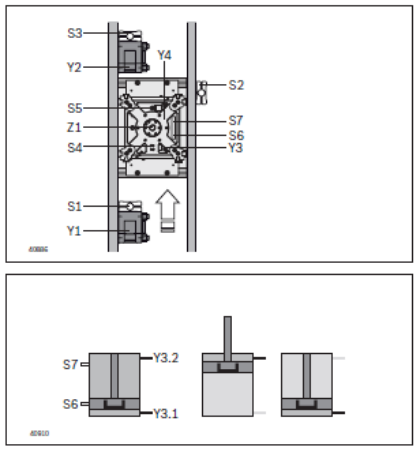
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 Lift Rotate Unit:

1. Function plan HD 2/H (BG1, BG2, BG3), ROTATION ANGLE 180°





S1 = WT after VE1
S2 = WT in position on HD
S3 = WT after VE2
S4 = Scanning 0° position rotation
S5 = Scanning 180° position rotation
S6 = Query lower limit position HD
S7 = Query upper limit position HD
Y1 = Pre-stop gate
Y2 = Main stop gate
Y3.1 (Z1) = Lifting cylinder moves to upper position
Y3.2 (Z1) = Lifting cylinder moves to lower position
Y4.1 (Z2) = Rotary cylinder rotates clockwise
Y4.2 (Z2) = Rotary cylinder rotates anticlockwise
See also explanation on page 10-7

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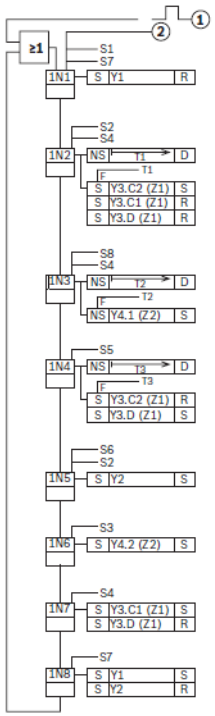
Development of TS2 Library

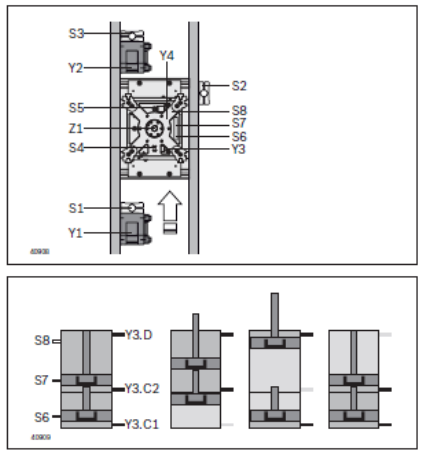
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 Lift Rotate Unit:

2. Function plan HD 2/H (BG1, BG2), ROTATION ANGLE 90° (NOT TIME-OPTIMIZED)





S1	=	WT after VE1
S2	=	WT in position on HD
S3	=	WT after VE2
S4	=	Scanning 0° position rotation
S5	=	Query 90° position rotation
S6	=	Query lower limit position HD
S7	=	Query central end position HD
S8	=	Query upper limit position HD
Y1	=	Pre-stop gate
Y2	=	Main stop gate
Y3.D (Z1)	=	Lifting cylinder moves to lower position
Y3.C2 (Z1)	=	Lifting cylinder moves to central position
Y3.C1 (Z1)	=	Lifting cylinder moves to upper position
Y4.1 (Z2)	=	Rotary cylinder rotates clockwise
Y4.2 (Z2)	=	Rotary cylinder rotates anticlockwise

See also explanation on page 10-7

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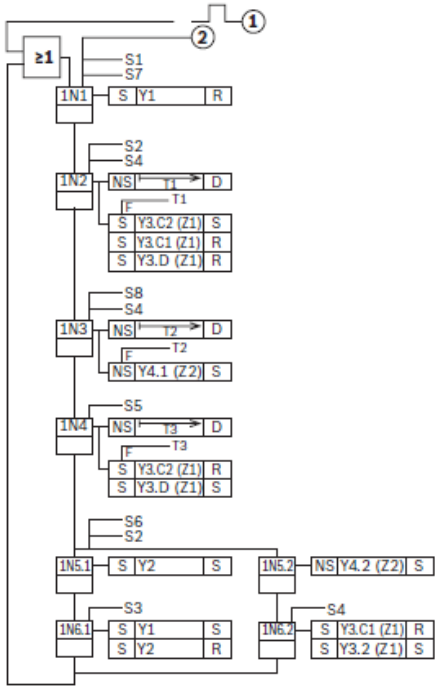
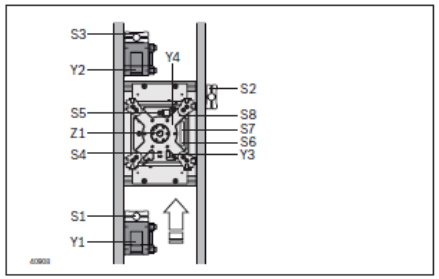
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 Lift Rotate Unit:

3. Function plan HD 2/H (BG1, BG2), ROTATION ANGLE 90° (TIME-OPTIMIZED)





S1	=	WT after VE1
S2	=	WT in position on HD
S3	=	WT after VE2
S4	=	Scanning 0° position rotation
S5	=	Query 90° position rotation
S6	=	Query lower limit position HD
S7	=	Query central end position HD
S8	=	Query upper limit position HD
Y1	=	Pre-stop gate
Y2	=	Main stop gate
Y3.D (Z1)	=	Lifting cylinder moves to lower position
Y3.C2 (Z1)	=	Lifting cylinder moves to central position
Y3.C1 (Z1)	=	Lifting cylinder moves to upper position
Y4.1 (Z2)	=	Rotary cylinder rotates clockwise
Y4.2 (Z2)	=	Rotary cylinder rotates anticlockwise

See also explanation on page 10-7

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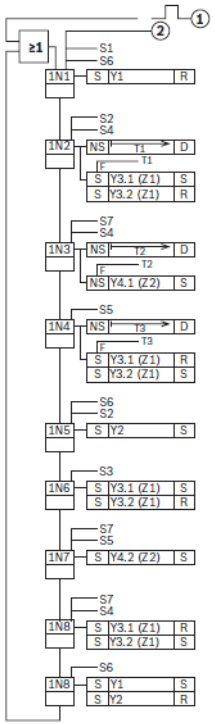
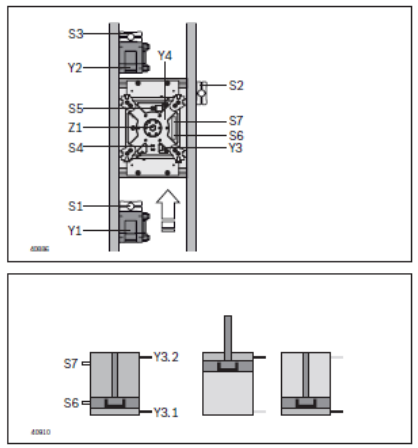
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 Lift Rotate Unit:

4. Function plan HD 2/H (BG3), ROTATION ANGLE 90°





S1	=	WT after VE1
S2	=	WT in position on HD
S3	=	WT after VE2
S4	=	Scanning 0° position rotation
S5	=	Query 90° position rotation
S6	=	Query lower limit position HD
S7	=	Query upper limit position HD
Y1	=	Pre-stop gate
Y2	=	Main stop gate
Y3.1 (Z1)	=	Lifting cylinder moves to upper position
Y3.2 (Z1)	=	Lifting cylinder moves to lower position
Y4.1 (Z2)	=	Rotary cylinder rotates clockwise
Y4.2 (Z2)	=	Rotary cylinder rotates anticlockwise

See also explanation on page 10-7

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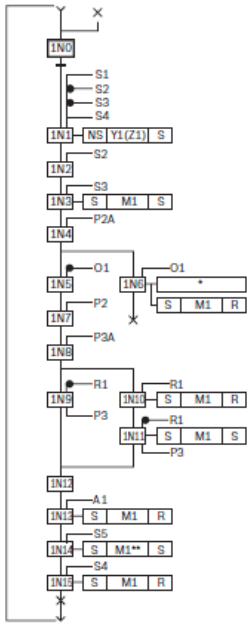
Development of TS2 Library

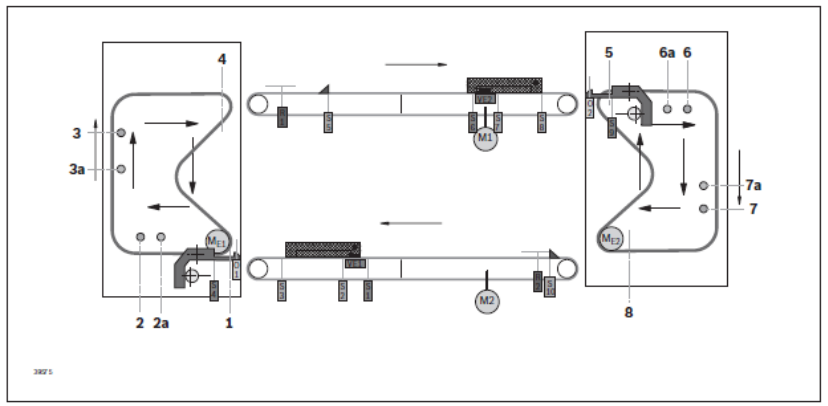
Requirement Specification

Evaluation TFE Product Catalogue > *Which TFEs exist?*

- Function Plans for TS2 Elevator EL2:

1. Lift EL 2 (infeeding + outfeeding)





1 *Infeeding*
2 When 01 = on, stop
2a Check 01
3 When R1 = on, stop
3a Check R1
4 Outfeeding
5 *Infeeding*
6 When 02 = on, stop
6a Check 02
7 When R2 = on, stop
7a Check R2
8 Outfeeding

① = Start pulse after end of start-up
② = Enable cyclic travel
S1 = WT before VE 1
S2 = WT after VE 1
S3 = WT on gripper arm
S4 = Gripper arm zero point
Y1 = VE 1 (Z1) main section
M1 = Servomotor
O1 = Optical sensor
P2A = WT at control point before vertical motion
P2 = WT at hold point before vertical motion
P3A = WT at control point before horizontal motion
P3 = WT at hold point before horizontal motion
R1 = Drain area occupied (rocker actuated)
S5 = WT has left the lift completely, start return
A1 = Position mode, steps reached

*) Malfunction
**) C-shape, reverse
See also explanation on page 10-7

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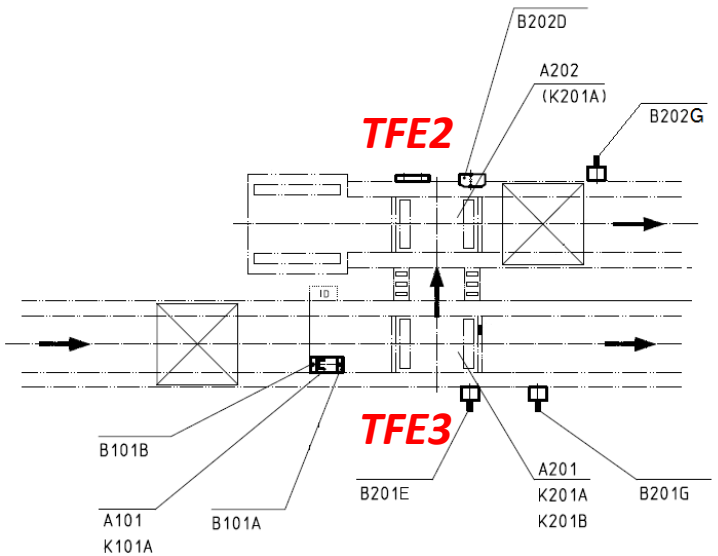
Development of TS2 Library

Requirement Specification

Evaluation TFE Product Catalogue > *Which ones are missing and must be covered?*

- Additional TFEs for TS2 LTU :

1. 



Combination of:

- TFE3 and
- TFE2 (w/o entry SG)

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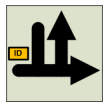
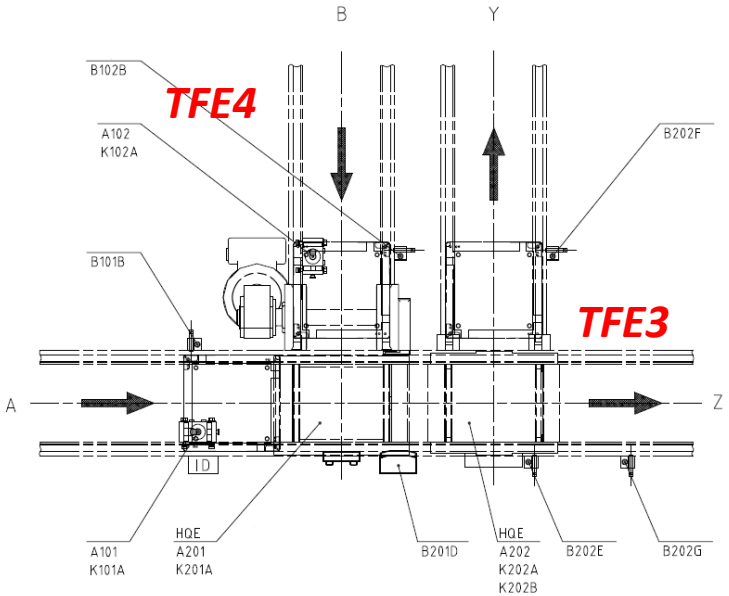
Requirement Specification

Evaluation TFE Product Catalogue > *Which ones are missing and must be covered?*

- Additional TFEs for TS2 LTU :

2. 



Combination of:

- TFE4 and
- TFE3 (w/o entry SG)

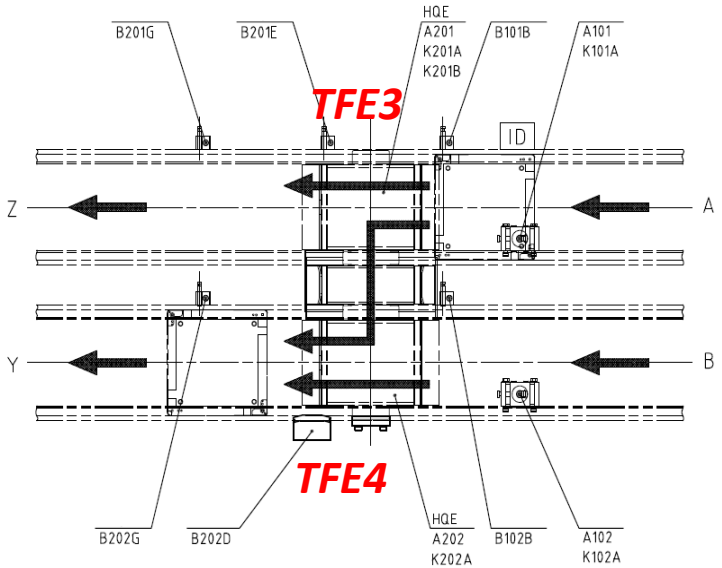
Development of TS2 Library

Requirement Specification

Evaluation TFE Product Catalogue > *Which ones are missing and must be covered?*

- Additional TFEs for TS2 LTU :

3. 



Combination of:

- TFE4 (w/o branch entry SG) and
- TFE3 (w/o branch exit Sensor)

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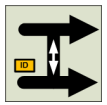
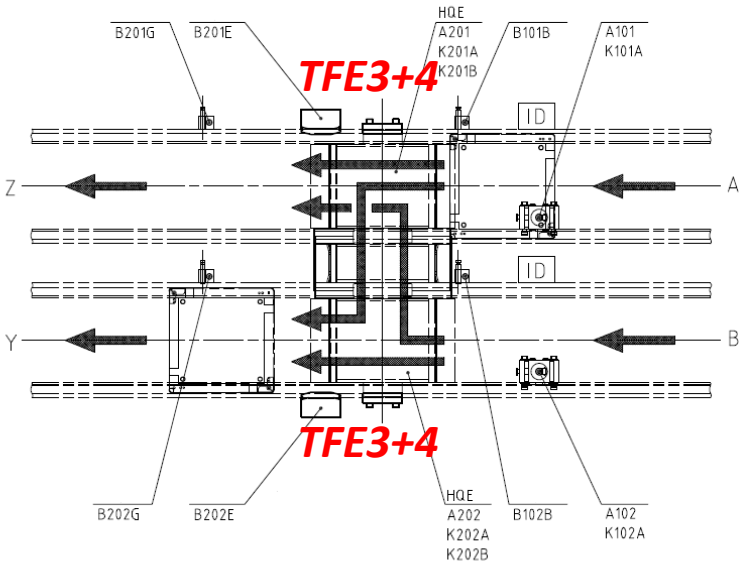
Requirement Specification

Evaluation TFE Product Catalogue > *Which ones are missing and must be covered?*

- Additional TFEs for TS2 LTU :

4. 



- A bit more complex and might need a separate TFE.

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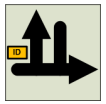
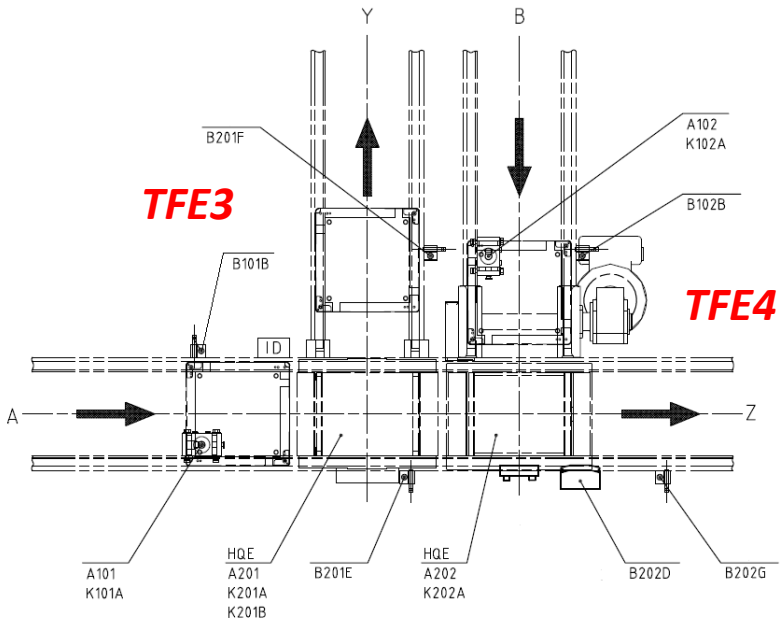
Requirement Specification

Evaluation TFE Product Catalogue > *Which ones are missing and must be covered?*

- Additional TFEs for TS2 LTU :

5. 



Combination of:

- TFE4 (w/o entry SG) and
- TFE3

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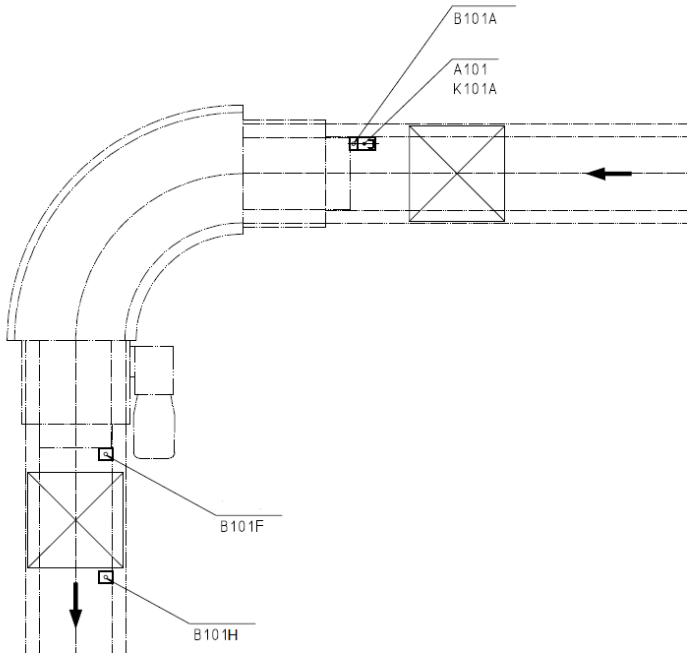
Requirement Specification

Evaluation TFE Product Catalogue > *Which ones are missing and must be covered?*

- Additional TFEs for TS2 :

1. 



Capacity based control

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Development of TS2 Library

Requirement Specification

Evaluation TFE Product Catalogue > *Which ones are missing and must be covered?*

Summary:

Except for the node involving TFE 3+4  er additional TFEs listed before can be implemented using existing basic four TFEs for the LTU.

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Development of TS2 Library

Requirement Specification

- **Functional Requirements Simulation Objects**

  >Which simulation objects are necessary?

  >Which ones are missing in the existing simulation library in Visual Components?

  All components of TS2 system library are tabulated and missing simulation components are listed down *(see Table: TS2 Components)*

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Development of TS2 Library

Requirement Specification

Component	Variant	Function plan available in product catalogue?	Simulation Object Available?	Comments
Lift Transverse Unit	HQ 2/T	Yes	Yes	
	HQ 2/S	Yes	Yes	
	HQ 2/O	Yes	Yes	
	HQ 2/U-U2	Yes	Yes	
	HQ 2/U-H	Yes	Yes	
	HQ 2/C-H	Yes	Yes	• Use of stop gate object VE 2/D100 or VE 2/D250 or VE 2/D410, and Damper in Function plan (Components missing) • Applicable for widths > 400mm • Material flow to be confirmed. (If sequence of flow is same, no change required to existing component).
	HQ 2/G-H	Yes	Yes	• The above applies here as well.
Stop Gate	VE 2	NA	Yes	• Do we need additional SG as mentioned above?
Switch Bracket	SH 2	NA	Yes	
Slide Stop	VA 2	NA	No	
Scraper		NA	No	
Rocker	WI 2	NA	No	
Damper	DA 2	NA	No	
Electrical Transverse Conveyor	EQ 2/TR	Yes	No	• Can be realised using existing LTU and belt section. • Corresponding function plans can be modelled using existing TFEs.
	EQ 2/TR-90	No	No	
	EQ 2/T	No	No	
	EQ 2/TE	No	No	
Position Unit	PE	Yes	Yes	• Signal evaluation required
	HP	Yes	Yes	• Signal evaluation required
Elevator	EL 2	Yes	Yes	• Signal evaluation required
Lift Rotate Unit	HD	No	Yes	• Signal evaluation required
	HD2/H	Yes	Yes	• Signal evaluation required
Rotate Unit	DE 2	No	Yes	• Signal evaluation required
Belt Section	BS 2	NA	Yes	
Conveyor unit	AS 2/	NA	Yes	
Curve 2/90	CU 2/90	NA	Yes	
Curve 2/180	CU 2/180	NA	Yes	
Legset	SZ 2	NA	Yes	

Table 1 : TS2 Components and availability of simulation object/function plans

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Development of TS2 Library

Requirement Specification

Sl.No	Functional Requirements Simulation Objects
1	The following list of TS2 components should be available as simulation objects in Visual Components: • Lift transverse unit • Stop gate • Switch bracket • Position Unit • Elevator • Lift rotate unit • Rotate unit • Belt Section • Conveyor unit • Curves Detailed list of available components are in "List of TS2 Components".
2	The simulation objects should have behavior and signals as described in product catalogue.
3	The following objects should be modified(properties,signals,functionality,python code): • Lift transverse unit • Stop gate • Position Unit • Elevator • Lift rotate unit • Rotate unit Detailed description of modification required described in "List of to be modified Sim Obj".

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Requirement Specification

- **Functional Requirements Simulation Objects**

  > Which objects must be modified (properties, signals, functionality, Python code, ...)?

Simulation Object	Modifications Required
Lift transverse unit	• Addition of 3 lift states (Up,Down,Middle) and corresponding moveLift signals. • Implementation of grabbing WPC with liftContainer to move WPC along with the lift. • Behaviour implementation: WPC moves forward only when lift is Down. • Behaviour implementation: WPC enters the LTU without manual trigger of powerOnRolls.
Stop gate	• Addition of missing signal to detect WPC after stopper.
Position Unit	• Addition of missing signals: S2-WPC at middle signal S3- LiftStateDown signal S4-LiftStateUp signal A1-Start process A2- Process ended • Additional signal control mode similar to LTU.
Elevator	• Addition of multiple missing signals.
Lift Rotate Unit	• Addition of multiple missing signals: S2-WPC in position(middle signal) S4-Scanning 0° position rotation S5-Scanning 180° position rotation S6-Lower limit state signal Central position state signal S7-Upper limit state signal MoveLiftUp signal MoveLiftDown signal MoveLiftCenter signal RotaryCylinder rotate CW RotaryCylinder rotate CCW
Rotate Unit	• Addition of multiple missing signals: MoveToPort1,MoveToPort2,MoveToPort3,MoveToPort4 signals

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Requirement Specification

- **Functional Requirements PLC Function Blocks**

  > How can TFEs be conceptually aggregated?

  >The target is a minimal amount of (configurable) function blocks, to each TFE can be realized by one of these function blocks.

  Which distribution and aggregation rules for configurable material flow controls must be defined?

  > Functional description of PLC function blocks

  - After careful evaluation, all the possible use cases for LTU routing were listed down (see previous slides) including existing basic ones from the product catalogue as well as special use cases and how these can possibly be realized using existing TFEs.
  - The aim is to realize most of these special use cases with the combination of these basic four TFEs namely TFE1,TFE2,TFE3 and TFE 4 with minimal changes in already implemented PLC function blocks.

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Development of TS2 Library

Requirement Specification

- **Functional Requirements PLC Function Blocks**

Sl.No	Functional Requirements PLC Function Blocks
1	List of all function plans defined in the product catalogue should be made.
2	List of additional TFEs to realize components' special use cases that are not specified in product catalogue should be made.
3	PLC FBs defining existing function plans of TS2 components from the product catalogue should be developed.
4	The basic FBs should be configurable and complex TFEs shall be realized by these basic configurable FBs.
5	Standard distribution and aggregation rules shall be possible using the standard configurable FBs.(eg. Cyclic, Specific pattern, Capacity based etc.)
6	The FBs should have early evaluation of error handling.

Development of TS2 Library

Requirement Specification

- **Functional Specification Sheet**

  Which threats and risks analysis for the development might occur?

  - If these special use cases cannot be realized by using the basic configurable function blocks, individual FBs should be defined to realize each specific use case resulting in higher development effort.
  - Since simulation objects like Lift rotate unit, Rotate unit, Position unit, Lift elevator lacks the signals defined in the existing function plans, each object needs to be modified by adding these missing signals to make it VCOM ready.
  - Performance concern (possible communication delays) when realizing larger layouts.

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Development of TS2 Library

Requirement Specification

- **Functional Specification Sheet**
  Which simulation objects and function blocks with which properties and capabilities are necessary? > Summary of development effort, necessary capabilities, and project risks.

  - No additional simulation objects required*.
  - Additional FB might be required to realize complex LTU use case using two TFE 3+4.

  - Automating or reducing effort in variable mapping.
  - *Simulation side development effort*: Adding missing signals to objects - Lift rotate unit, Rotate unit, Position unit, Lift elevator. Modification if necessary to accommodate configurable FBs.
  - *PLC side development effort*: Modification to existing FBs so that it can be used in combination to realize special use cases, developing additional FBs for nodes that cannot be realized using the existing basic FBs.

*(*Only if EQ2 can be realized using LTU and belt section and HQ 2 C-H, HQ 2 G-H is not required, ie. no damper object required).*

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Development of TS2 Library

Requirement Specification

- **Functional Specification Sheet**
  Which threats and risks analysis for the development might occur?
  - Project Scope:
  - Overview:
  - Development Effort:
  - Capabilities:
  - Risks: