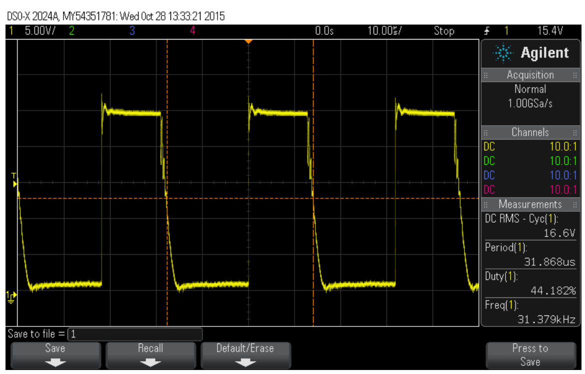
Issue

The recent Kysan Runda 69829 $24V_{DC}$ fans that have been received do not perform as well as the previous ones. Specifically, when *slowly* increasing the PWM duty cycle the new fan begins rotating and a much greater duty cycle (higher V_{RMS}) than the old fans. This is causing issues with GCode produced from Cura due to the nature as to how it increases the duty cycle as the layers increase.

From one experimental case study, increasing the duty cycle by 3.92% increments with ~20 second intervals between each increment resulted in the old ("better") fan starting at a 27.45% duty cycle whereas the new ("worse") fan started at a 90.20% duty cycle. The profiles used in Cura have a minimum duty cycle of 40%. The caveat with the new fans is that they will turn on if a discrete change in the duty cycle is made from 0% to ~40% whereas incremental changes will produce undesirable results. The datasheet produced by Kysan Electronics states that the minimum operating voltage is $15V_{DC}$, this corresponds to an RMS equivalent when the duty cycle is:

$$15\,V_{RMS} = 24\,V\sqrt{\frac{\text{Duty Cycle}_{min}}{100}} \quad \Rightarrow \quad \text{Duty Cycle}_{min} = 39.0625\%$$

Here is a screenshot of the oscilloscope's output when measuring the voltage at the fan at $\frac{102}{255}\times 100 = 40\%$ duty cycle which is the rated minimum operating voltage:



Note that the measured duty cycle is actually 44.182% but this is simply due to the non-ideal rise and fall times of the digital signal, and since the measurement is taken at $V_{DD}/2$ the duty cycle is measured to be slightly higher. Also note that V_{RMS} = 16.6V whereas the calculated RMS value is $15.18V_{RMS}$.

The only visually notable difference between the fans is the coating of the magnet wire. An inductance measurement of several data points for each fan type (~10 of each) will probably yield differing averages. The hypothesis is that since the energy is not being dissipated through mechanical energy that it is dissipated as thermal energy which reduces the effective inductance of the windings and inhibits the DC motor's ability to rotate at greater duty cycles.

Here is a sample GCode that Cura produced:

```
M106 S15 ;LAYER:1
...
...
M106 S33 ;LAYER:2
...
...
M106 S51 ;LAYER:3
...
...
M106 S66 ;LAYER:4
...
...
M106 S84 ;LAYER:5
...
...
M106 S102 ;LAYER:6  40% DUTY CYCLE!
...
...
```

Possible Resolutions

In no particular order:

- Inform Kysan and ask them to produce the previous fans even though the new ones are still within their specs (and still don't spin at lower duty cycles that can be applied).
- Used a “patched” version of Marlin (already implemented) or Cura which filters out requests of duty cycles below 40%.
- Switch to a Pelonis C4010L248PLP1b-7 which was tested to start at the lowest possible duty cycle Marlin can produce (0.392% or $1.50V_{RMS}$), it also has a minimum rated operating voltage of $15V_{DC}$. The single quantity retail price of this fan is $7.83.

Ideally the fan would spin even at a 0.392% duty cycle that way any parameter given to M106 will produce expected results. If the Pelonis fan is used then verifying and tweaking all Cura profiles would take a minimum of three (3) weeks to complete. The downside to filtering the lower duty cycle requests is that it is clearly non-ideal and can be considered a bandage or even a cripple.