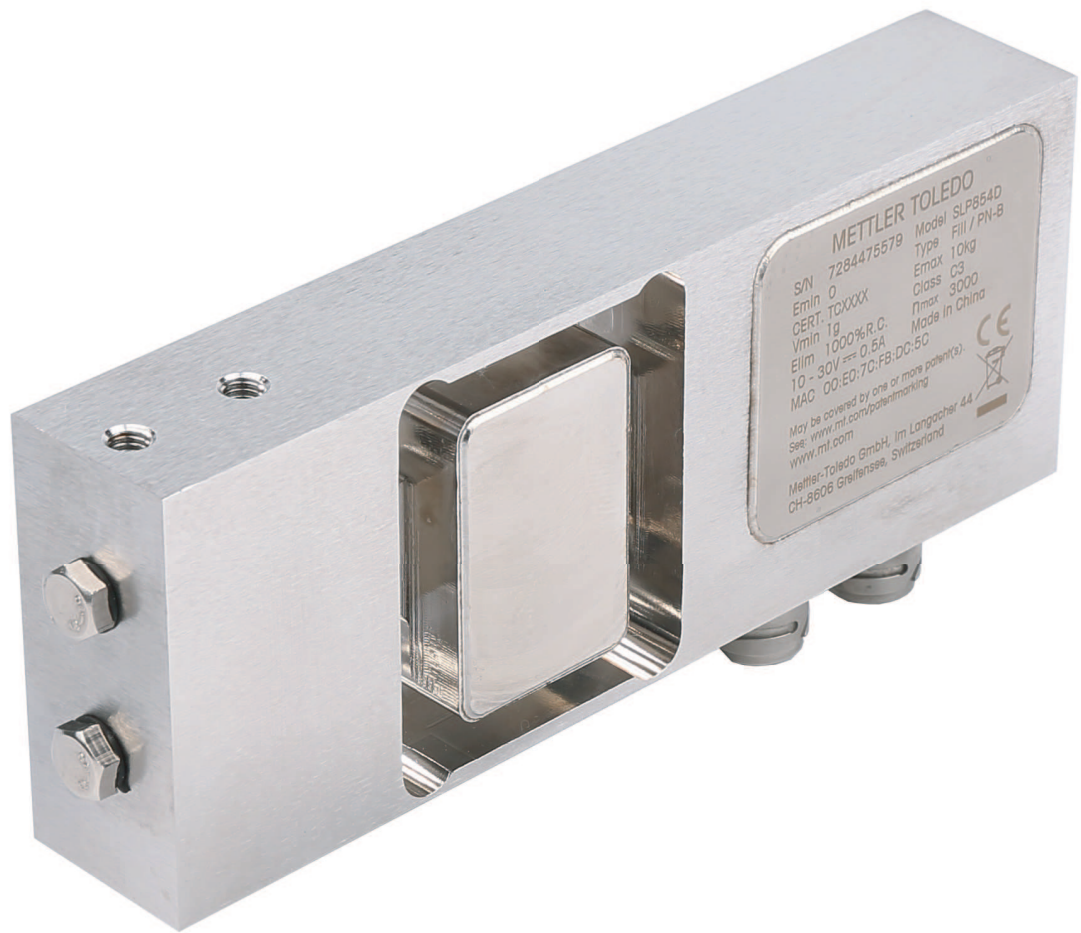


SLP85xD

Load Cells



METTLER TOLEDO

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1 Introduction

The following SLP85xD load cell models have an integrated filling application inside:

- SLP852D
- SLP854D

This filling application can be configured with software commands, so that the filled amount reaches the target weight (or the tolerance range) within the shortest possible time. After the load cell is configured, it can control a filling application or help the controller (e.g. PLC) to control the filling application.

The following parameters can be configured in a filling application:

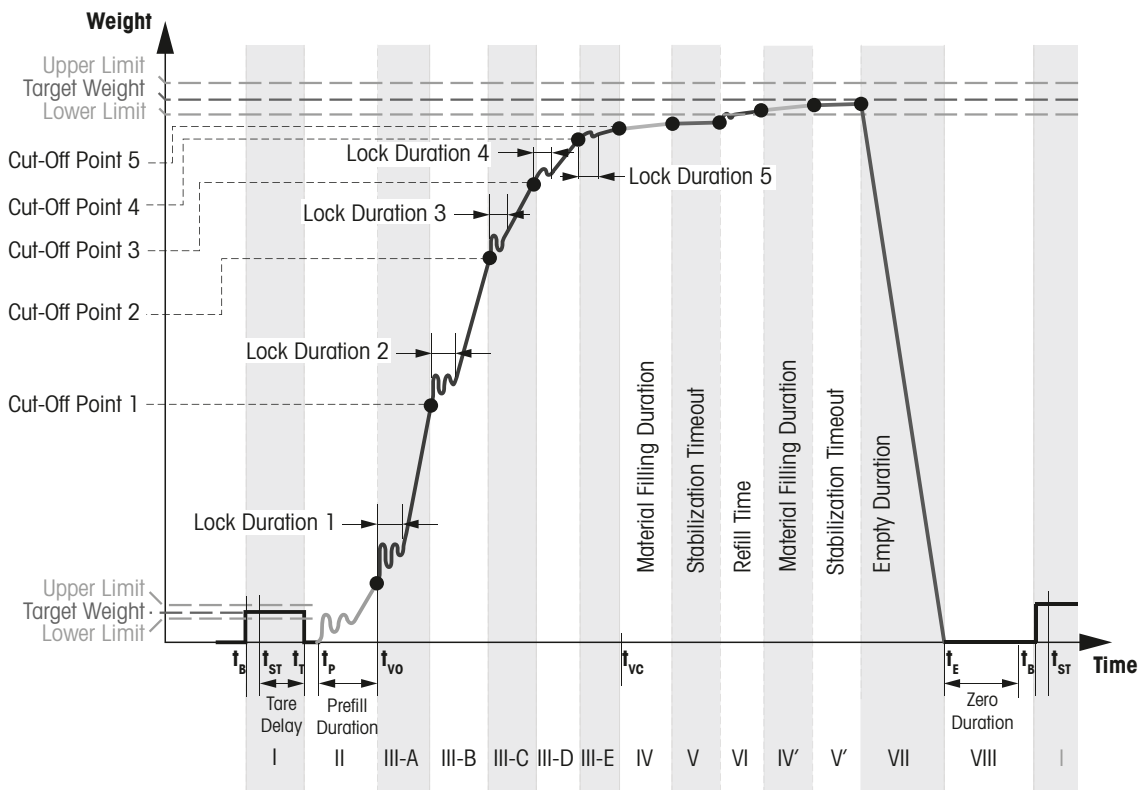
- "Target weight" with upper and lower tolerances
- "Tare weight" with upper and lower tolerances
- Weight value of the "Cut-off points" and the digital outputs which will be activated for a certain cut-off point
- "Material filling time" to capture the filling material that is still in the air after the last filling valve is shut
- "Stabilization conditions" to confirm the final stable filling result
- "Refilling time" if the filled amount is lower than the tolerance range of the target weight
- "Empty" and "Zero" duration to define the time delays for removing the filled product from the weighing platform and setting the zero command

In addition to defining the time and weight values of the filling cycle, the load cell can also be configured to allow automatic optimization of the cut-off points, so that the target weight is reached within the shortest possible filling time.

Another configuration option is to allow active monitoring of the filling cycle in terms of weight increase and time lapse, so that the load cell can issue error messages if some part of the filling cycle is not realized according to the expected time and weight conditions.

2 Description of the Filling Cycle

The figure below displays a whole filling cycle which consists of the following phases:



Phase I

At time t_B , the container is placed on the weighing platform, and the load cell is loaded with a start weight (tare weight). During this process, the control system checks whether there is a container coming or not.

After detecting that the load cell is in the appropriate position to start filling, the control system sends a "start filling" command or pulse to the load cell at time t_{ST} , and then the automatic filling sequence starts.

Following this start, the application continues with the below steps:

- Resetting the content of the application status register.
- If the target weight is configured as "0" or cut-off points are not activated (phase III), the filling cycle is aborted; otherwise it continues with the automatic tare process.

The automatic tare function can be activated if the filling process is controlled based on the net weight. If the control is based on the gross weight, this function can be left inactive.

During the automatic tare process, there are two conditions:

- If automatic tare is deactivated, the filling process will be controlled based on the gross weight, so skip this process.
- If automatic tare is activated, the load cell waits for a predefined time and at time t_P continues with the following steps:
 - If lower and upper tolerances are defined as "0", tare the container weight directly.
 - If the container weight is less than the lower limit or more than the upper limit, abort the filling cycle.
 - Otherwise, tare the container weight.

Phase II

The prefilling function can be activated in order to prevent the foaming of the liquid inside the bottle. For this purpose, the filling valve with the lowest filling speed should be activated for the duration of the prefilling process.

During the prefilling process, there are two conditions:

- If prefilling is deactivated, skip this process.
- If prefilling is activated, the corresponding valve remains effective to fill the container with a very low speed in order to avoid foaming during the prefilling duration.

After the prefilling process, the application continues with the normal filling phases.

Phase III (up to 5 Sub-phases)

Normal filling phases are part of the filling application, where up to 5 cut-off points can be defined and configured. These cut-off points form the different filling regimes from rough to fine filling. The output ports can be configured to control certain filling valves and thus control the filling application.

The user can configure up to 5 sub-phases by assigning one or more digital output ports to the corresponding phase.

For each active sub-phase, the assigned output port(s) remain(s) high throughout the filling phase. At the start of each sub-phase, the "Lock Duration" prevents the flow from being shut off too early due to peak loads. If the current weight reaches the corresponding cut-off point, then the assigned output port(s) is/are switched off.

Sub-phases must be configured in the right order (1 → 2 → 3 → 4 → 5), and if one sub-phase is deactivated, the following sub-phase(s) will also be skipped.

After the normal filling phase, the application continues with the waiting time for the material in the air.

Phase IV

After the last filling, the valve is shut, but there is still some material in the air, which needs to be captured by the container. The waiting time for the material in the air can be defined according to the filling speed of the valve and the viscosity of the filled material.

The waiting time for the material in the air starts at time t_{vc} in order to capture any material still flowing into the container after shutting off all filling valves. Upon the expiration of the "Material Filling Duration", this process will be over and the application continues with the final measurement process.

Phase V

After the material in the air is captured, the application continues with the final control weighing. During the final measurement, the final weight is tested for stability. If the stability condition is met, control weighing can start, even if the stabilization timeout has not yet expired. In any case, the last weight value will be taken as the filling result when the stabilization timeout has expired.

The following actions are taken during control weighing:

- The final filling result is determined:
 - If the optimization function is activated and there is no refilling during this phase, the cut-off points are optimized based on the weight difference between final filling result and biggest active cut-off point.
 - If the refilling process is activated and the final filling result is less than the lower limit value for the target weight, calculate the refilling time and continue with the refilling process.
- Otherwise, the following steps are performed:
 - Filling statistics are calculated.
 - The application status register is set:
 - If the final filling result is lower than the lower limit value for the target weight, "Tol-" will be set.
 - If the final filling result is higher than the upper limit value for the target weight, "Tol+" will be set.
 - "Ready" and "Empty" signals are set.

Then, continue with the emptying process.

When the "Ready" signal is high, the control system can read the filling statistics.

Phase VI

Start the refilling process after final measurement. Upon the expiration of the refilling time, this process will be over and the application will continue with the waiting time for the material in the air. Refilling is used when it is activated by prior configuration and in case the final filling result is less than the lower limit value for the target weight.

Phases VII and VIII

The duration of the "Empty" signal can be defined with the Emptying process. The "Empty" signal is set right after the final control weighing and is reset after the "Empty Duration" is over. The user can define this duration based on the required cycle time.

After the "Empty Duration", the user can also introduce a "Zero Duration" if the application is controlled based on the gross weight. During this phase, the control system removes the container from the weighing platform. The emptying process ends at time t_E .

After t_E , there are two conditions:

- If the filling process is controlled by the gross weight (automatic tare process deactivated), the application waits for the "Zero Duration" to check and clean the zero before loading the new container.
- If the filling process is controlled by the net weight (automatic tare process activated), the control system can load the new container/bottle immediately.

3 Filling Optimization

If activated, the optimization function can help to reconfigure the cut-off points automatically within the current or subsequent filling cycle so that the current final weight stays within tolerances of the target weight in the shortest possible filling time.

There are 5 optimization methods.

Method 1 (Feedback Weight Optimization)

In this method, the biggest cut-off point is optimized based on the deviation from the target weight. All other cut-off points are reconfigured according to the optimization step of the biggest cut-off point.

With this method, the current filling weight is optimized based on the deviation from the target weight.

An optimization step (OSN) can be selected based on the preference for the speed of correction.

OSN = 1 provides a short optimization time with big step sizes

OSN = 3 provides a long optimization time with small step sizes

Method 2 (Feedback Time Optimization)

In this method, all cut-off points are optimized according to the biggest cut-off point so that the filling time is reduced as much as possible.

With this method, all cut-off points are brought closer to the biggest cut-off point, in order to reduce the total filling time.

Method 3 (Feed-Forward Optimization)

This method can be used if there is a variable (not constant) flow rate from one or all of the filling valves. In this case, the average value of the variable flow rate over the last 10 filling cycles is calculated and the biggest cut-off point is optimized based on this value. All other cut-off points are reconfigured according to the optimization step of the biggest cut-off point.

Method 4

This method is a combination of both method 1 and method 3.

Method 5

This method is a combination of both method 2 and method 3.

Notes

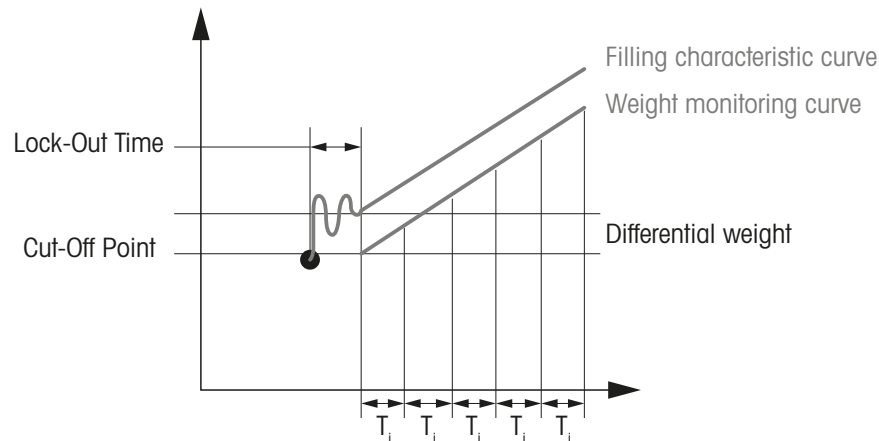
- We suggest to test the filling valve performance by disabling the optimization function, refilling function and fixing the configuration of filling parameters, including the below parameters:
 - Normal filling
 - Material filling duration
 - Stability criteria for final filling weight
- After at least 10 filling cycles test, if the final filling weights are very close to each other and the standard deviation of the filling statistics is in the permissible range, then we suggest to enable the optimization function, otherwise maybe making the final filling weight more worse when enabling the optimization function.
- After changing the normal filling parameters, such as "Normal Fill Weight", "Lock Duration", "Output", the optimization parameters will be reset and will do the optimization again if enabled from the changed normal filling parameters.

4 Filling Monitor

4.1 Weight-Based Filling Monitor

The current filling curve can be monitored by activating the monitor function. When activated, this function builds a monitor curve which sets the lower limit for the current filling curve. If the current filling curve goes below the monitor curve, this implies that there is an error in the filling application. This error is interpreted as bag/bottle breakage.

For the filling monitor function, a differential weight is entered, at which a monitoring characteristic curve follows the filling characteristic curve. Only the weight increases are added up in the monitoring curve. If the filling weight stays the same or decreases, the monitoring curve stops at its value. If the monitoring characteristic curve is cut by the filling characteristic curve (because filling material is escaping from the container), this is interpreted as bag/bottle breakage. The monitoring curve is depicted below:



The monitoring curve follows the filling characteristic curve at the sampling rate ($F_{\max} = 1 / T_i$).

This means that if the filling curve falls below the monitoring curve, bag breakage is detected no later than $T_i = 1 / F_{\max}$ later. Monitoring begins once the lock-out time for the cut-off point has expired.

If this error occurs, the following steps are taken:

- The remaining filling process is stopped.
- The error bit for the bag/bottle breakage is set.

After the error condition is removed, the filling process can be continued.

Potential reasons for bag/bottle breakage during the filling application are:

- The bag/bottle tears and the material trickles out faster than it is being filled.
- The bag/bottle bursts.

4.2 Time-Based Filling Monitor

This type of monitor function can be used to monitor whether filling material is filled continuously. If filling is interrupted, it is possible based on the timeout parameters to determine where the problem has occurred.

In this approach, the user can define timeout durations for the cut-off points and the filling monitor function checks whether the cut-off points are reached within these predefined timeout durations. If one of these timeout parameters is exceeded, the remaining filling application is stopped and the corresponding error bit is set. This error is interpreted as the interruption of the filling material.

After the error condition is removed, the filling process can be continued.

Potential reasons for the timeout error are the following:

- Wrong timeout parameter defined by the user.
- Filling valve broken or stuck.

5 Filling Application Status

All application-specific errors and status bits are stored in the load cell inside a register. The load cell continuously monitors the filling application and updates the content of this register. The control system can monitor the filling process by reading the content of this register.

The content of this register is given in the table below:

| Bit | Designation | Status / Error Condition |
|-----|---------------------|--|
| 0 | General Status Bit | Set if any other error bit (Bit-1 to Bit-10) is 1 <ul style="list-style-type: none"> If this bit is 1, it means that the current filling cycle is stopped by error conditions If this bit is 0, it means that the current filling cycle is finished successfully |
| 1 | TareWeight+ | Set if container weight > upper limit for tare weight |
| 2 | TareWeight- | Set if container weight < lower limit for tare weight |
| 3 | TOUT1 | Set if filling time until 1st cut-off point > timeout parameter 1 |
| 4 | TOUT2 | Set if filling time until 2nd cut-off point > timeout parameter 2 |
| 5 | TOUT3 | Set if filling time until 3rd cut-off point > timeout parameter 3 |
| 6 | TOUT4 | Set if filling time until 4th cut-off point > timeout parameter 4 |
| 7 | TOUT5 | Set if filling time until 5th cut-off point > timeout parameter 5 |
| 8 | Bag/Bottle Breakage | Set if the weight value of the actual filling curve < weight value of the monitor characteristic curve |
| 9 | TOL- | Set if the final filling weight < lower tolerance limit of target weight |
| 10 | TOL+ | Set if the final filling weight > upper tolerance limit of target weight |
| 11 | EMPTY | Remains high during the emptying process (See command F16) |
| 12 | READY | Set once the final filling weight is determined and reset once a new container is placed |
| 13 | reserved | |
| 14 | reserved | |
| 15 | reserved | |

The general status bit is set automatically if one of the error bits (Bit 1 to Bit 10) is set. The filling application is stopped automatically if one of the error bits (Bit 1 to Bit 8) is set.

The values in this register are reset automatically when a "run" or "abort" command is received by the load cell.

The status bits READY and EMPTY can be monitored by the control system to check when it is the right time to place a new empty container on the weighing platform after a filling cycle is finished.

6 Filling Statistics

SLP852D and SLP854D load cells also have the capability to store statistical information inside a register. The following information is stored by this register:

- Mean value of all actual filling results
- Standard deviation of all actual filling results
- Accumulated weight value of all previous filling cycles
- Number of total filling cycles
- Last filling result recorded by the load cell
- Last total filling time recorded by the load cell

Filling statistics can be viewed by the user. These statistics are calculated by the load cell on a continuous basis, until it is reset by the user. This way it is possible to keep individual statistics for different batches.

Only successful filling cycles are reflected in the statistics that are not interrupted by manual intervention or cancelled due to an error.

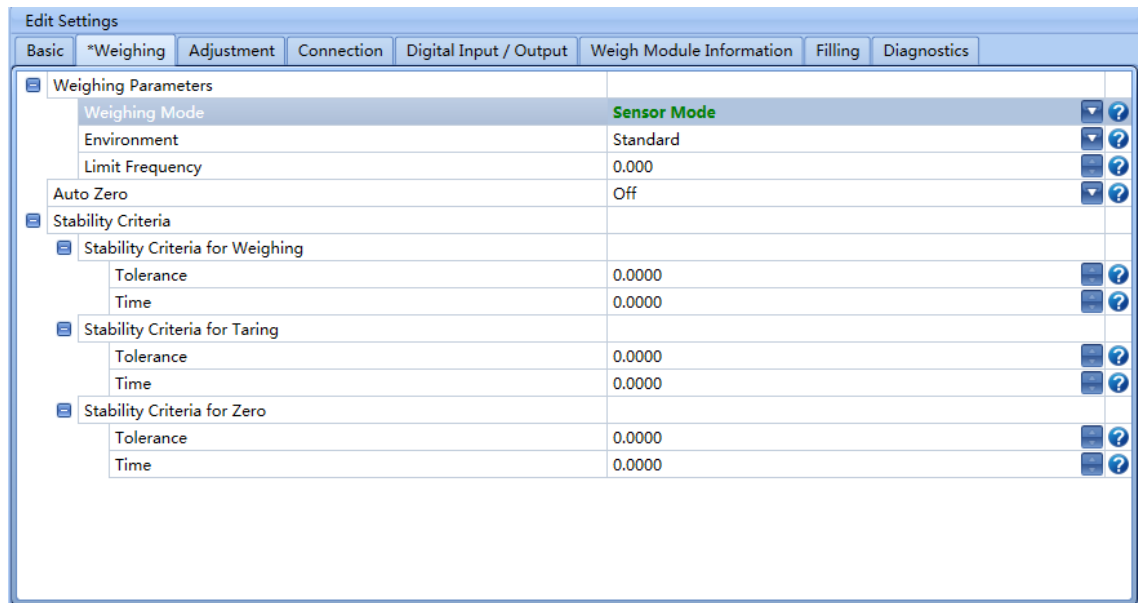
7 Appendix

7.1 Configuration Steps for the Filling Application

- 1 Configure the weighing mode → Sensor Mode.
- 2 Configure the digital output → Valve Function.
- 3 Configure the digital input → Filling Control or other functions.
- 4 Configure the filling process → enable or disable functions according to your requirements
 - ⇒ Automatic Tare
 - ⇒ Prefilling
 - ⇒ Normal Filling
 - ⇒ Refilling
 - ⇒ Weight Based Monitoring
 - ⇒ Time Based Monitoring
 - ⇒ Cut-off point optimization
 - ⇒ Emptying Function
- 5 Configure the target weight and tolerance.

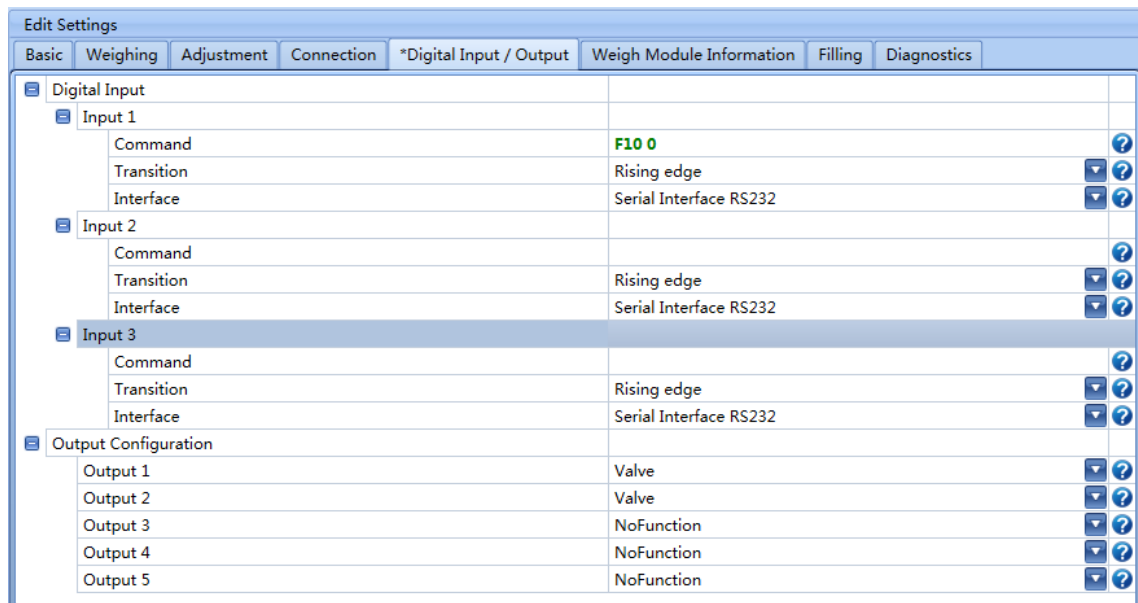
7.2 Sample MT-SICS Commands for Filling Application by APW-Link

- 1 In the "Weighing" tab, configure the "Weighing Mode" of the load cell as "Sensor Mode" (**MT-SICS: M02**).



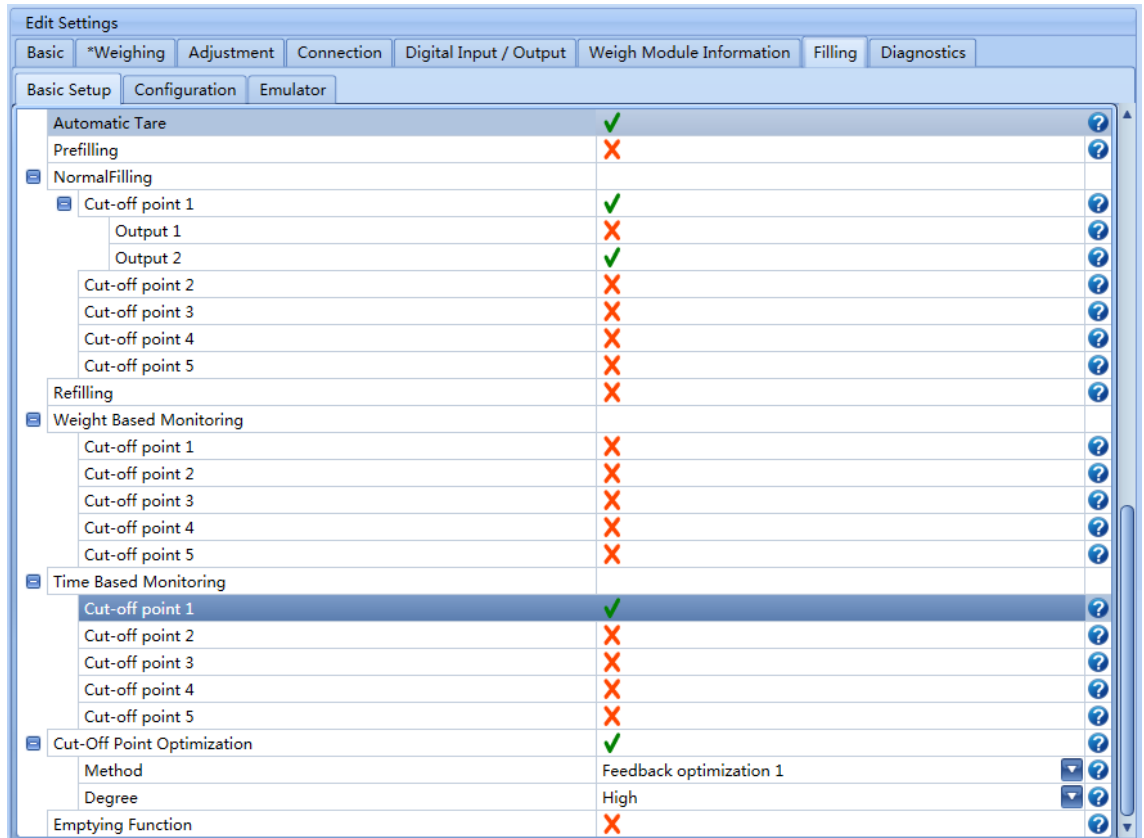
- ⇒ You can see the "Filling tab", see Step 3.
- ⇒ The "Sensor Mode" is specifically designed for the filling application and must be set correctly. Otherwise it will influence the filling accuracy.

- 2 In the "Digital Input / Output" tab, configure the following:



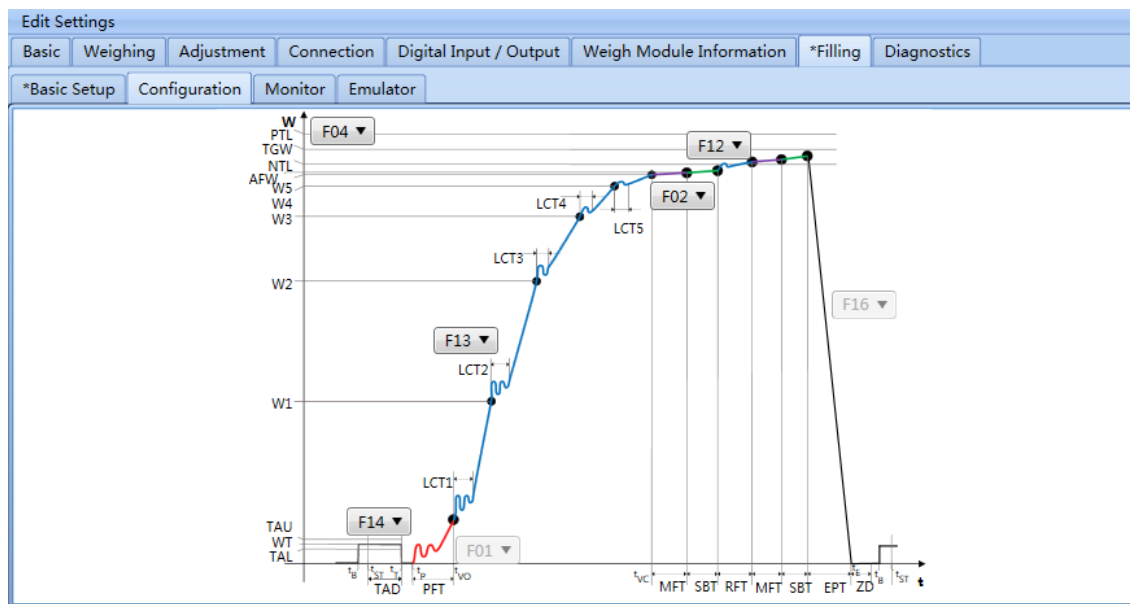
- ⇒ Digital inputs as "Start Filling" or other functions you need (**MT-SICS: F10 0**)
- ⇒ Digital outputs as "Valve" (**MT-SICS: F15**)

- 3 In the "Filling" tab and "Basic Setup" sub-tab, enable or disable the filling functions according to your requirements.

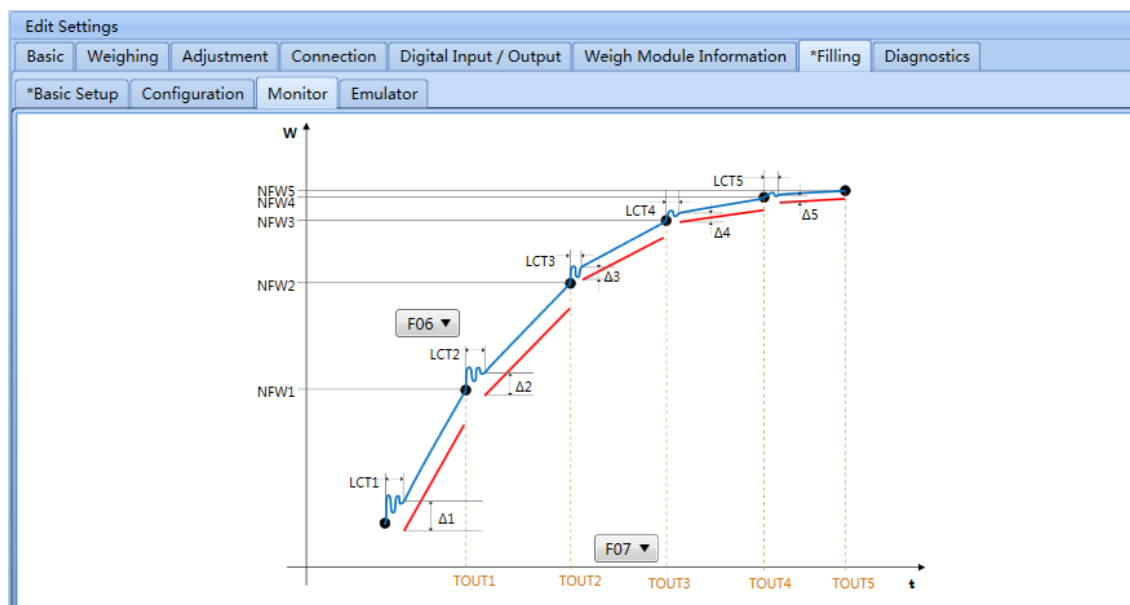


- ⇒ Automatic Tare (**MT-SICS: F14**)
Enable/disable the automatic tare function.
If enabled, the filling process will be controlled by the net weigh, otherwise it will be controlled by the gross weight.
- ⇒ Prefilling (**MT-SICS: F01**)
Enable/disable the prefilling function based on the machine performance.
Normally disable the prefilling function.
- ⇒ Normal Filling (**MT-SICS: F13**)
Select how many control points you need and which digital output you want to be used for each control point.
- ⇒ Weight Based Monitoring (**MT-SICS: F06**)
Enable/disable the weight monitoring function.
If you know the material flow rate during the filling process very well, we suggest to enable the function. Otherwise disable the function.
- ⇒ Time Based Monitoring (**MT-SICS: F07**)
Enable/disable the time monitoring function.
If you know the time for each filling process very well, we suggest to enable the function. Otherwise disable the function.
- ⇒ Cut-off Optimization (**MT-SICS: F05**)
After enabling the automatic optimization function, choose the optimization. Normally choose the "Feedback optimization" method.
- ⇒ Empty Function (**MT-SICS: F16**)
Enable/disable the emptying function.
If you know the timer for the emptying process very well, we suggest to enable the function. Otherwise disable the function.

- 4 In the "Filling" tab and "Configuration" sub-tab, configure the detailed parameters for your enabled filling function of the previous step.

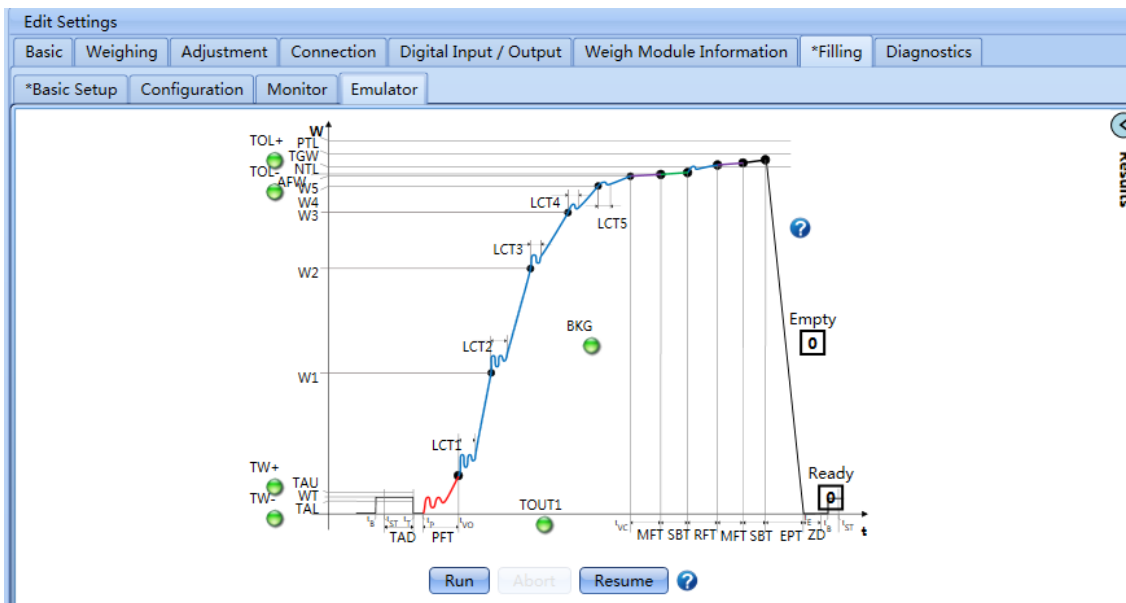


- ⇒ **MT-SICS F04**: Configure the target weight and permissible tolerance range.
 - ⇒ **MT-SICS F14**: Configure the automatic tare permissible weight range and time for doing it.
 - ⇒ **MT-SICS F01**: Configure the prefilling duration time.
 - ⇒ **MT-SICS F13**: Configure the normal filling process, including the control point value and lock duration time.
 - ⇒ **MT-SICS F02**: Configure the time for material filling duration.
 - ⇒ **MT-SICS F12**: Configure the stability criteria for the final filling weight.
 - ⇒ **MT-SICS F16**: Configure the time for empty duration and zero duration.
- 5 In the "Filling" tab and "Monitor" sub-tab, configure the detailed parameters for your enabled monitoring function.



- ⇒ **MT-SICS F06**: configure the weight monitoring function for the filling application.
- ⇒ **MT-SICS F07**: configure the time monitoring function for the filling application.

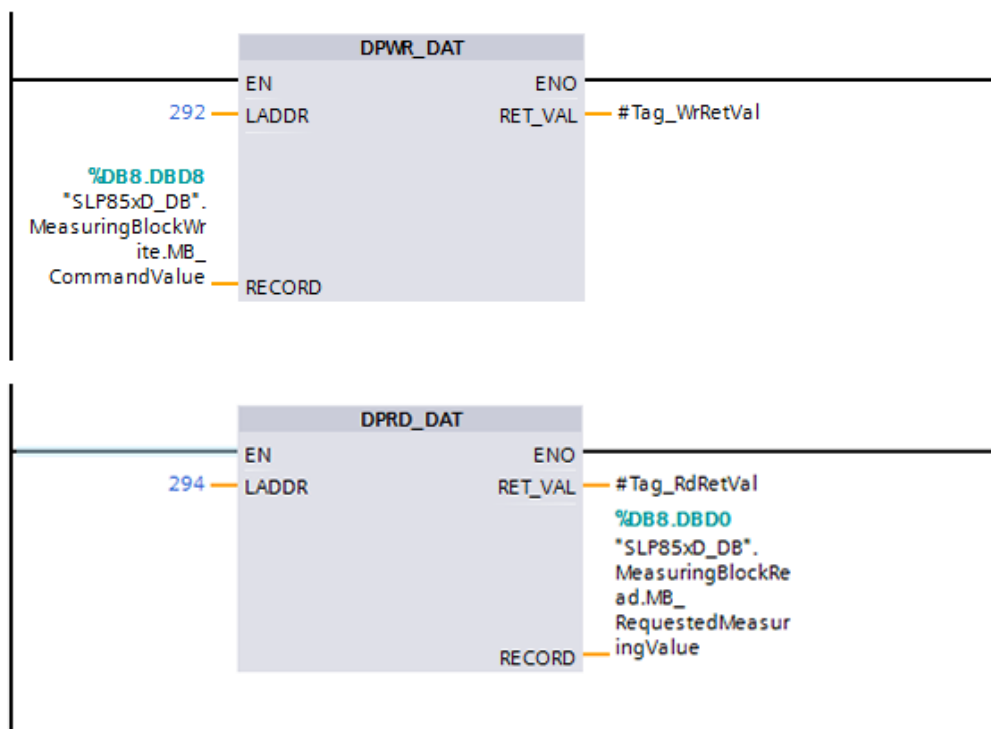
6 In the "Filling" tab and "Emulator" sub-tab, you can emulate the filling process



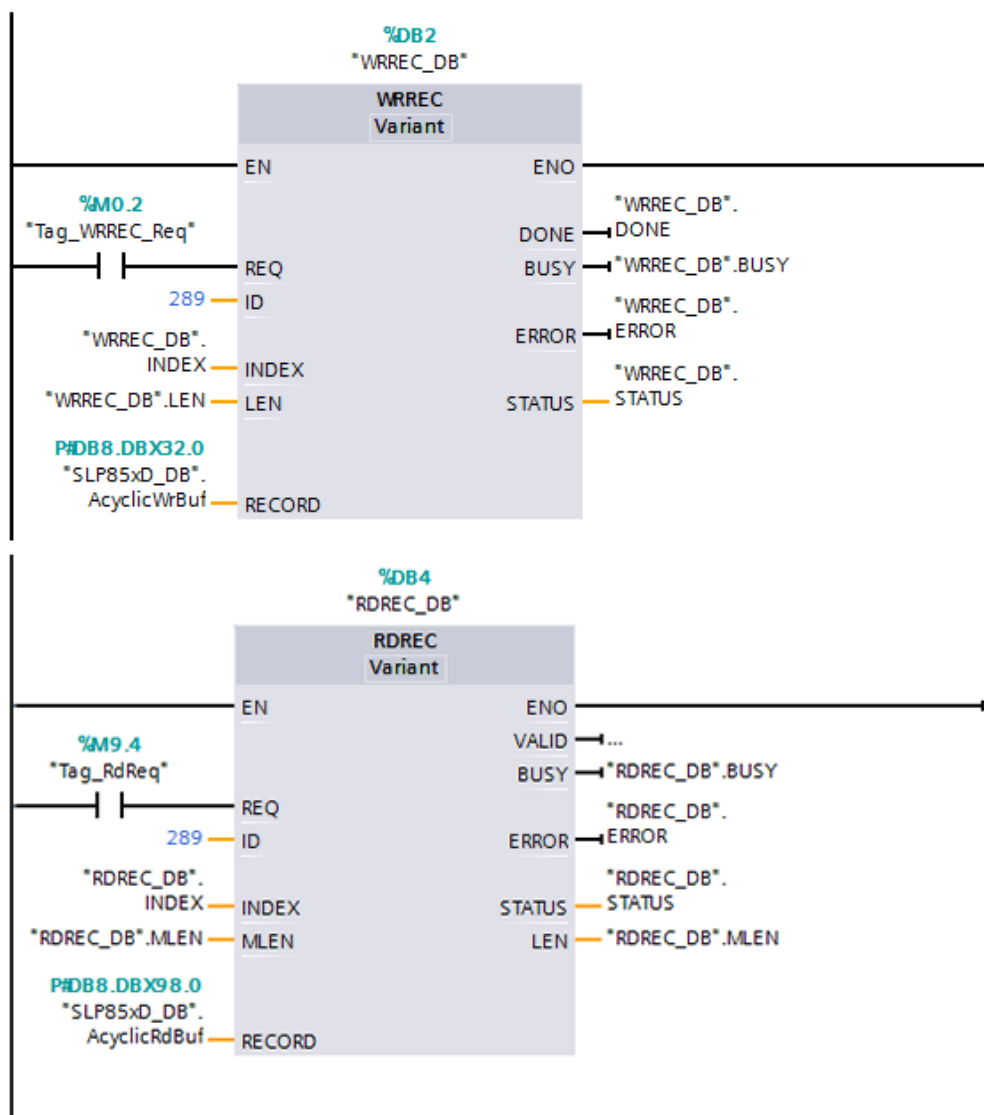
- ⇒ Run (**MT-SICS F10 0**) to start the filling process.
- ⇒ Abort (**MT-SICS F10 1**) to interrupt the filling process.
- ⇒ Resume (**MT-SICS: F10 2**) to continue the filling process after interruption.

7.3 Sample SAI Commands for Filling Application by PLC

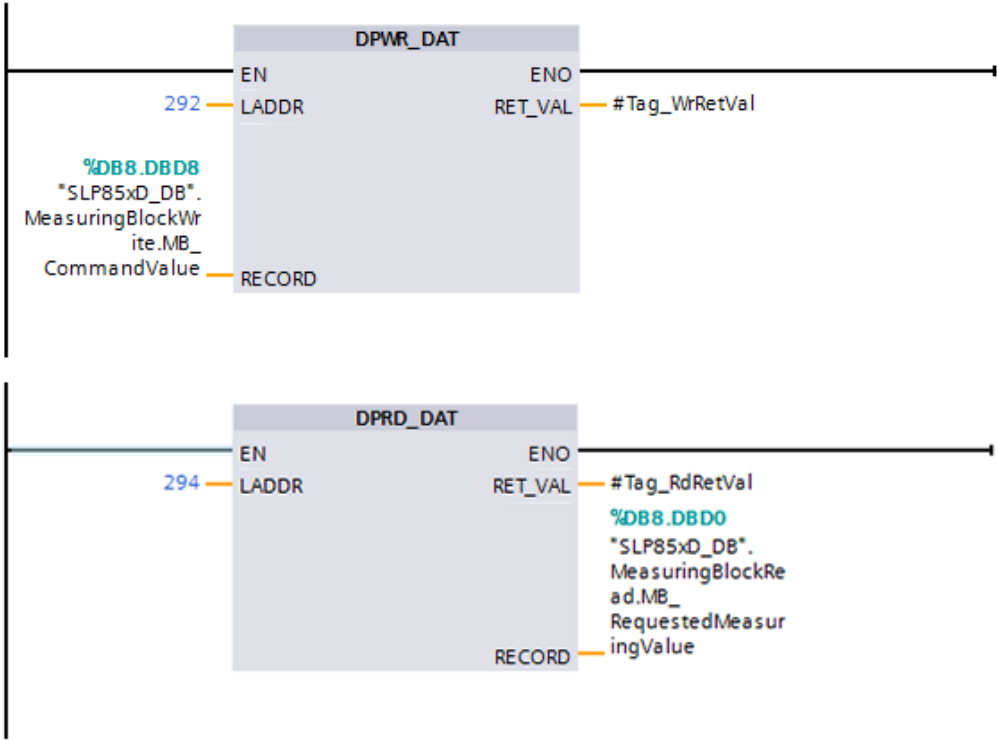
- 1 Configure the "Weighing Mode" by SAI cyclic command (**Value: 290**) to "Sensor Mode".
Taking SIEMENS S7-1200 CPU1215C as an example, you can use the "DPWR_DAT" function to send the command to the device and then use the "DPRD_DAT" function to read the feedback from the device.



- 2 Configure the filling parameters by SAI acyclic commands, see the "SAI Commands for Filling Application".
 Taking SIEMENS S7-1200 CPU1215C as an example, you can use the "WRREC_DB" function to write the filling parameters to the device step by step. You can also use the "RDREC_DB" function to read the feedback from the device..



- 3 Run the filling cycle by SAI cyclic command (**Value: 500**).
 Taking SIEMENS S7-1200 CPU1215C as an example, you can use the "DPWR_DAT" function to send the command to the device and then use the "DPRD_DAT" function to read the feedback from the device.



7.4 MT-SICS Commands for Filling Application

The following MT-SICS commands are available for the filling application.

| Command | Description |
|---------|--|
| F01 | Automatic prefilling configuration |
| F02 | Material filling duration configuration |
| F03 | Automatic refilling configuration |
| F04 | Target weight configuration |
| F05 | Optimization function configuration |
| F06 | Weight monitor function configuration |
| F07 | time monitor function configuration |
| F08 | Filling statistics |
| F09 | Filling application status |
| F10 | Control filling |
| F11 | Report filling status |
| F12 | Filling stability criteria configuration |
| F13 | Normal filling configuration |
| F14 | Automatic tare configuration |
| F15 | Digital output function configuration |
| F16 | Emptying function configuration |

Note

For more information on MT-SICS commands refer to the "Reference Manual for MT-SICS Interface Commands", 11781363 (English).

7.5 SAI Commands for Filling Application

Cyclic commands

| Command | Description | Value |
|---------------------------|---|-------|
| Write Filter Mode | Set the weighing mode: Normal weighing, Dosing, ... | 290 |
| Write Filter Environment | Set the environment condition: Very stable, Standard, ... | 291 |
| Write Low Pass Frequency | Set the cut-off frequency of fixed filter | 292 |
| Report Filter Mode | Get the current weighing mode: Normal weighing, Dosing, ... | 90 |
| Report Filter Environment | Get the environment condition: Very stable, Standard, ... | 91 |
| Report Low Pass Frequency | Get the cut-off frequency of fixed filter | 92 |
| Start Target | Run the filling application | 500 |
| Pause Target | Abort the filling application | 501 |
| Resume Target | Resume the filling application | 502 |

Acyclic commands

| Command | Description | Profibus slot / index (hex) | ProfiNET slot / subslot / index (hex) | EIC class / instance / attribute (hex) | Data type |
|----------------------------|---|-----------------------------|---------------------------------------|--|-----------|
| Automatic prefilling | Activate or deactivate the prefilling function and configure the digital output which will remain high during prefilling and the prefilling duration | 1 / 0xEF | 0 / 1 / 0x4201 | 0x414 / 1 / 0x01 | Struct |
| Material filling duration | Configure the material filling duration for filling applications. This is the waiting time in order to capture the filling material in the air | 1 / 0xF0 | 0 / 1 / 0x4202 | 0x414 / 1 / 0x02 | Integer |
| Automatic refilling | Activate or deactivate the refilling function. It automatically sets the selected digital output port for a time calculated by the optimization function. | 1 / 0xF1 | 0 / 1 / 0x4203 | 0x414 / 1 / 0x03 | Binary |
| Target weight | Configure the target weight for filling applications | 1 / 0xF2 | 0 / 1 / 0x4204 | 0x414 / 1 / 0x04 | Struct |
| Optimization function | Activate or deactivate the optimization function and configure the optimization method and degree | 1 / 0xF3 | 0 / 1 / 0x4205 | 0x414 / 1 / 0x05 | Struct |
| Weight monitor function | Activate or deactivate the weight monitor function and configure weight monitor function | 1 / 0xF4 | 0 / 1 / 0x4206 | 0x414 / 1 / 0x06 | Struct |
| Time monitor function | Activate or deactivate the time monitor function | 1 / 0xF5 | 0 / 1 / 0x4207 | 0x414 / 1 / 0x07 | Struct |
| Filling stability criteria | Query or reset the statistics for the filling application | 1 / 0xF6 | 0 / 1 / 0x4208 | 0x414 / 1 / 0x08 | Struct |
| Filling phase | Configure the normal filling process for filling applications | 1 / 0xF7 | 0 / 1 / 0x4209 | 0x414 / 1 / 0x09 | Struct |
| Automatic tare | Activate or deactivate the automatic tare function and configure the tare weight limit | 1 / 0xF8 | 0 / 1 / 0x420A | 0x414 / 1 / 0x0A | Struct |
| Digital output function | Configure the digital output function for filling applications | 1 / 0xF9 | 0 / 1 / 0x420B | 0x414 / 1 / 0x0B | Struct |
| Emptying function | Activate or deactivate the emptying function and configure the duration of it | 1 / 0xFA | 0 / 1 / 0x420C | 0x414 / 1 / 0x0C | Struct |
| Filling statistics | Query the statistics for the filling application | 1 / 0xFB | 0 / 1 / 0x420D | 0x414 / 1 / 0x0D | Struct |
| Clear filling statistics | Reset the statistics for the filling application | 1 / 0xFC | 0 / 1 / 0x420E | 0x414 / 1 / 0x0E | Binary |
| Filling application status | Query the status of the filling application | 1 / 0xFD | 0 / 1 / 0x420F | 0x414 / 1 / 0x0F | Binary |
| Report filling status | Report filling status | 1 / 0xFE | 0 / 1 / 0x4210 | 0x414 / 1 / 0x10 | Binary |
| Control filling status | Control filling status | 1 / 0xFF | 0 / 1 / 0x4211 | 0x414 / 1 / 0x11 | Binary |

GWP®

Good Weighing Practice™

GWP® is the global weighing standard, ensuring consistent accuracy of weighing processes, applicable to all equipment from any manufacturer. It helps to:

- Choose the appropriate balance or scale
- Calibrate and operate your weighing equipment with security
- Comply with quality and compliance standards in laboratory and manufacturing

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