BED LEVELING EXPERIMENTS
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Introduction

This document is derived from the much larger document created as a record of transforming a stock SV06 using the original Marlin software to the open source Klipper version, using a BigTreeTech Pad 7 as the mcu. The original file can be found in the same directory as this file.

This information is a more detailed discussion of the bed leveling process, because of onfusing issues that developed while trying to produce uniform first layer prints. I suspect some of the issues likely affect other users. Not being an 3D printer expert, some of the issues may be my own lack of understanding. However, I believe I did enough work to show that there may be more fundamental issues to the bed mesh leveling calibration than are resolved by the standard methods. At least with my SV06.

Excel is used extensively to deal with data, using formula's and vba macros for more complicated data calculations, and for directly copying to the document. In the directory, with this document is a parred down version of the original Excel file that was used to scrape, record, and manipulate data. Missing are the many phases of data reduction calculation ideas, ultimately leading down false and correct paths. Even though streamlined, it is not a simple template of plug and play operations. Effort will be needed to understand what some of the worksheets are doing, though ins some cases there are some efforts to describe the general operations on a worksheet.

Temperature and Bed Leveling

The Klipper documentation recommends bed leveling with the bed heated. Moreover, the SV06 Marlin bed leveling process sets the bed temperature at 60 °C and extruder temperature at 120 °C. In early efforts to deal with a warped bed, calibrations were at room temperature, resulting in days of frustration trying to get even near a level bed. While trying to understand all the reasons for bed mesh levels that did not result in good first layer prints, I did a number of tests using the Klipper PROBE command under different temperature scenarios: Room Temperature, E@RmTB60, E120B60, and E195B60 (E=Extruder; B = Bed). The results showed large bed mesh differences at between Room Temperature and bed-only heated to 60 °C, versus E120B60, and E195B60.   The bed mesh done at E195/60 showed no statistically different probe values than the E120B60 bed mesh.

The table below is the result of subtracting the average of two bed mesh calibrations done at ~17.5 °C from the average of two bed mesh calibrations done at E120B60a shows an experimental test of the temperature issue,

204.996	-0.154	-0.119	-0.092	-0.075	-0.072	-0.077	-0.097	-0.113	-0.144	-0.174
183.552	-0.105	-0.078	-0.062	-0.047	-0.045	-0.050	-0.071	-0.077	-0.114	-0.141
162.108	-0.069	-0.047	-0.034	-0.022	-0.021	-0.029	-0.036	-0.033	-0.038	-0.063
140.664	-0.035	-0.017	-0.006	-0.001	-0.003	-0.008	-0.009	-0.010	0.003	-0.006
119.22	-0.019	-0.004	0.007	0.012	0.011	0.004	0.010	0.011	0.015	0.024
97.776	-0.006	0.008	0.015	0.021	0.021	0.015	0.021	0.020	0.029	0.033
76.332	-0.011	0.006	0.014	0.016	0.016	0.010	0.020	0.026	0.021	0.024
54.888	-0.013	0.003	0.011	0.016	0.012	0.008	0.014	0.022	0.002	0.010
33.444	-0.028	-0.009	0.002	0.010	0.010	0.008	0.015	0.016	0.000	0.013
12	-0.029	-0.005	0.013	0.019	0.022	0.021	0.028	0.029	-0.011	0.011
Y↑; X→	**27**	**47.333**	**67.666**	**87.999**	**108.332**	**128.665**	**148.998**	**169.331**	**189.664**	**209.997**

The especially large negative differences across the back of the bed correspond to a downward warp of the bed with increasing temperature.

Basically, the temperature data confirmed bed mesh calibration with the Marlin/Sovol SV06 recommended temperatures of 120E/60B.

First Shimming and Bed Mesh Calibration Attempts

What I thought would end up as my final bed mesh was the result of a shimming process involving a combination of aluminum shims and judiciously placed 10 mm and 20 mm Kapton tape strips interspersed with Z tramming of the z axis screws to achieve a reasonably uniform and flat bed parallel to the extruder x travel direction. The process was:

1. Copy the *printer.cfg save_config* section bed mesh data derived from a *BED_MESH_CALIBRATE* command to Excel and see what changes in shimming and/or Z tilt needed to be made.
2. Use g code *M84* to disable steppers to be able to move bed for convenience, or adjust the z screws.
3. Add shims, or adjust the Z feed screws as directed by calculation (see section of revisiting tramming below).
4. Heat the printer 120E/60B (usually from mainsail). Wait a minute or so for temperatures to stabilize.
5. *Home All (G28)*
6. *BED_MESH_CALIBRATE*
7. Look at Heatmap.
8. Open *printer.cfg* file. Transfer data to Excel to create plots to see magnitude of shimming needed and to calculate z tilt for z axis tramming adjustment, and watch standard deviation and variance, for improvements (lower values).
9. Repeat above steps as needed.

All data was based on bicubic interpolation with 10x10 mesh, probe count=3; pps 4,4; tension 0.5.

Rarely were shim changes and Z axis screw adjustments made simultaneously. Changing too many variables at once easily leads to just confusion, on what changes were really accomplishing, especially as the bed gets closer to a flat surface.

Below is heatmap generated in Excel, of what I thought would be the final mesh. Blue represents negative values, white is 0.0 mm, and bright red positive values. In all cases the color range limit is set to -0.15 of 0.15 mm. There are points, where this range was exceeded, so examining the numbers may be important. The reason for holding to a constant range is for easy comparison of the heatmaps.

Clearly, in this “optimized” bed mesh there are still probe points particularly at the bed periphery, with fairly large negative regions. The central area was expected to show only very small differences from zero based on using the average slopes to make changes to the z tilt, and z offset with probe at center of bed. The color scale runs from blue, -0.15 to red, 0.15.

205.00	0.016	0.010	-0.010	0.013	-0.037	-0.040	-0.065	-0.078	-0.084	-0.027
183.56	0.001	-0.008	-0.039	-0.020	-0.048	-0.047	-0.073	-0.079	-0.086	-0.036
162.11	0.034	0.018	-0.023	-0.005	-0.042	-0.043	-0.076	-0.076	-0.068	-0.030
140.67	0.039	0.032	-0.007	-0.002	-0.043	-0.041	-0.068	-0.069	-0.067	-0.025
119.22	0.045	0.030	-0.008	-0.007	-0.061	-0.053	-0.073	-0.067	-0.059	-0.015
97.78	0.036	0.031	-0.005	-0.001	-0.047	-0.041	-0.072	-0.062	-0.067	-0.018
76.33	0.020	0.010	-0.028	-0.018	-0.055	-0.045	-0.070	-0.060	-0.068	-0.018
54.89	0.011	0.013	-0.046	-0.044	-0.076	-0.063	-0.085	-0.073	-0.075	-0.040
33.44	-0.039	-0.042	-0.100	-0.086	-0.104	-0.094	-0.104	-0.091	-0.081	-0.091
12.00	-0.035	-0.054	-0.112	-0.100	-0.130	-0.109	-0.117	-0.111	-0.104	-0.092
	27.00	**47.33**	**67.67**	**88.00**	**108.33**	**128.67**	**149.00**	**169.33**	**189.67**	**210.00**

I was quite pleased with this bed mesh, until I ran the first layer test. Despite all the effort to achieve a flat mesh with shimming, z tilt adjustments, and X Axis Twist Compensation, the first layer results were disappointing. The mesh produced some leveling compared to turning off the bed mesh correction, but consistently, on multiple tests, the mesh calibration produced clearly uneven first layer prints. The left side square prints always showed more squishing, or in some previous iterations, evidence of the start of blobbing, while the right side prints exhibited gaps between some or all the lines. Not only could the differences be seen, but even gently rubbing a fingertip or fingernail over the squares, the differences could be felt. The consistent result for many prints and minor tweaks of the shimming was that consistently the left side of the bed presented a more squished first layer, and the right side presented too thin first layers. Some micrographs are in the original document file.

Whatever bed mesh calibration is supposed to do, it was not working as anticipated or expected with my SV06 with the Pad 7. One relatively new process that has been added to Klipper is X axis twist compensation. I initially though this might have something to do with my lack of attaining uniform first layer prints.

X Axis Twist Compensation

I was somewhat skeptical of this process, although some users claimed great benefit for printers like the SV06. Despite what the Klipper docs say, the twist range is not based on the nozzle position, but the probe position. So X had to start at 27 and end at 193. Y at 20 and 200. I ran AXIS_TWIST_COMPENSATION_CALIBRATE and AXIS_TWIST_COMPENSATION_CALIBRATE AXIS=Y. Here are the results of my tests:

X axis: AXIS_TWIST_COMPENSATION_CALIBRATE: Calibration complete, offsets: [0.03555555555554646, 0.03430555555558179, -0.0698611111111278], mean z_offset: 1.567454

Y axis: AXIS_TWIST_COMPENSATION_CALIBRATE AXIS: Calibration complete, offsets: [0.02027777777777917, -0.005138888888883919, -0.015138888888895252], mean z_offset: 1.585407

Except in the case of the X axis, the variations were quite small. The bad news was the prints with and without this compensation were effectively the same as before, with no visible effect on the final first layer prints. I ended up commenting out the calibration in *printer.cfg* and manually removed the section from the *SAVE_CONFIG* section.

I am not clear on just how effective this axis compensation is in the case here. I began to wonder whether it even makes sense, if the bed z-tilt is compensated using the bed mesh calibration values, instead of smashing the gantry into the top printer support. One might expect directly reading the bed mesh to adjust the bed tilt, automatically would incorporate any twist compensation. In addition, if I understood enough of the axis compensation python code, what it does is calculate an average twist across the bed, in the x and y directions. If true, then by its nature, this compensation is likely to smooth out some, but not all, of the needed compensation, especially if the twist is nonlinear across the bed. Of course, if twist is linear in the X direction, z tilt changes based on the bed mesh, might already compensate for the twist (but not for Y twist). A bit more on whether twist is an issue will be addressed later.

Final Process to Produce More Even First Layer

Before discussing the final push to get a flat bed, there are a couple of points to be made. The variations in bed mesh are quite small. The range of values falls within 0.11 mm, about ½ of my first layer thickness 0f 0.20 mm. The standard deviation of 0.023 mm represents 12% change of the layer height for 67% of the values. However, that is within a single mesh. From additional runs, the overall standard deviation came out to 0.015. The 95% confidence interval of the bed was calculated as -0.0127175 ±0.00455 mm, which means 95% of the values are expected to fall in the range.

At this point, experts or less discerning print makers, could be saying “overkill”, in any further effort to obtain a flatter bed. Instead of trying to fix the bed, just increase the first layer thickness, or just ignore it. Basically, live with it. However, considering the supposed accuracy of the inductive probe, why should I not be able to achieve a more uniform bed? It bothered me.

Second, be forewarned I am discussing direct changes to the section of the printer.cfg file that is not recommended to make changes. Anyone considering doing the what is discussed below, better be comfortable with spreadsheet manipulations, creating csv files from spreadsheets, and thoroughly familiar to what the SAVED_CONFIG section of printer.cfg is all about. By the end of several weeks work to change over to Klipper, I had developed a sense of how Klipper interacts with printer.cfg, to feel confident enough to manipulate the bed mesh section. But still, clearly no expert.

Although I initially based my alterations on a single bed mesh calibration, I subsequently found that it was better to do several (like 4, in my final case) calibrations and average the results. This was the base bed mesh to work from. I also found that BEFORE EACH CALIBRATION IT IS CRITCAL TO HOME FIRST. When I did not do this, I found major changes to the bed mesh values. Generally, the bed mesh surface pattern was the same, but the absolute position values changed by as much as 0.13 mm.

In a final attempt to see if it was even possible to achieve even first layering printing, I began to manually change the bed mesh values in *printer.cfg*. This was a repetitive 6-hour long process of adding small increments of 0.01-0.02 mm to selective mesh probe points on the left side of the bed, and subtracting 0.01-0.02 mm increments on the right side probe points, and running 3x3 first layer prints. The largest value changes to mesh X probe matrix rows 1 and 2 or 9 and 10. Many of the initial corrections were made across the entire Y axis, but some final tweaks were to individual probe points, especially at the corners.

I did not alter the central probe points, so the z offset was held to -1.50 mm, which I had established under the "best" bed mesh calibration. I have always found the paper test for z offset to be just a starting point. Consistently, I end up moving to a lower value. For instance, I initially found -1.50 mm with the paper test, and even then, there was quite a bit of resistance against copier paper (which I later found had an average thickness of 0.092 mm).

Below is the final mesh, which could be also termed the point I just finally gave up (same color scale as original):

205.00	-0.083	-0.050	-0.050	-0.018	-0.067	-0.070	-0.095	-0.108	-0.164	-0.175
183.56	-0.070	-0.068	-0.069	-0.040	-0.068	-0.067	-0.093	-0.099	-0.165	-0.176
162.11	0.024	-0.018	-0.033	-0.015	-0.052	-0.053	-0.086	-0.086	-0.122	-0.151
140.67	0.029	0.022	-0.012	-0.007	-0.048	-0.046	-0.073	-0.074	-0.085	-0.135
119.22	0.035	0.020	-0.008	-0.007	-0.061	-0.053	-0.073	-0.067	-0.074	-0.135
97.78	0.026	0.021	-0.005	-0.001	-0.047	-0.041	-0.072	-0.062	-0.068	-0.132
76.33	0.010	0.000	-0.028	-0.018	-0.055	-0.045	-0.070	-0.060	-0.058	-0.114
54.89	0.001	0.003	-0.046	-0.044	-0.076	-0.063	-0.085	-0.073	-0.083	-0.106
33.44	-0.004	-0.062	-0.100	-0.086	-0.104	-0.094	-0.104	-0.091	-0.091	-0.121
12.00	0.029	-0.074	-0.127	-0.110	-0.130	-0.109	-0.127	-0.121	-0.103	-0.131
	27.00	**47.33**	**67.67**	**88.00**	**108.33**	**128.67**	**149.00**	**169.33**	**189.67**	**210.00**

Comparing the last two heatmap tables, note the large differences that had to be made to improve the first layer results. Clearly this was not simple a z tilt issue. The right half of the bed clearly drops off faster than the left half rises.

I decided that this was going to be my final bed calibration. For one, only rarely would I be printing to the edges of the bed. Fade was set in the [bed_mesh] section. An important point is that in the manually unaltered case, as well as the final mesh case, all first layers were binding sufficiently to the bed. However, I did not check whether subsequent layers would cause delamination with the bed

Below is the correction matrix that was applied to the original bed mesh to at least provide satisfying first layer prints,

Correction Matrix max:-0.06 mm; min=-0.15; color range blue->red:+/- 0..15										
205.00	-0.098	-0.060	-0.040	-0.030	-0.030	-0.030	-0.030	-0.030	-0.080	-0.149
183.56	-0.071	-0.060	-0.030	-0.020	-0.020	-0.020	-0.020	-0.020	-0.079	-0.140
162.11	-0.010	-0.035	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010	-0.054	-0.121
140.67	-0.010	-0.010	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.018	-0.110
119.22	-0.010	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	-0.015	-0.120
97.78	-0.010	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.114
76.33	-0.010	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.010	-0.096
54.89	-0.010	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	-0.008	-0.066
33.44	0.036	-0.020	0.000	0.000	0.000	0.000	0.000	0.000	-0.010	-0.030
12.00	0.065	-0.020	-0.015	-0.010	0.000	0.000	-0.010	-0.010	0.001	-0.039
Y↑; X→	**27.00**	**47.33**	**67.67**	**88.00**	**108.33**	**128.67**	**149.00**	**169.33**	**189.67**	**210.00**

The final bed mesh is the sum of the original bed mesh and the height adjustments above. Although there are certainly many positions that required no manual adjustment, significant compensations were made along the right side, front left corner and back left corner. Without these corrections, it was not possible to produce a reasonably even first layer across the bed. A "reasonable" first layer is when all nine first layer squares are filled between the extruded lines, i.e., properly smooshed to yield a smoother texture and minimal blobbing is evident in either micrographs, or by examining the low angle reflections, with low angle lighting across the surface.

This correction matrix also reinforces my skepticism that X axis twist is a factor in this specific case. Based on what I think I understand about the twist, I would expect that the twist would add or subtract a constant value in the x and y directions across the bed surface. Even though there is some evidence of a pattern, the magnitude of the changes across the board do not exhibit any sort of constant magnitude, especially associated with the xy axis compensation values that were found. Certainly, the manual adjustment process has a potentially higher error associated with it, but those errors are still well below the correction differences needed.

Unfortunately, the correction matrix serves only as a bookkeeping aid rather than a mechanism to apply to any bed mesh to flatten the bed. Only if z tilt, which in the present case is based on the relative gantry position, and the bed plate(s) do not change, is it possible to use the correction matrix in a reverse sense to a change made only to the extruder, such as a probe or nozzle change.

What's going on?

Before discussing the potential reasons for the lack of correction by the bed mesh calibration procedure, this forewarning in the Klipper documentation is appropriate:

"The Bed Mesh module may be used to compensate for bed surface irregularities to achieve a better first layer across the entire bed. It should be noted that software based correction will not achieve perfect results, it can only approximate the shape of the bed. Bed Mesh also cannot compensate for mechanical and electrical issues. If an axis is skewed or a probe is not accurate then the bed_mesh module will not receive accurate results from the probing process"

From <https://github.com/Klipper3d/klipper/blob/master/docs/Bed_Mesh.md>

In the current case, the magnitude of the corrections needed at some positions, represents more than ½ a layer height. I had expected that given a reasonable shimmed and reasonably non-tilted bed, the automated bed mesh calibration would adequately compensate for the differences. Clearly, it did not.

BED_MESH_CALIBRATE and X Axis Compensation did not adequately compensate for an uneven bed surface, even when adjusted for temperature. This is confusing, considering the precision of an inductive probe. Only manual, time-consuming, probe adjustment achieved an acceptably even first layer.

One potential perspective is that the SV06 is not an industrial strength printer, so I should just expect and tolerate more variations. However, print to print, calibration to calibration, the results had a consistent precision and accuracy, much better than the needed manual adjustments that were ultimately made. My probe with 5 measurements at each point, leads to an overall standard deviation of +/- 0.0021 mm. The average error in my probe measurements was +/- 0.013 mm, which is ~10% of the worst variations observed in the correction matrix.

Temperature as the source of error was previously discussed. E195B60 AND E120B60 produced heatmaps that were very similar. Any deviations were within the expected error range, ruling out temperature as a cause for the discrepancies.

To get some kind of handle on what is going on, I found myself immersed in trying to understand just what is Z offset? Part of my initial confusion was the word "offset" being used in different contexts in different explanations. Each context has a great deal to do with printing, but little to do with each other. An excellent, brief description of the process is here:

How the bed leveling algorithm works?...Prusa Forum
From <https://forum.prusa3d.com/forum/general-discussion-announcements-and-releases/how-the-bed-leveling-algorithm-works/>

With a sensorless inductive probe, the bed mesh calibration goal is to find the point where the inductive probe reaches a height above the bed that satisfies the trigger voltage of the inductive sensor circuitry at various bed positions. This height is not directly the height needed to make a good first layer. This is one kind of offset, the bed mesh offset; this probe height is too high to do any printing.

The calibration process is over a matrix of bed positions, with the probe obtaining the trigger distance for every position in the matrix. The number of positions probed depends on what we consider the best and most efficient number to model the bed architecture for flatness. The bed mesh calibration software then generates a matrix of evenly spaced positions in the X and Y bed directions. Of course, the mesh positions are also subject to compensation for extruder endstops and xy "offsets" between nozzle and probe…another use of "offset".

A bed mesh calibration always does, or forces you to do, a G28 – "Home All", before it analyzes the bed surface. The reason is that the final bed mesh value is the difference between the probe trigger distance found at the home position, and each probed value for matrix positions. This difference at each position is the bed mesh "offset". Usually, homing is near the center of the bed. I suspect the reason is convenience, and that the center of the bed is likely to be a generally flatter area.

However, the bed mesh calibration process is more complicated. The bed mesh needs to represent all the space on the bed. This means some sort of interpolation calculation is needed to figure out the bed mesh offset value between the probed positions. I am not clear on just how many probed positions are included in the interpolation range. I suspect the equation is fitted over multiple probed points, where the range of points used is somehow controlled by the *bicubic_tension* parameter (if using bicubic algorithm). I tried to understand the Klipper python code, but kept getting lost in the object coding stream and python module #include references. If the latter is true, then the original measured probed values will be modified according to how well the fitting equation fits the bed curvatures. In addition, any points outside the matrix range are assumed to be the same as the nearest last point read. (I suspect a forward-looking prediction algorithm, such as Kalmin filtering might be a better choice, but is more complicated to implement.)

The upshot of the interpolation procedure is that the final difference value representing the bed flatness is unlikely to remain as the originally measured value. Thus, it is possible some bed configurations may not adequately compensate for unevenness and can lead to under- or over-compensation relative to the "real" bed mesh variations.

Also involved in this interpolation procedure, is the incorporation of the mesh_pps, mesh points per segment values. We end up with a bed map of height differences relative to the Home bed mesh probe value for each position. The values are related to what is found in the SAVED_CONFIG section of *printer.cfg*.

However, that does not tell the printer where the nozzle needs to be, to create a decent first layer. The data only signifies that the bed itself has all sorts of problems and here is the value to compensate for whatever created the uneven bed. The second height "offset", the z offset, is where the magic happens to tell the printer how much lower to go from the bed mesh value to create a properly smooshed line to give an even first layer.

For practical printing, the distance at which the nozzle smooshes the extruding filament to also fill at least half way between the current line being printed and the next line to be printed. This inherently lowers the extruded line depth, but leads to even first layers. Generally, the necessary height above the real bed surface is going to be related to the first layer height set in the slicer. The bed and extruder temperatures likely also play a role. In the present case, the first layer height was 0.2 mm. I imagine smooshing should be around 0.1 mm, which is near the height of a piece of paper. In my case, the paper was 0.092 mm. The distance between where the bed mesh is triggered to stop, and where we need the nozzle to be to get good first layer prints is the z offset. This value is determined manually. It will always be a negative number, although it shows up in *printer.cfg* as a positive number.

Generally, this Z offset is determined at the same position as the probe Homing position. For instance, in Klipper, using the PROBE_CALIBRATE tool, the macro first reads the probe at the current user defined position, then based on the x and y nozzle offsets, moves the nozzle to the same position the probe just occupied, and waits for the user to manually lower the nozzle to find the optimum position using the "paper test" or feeler gauge. In either case, it is likely that a bit of tweaking may be necessary.

Is the mesh algorithm causing the anomalous offsets? Most likely not. The question was resolved using the PROBE command was used at nine points representing near corner and mid-height values to get z height values. The process consisted of: heating to E120B60, followed by repetitive rounds of: Homing-*G28*, use *G1 X### Y###* to move to a specific position, followed by "*PROBE*", which performed 3 readings, producing an average. The data was finally transferred to Excel. The G1 position values were converted to probe positions. Each probe height was subtracted from the central position of the bed at xy:110:110. The results were:

205	-0.006	0.102	0.081
110	-0.065	0.000	0.025
0	0.081	0.081	0.091
Y↑; X→	**27**	**110**	**220**

Comparison of this small matrix with the original and the manually adjusted version point to the problem not being bed mesh algorithm problems. Especially the values on the right side of the bed are closer to the original bed mesh calibration values.

At this point, temperature, bed mesh algorithm, and x axis compensation seem to be ruled out as causes for the inability of Klipper to compensate for the true height variation the right side of the bed.

What is left to consider? A lot of speculation.

One possibility is that this is an emergent problem of a host of small differences adding up to produce the large anomalous bed mesh offsets. Certainly, the measurements exhibit errors, due to natural measurement errors, and inherent errors in the mechanical and electrical properties of the printer. However, if this was just a host of small errors, more inconsistency in the anomalous areas would be expected from run to run, which is not observed. This is also not consistent with the observation that most probed points do not require any manual intervention.

Is the use of the Kapton tape to shim the bed, altering the distance between the probe and metallic surfaces sufficient to throw off the probe heights? Not likely. Some regions with Kapton tape do not show any anomalous heights. The overall character of bed unevenness was encountered before any shimming with Kapton tape. If it does affect the probe measurement, the effect is very small. Without the tape, there is little chance of getting anywhere near a flat surface on the printer, with only five mounting screws for shimming.

Another speculation is that for the probe to function properly, the metal bed material itself must be uniform in thickness and in homogeneous in metal composition. Both these are unknown factors.

Another possibility: Some sort of complex interaction with the plates magnetic field. An inductive probe works by inducing a field in the metal bed, which in turn produces an eddy current that changes the energy field of the probe. The change in energy is detected and amplified by the sensor circuit. An inductive sensor is not affected by a static magnetic field. Of course, the SV06 uses a magnetic bed to hold down the printing plate. Does the inductive probe really see a static magnetic field on a magnetic plate? The sensor moves up and down to sense the eddy current that the metallic bed generates, and the probe circuitry senses with respect to some threshold. As the probe mechanically moves down to trigger the detection circuitry, it moves through the plate's static magnetic field gradient as it approaches the bed. Moving in a gradient field produces a change in magnetic field, in addition to the induced field produced in the metal. If the change is short enough and significant enough to interact with the probe's electronic oscillator circuitry and detection threshold, any variations in the uniformity of the bed plates magnetic field, might cause calibration issues.

The above are speculative, and maybe nonsensical. The ultimate reason why the bed mesh does not properly allow good first layer prints remains enigmatic.

There is a lot of hype now about adaptive mesh calibration. Forget it, if the probe can't adequately represent the bed, adaptive meshing is not going to improve anything in the badly calibrated regions.

In such a case as described here, with the failure of the bed mesh calibration to adequately reflect the bed surface features, there are two possible fixes. Live with it, and when changes happen to the printer, go through the manual leveling process described above. If you don't have many bed crashes, and physically the printer is maintained in good condition, the process does not have to be done ofen. Alternatives are to change the bed itself, or use a different type of probe. Of course, on the former there is no guarantee, you won't end up with something just as bad or worse.

A BLTouch type of probe is the other option. The accuracy of some of these probes can exceed an inductive probe. However, be forewarned that a touch probe substitution for an inductive probe is not a simple changeover. I was initially enthusiastic about this route, but there is a lack of confirmed reliable information on electronic configuration issues for the SV06.