Witbox 2

Firmware update and autolevelling guide

Version:	1.0
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Approved by:	Jon Goitia
Effect date:	28/06/2018
Project:	Witbox 2

June 28th 2018

Changelog

Version	Date	Changes	Author
1.0	June 28th 2018	Document created	BQ

Contents

Introduction

BQ pioneered the use of inductive sensors as an autolevelling solution for 3D printing. The Witbox 2 uses this technology to automatically correct the inclination of the print surface, although the user can also turn off this option and level the print bed manually.

This guide aims to help customers understand this autolevelling feature and how to adjust the offset (distance from the nozzle to the print bed). It also explains the changes introduced in the new firmware version (3.0.0) and how to get the most out of the new levelling algorithm.

There is an important change that must be done to the print bed for autolevelling to work correctly with the new firmware version. Please make sure to read the section *Print Bed Changes* before updating your printer.

Updating Firmware

As part of BQ's commitment to continuous improvement of our products, we maintain periodic firmware updates to fix bugs, include new functionality, or improve existing features. Customers can update their printer using the Software Updater or by directly downloading the new firmware. Both options are available on the Witbox 2 downloads page.

The focus of this update is to improve autolevelling performance and reliability. To do so, we have tested over 15 different variables and tweaked several parameters that affect the levelling procedure. The main changes are the following:

1) 9-point mesh levelling

The current firmware (2.5.1) uses 3 points to determine the inclination of the print bed. It calculates a single plane that represents a completely flat surface.

The new levelling algorithm measures 9 points and creates a mesh that represents smaller regions of the print bed. This additional information allows more control over the inclination and curvature of the print surface. Additionally, the effect of any measurement error is reduced with this approach.

2) Single measurement per point

Most printers measure each levelling point several times at a slow speed because it is generally accepted that repeating measurements provides greater precision. However, this depends on the type of sensor and its behaviour. After extensive testing, we have determined that the first measurement of each point is actually the most precise, and repeating the measurement gives data with higher error.

For this reason, the new algorithm only measures each point once, which also saves time in the levelling routine.

3) Lower preheat temperature

Temperature has a big effect on the measurements of inductive sensors and must be compensated. BQ's sensor has an integrated temperature sensor that corrects the data obtained for levelling. This is adequate to compensate variations in room temperature. However, large or fast changes in temperature (such as the hotend heating up to 200ºC) may cause slight differences in the readings.

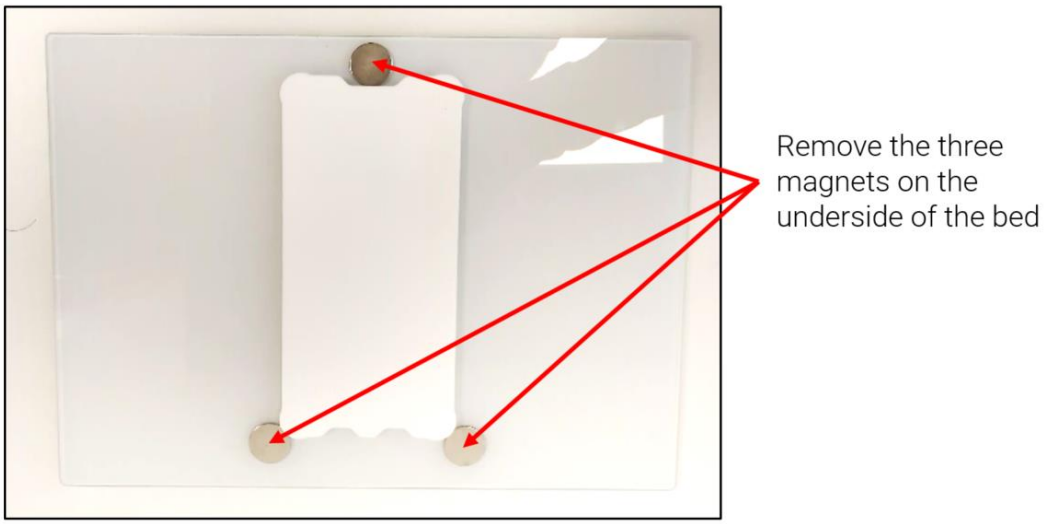
The levelling is now done with the hotend at 140ºC, where this effect is reduced but any PLA still on the nozzle will be molten. This provides greater precision in the levelling without interfering with previously defined routines.

Print Bed Changes

In order to allow 9-point levelling, **the magnets must be removed from the print bed**. The magnetic field affects the inductive sensor and it will give wrong measurements when sensing close to the magnets.

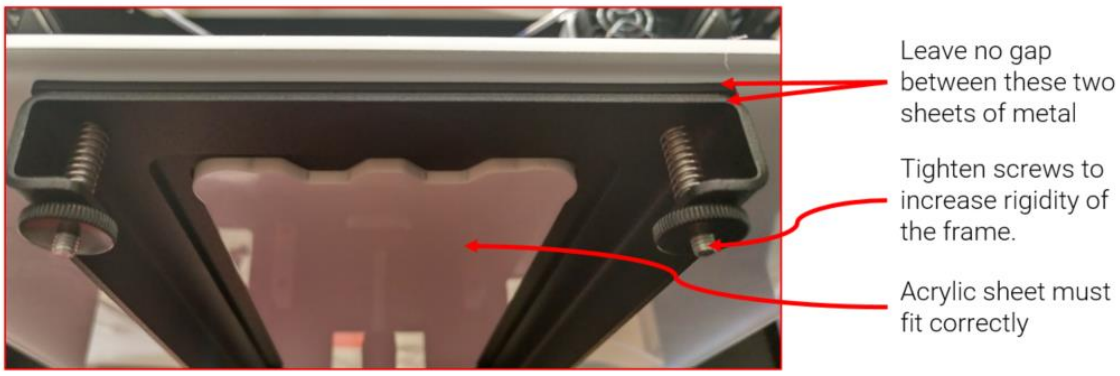
Removing the magnets will not have any negative effect on the printer's operation, and they are not necessary to hold the print bed (the acrylic shape on the bottom of the print bed already ensures a correct and tight fit)

The easiest way to remove the flat magnets is to use the spatula included with your Witbox 2. You can see a video of how to do this here.



Be careful when removing the magnets. The metal spatula has sharp edges. Make sure the bed is tightly gripped and do not put your hands near the magnet you are removing. Use gloves to protect your hands.

An optional change is to **tighten the manual levelling screws** to increase the rigidity of the bed support structure. This will eliminate the possibility of manual levelling, but will simplify the process for some users.



Make sure you do not overtighten the screws. There is no need to put excessive pressure on them. Tighten all three knobs together so the force is evenly distributed.

First Layer Settings

The success of the first layer depends greatly on the parameters used. The following table lists the minimum recommended settings for the first layer:

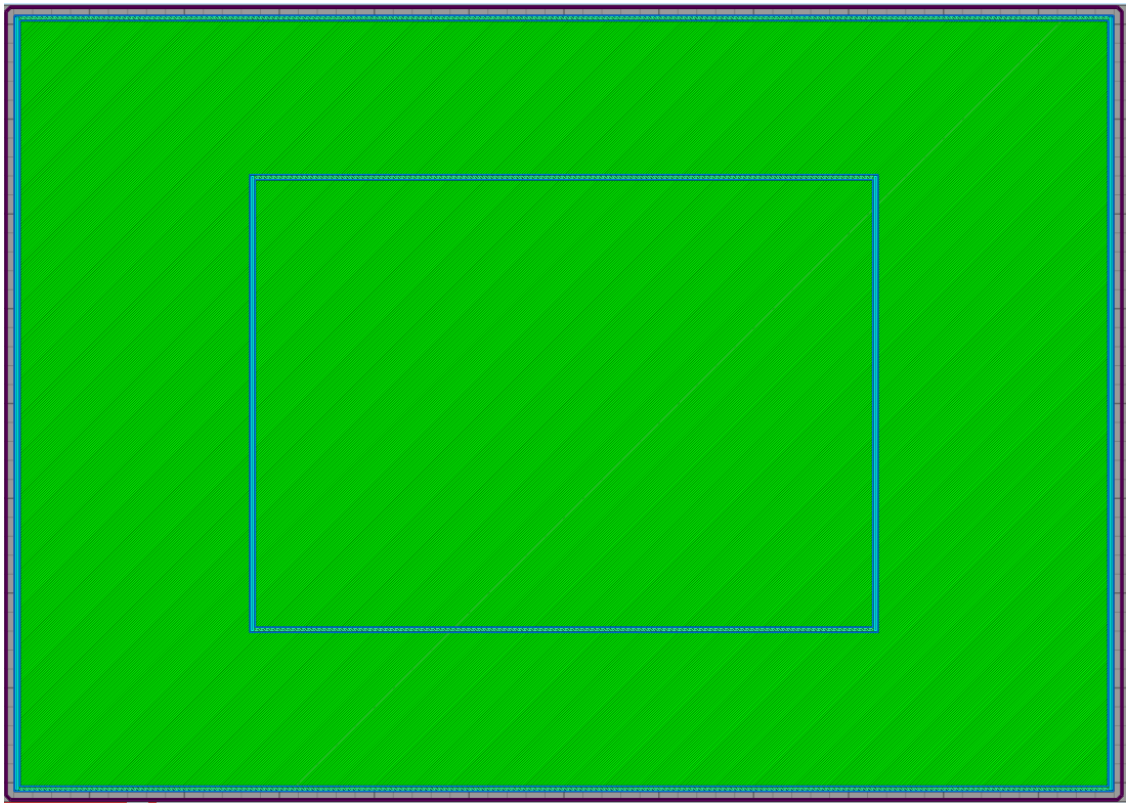
Layer height	≥ 0.2mm	Even if the rest of the print uses a different layer height, make sure the first layer is at least 0.2mm thick. Using higher layer heights will greatly reduce any levelling errors.
Extrusion width	≥ 0.4mm	Increasing the extrusion width on the first layer can improve adhesion to the print bed. Recommended value: 0.48.
Layer speed	15 - 20 mm/s	Printing the first layer slowly dramatically increases the chances of a successful print.

Remember these parameters **apply only to the first layer**. The rest of the part can be printed with any other values.

Test Gcode

When evaluating the printer's levelling, it is important to always print the same pattern. BQ tests autolevelling with a single layer that covers the full print area. It has two thin rectangles on the second layer that keep everything together and allow easy peeling from the print bed.

You can download BQ's standard Levelling Test Gcode for Witbox 2 here.



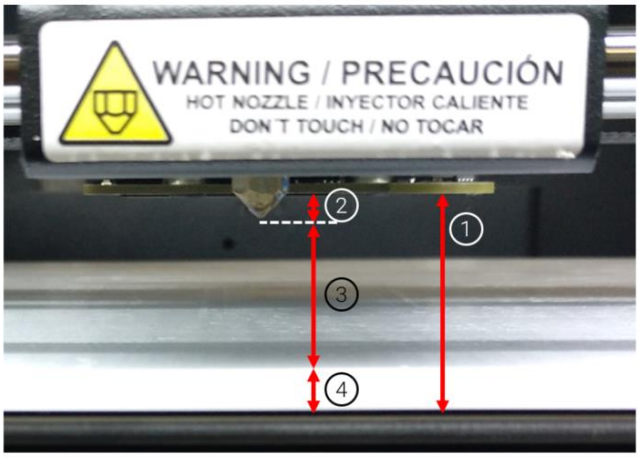
Before printing the Test Gcode:

- Run the Offset calibration routine so the nozzle height is correct.
- Make sure that Autolevelling is ON in the Settings menu
- DO NOT touch the manual knobs when the Gcode is printing! We need to see the result without human intervention in the levelling process.

Understanding the Offset Parameter

The next few sections deal with issues related to levelling and offset calibration. Before discussing these specific topics, it is important to understand why we have an offset value and its role in the printer configuration.

Here is a visual representation of what the Offset value is, considering all the components involved in the levelling process:



1. Sensing distance - sensor to steel sheet (~7mm)
2. Nozzle to sensor distance (~2mm)
3. Offset value (2 ~ 3.5mm)
4. Glass thickness (3mm)

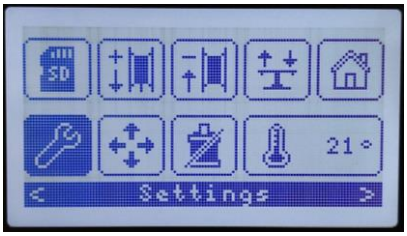
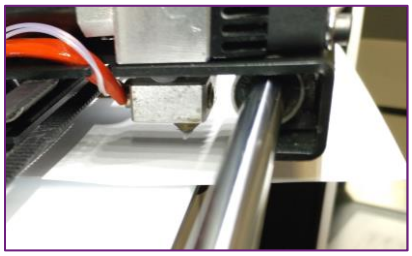
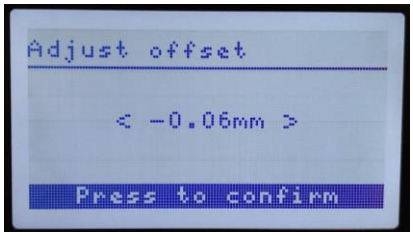
Basically, distances (1), (2) and (4) are fixed and constant. To make sure the nozzle is at the perfect height, we need to compensate by moving the hotend down by distance (3). This is the Offset value that must be calibrated for each printer (or if any other component is changed - hotend, print bed, inductive sensor).

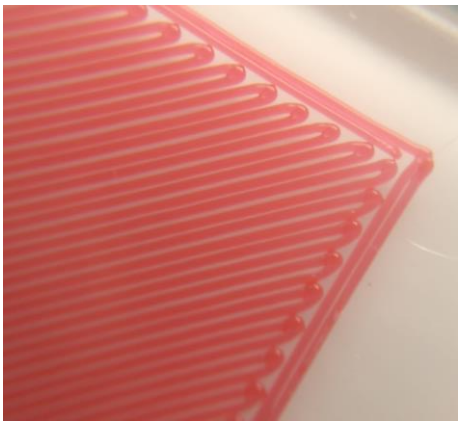
Notes:

- Increasing the Offset value moves the hotend closer to the print bed.
- Decreasing the Offset value means the hotend will be higher off from the print bed.
- The Offset value is stored in the printer's EEPROM, and will not be erased even after flashing a new firmware version. Only a Hard Reset will erase the Offset value.

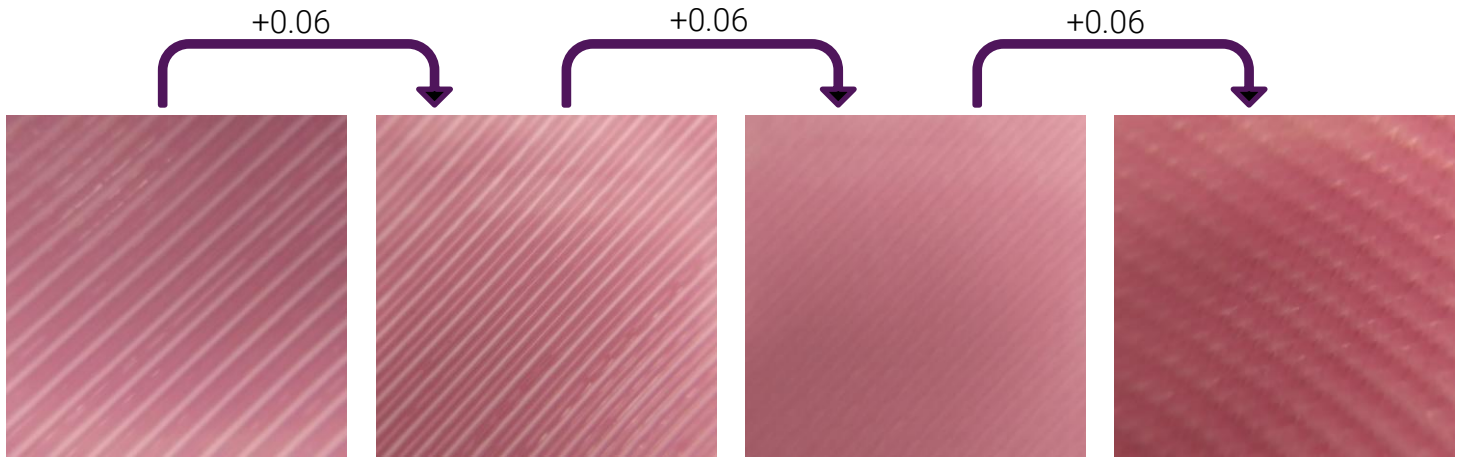
Offset Calibration Procedure

Offset calibration must be done to achieve good print results, independently of the type of levelling used (auto or manual). To calibrate the offset correctly, follow the instructions below:

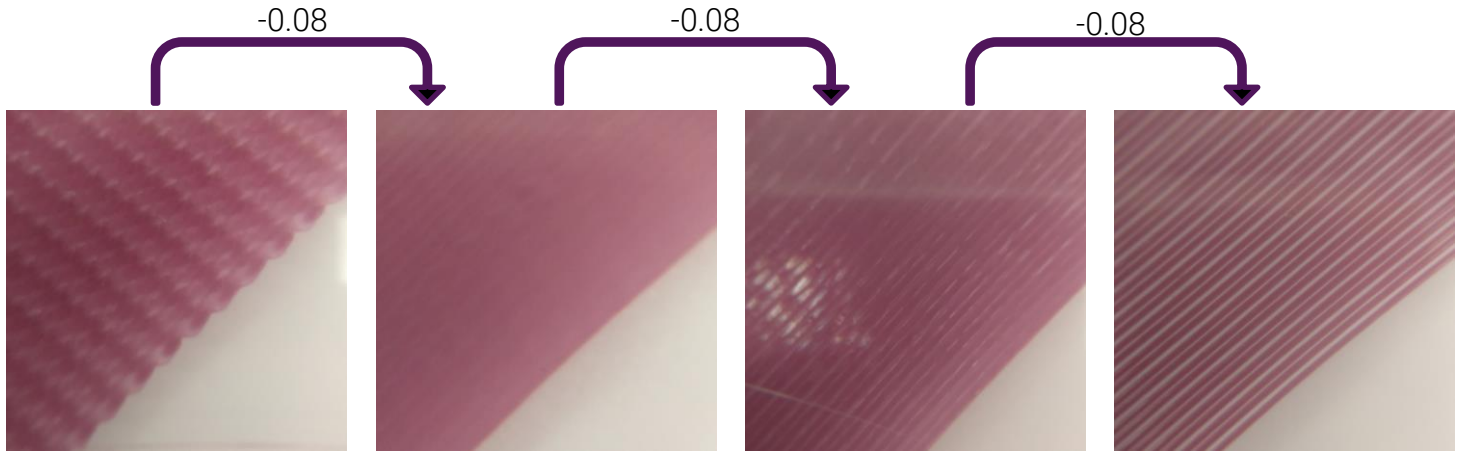
	Steps	Picture
	Go to Settings > Adjust Offset > OK The printer will preheat the nozzle and move it to the center of the print bed. In the Z-axis, the printer will move to the current offset level. The wizard that guides you through the calibration is always the same, but we can use it in two different ways depending on how far away we are from the desired result.	
1.	Coarse calibration Used when the hotend is far from the print bed (i.e. after a hard reset, Offset value is 0) Put a piece of paper under the nozzle and turn the dial so the bed starts moving up (positive offset values) Move the piece of paper under the nozzle while slowly moving the print bed upwards. Stop when you feel the nozzle creating friction and it becomes hard to keep moving the paper. Exit the process when everything is ready.	 
2.	Fine tuning Used when the hotend is already very near the print bed (not practical to use the paper). Simply adjust the dial up or down to make small changes to the nozzle height (recommended steps of ±0.06mm) Exit the process when everything is ready.	 

Print the Test Gcode to check if adhesion is correct. In this example the nozzle is still too high: the plastic is not fusing together and there are some gaps.	
Go back to fine tuning the Offset again and adjust +0.06mm (the nozzle will be 60 microns closer to the print bed).	
Print the Test Gcode again and check if adhesion is correct. Here you can see that the gap has almost disappeared and the plastic is pressed against the print bed.	
Keep repeating these steps (print test Gcode, fine tune offset value) until the desired level of adhesion is reached.	

Positive Offset change = nozzle closer to bed = more adhesion



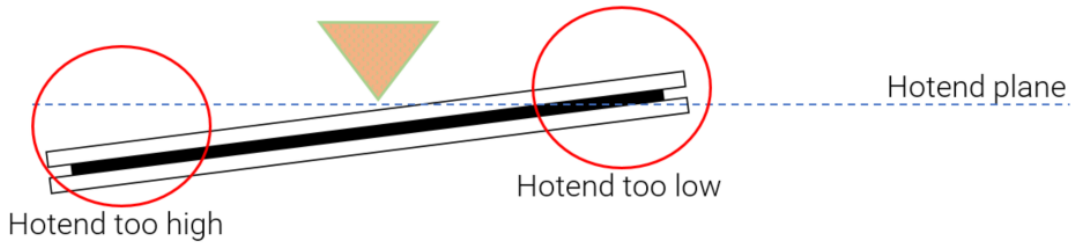
Negative Offset change = nozzle further away from bed = less adhesion



Slightly higher increments might be needed when decreasing the offset value to compensate Z-axis screw backlash. Even though the offset can be adjusted with a resolution of 0.02mm, making adjustments smaller than 0.06mm is not recommended, since real-world tolerances and errors will normally be larger.

Offset Considerations with Manual Levelling

When using manual levelling, it is important to understand that changing the offset and turning the knobs to compensate the bed tilt may have undesired effects. The following examples illustrate two situations where making the wrong change to the printer will not solve the problem and can lead to frustration. To avoid these situations, autolevelling is usually a better option for most users.

Case 1 Uneven adhesion	Adhesion of the first layer is not even. The hotend is too high on one side and too low on the opposite side.
Analysis	**Offset is correct** (well calibrated on center of print bed) **Manual levelling is wrong** (print bed is tilted)
Solution	DO NOT recalibrate the offset. Changing the offset will only make one of the sides worse (even higher or even lower). The solution is to level the bed with the manual knobs. The bed needs to be parallel to the hotend plane to achieve even adhesion.
Diagram	

Case 2 Wrong Offset	Adhesion of the first layer is the same on the full surface, but it is either too high or too low.
Analysis	**Offset is wrong** (prints too high) **Manual levelling is correct** (print bed is parallel to hotend plane)
Solution	DO NOT use the knobs to adjust the height of the print bed. The bed will likely become uneven and the offset will still be too high. This means that on the next print the problem will repeat itself and you will have to turn the knobs once more. After a few prints, the screws will run out of travel and will need resetting (unscrewing to a center position). The solution is to adjust the offset in increments of ±0.06mm and test the print again. This will allow you to carefully tune the offset value and achieve perfect adhesion on the full surface area (see the section “Offset Calibration Procedure”).
Diagram	

Summary
The first step is to make sure that adhesion of the first layer is similar everywhere on the print bed (it does not matter it is too high or too low, but it needs to be the same everywhere).

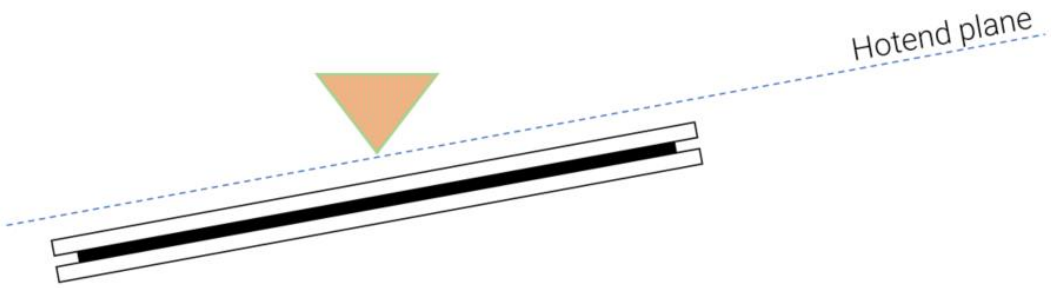
Once adhesion is even, adjust the offset in small increments (±0.06mm) to slowly increase or decrease the distance to the print bed and achieve the desired level of adhesion.

Note: When levelling manually, it is possible to change both the height and tilt of the bed by turning the manual knobs. However, this will require small adjustments with every print if the bed is not placed in the same exact position every time. As seen in the example above, if the offset is not properly calibrated, it will be necessary to make changes constantly.

To avoid this situation, Autolevelling is recommended for most prints and users. Once the Offset is calibrated, Autolevelling allows printing without having to compensate for the tilt of the print bed manually (see next section).

Offset Considerations with Autolevelling

It is important to realize that when using Autolevelling, the tilt of the print bed is compensated by the Z-axis moving up and down. Therefore, the plane of the hotend rotates with the bed and the only step necessary is calibrating the Offset value.

Case 1 Wrong Offset	Adhesion of the first layer is the same on the full surface, but it is either too high or too low.
Analysis	Offset is wrong (prints too high) Autolevelling automatically compensates the tilt of the print bed. There is no need for manual intervention.
Solution	The solution is to adjust the offset in increments of ±0.06mm and test the print again. This will allow you to carefully tune the offset value and achieve perfect adhesion on the full surface area.
Diagram	

- If the adhesion is uneven, make sure you are using Autolevelling in the settings menu and that the print bed is properly secured to the Z-axis.
- If the height of the nozzle seems correct but the filament is not sticking properly to the print bed, try using hairspray or tape to increase adhesion of the first layer.
- There might be minute differences in height that can be visible as the filament is laid down, but all fall in the spectrum of proper adhesion.