# New Scales-based HOW wizard

**Keshet Printer,** Revision 4c

## 

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### List of changes from previous revision

### Table of Changes, Rev 4 (Keshet printer)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| # | **change:** | **parameters** | **Sections** | **Reason for Change** |
| 1 | new parameter | FA counter max | Weight measurements | updating SRS according to code |
| 2 | new parameter | Gain\_min Gain\_max | Find Target Layer | to ensure that the obtained Gain is within defined limits [Gain\_min,Gain\_max] |
| 3 | new values for existing parameters | VH=voltage\_FTL\_H VL=voltage\_FTL\_L |  | Provide lower voltages for Support heads |
| 4 | Purge sequence improvement |  | Purge sequence | Add fire-all at purge unit after every purge |
| 5 | Check if ‘next voltage’ is within limits |  | Iterations | Need scenario in case the ‘next voltage’ is outside limits |
| 6 | new sections added: |  | 1. GUI options #1 2. Check Current Calibration Test 3. GUI options #2 | Add option to check current calibration of heads, followed by option to calibrated only the necessary heads. |
| 7 | new parameter | head\_status | various | Parameter head\_status (vector) has a value of 0 or 1 for each head, 1=calibrate, 0=skip |
| 8 | new parameter | temp\_MinLayerHeight temp\_MaxLayerHeight | GUI #2 Find Target Layer | In 'Find Target Layer' these parameters replace MaxLayerHeight and MinLayerHeight. If the user chooses to calibrate only some of the heads- both values will be made equal to the current layer height. |
| 9 | new parameter | V\_tweak\_enable | 1 (true) | Enable\disable tweaking of heads that are not on target but close enough. |
| 10 | Add fire-all to container before first measurements |  |  | Very often the scale reading at start of wizard is not negligible (difference between open and closed printer). If it is non-negligible and also negative- the result will be wrong (too low) reading of the first fire-all on head 0. This has happened. Rev 4b |
| 11 | Missing nozzle determination – improvement |  |  | In case there are too many missing nozzles, repeat pattern-test after adding 1.5V to the problematic heads. This is very likely to revive the head (if the missing nozzles RC is partial blocking of the filter) and allow it to be properly calibrated. Rev 4c |

### Details of the changes in Rev4:

* 1. SRS updated to include parameter: [FA\_counter\_max](#_Compare_Fire-all_couple): The maximum number of Fire-all tests to perform for each measurement. This is already in the code.
  2. Verify that the Gain for each head is within the allowed range:
     + Introduce two new parameters: Gain\_min, Gain\_max in Parameter manager. These parameters do not vary between modes\materials (should be the same for all printheads of the same type).
     + During ‘[Find Target Layer](#_Find_Target_Layer)’, Gain calculation, after equation1 (Gain\_m): add logic test to ensure that the Gain is within the allowed limits.
  3. Updated (in Parameter Manager) the values for the First and Second voltages of the ‘Find Target Layer’ – different values for Model and Support. No code change.
  4. Iterations: added logics for scenario where the ‘next voltage’ is outside the allowed voltage limits. Theoretically this should never occur.
  5. Add the ‘Check Voltage Calibration’ option at the start of the wizard. With this option there are further modifications to enable the calibration of chosen heads (and not all heads).
     + Introduce vector parameter ‘head\_status’ (one value per each head). During ‘Find Target Layer’ and ‘Iterations’ – skip actions on heads if for them the head\_status is 0.
     + Modify [‘Find Target Layer’](#_Find_Target_Layer) so that the Layer Height will not change. For this: introduce two new parameters: temp\_MaxLayerHeight and temp\_MinLayerHeight. These parameters replace MaxLayerHeight and MinLayerHeight within the code of the ‘Find Target Layer’ step.
     + Two new GUIs.
  6. Change in Rev 4b: Perform fire-all into container at the start of the wizard, to eliminate chance of negative reading of the scale at start of the wizard.
  7. Change in Rev4c: At Pattern-Test, if there are heads with number of missing nozzles exceeding the max number allowed, increase the voltage for these heads by 1.5V and repeat pattern test.

### List of relevant parameters

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter name | Exists in previous revision | Exists in old HOW | Initial value Keshet | | | Exists in Parameter Manager? | comment |
| [noise\_level\_error](#_Weight_measurements) | Yes | No | 0.1 | | | Y | Should be above noise level – used to make sure that a fire-all was indeed done. |
| MaxV | Yes | Yes | 30 | | | Y | The maximum voltage allowed for the printheads (defined by manufacturer). |
| [FA\_counter](#_Compare_Fire-all_couple) | Yes | No | - | | | N | Restarted for each measurement – will count how many times there is need to send to purge |
| [FA\_counter\_max](#_Compare_Fire-all_couple) | ? | No | 3 | | | Y | Max value for FA\_counter |
| VH=voltage\_FTL\_H | Yes | No |  | HQ | HM | Y | first voltage in Find Target Layer  Per Mode, per material |
| Model | 25 | 25 |
| Support | 23 | 23 |
| VL=voltage\_FTL\_L |  | No |  | HQ | HM | Y | Second voltage in Find Target Layer  Per Mode, per Model\Support |
| Model | 22 | 22 |
| Support | 19 | 19 |
| Max\_iterations | Yes | Yes | 3 | | | Y | Changed from 10 (old HOW) to 3 |
| [Gain\_min](#_Find_Target_Layer) | No | Yes – v4 | 1.35 | | | Y |  |
| [Gain\_max](#_Find_Target_Layer) | Yes – v4 | Yes – v4 | 2 | | | Y |  |
| Head status | No | No | - | | | N | Restarted at beginning of wizard, updated throughout the wizard |
| MaxLayerHeight | Yes | Yes | 27 | | | Y |  |
| MinLayerHeight | Yes | Yes | 24 | | | Y |  |
| Temp\_ MaxLayerHeight | No | No | Default value= MaxLayerHeight | | | Y | Default value equals MaxLayerHeight. This value will be updated after every HOW run. It is the current value of the Roller Height. |
| Temp\_ MinLayerHeight | No | No | Default value= MinLayerHeight | | | N | This value will be set after the GUI with the option to choose between ‘full calibration’ and ‘subgroup’ calibration. If ‘Full calibration’ is chosen set to **Min**LayerHeight. Otherwise, to Temp\_**Max**LayerHeight. |
| V\_tweak\_enable | No | No | 1 (true) | | | Y | During ‘check current calibration – do we enable ‘tweaking’ of the print-heads. |

### Pattern-test repeat

Reason for change: Heads with several hundred printing hours often have filters partially blocked, and as a result they require higher voltage for calibration. This can be manifested also in missing sections in the Pattern-Test (too many missing nozzles). It was observed that adding 1.5V to such a head results in a Pattern-Test with less missing nozzles, and the head can function. It is in the application note of Keshet now to repeat Pattern-Test with the addition of 1.5V, so this is to be added to the HOW.

Sequence:

* 1. Pattern Test #1
  2. User is asked to fill in number of missing nozzles
  3. If there are heads for which the number of missing nozzles exceeds the ‘max’ allowed (currently this parameter is set to 10):
     + For each such head, define New Voltage=Current Voltage+1.5
     + If New Voltage>30V
       - Set Voltage (for this head)=30V.
     + Else, set Voltage (for this head)=New Voltage
     + End If
     + Write to log: Head Optimization Wizard: Head \*\* too many missing nozzles, will repeat pattern-test at a higher voltage
     + Write to log: Head Optimization Wizard: Head Optimization Wizard: Head \*\*, Next Voltage = \*\*
  4. Perform Pattern Test #2
  5. User is asked to fill in number of missing nozzles
  6. If there are heads for which the number of missing nozzles exceeds the ‘max’ allowed, cancel wizard (same code as existed in previous revisions)

### Fire-all to container at start of the wizard

Reason for change: There is always a difference between the scale reading when the printer is open and when it is closed. Discrepancies of up to 0.3 gram were observed. If the difference is negative (the scale reading when the door is closed is negative) – it will impact the result in low reading of the weight of the first fire-all performed on head 0.

Fix:

After Missing Nozzle determination, after scale is brought on top of the container, perform the following sequence:

* Set Volage to 25V for head 0
* WeightTest (as weight test in calibration)
  1. Fire from head 0
  2. Read Scale
  3. Set prev weight.

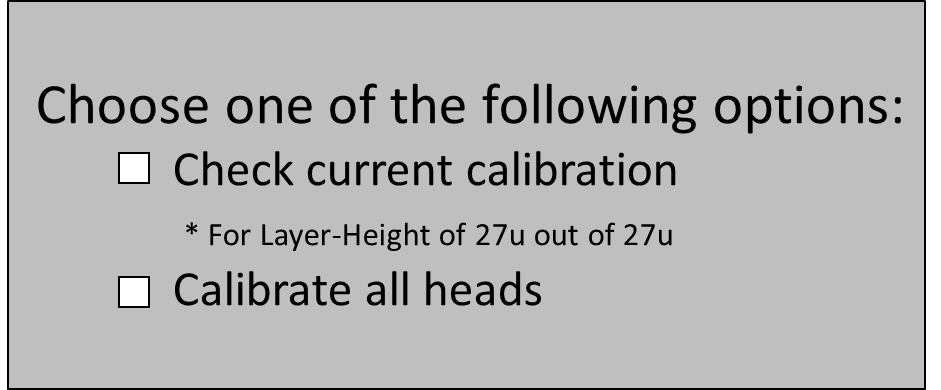
### New Sequence for HOW to include ‘Check Current Calibration’ test

### Overall view of new sequence

* 1. Begin Wizard as before (all steps that come before ‘Find Target Layer’):
     + Print Frame
     + Print Test-Pattern to determine number of missing nozzles
     + Fire-all into container
  2. **GUI #1:** To choose “calibrate all heads” or “check current calibration”.
     + Full calibration: proceed as in previous HOW versions (new HOW version 4). To achieve this set head\_status to 1 for all heads (head \_status=[1,1,1,1,1,1,1,1])
     + Check Current Calibration Test – in detail below
       - Perform [weight measurement](#_Weight_measurements_1) for each head at its current voltage.
       - Provide conclusion- which heads should be calibrated or not, and if ‘V\_tweak\_enabled’ is activated – these heads will be tweaked and will not require calibration.
       - **GUI # 2: T**o choose whether to calibrate all heads or a subgroup. Heads which ‘failed verification’ will be marked.
       - Update parameters such as temp\_MinLayerHeight and head\_status, details below.
  3. Proceed with Wizard with the following modifications:
     + Find Target Layer (see full details [below](#_Find_Target_Layer)):
       - Skip the heads with ‘head\_status’ of 0.
       - Replace, in the current code, the parameter MaxLayerHeight with temp\_MaxLayerHeight and MinLayerHeight with temp\_MinLayerHeight (see below).
       - If MinMaxLHnet<Temp\_MinLayerHeight Then there will be two scenarios (see below): cancel wizard and ask head replacement or go to calibrate all heads (since a lower LayerHeight is required) – i.e. restart ‘Find Target Layer’ with head\_status of 1 for all 8 heads.
     + Iterations:
       - Skip the heads with ‘head\_status’ of 0.

### GUI #1: HOW options:

* In this GUI display the current Layer-Height (ParameterManager->Setup->LayerHeightDPI\_um) and the MaxLayerHeight.
* Display two options:
  + Check current calibration
  + Calibrate all heads



### Check Current Calibration Test:

* + Set temp\_MaxLayerHeight to be the current Layer Height (ParameterManager->Setup->LayerHeightDPI\_um).
  + For each head:
    - Using temp\_MaxLayerHeight calculate the target weight.
    - Read the current voltage value of this head and perform [weight measurement](#_Weight_measurements_1) for each head at this voltage (it’s the same Weight measurement sequence used throughout the wizard, section [Weight measurements](#_Weight_measurements_1).
    - Calculate deltaW= target weight – measurement.
      * Write to log: Head Optimization Wizard: Head \*\* delta weight \*\*
      * If |deltaW|<scale\_resolution\*1.5
        + Set head\_status 0 for this head
        + Write to log: Head Optimization Wizard: Head \*\* calibration is satisfactory.
      * Else if |deltaW|<scale\_resolution\*3
        + If V\_tweak\_enable=0 :

Write to log: Head Optimization Wizard: Head \*\* calibration requires small voltage calibration.

Set head\_status 1 for this head (requires calibration)

* + - * + If V\_tweak\_enable=1 :

Calculate recommended voltage change dV using the parameter Gain\_max:

Save voltage V=Current\_voltage+dV for this head

Set head\_status 0 for this head

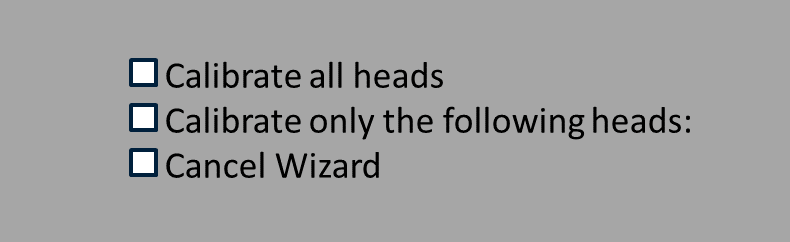
Write to log: Head Optimization Wizard: Head \*\* voltage tweak done

Write to log: Head Optimization Wizard: save voltage \*\* for head Head \*\*

* + - * Else
        + Set head\_status 1 for this head (requires calibration)
    - The conclusion for this test is the setting of the vector parameter head\_status.

### Gui #2: Calibration options:

* + GUI to choose whether to calibrate all heads or a subgroup. Heads with head\_status of 1 will be marked (must be calibrated).
  + If the ‘Calibrate all heads’ is chosen:
    - Set temp\_MinLayerHeight= MinLayerHeight
    - Set temp\_MaxLayerHeight=MaxLayerHeight
  + Otherwise, set temp\_MinLayerHeight=temp\_MaxLayerHeight.
  + End if



### Weight measurements

### Noise Level:

Introduce a new parameter - noise\_level\_error.

At each fire-all check: If Measurement < noise\_level\_error (no fire-all was done?):

* 1. Write to log: Head Optimization Wizard: Scale reading error: Measurement too low, repeat scale reading
  2. Wait 10 seconds and repeat scale reading (scale tmp measurement).
  3. If the reading changes (WT>noise\_level\_error):
     1. Write to log: Head Optimization Wizard: Scale reading error: second scale reading successful.
     2. Continue to the next step
  4. Otherwise:
     1. Write to log: Head Optimization Wizard: Scale reading error: second scale reading failed, send to purge
     2. Send to purge and repeat from the fire-all test.
     3. If the reading changes (WT>noise\_level\_error): continue the wizard.
     4. If the reading is too low again (WT<noise\_level\_error)
        1. Write to log: Head Optimization Wizard: Scale reading error: cancel wizard, check scale and check heads.
        2. Cancel wizard with request to check scale and perform pattern-test.

### Compare Fire-all couple

The sequence today includes the test:



And sends to purge if the test fails. Need to add a counter (FA\_counter) so that there won’t be more than FA\_counter\_max such purge cycles for any measurement.

### Summary: full measurement sequence

1. Set Voltage
2. Set FA\_counter=0
3. Perform 1st fire-all, check if larger than noise level, [section a](#_Weight_measurements)
4. Get scale reading M1 (V)
5. Perform 2nd fire-all check if larger than noise level, [section a](#_Weight_measurements)
6. Get scale reading M2 (V)
7. Check the following condition: (same as was before)

**If** M2(V)<FA\_weight\_factor\*M1(V) **Then:**

* 1. FA\_Counter=FA\_counter+1
  2. if FA\_counter<FA\_counter\_max Then
     1. Send to purge
     2. Update the ‘previous scale reading’ (perform 5 scale readings)
     3. Repeat from step III.

Else- cancel wizard

End If

Else: continue to step VIII.

End if

1. Perform 10 scale readings, and **Measurement(V)=average of these 10 scale readings-“previous scale reading”**
2. Continue to next step.

### Find Target Layer

The concept of the new HOW is changed! Will include two iterations (to avoid the measurement at MaxVoltage)

Rev 4 changes are marked in cyan or yellow.

* For each head – check the ‘head\_status’:

For head #n: If head\_status(n)=0 then skip this head.

* Perform weight measurement test at the following voltages: voltage\_FTL\_H (VH) and voltage\_FTL\_L (VL), where VH>VL, taken from Parameter Manager. These parameters will vary between products, modes and materials (Model vs. Support)
* Repeat these two measurements for all heads.
* In each case write to the log as before.
* Target Layer Height Calculation:
  1. Use the results of iterations 1-2 to extrapolate the weight at the Maximum Voltage (MaxV), and from this value- the Maximal possible layer height per head.
  2. Calculate Gain:
     + Eq. 1a.
     + Check if the value of Gainm is consistent (verify that it is within the range of [Gainmin,Gainmax]:
       - If Then:
       - Else If Then:
     + Eq. 1b:
  3. Write to log: Head Optimization Wizard: Gain for Head head \*\*
  4. Calculate Weight(MaxV):
     + If VH=MaxV, Weight(maxV)=Weight(VH)
     + If VH<MaxV, derive the weight at maximum voltage according to:

Eq.2

* + - Write to log: Head Optimization Wizard: Head \*\*, Weight\_maxV=
  1. Calculate Max Layer (gross)
     + Eq. 3:
     + Write to log Head Optimization Wizard: Head \*\*, Maximal layer head = \*\*
  2. Find the minimal value of the Max possible layer height for all heads (MinMaxLH (gross)). Derive the net value

Eq. 7a: LHgross=(LHnet+m)\*n,

Eq. 4b: MinMaxLHnet=(MinMaxLHgross/n)-m

* + - Write to log Head Optimization Wizard: Head \*\*, Minimum of Maximal layer head =\*\*
  1. If MinMaxLHnet<temp\_MinLayerHeight Then:
     + If MinMaxLHnet<MinLayerHeight Then: cancel wizard and request replacement of weak heads (heads with Maximal layer height smaller than MinLayerHeight.
     + Otherwise:
       - Write to log: Head Optimization Wizard: Calibration to lower Layer Height required, restarting Wizard, calibrating all heads.
       - Set head\_status of 1 for all heads [1,1,1,1,1,1,1,1]
       - Set temp\_MaxLayerHeight=MaxLayerHeight
       - Set temp\_MinLayerHeight=MinLayerHeight.
       - Restart ‘Find Target Layer’
  2. Otherwise set Target Layer Height to be:

min(MinMaxLH, temp\_MaxLayerHeight)

* 1. Calculate the Target Weight for each head based on the derived Target Layer-Height and all the relevant factors (material factor, heads factor, mode factor etc’). Here again, skip the heads for which head\_status is 0.

### Iterations:

(done separately for each head). *Here again there are major changes*.

Rev 5 changes are marked in cyan.

For each head – check the ‘head\_status’:

For head #n: If head\_status(n)=0 then skip this head.

#### Prior to iteration step

* Use the Gain calculated after the second iteration (Eq. 1b) , and the Voltage VL and Weight W(VL) to calculate the first iteration voltage.
* *First iteration voltage ==*

#### Iteration n

* Voltage adjustment:
  + - Calculate ‘delta weight to target’ of previous step:

Eq. 6:

* + - Calculate the voltage:

*Voltage ==*

* + - Verify that Vn is within voltage limits (MinVoltage\MaxVoltage)
      * If Vn<MinVoltage
        1. If Vn-1=MinVoltage (previous iteration voltage also below limits) Then

Set Vn=MinVoltage, save and continue to next head

Write to log :Head Optimization Wizard: voltage Head \*\* requires voltage lower than minimum.

Write to log :Head Optimization Wizard: save voltage \*\* for head Head \*\*

* + - * 1. Else – set Vn= MinVoltage and continue.
      * IF Vn>MaxVoltage
        1. If Vn-1=MaxVoltage cancel Wizard
        2. Else – set Vn=MaxVoltage and continue.
  1. Perform Measurement (‘Current weight’):
     + Perform measurement according to [section II](#_Weight_measurements)
     + Check Convergence condition:

|Target\_weight-Current\_weight|<Scale\_Res (parameter).

* + - If True: Save last voltage and continue to next head.
    - If False:
      * if n=max\_iterations:

Save final voltage=

Write to log

* + - * + Head Optimization Wizard: final voltage taken as average of last 2 voltages
        + Head Optimization Wizard: Save voltage \*\* for head Head \*\*

Continue to next head\finish.

* + - * if n< max\_iterations,  Check Convergence progress:

|Target\_weight-Current\_weight|< | dWn|\*1.2

* + - * 1. If True: Calculate the voltage for the next iteration (Eq6) and continue.
        2. Otherwise: check if sign (dWn-1)=sign(dWn) . (can only be explained by a change in number of effective nozzles)
        3. True:

Write to log Head Optimization Wizard: no progress, repeating measurement.

Send to purge

Repeat measurement with the same voltage (save it as current\_weight instead of the previous measurement)

If convergence condition is not reached, continue to next iteration (without checking convergence progress again).

* + - * 1. False:

set Gain=Gain\*1.05

Write to log: Head Optimization Wizard: Increasing gain by 5%.

Continue to next iteration

### Purge sequence

Perform fire-all (still at the purge unit) after every time the head is sent to purge (to ensure nozzle functioning).

### Wizard Cancellations (Summary):

Need to go over and map all the scenarios for wizard cancellation, and what are the messages to the customer in each case.

* Technical problems (scale reading etc’)- as before
* Obsolete issues (remove from wizard):
  + If max number of iterations is exceeded (see different approach in [section VI](#_Iterations_n=3_to)II )

### Weak head: The following scenarios must remain but with minor corrections

#### If max number of missing nozzles is exceeded:

* + - * Ask for verification (maybe there was a typo)
      * Cancel wizard due to too many missing nozzles:

“Allowed number of missing nozzle exceeded, please replace head”

“\* To avoid replacing head the following steps may be taken:

Perform head-cleaning wizard

Send to purge 5 to 10 times

Perform “pattern-test” to check status”

* + - * This should be the only place in the wizard where there is a cancellation with the message that the number of missing nozzles is exceeded. Need to delete if this appears in other places in the wizard.

#### Failure at measurement stage:

* + - Weight is too low (smaller than 2\*noise\_level\_error) [See below](#_Noise_Level:_1)
    - Weight inconsistency for a particular measurement: if there is a difference between the Weight of the two fire-all stages, see [below](#_Compare_Fire-all_couple).
    - Failure at ‘Find Target Layer’ step – maximal layer height possible for a head is lower than MinLayerHeight. [See below](#_Find_Target_Layer).
  + **If next iteration voltage is outside of limits** (lower than minV or higher than maxV)

In general, this should not occur (since we are checking the convergence progress). In some cases (such as Objet1000) there is a chance that the Support requires a lower voltage than the minimum, in that case the wizard provides the minimum voltage and continues.