GÜDEL

Requirements to the

Lubrication Control of the FlexxPump 404DLS

Customer:	External, for information purposes only
Location:	GCH
Project / Order:	No
Serial number:	No

Original Manual

Abstract

This document describes the requirements to the lubrication control.

Document control

Version	Datum	Name	Beschreibung
V1.0	24.10.2017	martho	Document created
V1.2	23.11.2017	martho	First release
V1.3	16.01.2018	martho	Timing diagrams and times adapted, based on the right firmware document from TriboServ Different optimization and improvements of the function description (Fill / Normal Cycle) Included HMI sample with minimal and maximal implementation.
V1.4	06.02.2018	martho	Explanation of indicator time as an option. Optimization of the indicator descriptions. Included input value for counting up time depending on the axis motion HMI sample updated
V1.5	22.02.2018	martho	Included output signals from the indicators. 3 outputs for the axis distance and 1 output for the current cycle counter value and 1 output for the time that passed since the last lubrication cycle. HMI sample updated Flow chart replaced Improvements made to detail description
V1.6	06.07.2018	martho	Title picture exchanged Link for lubricant calculator included

Version	Datum	Name	Beschreibung
V1.7	07.02.2019	martho	Replace picture timing diagram Fig. 5

Tab. 1 Revision History

Content

1 Function block overview

The lubrication function can be divided into three main areas of functionality:

- Indicator handler for starting the lubrication cycle
- Pump control, lubrication cycle control
- Reaction / warning / error handling

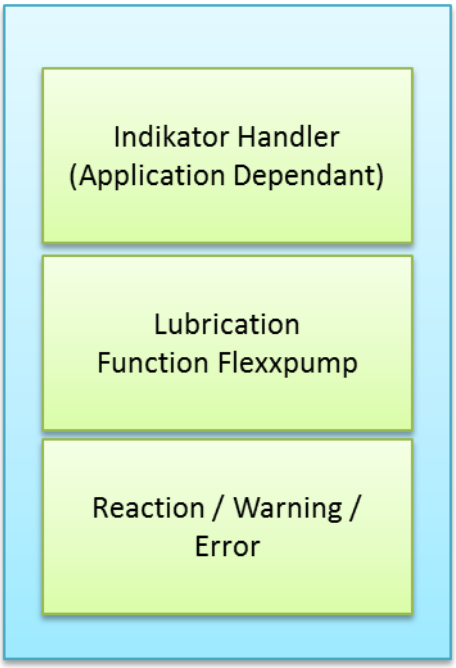
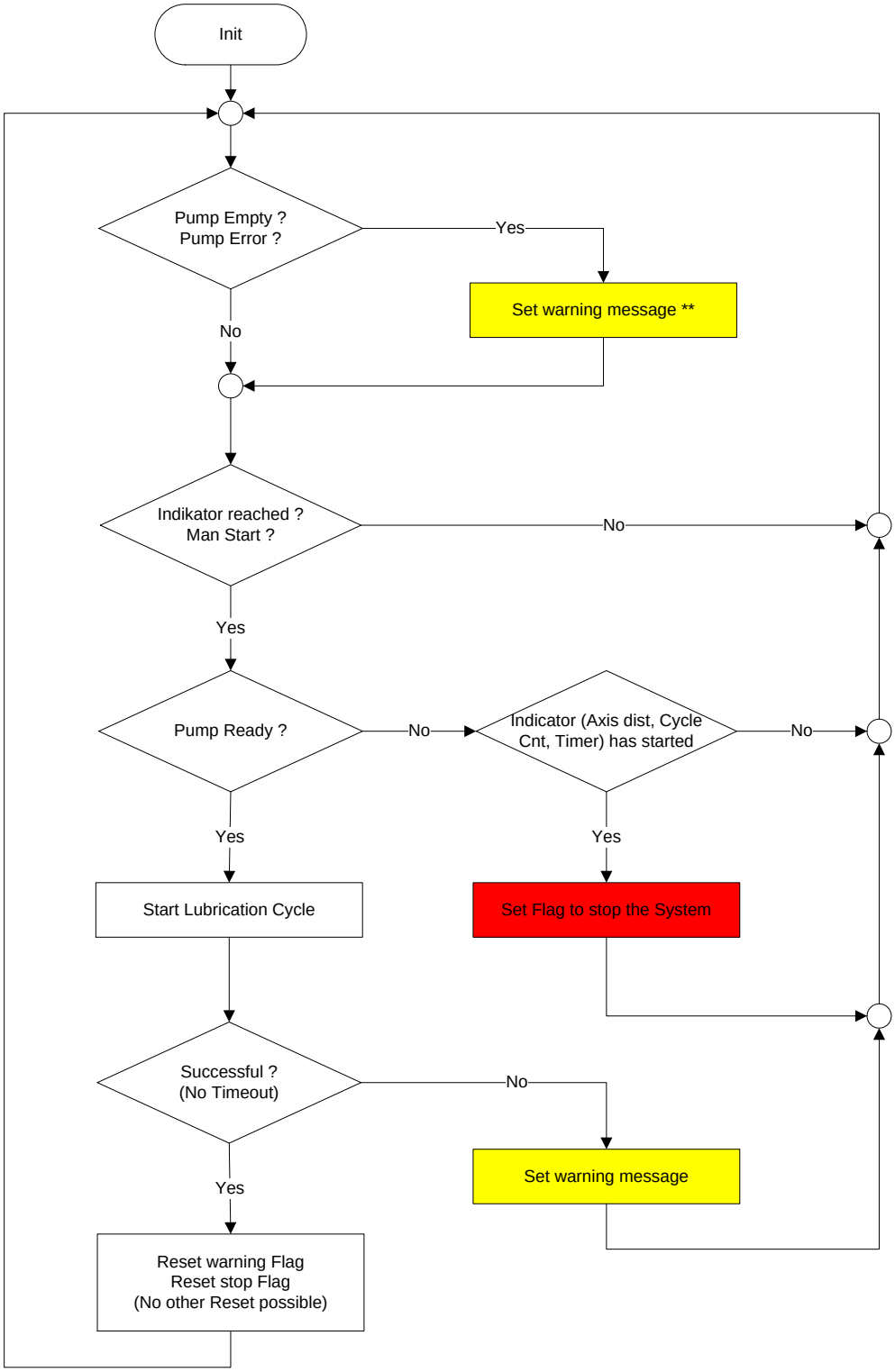


Fig. 1 Function block overview

1.1 Flow chart: Lubrication process



Pump Ready = No Error (5s Input) **AND** Not Empty **AND** Lubrication process not started

** Reset the corresponding warning message as soon as it is ok again

Fig. 2 Flow chart

2 Interface description: Function block

2.1 Inputs

Inputs	Description
bHW_Input	24 V DC hardware input feedback signal from the FlexxPump lubrication. The input signal has different meanings, depending on the signal frequency.
udiDistAxis_1	Accumulated axis distance of one of the axes in the system in [km]. It does not matter which axis it is. A value of 0 deactivates the influence of the axis.
udiDistAxis _2	Accumulated axis distance of one of the axes in the system in [km]. It does not matter which axis it is. A value of 0 deactivates the influence of the axis.
udiDistAxis _3	Accumulated axis distance of one of the axes in the system in [km]. It does not matter which axis it is. A Value of 0 deactivates the influence of the axis.
udiAxisDistForLub	If one of the axes accumulates this relative distance since the last lubrication cycle, the lubrication cycle will be started. Typically, this parameter value can be adjusted from the HMI. The engineering unit of the value is [km]
bCntAutoCyc	With a rising trigger, the internal automatic cycle counter will count up by 1.
udiAutoCycForLub	If the internal automatic cycle value reaches this value, the lubrication cycle will be started. Typically, this parameter value can be adjusted from the HMI.
bAxesInMotion	At least one axis is in motion. The value should be 'True' when there is no information about the axis movement
udiTimeForLub	If the internal timer reaches this value since the last lubrication cycle, the lubrication cycle will be started. Typically, this parameter value can be adjusted from the HMI. If the value is 0, the timer function is deactivated. Time unit [h]
bManStartForLub	A rising trigger will start the lubrication cycle / the lubrication cycles are dependent on the set number of cycles
udiNumOfLubCycle	Number of lubrication cycles. This value depends on the Güdel module (ZP/FP/EP/TMO/TMF) and will be defined in the Güdel lubrication calculator.

Inputs	Description
bManStartFillFnc	A rising trigger will start the lubrication fill function.
udiPreSetVolume	Currently estimated volume of the cartridge in [%]. Typically, the value is 100% and will be set to this volume after a cartridge has been exchanged.
bPreSetVolume	With a rising trigger, the current output volume will be set to the udiPreSetVolume value.
udiLevWarnVolume	Volume level for issuing a warning message. If the calculated output volume is less than this value. the output warning message will be set. This threshold value is in [%]. If the value is 0, no warning will be set.

Tab. 1 Input Desctiption

2.2 Outputs

Outputs	Description
bHW_Output	24 V DC hardware output to the pump. The signal has different meanings, depending on the signal frequency.
udiCurDistAxis_1	Current axis distance from axis 1 [km] since the last lubrication cycle
udiCurDistAxis_2	Current axis distance from Axis 2 [km] since the last lubrication cycle
udiCurDistAxis_3	Current axis distance from Axis 3 [km] since the last lubrication cycle
udiCurAutoCyc	Current auto cycle since the last lubrication cycle
udiCurTime	Current axis moving time [h] since the last lubrication cycle
bLubProcStarted	Status: Lubrication process is in progress. No other commands can be started.
bWarnMsgCmd	Warning message when the lubrication cycle was not successfull and failed during the sequence, or when there was a start while the lubrication cycle was in progress.
bWarnMsgEmtpy	Warning message when the lubricant is empty
bWarnMsgPump	Warning message when the pump state is not ok
bErrMsgStopReq	Error message with a stop request for the system. If this output is active, no axle motion is allowed till the lubrication cycle was successful again. If the axles are moved nevertheless, the mechanical system will be detroyed.
udiCurVolume	Current cartridge volume in [%] (optional)
bWarnMsgVolume	Warning message when the lubricant level is less than the defined threshold value

Tab. 2 Output description

3 Detailed description of functions

3.1 Indicator handler

If one of the following indicators has been triggered, the lubrication cycle will start if the pump is ready for the lubrication cycle.

- Axis distance (up to 3 axes in parallel)
- Auto cycle counter
- Timer

Pump State	Operator	Condition
Pump Ready =		"bHW_Input" is true for at least 3s
	AND NOT	Empty (1s flash feedback signal)
	AND NOT	Lubrication process active

When one of the indicators is triggered, all indicator values will be reset to the beginning (initial value). This has to be done even if the pump status is 'not ready'.

It does not make sense to use the axis distance, cycle counter and timer indicators in parallel. Depending on the application, the following priority is recommended:

If there is no other option than using the time indicator, it would be best to count the time when the axes are moving. The worst case is referencing the elapsed time since the last lubrication cycle.

3.1.1 Axis distance

Three inputs have been defined for the accumulated axis distances. These are the traveled distances which are never reset and simply count up continuously.

"udiDistAxis_1"

"udiDistAxis_2"

"udiDistAxis_3"

It is not necessary to use all three inputs. This depends on the number of relevant axes which are involved in the lubrication system. If an input is set to 0, it does not influence the logic for the lubrication cycle.

Internally, the difference to a persistent distance variable will be calculated for each axis.

E.g: DifferenceAxis_1 = "udiDistAxis_1" - udiDistToLastLubcycleAxis_1

As soon as one of the three differences is bigger than or equal to the threshold value "udiAxisDistForLub", the lubrication cycle will be triggered. With the same trigger, all persistent variables udiDistToLastLubcycleAxis_1, udiDistToLastLubcycleAxis_2 and udiDistToLastLubcycleAxis_3 will be set to its current distance input "udiDistAxis_1", "udiDistAxis_2" and "udiDistAxis_3"

The other indicators (automatic cycle counter and timer) must be reset as well.

Note

- To not influence the system after a controller restart, the internal distances moved since the last lubrication cycle, udiDistToLastLubcycleAxis_1,2,3, should be stored as persistent values. (As long as the input distance is persistent as well)

3.1.2 Automatic cycle counter

In some applications, it makes sense to count up the automatic cycles of the system. A rising trigger of the input value "bCntAutoCyc" will increment an internal persistent automatic cycle counter value by 1. If the counter value is bigger than or equal to the threshold value "udiAutoCycForLub", the lubrication cycle will be triggered. With the same trigger, the counter value will be reset to 0. The other indicators (axis distance and timer) must be reset as well.

Note

- To not influence the system after a controller restart, the automatic cycle counter value should be stored as a persistent value.

3.1.3 Timer

The timer is only to be used when it is not possible to get the axis distance or the automatic cycle counter. If possible, the timer should at least be dependent on the axis movement. (No counting during stop). In the worst case, when there is no information about the axis movement, the elapsed time since the last lubrication cycle is to be used. An internal persistent timer should be started as soon as the input "bAxesInMotion" is true. If the elapsed time is bigger than or equal to the threshold value "udiTimeForLub", the lubrication cycle will be triggered. With the same trigger, the timer will be reset. The other indicators (axis distance and automatic cycle counter) must be reset as well.

Note

- To not influence the system after a controller restart, the elapsed time should be stored as a persistent value.

3.1.4 Manual start

Typically, checking the lubrication function during commissioning or service work requires a manual start of the lubrication cycle. With the rising trigger of the input value "bManStartForLub", the lubrication cycle will be started. With the same trigger, the other indicators (axis distance, automatic cycle counter and timer) need to be reset.

3.2 Lubrication function of the FlexxPump

Several lubrication cycles can be triggered on the FlexxPump. In the case of the Güdel application, the functions will be reduced to two sensible ones. One is the fill function (used to fill up the lubricant points) and the other is the normal lubrication cycle where both pump pistons are triggered forward and backward; this means a discharge at all 4 outputs. Other controls make no sense and are also not matched with the hydraulic design.

3.2.1 Normal lubrication cycle

If one of the indicators, i.e. axis distance, automatic cycle counter, timer or the manual start "bManStartForLub", is triggered, the lubrication cycle can be started when the pump is in a ready state.

Pump State	Operator	Condition
Pump Ready =		"bHW_Input" is true for at least 3s
	AND NOT	Empty (1s flash feedback signal)
	AND NOT	Lubrication process active

If one of the conditions is not met, and a start trigger occurs, the flag "bWarnMsgCmd" must be set. If one of the conditions is not met and one of the indicators, i.e. axis distance, automatic cycle counter or timer, triggered the cycle, the flag " bErrMsgStopReq" must also has to be set. (Chap. 3.3)

Depending on the module size and the mechanical design, it is possible that several consecutive lubrication cycles (multiple actuations of all 4 outputs) are necessary. The number of lubrication cycles needed can be determined with the lubrication amount calculator.

 LubricationCalculator

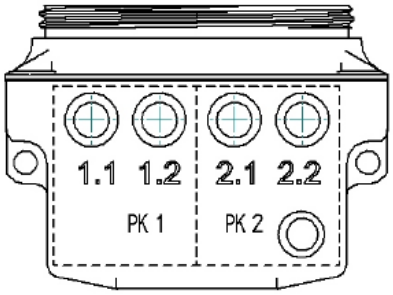


Fig. 3 *Pump body and outputs*

With the 8s pulse output signal, the first pump body PK1 is triggered to do a piston stroke, followed by pump body PK2. This means there will be a discharge at output 1.1 or 1.2 and 2.1 or 2.2. With a second output signal of 8 s, it starts pump body PK1, followed by PK2 again, to do another piston stroke. This means there will be a discharge at the other output 1.1 or 1.2 and 2.1 or 2.2. **Finally, after two output pulses of 8s, there will be a discharge at all 4 pump outputs**. (See Fig. 3) The permissible pulse length deviation of +/- 0.5s must not be exceeded.

For one normal lubrication cycle with discharge at all 4 outputs, the 8s pulse is needed at the hardware output **twice**. In the case of more than one requested lubrication cycle "udiNumOfLubCycle", this procedure must be repeated accordingly (e.g. 4x8s pulse for two lubrication cycles).

A successful piston stroke will be confirmed with a trigger on the hardware input. This means that for one successful 8s pulse, there will be 2 rising triggers on the hardware Input.

Instead of checking the pulse time on the feedback signal, it is better to count up each rising trigger of the feedback signal. As soon as 2 positive triggers have been counted on the feedback signal, the procedure on the pump body is finished and the next pulse can be started after a minimum timeout of 5s.

Depending on the lubricant system (tube length, viscosity), the 'signal low' time of the feedback signal "bHW_Input" will be different.

It makes sense to monitor the time during the 8s cycle in order to stop the function if the total of 2 rising edges is not reached during this time. (Timeout protection: Chap. 3.2.5)

After the output signal has been high for 8s, the flag "bLubProcStarted" should be set to true. After the total number of lubrication cycles has been reached, or if a timeout occurred, the signal needs to be reset to false.

If the required two triggers are not reached after the 8s pulse command, the function will be canceled via the timeout, and the output message "bWarnMsgCmd" must be set. It will be reset after a successful lubrication cycle.

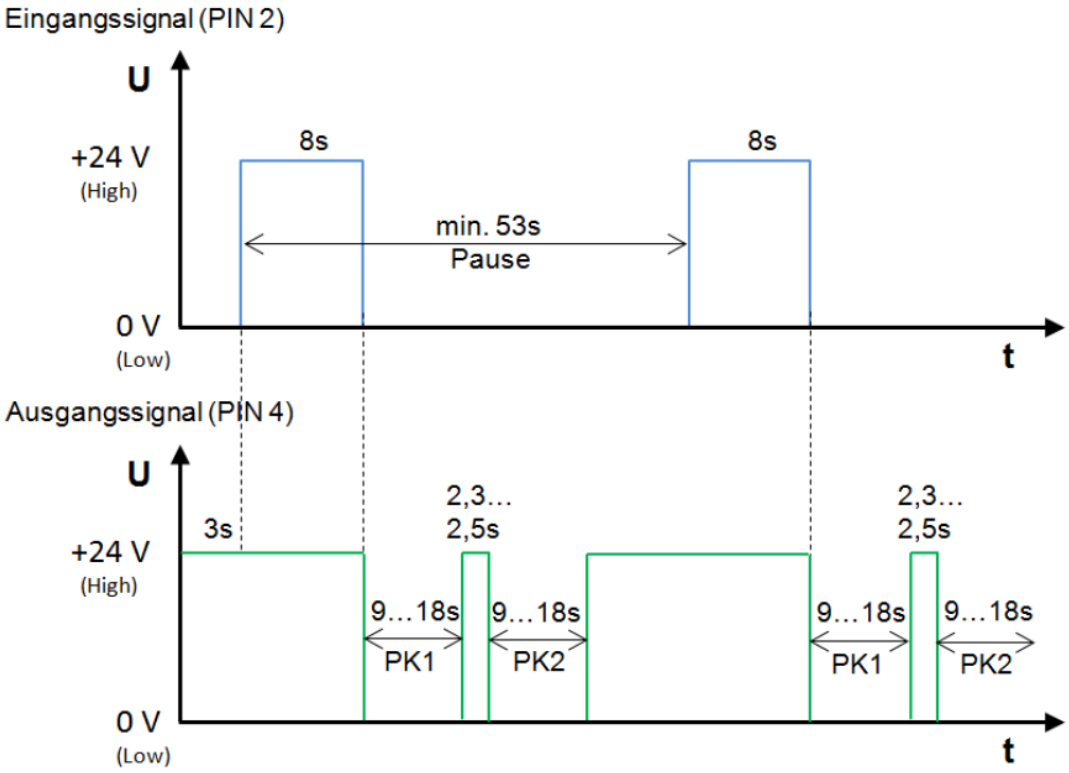


Fig. 4 *Timing diagram of normal lubrication cycle with firmware "TD d Software D2 Art300135 20160301"*

3.2.2 Fill function

The fill function can be started with the rising trigger of the input "bManStartFillFnc" when the pump is in a ready state.

Pump State	Operator	Condition
Pump Ready =		"bHW_Input" is true for at least 3s
	AND NOT	Empty (1s flash feedback signal)
	AND NOT	Lubrication process active

If one of the conditions is not met and a trigger occurs, the flag "bWarnMsgCmd" must be set.

With the 12s pulse output signal, the fill function on the pump is triggered. The permissible deviation of +/- 0.5 s must not be exceeded. Instead of checking the pulse time on the feedback signal, it is better to count up each rising trigger of the feedback signal. A trigger is given when the pump piston (PK1 or PK2) reach one of the end positions. Depending on the pump version (FW release before or after March 2016). it counts up 40 times (20 on PK1 and 20 on PK2) or 80 times (40 on PK1 and 40 on PK2). This means: At each output, 10 or 20 discharges will

occur. As soon as 40 or 80 positive triggers have been counted on the feedback signal, the fill function cycle is finished. Depending on the lubricant system (tube length, viscosity), the total time will differ.

It makes sense to monitor the time over the whole cycle in order to stop the function if the number of edges is not reached during this time. (Timeout protection, Chap. 3.2.5)

After the output signal has been high for 12s, the flag "bLubProcStarted" should be set to true. After 40 or 80 triggers have been reached, or after the timeout, the signal needs to be reset to false.

If the 40 or 80 triggers are not reached in time, the function will be canceled by the timeout. The output message "bWarnMsgCmd" must be set. It will be reset after a successful lubrication cycle.

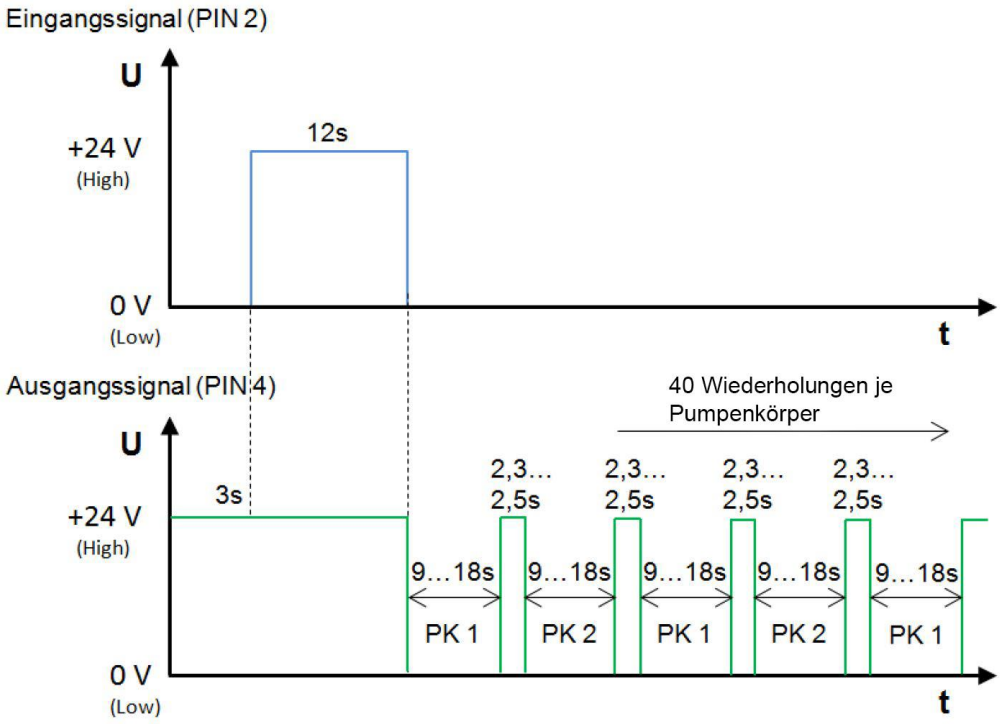


Fig. 5 *Timing diagram of fill function for the firmware "TD d Software D2 Art300135 20160301"*

3.2.3 Feedback signal

Independent of the lubrication function pulse (8s or 12s), the hardware input signal "bHW_Input" must be monitored for the following state all the time.

Flashing with a 1sec frequency means an empty cartridge. The output message "bWarnMsgEmtpy" needs to be set to true. If the flashing with this frequency stops, the message needs be reset to false again.

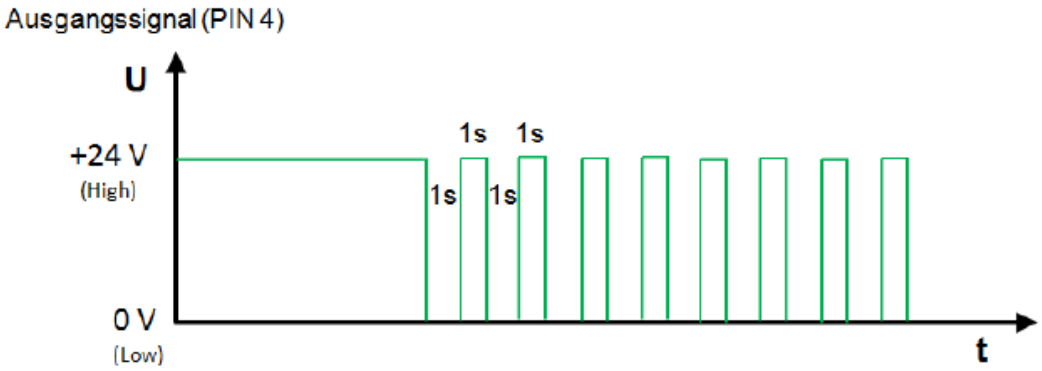


Fig. 6 *Timing diagram for empty cartridge*

If the signal is false for more than 40s, an error has occurred in the pump or there is a problem with the wiring. The output "bWarnMsgPump" needs to be set to true. It needs to be reset when the input is true again for at least 5s.

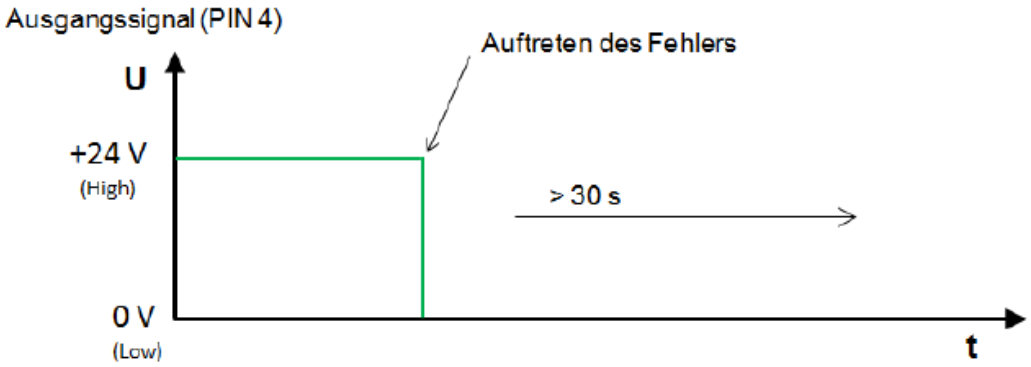


Fig. 7 *Timing diagram for error in pump state*

Note

- In case of an error in the pump (wiring is ok and signal is off) it can be reset only by switching off the 24 V DC power for at least for 5s.

3.2.4 Level indicator (optional function)

With this optional function, the level indicator of the cartridge can be calculated and displayed on a HMI. The current volume of the cartridge can be adjusted with the preset function.

With the rising trigger of the flag "bPreSetVolume", the value "udiPreSetVolume" is stored to an internal volume flag. The volume in [%] needs to be calculated as a volume in cm^3

- A fully filled cartridge has a volume of 400cm^3
- Each pump stroke has an output volume of 0.15 cm^3

Internal volume in cm^3 in case of PreSet = ("udiPreSetVolume" / 100) x 400.

With each rising trigger of the feedback signal "bHW_Input" during a lubrication cycle, the volume can be reduced by 0.15cm^3.

In the case of a normal lubrication cycle when all 4 outputs are discharged, this means:

Internal Volume in cm^3 = Internal Volume - (4 x 0.15)

The current output level needs to be recalculated in percent.

"udiCurVolume" = (Internal Volume / 400) x 100

The warning will be set when the current output volume is less than the level warning volume.

"bWarnMsgVolume" = "udiCurVolume" < "udiLevWarnVolume"

With the threshold value "udiLevWarnVolume" = 0, the warning can be deactivated.

3.2.5 Recommended constant values

- 5s "bHW_Input" high before a command pulse can start a lubrication cycle.
- "bWarnMsgPump" when "bHW_Input" is false for more than 40s.
- Timeout protection for normal lubrication cycle 53s after rising trigger of the 8s pulse (two times for the whole lubrication cycle)
- Timeout protection for fill function 1660s after rising trigger of the 12s pulse
- Time between two rising triggers for the empty detection: 1.9s to 2.1s

3.3 Reaction / warning / error

bWarnMsgCmd:

Warning message when the lubrication cycle was not completed successfully. E.g.: Number of triggers of the feedback signal was not reached in time (as described in Chapter 3.2.1 and 3.2.2). Or when there is a pump cycle start request and the pump is not in a ready state.

Pump State	Operator	Condition
Pump Ready =		"bHW_Input" is true for at least 3s
	AND NOT	Empty (1s flash feedback signal)
	AND NOT	Lubrication process active

After a successful lubrication cycle (normal or fill), the warning can be reset. The warning just provides the information that something happened with the lubrication; no system reaction is required.

bWarnMsgEmtpy:

The hardware input signal "bHW_Input" needs to monitored constantly for a 1s flash frequency. As long as there is a 1s flash, the warning needs to be set. (See Chap. 3.2.3). The warning just provides the information that something happened with the lubrication; no system reaction is required.

bWarnMsgPump:

The hardware input signal "bHW_Input" needs to be monitored for a true state all the time. If its state is false for longer than 40s, the warning needs to be set (see Chap. 3.2.3). The warning just provides the information that something happened with the lubrication; no system reaction is required.

bErrMsgStopReq:

If one of the indicators (axis distance, automatic cycle or timer) requires a start of the lubrication cycle and the cycle failed (pump not ready), this error message needs to be set.

Pump State	Operator	Condition
Pump Ready =		"bHW_Input" is true for at least 3s
	AND NOT	Empty (1s flash feedback signal)
	AND NOT	Lubrication process active

It is not required to set it by manual start of the lubrication cycle. After a successful lubrication cycle (normal or fill) the "bErrMsgStopReq" needs to be reset.

⚠Danger

- With this error message, the involved axis of the lubrication system needs to be stopped. Typically, this will be done with a cycle stop and a corresponding error message.

If the customer nevertheless wants to produce with the system, the stop request mentioned above can only be ignored by a trained maintenance staff member using a key switch or a password-protected button. A message must be shown with the information that the mechanical system will be destroyed if the lubrication function is not running well. The plant operator is responsible for manual and sufficient lubrication.

4 Sample of an HMI screen

4.1 Minimal implementation

Below a sample that shows how an HMI page can be implemented with a minimum number of elements at Status, Settings and Commands.

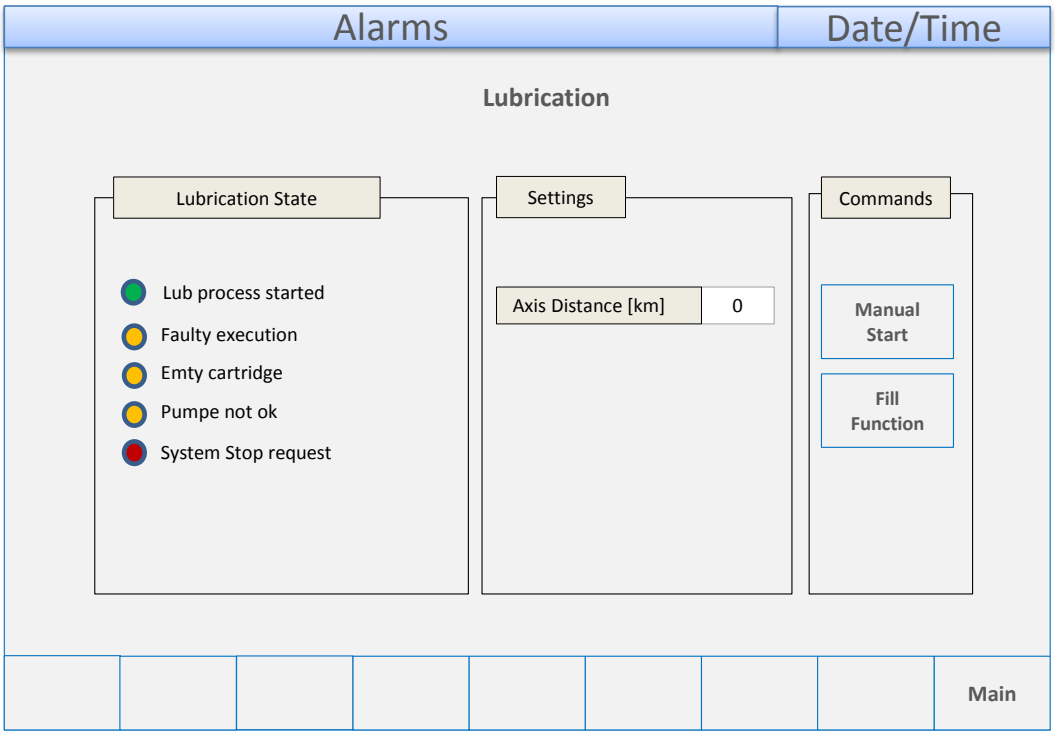


Fig. 8 *Sample HMI page with minimal implementation*

4.2 Maximal implementation

Below a sample that shows how an HMI page can be implemented with a maximum number of elements for Status, Settings and Commands.

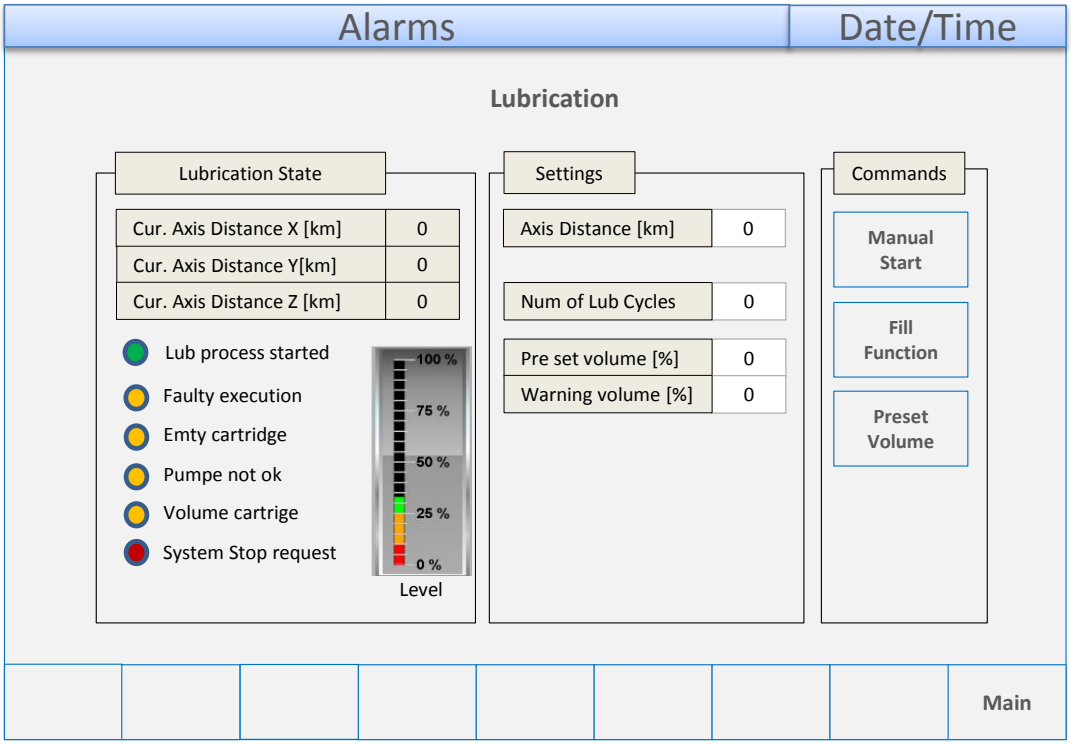


Fig. 9 *Sample HMI page with maximal implementation*

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