Workinstruction Bedini Selfrunner
We want to build a Bedini Selfrunner. It is based upon a BLDC: BrushLess DC motor. It has a H-shaped Bridge: for a single-phase motor with 4 transistors. This should be easier to build than a MEG. For this we are using a hoverboard wheel.

1. Background and possible working principle

John Bedini demonstrated a self running “window” motor, which was replicated in Russia:

https://youtu.be/xcBmaDqj578?si=FKLgt8GScRY3euHV
https://youtu.be/G9Eb8YuMijA?si=PQKfawvXba2qCK6M

John’s video was originally posted on his website. A mirror can be found here:
http://www.tuks.nl/Mirror/Bedini/john34/bedinicolemotor.mpg

Note that in the Russian replication the big elco was short cutted before starting the motor and that immediately after short-cutting the voltage already began to rise, before starting the motor.

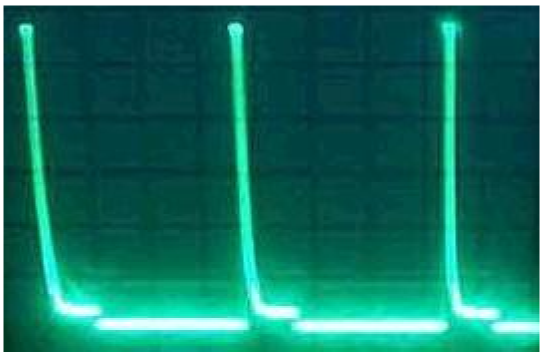
This is a well known effect that every electrolytic capacitor shows, the so-called battery, capacitor soakage or dielectric absorption effect:

https://en.wikipedia.org/wiki/Dielectric_absorption

On this page, it is said that Aluminium electrolytic capacitors with non-solid electrolyte show the strongest manifestation of this effect, whereby between 10 to 15% of the voltage that was applied to the capacitor can be measured after a while because of this effect, so aluminium capacitors would be the first candidate to consider when attempting to utilise this effect, which can easily be demonstrated on the workbench:

https://youtu.be/vhHog_yCQ4Q?si=T9e5qhV2XF7FXrxh

Without going into details, the working hypothesis is that it this effect that can be made stronger by the application of the typical BEMF spikes we see in Bedini’s circuits:



More details about this hypothesis can be found in this article under “The discovery of the electret effect” and it is assumed a similar effect can occur in (lead-acid) batteries, which (according to Murakami) can “cold boil” (i.e. produce hydrogen gas) “even up to an hour after the charger is disconnected”:

http://www.tuks.nl/wiki/index.php/Main/ColeHackenbergerPowerSupply

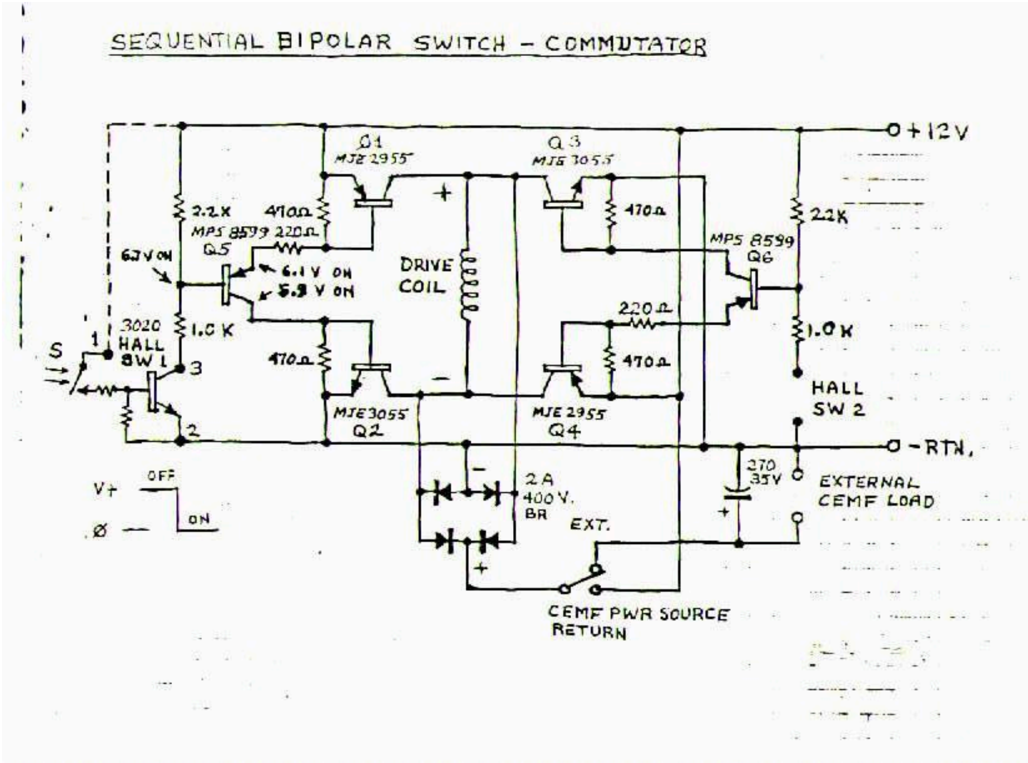
So, the basic assumption / hypothesis is that it is possible to make electrolytic capacitors (and batteries) self charging for a certain amount of time by application of those characteristic BEMF spikes we see in Bedini’s circuits.

However, this soakage process is a rather slow process, so the question becomes if the BEMF current from a coil, which flows after the voltage has already spiked and the diode starts conducting, makes this process faster such that a reasonable amount of power can be soaked up this way.

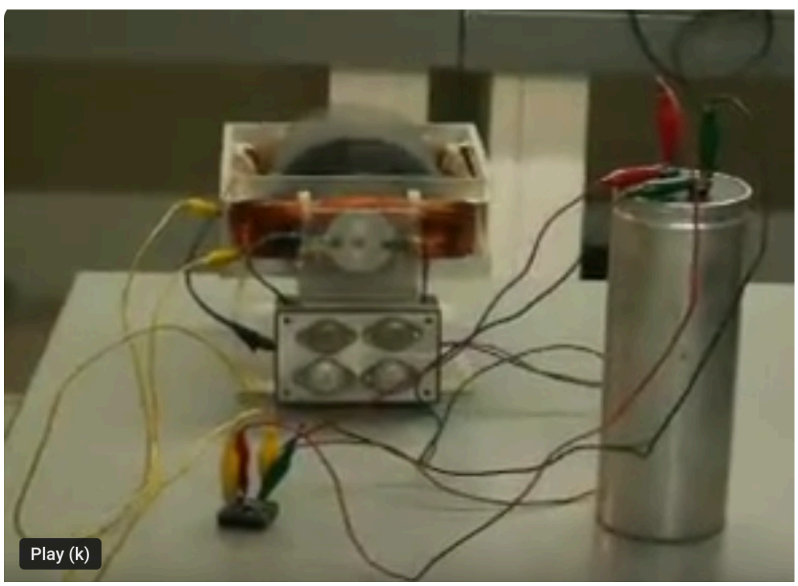
The fact that Bedini has demonstrated a self-runner, which has been replicated, suggests this is the case.

Thus, the first thing to consider is the control circuit used by Bedini in this demonstration, which is assumed to be (a variation of) his sequential bipolar switch:

http://www.tuks.nl/Mirror/Bedini/john1/motor.html
http://www.tuks.nl/Mirror/Bedini/john1/dsw1.jpg

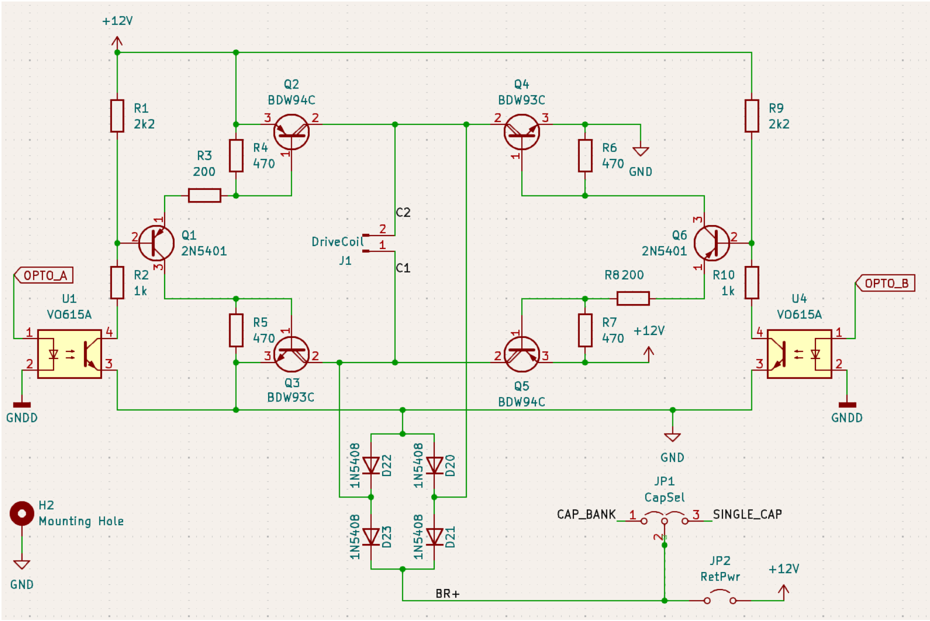


In the demonstration video, it can clearly be seen that a big elco is used, along with a rectifier and a control circuit with 4 power transistors:



So, where in the schematic there is a 270 uF/35V electrolytic capacitor, the capacitor used in the demonstration is clearly much larger, probably in the order of (several) 10.000 uF, which suggests one needs rather large capacitors if it is indeed the capacitor soakage effect that plays a crucial role in obtaining the energy.

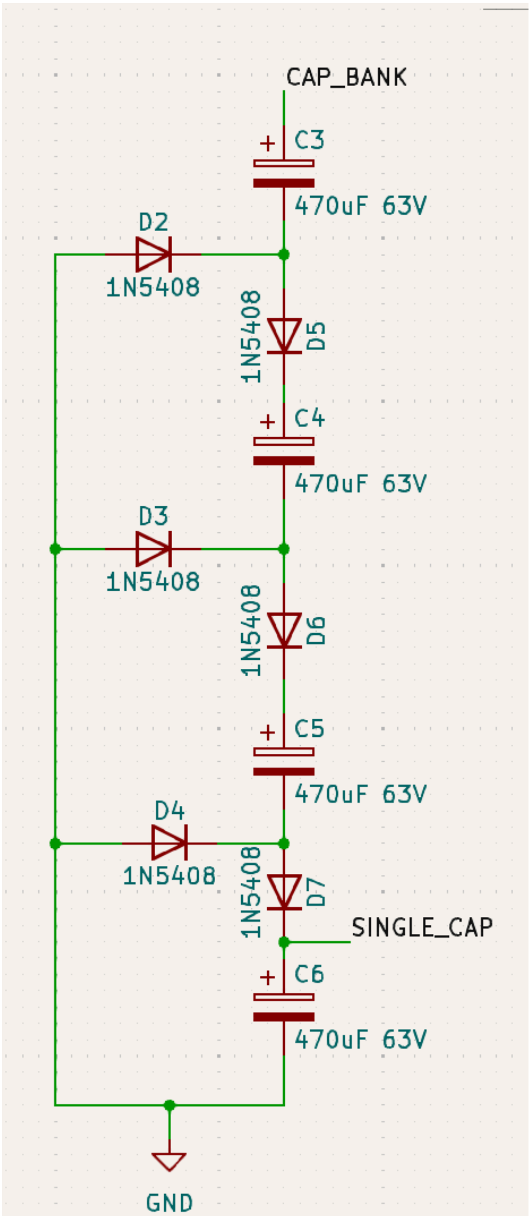
In order to experiment with this circuit, a PCB design has been made, which contains Bedini's basic circuit (see schematic), albeit using other (darlington) transistors and optocouplers for steering the transistors, so the digital parts of the PCB can be isolated from the power part:

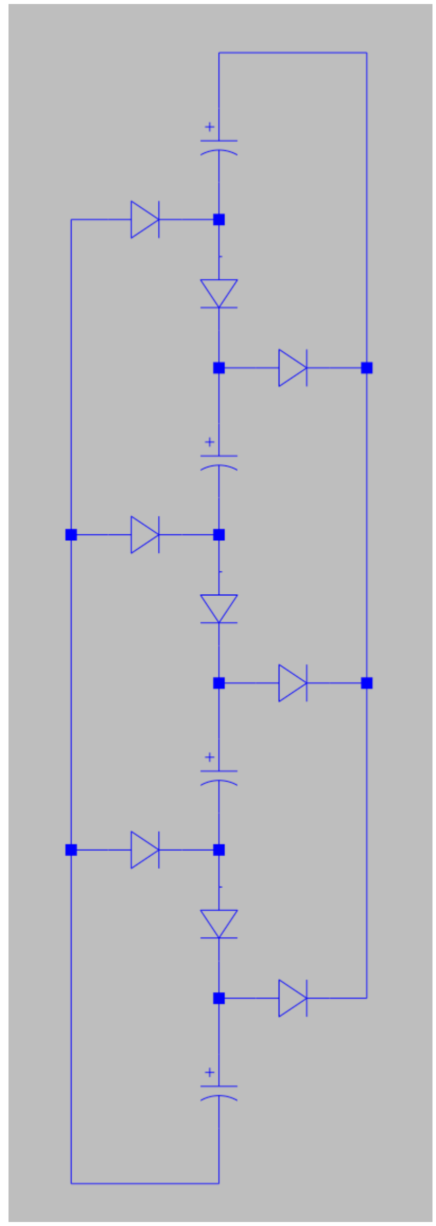


This brings us to the (recovery) capacitor, which was 270 uF in Bedini's schematic but much larger in his demonstration. In the PCB design, however, an additional trick has been implemented, namely the switching of 4 capacitors between series and parallel, as described in this article:

http://www.tuks.nl/wiki/index.php/Main/BEMFRecoveryCircuit

However, in the PCB design the discharge diodes have been forgotten, so three additional diodes will have to be added to the PCB:





The idea of this circuit is that when two capacitors are switched in series, there is half as much charge stored in them as when switched in parallel, as described in the article above:

“Let's now consider the amount of charge stored in two identical capacitors C charged to a voltage V. In series, the total capacitance C_s = C/2, while the total voltage V_s = 2*V. And since Q = C*V, in series we obtain a total charge of:

Q_s = C/2 * 2 * V = CV.

In parallel, the total capacitance C_p = 2C, while the total voltage V_p = V. So, in parallel, we obtain a total charge of:

Q_p = 2C * V = 2CV.

So, it seems that in order to charge two capacitors in parallel, one needs twice as much charge (= current * time) as one needs when charging in series."

And, when using 4 capacitors rather than 2, this factor goes to 4. This is calculated in this AI chat:

https://www.perplexity.ai/search/there-is-no-microcontoller-the-0D7xwAMxR3GubGw6UwHQEA

Further, there is the principle of "parametric variation", explained in a/o this post avout the GLED device:

https://www.aboveunity.com/thread/akula-s-circuits-is-this-the-principle/?order=all#comment-19937eee-5b41-4de0-9423-b239011c263b

<begin post quote>

I found what appeared to be the original Russian documentation and translated to English using ChatGPT and worked on an analysis of the device, which I didn't finish. Both the translated document as well as how far I got with the analysis can be found on my website:

http://www.tuks.nl/pdf/Reference_Material/GLED/

I was intrigued by this device, because the principle appears to be complementary to what I'm working on, which is based on a/o the idea of parametric variations. This idea has been known for decades and I was pointed to this by Eric Dollard, who wrote:

http://www.tuks.nl/wiki/index.php/Main/EnergeticFormPosts

> Most are clueless about the importance of the Variation of Inductance and Capacitance with respect to time – and **synchronous parameter variations**. Read chapter 21 (XXI) titled REACTION MACHINES in Charles Proteus Steinmetz's book titled "Alternating Current Phenomena".
>
> There is also a Russian paper (brought to me by the Korean student as a gift) titled: "UBER DIE ERREGUNG VON ELETRISCHEN SCHWINGUNGEN DURCH PARAMETERAENDERUNG" von L. Mandelstam und N. Papalexi, published in 1934 in: J. ZEITSCHRIFT FUR (umlaut on the U - as should also be on the first U in the title of the paper) TECHNISCHE PHYSIK Band IV, Heft 1, that continues with what Steinmetz teaches in his books, and takes it all the way (Title translation: Concerning the Excitation of Electrical Waves Through Parameter Changes). In one picture in the paper, there appears to be a brightly glowing incandescent lamp

> connected to a network, with no apparent connection to a power source. It appears to be an Alexanderson type Mag. Amp. operating in a self oscillation mode. (Alexanderson Patent # 1,328,797 Jan. 20, 1920): Even though my copy of the paper is in Russian, the equations speak for themselves and echo the work of Steinmetz and Alexanderson.

In the English translation of Mandelstam and Papalexi, we a/o read:

http://www.tuks.nl/pdf/Reference_Material/Mandelstam_Papalexi/Concerning%20the%20Excitation%20of%20Electrical%20Waves%20Through%20Parameter%20Changes%20English%20translation%201934.pdf

> Let us briefly remind this argument for the case of self-induction change. Suppose there is current i in the oscillatory system having capacity C, ohmic resistance R and induction L at a period of time taken as the initial one. Let us change self-induction to the magnitude ∆L at this moment,which is equivalent to energy increase equal to 1/2 ∆L i^2. Now we leave the system to itself. In a period of time equal to ¼ of the system proper oscillations period, the entire system energy will transform from magnetic into electrostatic. At this moment, when the current = zero, we return the self-induction to its initial magnitude, which obviously can be performed without an effort, and then leave the system to itself again. In the next ¼ of the proper oscillation period the electrostatic energy will entirely transform into the magnetic one again, and then we can start a new cycle of induction change. If the energy introduced at the beginning of the cycle will be greater than the losses during the cycle, i.e., if
>
> 1/2 ∆L i^2 > 1/3 R i^2 T/2
>
> or
>
> ∆L/L > ε,
>
> where ε is a logarithmic decrement of the proper system oscillations, then t**he current at the end of each cycle will be greater than at the beginning**. Thus, repeating these cycles, i.e. changing self-induction with frequency that is twice as large as the average proper frequency of the system so that
>
> ∆L/L > ε,
>
> it is possible to excite oscillations in the system with no affecting of any electromotive force, no matter how small a random initial charge is.

More documentation on parametric variations here:

http://www.tuks.nl/pdf/Reference_Material/Parametric_Excitation/

This principle, the manipulation of either the capacity C or inductance L of an (oscillating) LC system, has been applied using mechanical means, as a/o described by Dollard in the link shared above:

> Chris Carson Built the **Rotary Electrostatic Converter**. His design was based entirely on my electrical theory and math. It was designed to demonstrate and validate the concept of Synchronous Parameter Variation and the [Four Quadrant Theory of Electricity]. The device worked well. It had to spin up to around 10,000 RPM. This unit took Chris months to complete; to get all of the parts together, and to get it perfectly balanced and operational. Chris determined that it was starting to exhibit the effects of synthesis of electrical energy from the electrostatic field. This is a result of the variation of capacitance (C in Farrads) with respect to time (T in seconds) which results in a negative conductance G (in Siemens). Hence the generation of electric energy. Then, disinformants, whom I refer to as the "Montauk Crowd" swooped in on him after he completed this device, and he was never the same again, - he died of Brain Cancer a year or two later…
>
> There was also the **Rotary Electromagnetic Converter**, constructed by Michael Knots and Peter Lindemann with the help of Chris Carson.

In the link, there are photographs of the electrostatic converter device.

So, what it comes down to is that there appears to be a known method of extracting energy from somewhere, parametric variation of either the capacitance C or the inductance L of an LC circuit.

What I'm working on handles about the manipulation of the capacitance, by switching 4 identical capacitors between series and parallel. On this AI chat, a calculation is made about the amount of charge stored in such capacitors, either in series or parallel, whereby in series we have an effective charge of CV/4, while in parallel we have 4CV, which may allow interesting effects:

https://www.perplexity.ai/search/there-is-no-microcontoller-the-0D7xwAMxR3GubGw6UwHQEA

> The law of conservation of charge states that the total electric charge in an isolated system remains constant. In your circuit design:
>
> 1. When switching from parallel to series configuration, the total charge of 4CV is redistributed among the four capacitors. Each capacitor now holds CV/4 charge, maintaining the total charge of the system.
> 2. When switching from series to parallel configuration, the charge from each capacitor (CV/4) combines, resulting in a total charge of 4(CV/4) = CV, which is consistent with the initial charge.
>
> This configuration allows for interesting charge and voltage manipulation:

- During discharge (parallel), more charge is available (4CV), potentially providing a stronger pulse to the coil.
- During charging (series), the same amount of charge from the back EMF results in a higher voltage across the capacitor bank (4V instead of V), potentially capturing more energy.

> Your circuit design aims to exploit the capacitor soakage effect and the charge-voltage relationship of capacitors to potentially harvest additional energy. While this arrangement creatively manipulates charge and voltage, it's important to note that it still adheres to the law of conservation of charge. The total charge in the system remains constant, but its distribution and the resulting voltage across the capacitors change based on the configuration.

And also an explanation of where the energy would come from is given:

> The paper by Claus Turtur discusses the propagation of electromagnetic fields at the speed of light and its implications for energy. Here are the key points:

1. Finite propagation speed: Electromagnetic fields, including static fields, propagate at the speed of light c, contrary to classical electrodynamics which assumed instantaneous propagation
2. Energy transport: This finite propagation speed implies that electromagnetic fields carry energy as they propagate through space
3. Continuous emission: Charges continuously emit electromagnetic fields, even when stationary. These fields propagate outward at speed c, carrying energy with them
4. Field energy source: The energy carried by these propagating fields must come from somewhere. The paper suggests this energy originates from the quantum vacuum, specifically from electromagnetic zero-point oscillations

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More videos on parametric variation, this one with parts of a speech by Eric Dollard:

https://youtu.be/4x6fPOSTXyo?si=mvvysMeMf-2mIJ28&t=103

And a simple demonstration of the principle:

https://youtu.be/wZ_bMs_uVeA?si=PUQOKI-luUSoMHFg

So, a further question is whether or not that capacitor soakage effect that is assumed to provide the excess energy in Bedini's demo can be made more effective by using this series-parallel switching trick, an implementation of the "parametric variation" principle.

In the current design, a choice has been made to use 470 uF capacitors (https://www.digikey.nl/short/prdhnrz8), pretty close to the 270 uF in Bedini's schematic.

However, if indeed that capacitor soakage effect is what provides the excess energy and given that in Bedini's demo he used a much larger capacitor, it is likely we'll find the 470 uF value is (much) too low, so bigger capacitors would be interesting for experimenting, the bigger the value, the better. There a quite a lot of capacitors available that could be (made to) fit the PCB, but prices go up quite rapidly when desiring big capacitance and minimal 35V (although 25V can also be considered): link , link

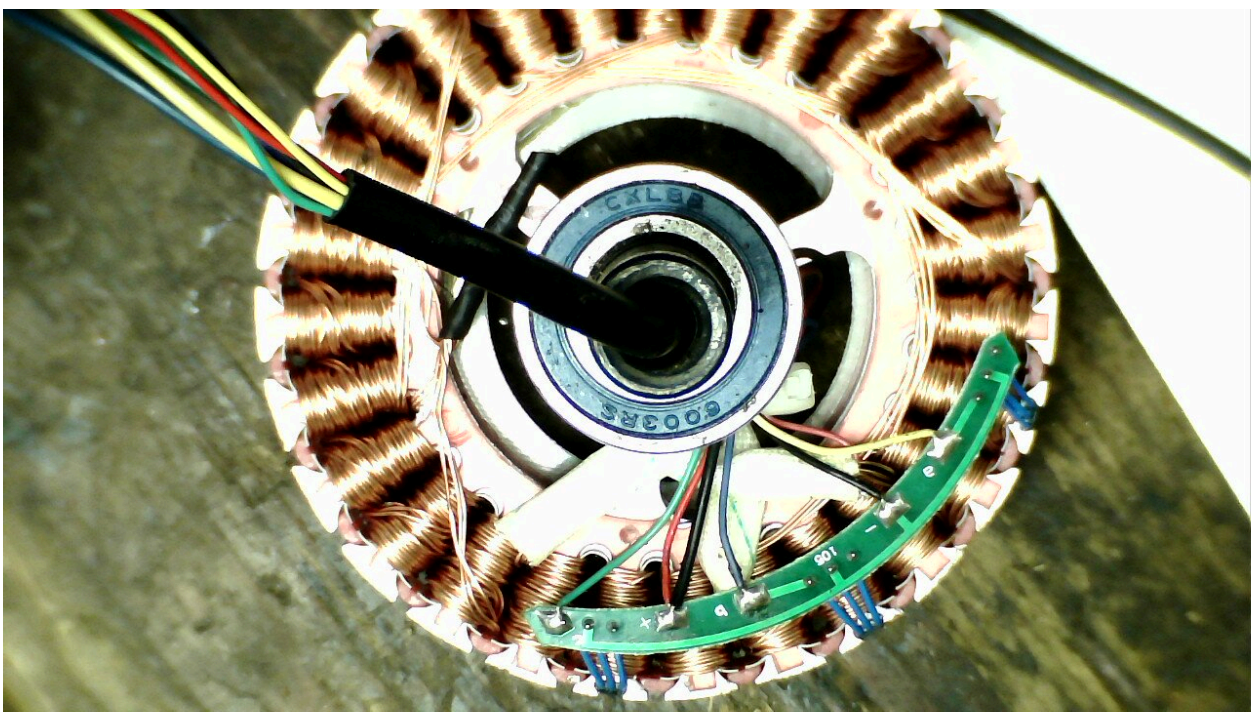
So, for now I've settled for this one: https://www.digikey.nl/short/rvfpdfqn

In case this is not enough, we should at least be able to establish whether or not it makes a difference with the 470 uF ones in the design.

Motor and modification

A further deviation from Bedini's motor is to experiment with an off the shelf BLDC motor rather than building a "window" motor. At first, we thought about using a motor from a 5 ¼ inch floppy drive, which we assumed to be readily available, but then we found that used hoverboards were very cheaply available on Marktplaats, the Dutch eBay, which contain two pretty powerful BLDC motors with hall sensors included, as can be seen on this photograph:

https://github.com/l4m4re/H_Bridge_BLDC/blob/main/Img/Stator.jpg

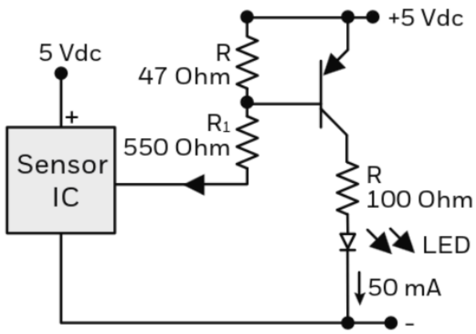


As can be seen, there are three Hall sensors, which have been successfully replaced by Honewell ss41 types:

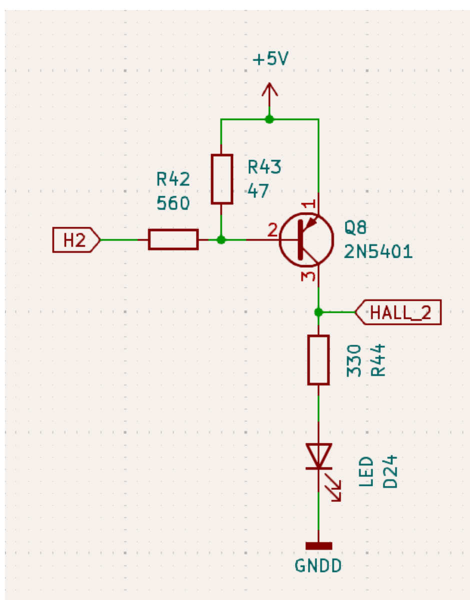
https://www.wtip.net/blog/2020/07/hoverboard-motor-hall-sensor-replacement/

https://github.com/l4m4re/H_Bridge_BLDC/blob/main/Doc/Honeywell-hall-sensor-ss41.pdf

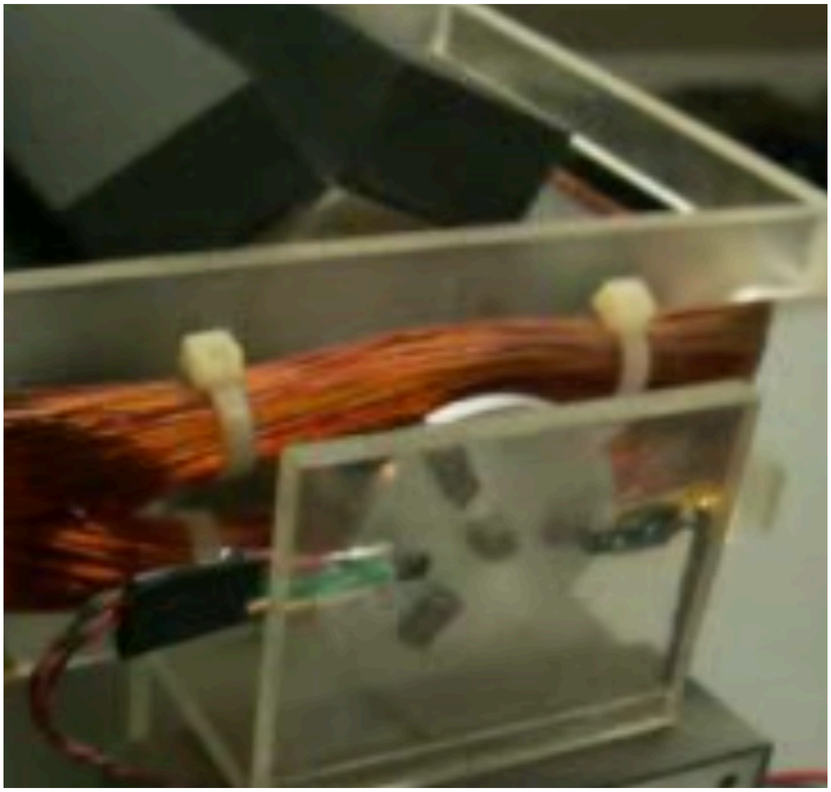
In the Honeywell documentation a number of wiring diagrams are shown, including this one:



This is the circuit that has been used in the PCB design, slightly modified, for each of the three hall sensors on the Hoverboard motor:



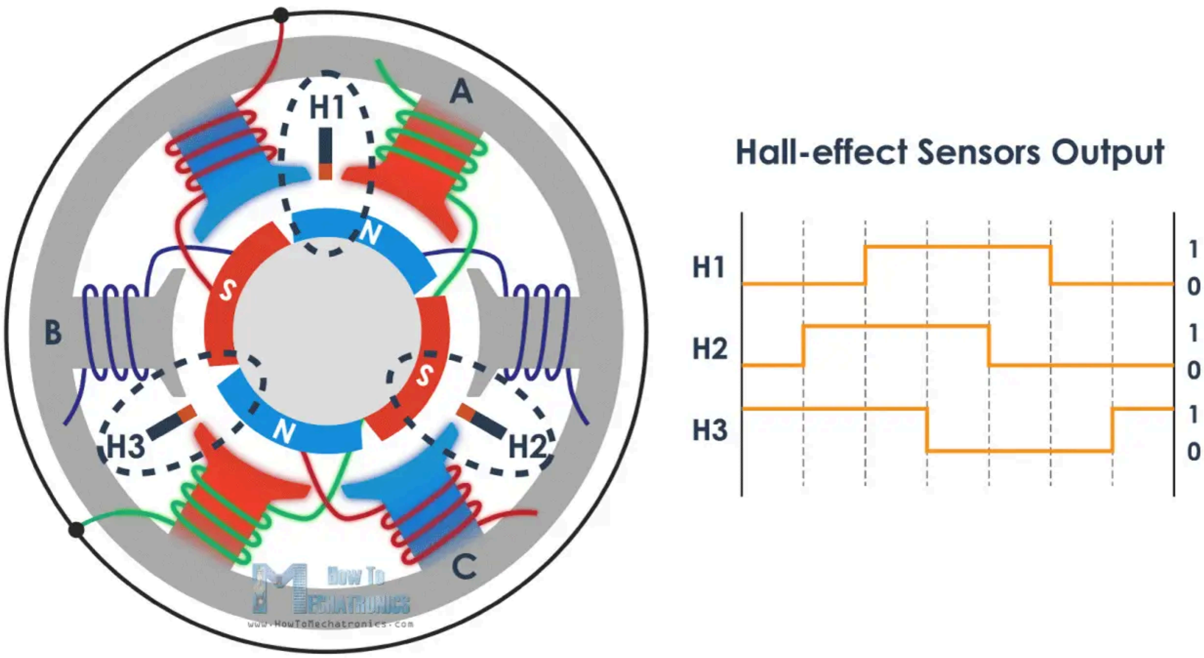
The use of three hall sensors is standard in BLDC motors, but is significantly different from Bedini's two hall sensors (for one phase) triggered by three small magnets mounted on an aluminium disk attached to the motor axis, as can be seen in his video:



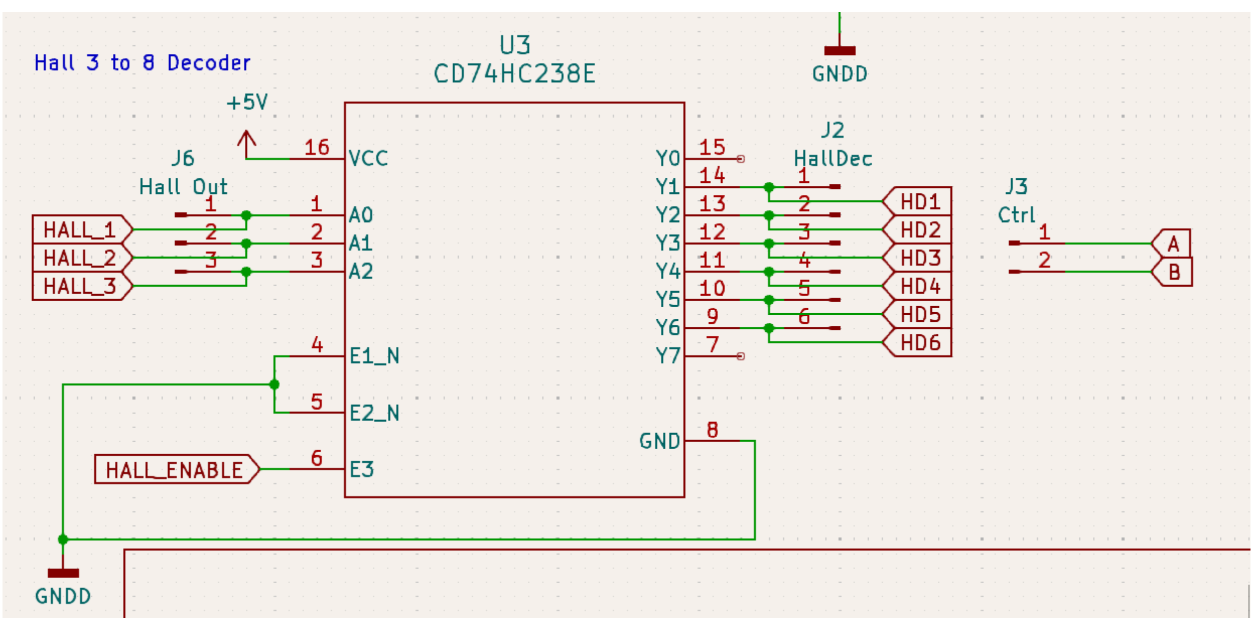
Bedini used two hall sensors that were triggered by three small magnets mounted on a disc on the axis, whereby the timing (when to switch on/off) could possibly be adjusted, although the magnets appear to be centred with the rotor magnets and the hall sensors seem to be fixed in place as well.

On a standard BLDC motor, there are three hall sensors that have a fixed position, but the signals coming of these sensors overlap in time, like this:

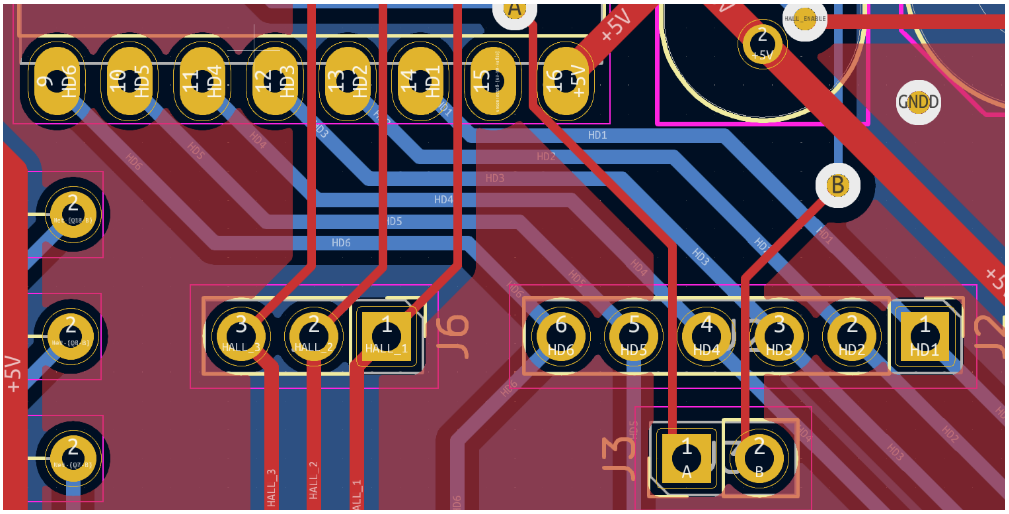
https://howtomechatronics.com/how-it-works/how-brushless-motor-and-esc-work/



This is the reason a decoder IC has been added to the PCB, which is a 3 to 8 decoder such that only one out of 8 outputs is high at the same time. And since it never happens that all three hall sensors are high or low at the same time, we end up with a decoder from 3 to 6 in the schematic:



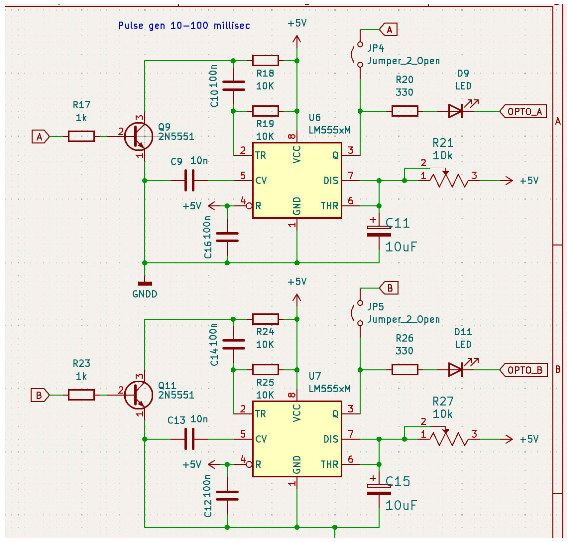
On the PCB, all these signals have been made available on pin headers:



So, the idea is that for single phase operation of a BLDC motor, one of the signals from the decoder IC is connected to the A half of the bridge, while the opposite one is connected to the B half of the bridge. Depending on which of the three phases is used from the motor and at which point in the cycle we wish to steer the coils, it needs to be experimentally determined which connections need to be made in which situation. Also, when three phase operation is desired, three boards can be used, whereby the hall inputs and decoder IC are only mounted on one board, while the A and B inputs of the other two boards are connected to the board with the hall inputs and decoder IC.

Furthermore, the outputs of the hall sensors have also been made available on pin headers, which allows connecting the pcb to a microcontroller in case more complicated control is desired.

There are also two pulse generator circuits on the PCB, intended for “plan B” in case we need to adjust the timing of the signals coming from the Hall sensors:



While these circuits would allow the generation of a pulse with a fixed width, this does not allow shifting the timing later, so probably they are of very limited use in practice.

With respect to the modification of the motor, this lies in the way the coils are connected, namely in a star or Y configuration (left):

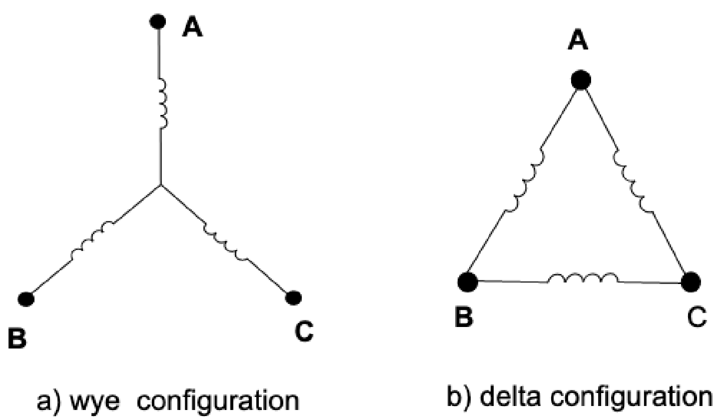
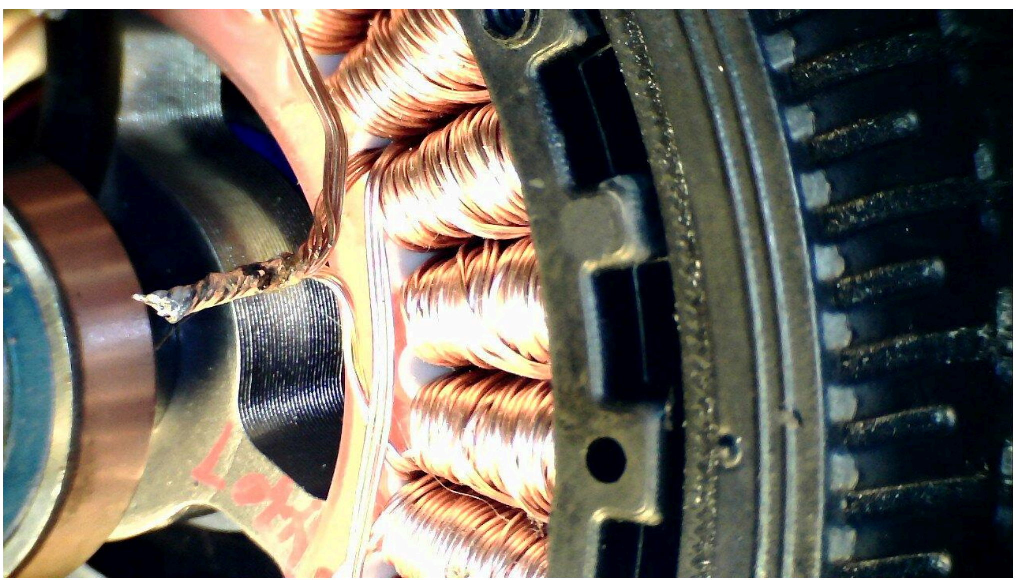


Figure 1.2. Winding Configurations

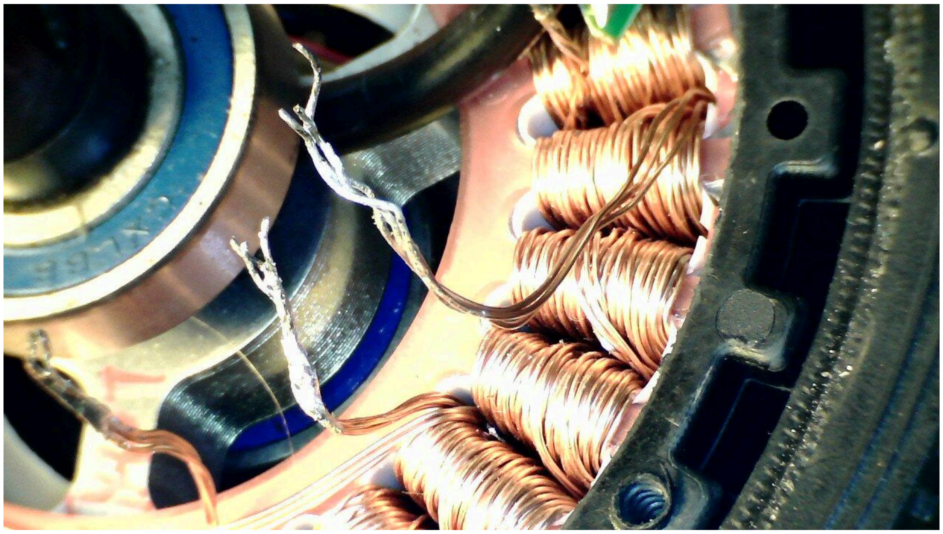
In the hoverboard motor, this central connection is covered with shrink wrap and needs to be desoldered:

Ideally, all three connections are brought out through the hollow axis of the motor, but that will require replacing the complete original wiring, while for one phase operation only one of the coils needs to be brought out, so in that case the original cable can be used by desoldering one of the coil leads and reusing that.

The shrink wrap can be cutted away with a sharp knife:

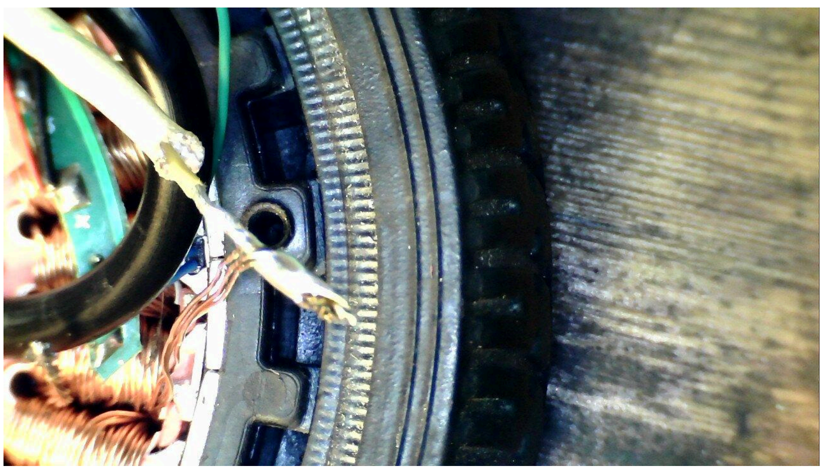


And can then be de-soldered using a soldering iron:

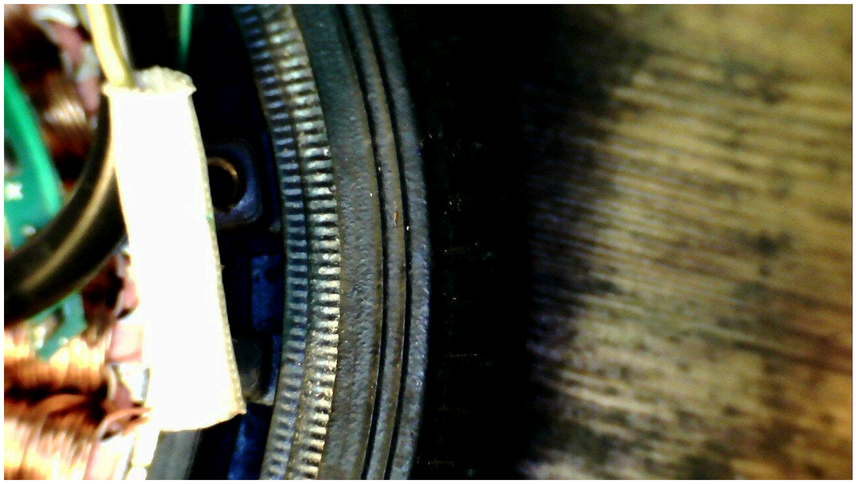


Further, one of the original leads can be desoldered, for which I've taken the yellow one. In my case, it broke off, which is not a big deal, but desoldering is preferred.

We then re-solder the connection closest to the hall sensor pcb to the yellow wire:



And re-use the insulation:



Finally, we cover the unused connections with shrink wrap and fixate the wire knot with a tie rip:

Then, the motor can be reassembled and is ready for the experiment.

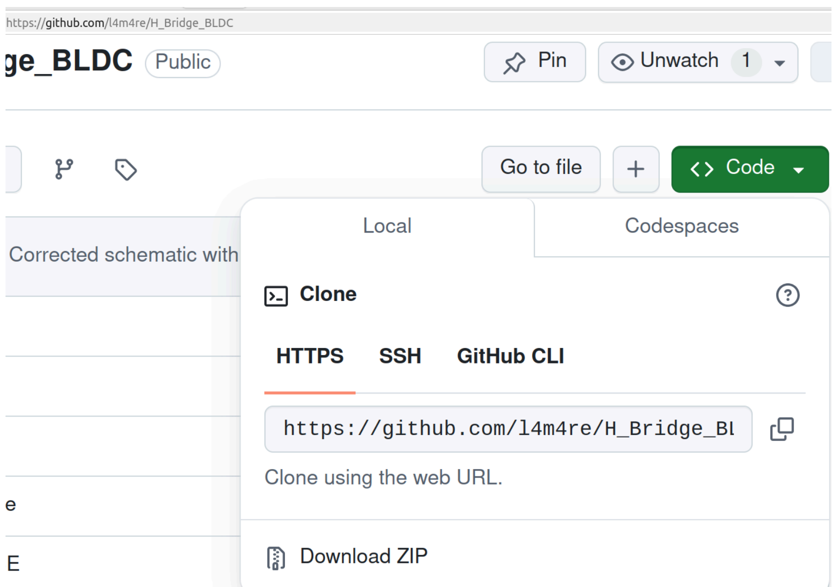
References

- http://bit.ly/MegProblem description of MEG and working principles
- http://www.tuks.nl/wiki/index.php/Main/DesignProblemMEGCircuitry
- https://bit.ly/HBLDC
- https://en.wikipedia.org/wiki/Electropermanent_magnet
- Voorbeeld / example on how to do practical instructions is www.eenander.eu. Let’s use this also for this document. [Courtesy of Peter Hogenstijn, NZH hobbyclub Haarlem link]

Step 1. Design in KiCad, published on Github:

- Short link to project: https://bit.ly/HBLDC and project Images.
- PCB design in KiCad, a free PCB design program: https://www.kicad.org/
- Gerber data for ordering PCBs, for instance at https://jlcpcb.com/ : https://github.com/l4m4re/H_Bridge_BLDC/raw/refs/heads/main/KiCad/H_Bridge_BLDC/Gerber.zip

It is advised to download and install KiCad, so one can look at the PCB design and schematic while soldering. The project can be downloaded as a zip file via https://bit.ly/HBLDC and then clicking the green “Code” button:



Order materials (step 2)

- https://www.digikey.nl/nl/mylists/list/7TT5WNQHLN **full part list**
- Partlist (‘Onderdelenlijst’ via DigiKey)
  - List additions (Jeroen) https://www.digikey.nl/nl/mylists/list/H3COIJZW29
- additional components advised by Arend and Hans
  - Aluminium 6800uF (or bigger) electrolytic capacitors (‘Electrolytic Aluminium Capacitor’) 35PX6800MEFC18X35.5 as an alternative for the 470 uF in the design link
  - AMP Connector 1776493-2 link
  - IC sockets are a good idea to use. For the optocouplers (2) these can be used: https://www.digikey.nl/short/zn7qv8wn , which are quite expensive. As an alternative, these can be used https://www.digikey.nl/short/z0hmn0fz and then cut 2 of the 6 wires. For the decoder IC, this one can be used: https://www.digikey.nl/short/h213b70h

There are multiple alternative suppliers, like for instance Conrad, Farnell and Mouser.

- https://www.digikey.nl/short/r5fcq88w

There are two pulse generator circuits on the PCB, intended for “plan B” in case we need to adjust the timing of the signals coming from the Hall sensors. These parts can be omitted.

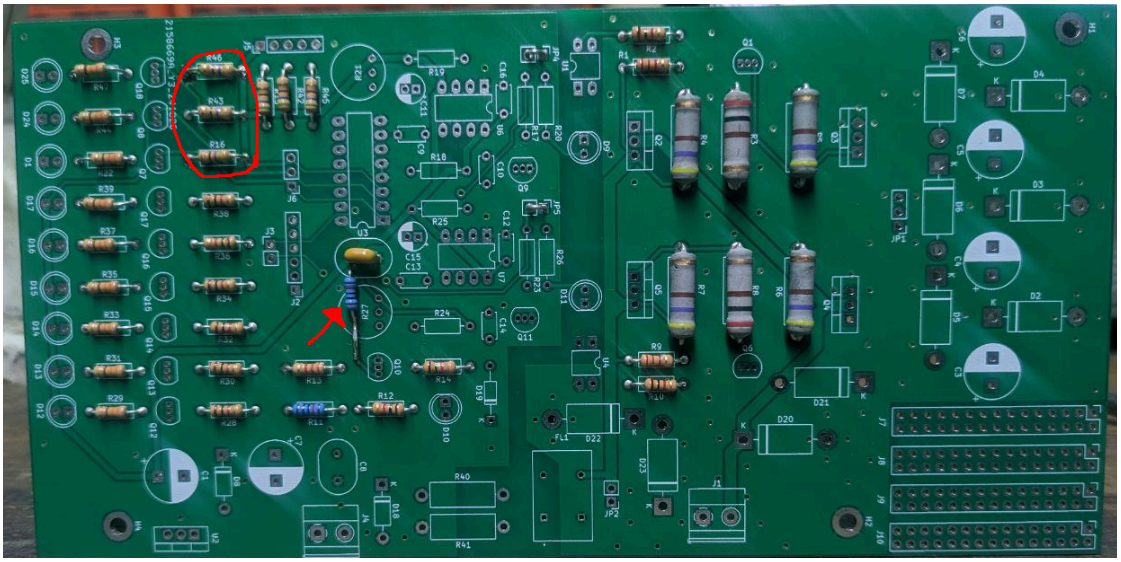
Further, a “third hand” is a very useful tool:

2. Soldering and Mounting (step 3)

- (‘Solderen en Monteren’)…
- Tips in het Nederlands: https://nl.ifixit.com/Guide/Elektronica-vaardigheden+101/6190 https://www.budgetronics.eu/nl/leer-hoe-te-solderen/c-27

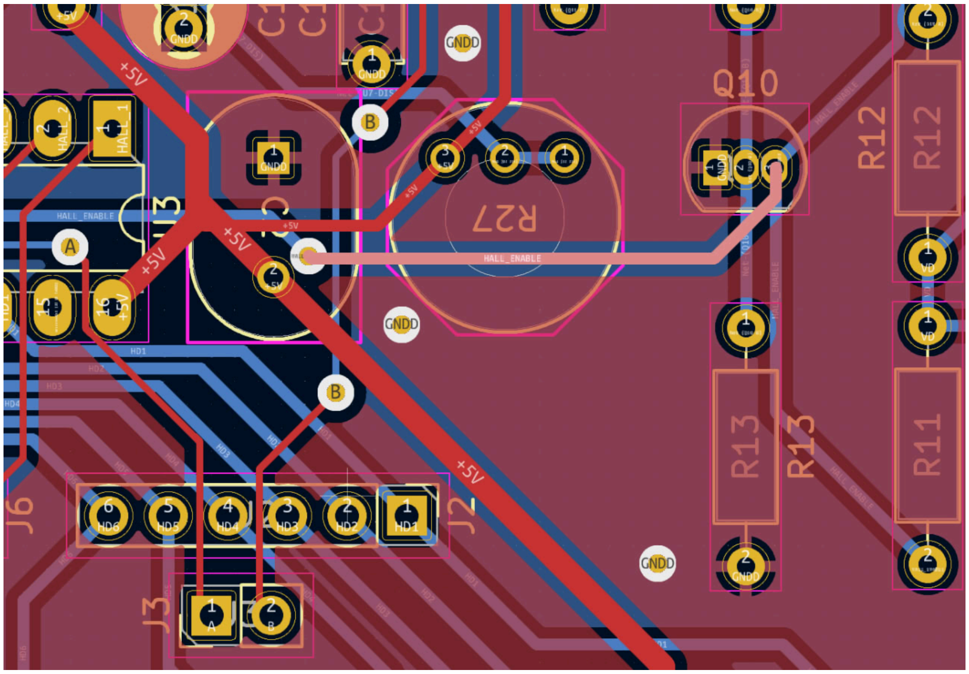
It’s not very critical in which order the components are soldered onto the board, but in general one first mounts the resistors, then the diodes, the capacitors, the transistors and finally the IC’s. The IC’s are generally mounted last, because these are the most sensitive for static discharges, etc. Also, it’s handy to solder the smaller (lower) components first and the bigger ones later.

In this photograph, all resistors are in place, including the extra 10k resistor indicated by an arrow:

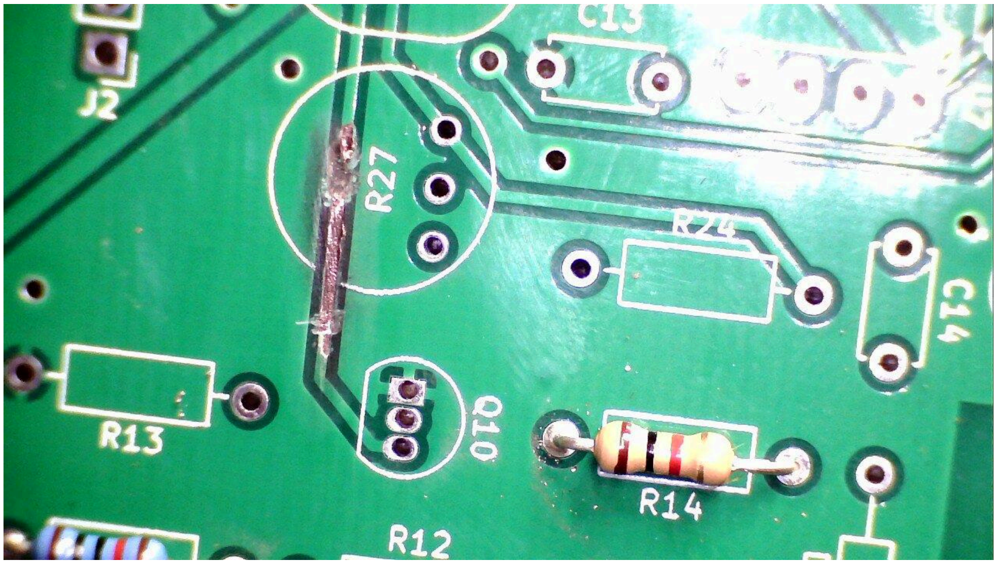


Note that the three resistors in the red circle (R16, R43 and R46) are 47 Ohm, while the rest of the row are 1k.

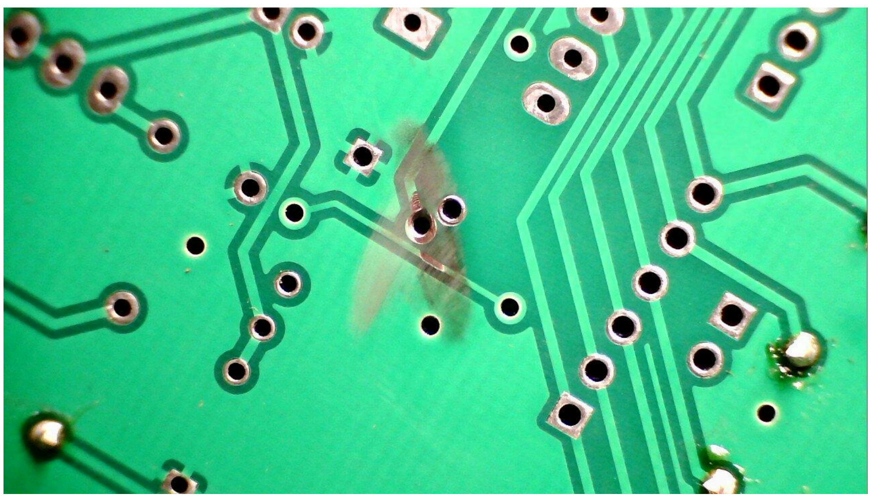
The resistor indicated by the arrow (R48) is 10k, which needs to be added to prevent over voltage on the enable input of the decoder IC. In order to mount this resistor, a trace on the pcb needs to be scratched at the upper side of the pcb and cleared of lacquer for about 5-10 mm:



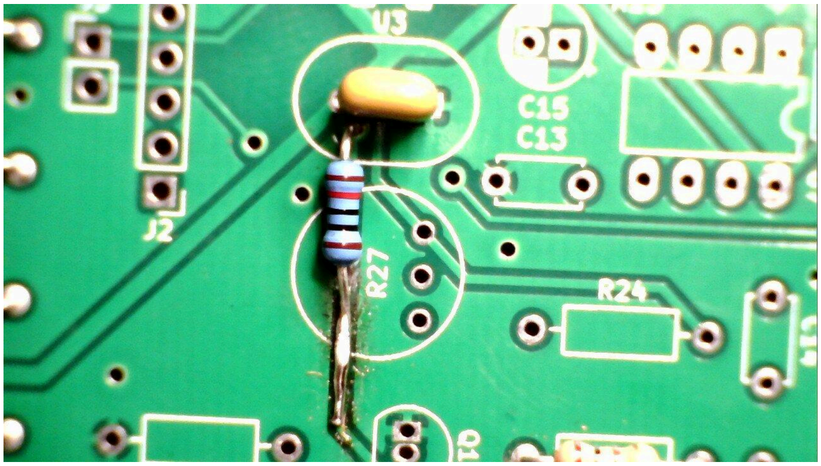
This can be done with a Dremel-like tool:



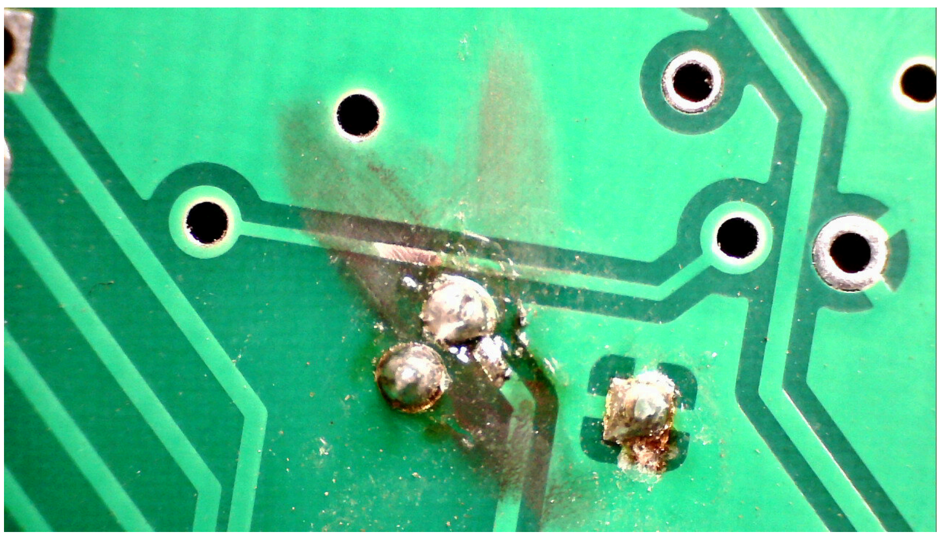
On the bottom side of the pcb, the via near C2 needs to be cleared of lacquer as well:



Then, the resistor and C2 can be soldered into place, whereby the via is used for the resistor, while the other leg of the resistor is connected to the trace from the transistor:

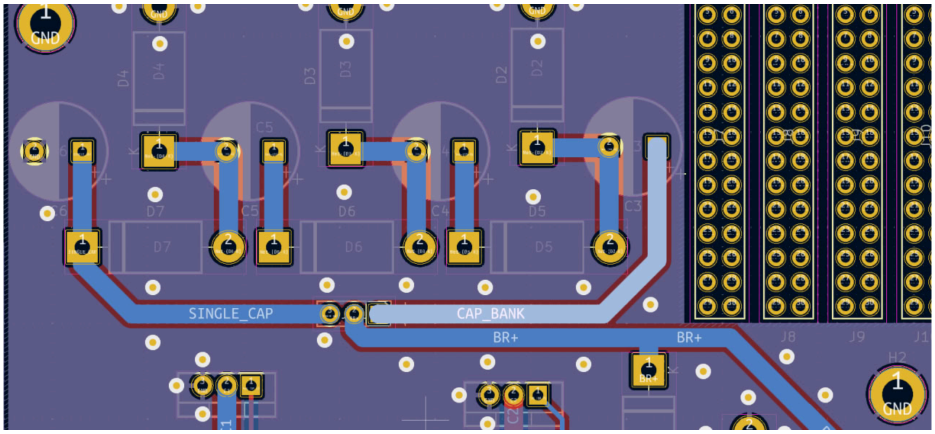


At the bottom, the via is quite close to one of the connections of C2, but it can be soldered:

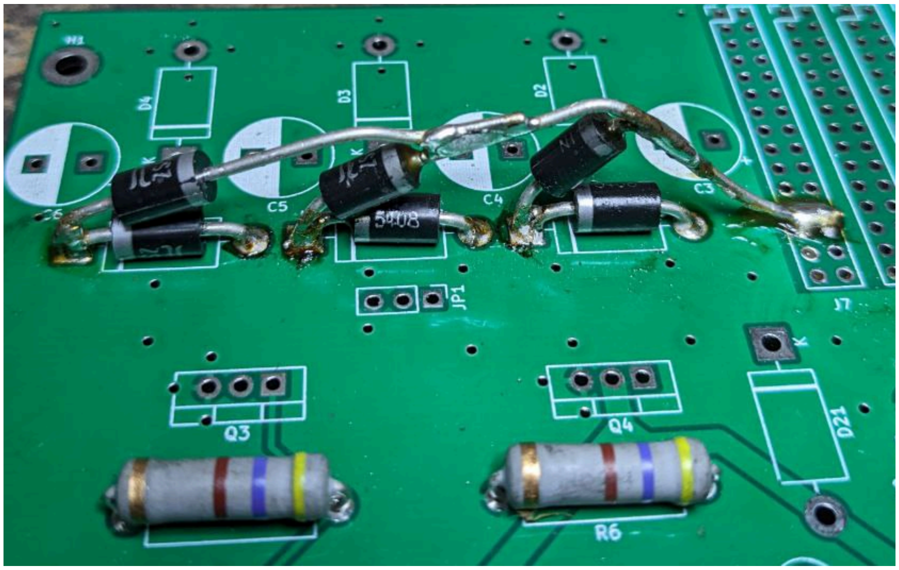


To make sure no shortcut has been established by the soldering, the resistance between the two solder points can be measured, which should be infinite since nothing is connected to the hall enable trace with the resistor if the transistor and decoder IC have not been mounted yet.

A further problem are the three forgotten diodes, which need to be connected to the CAP_BANK trace at the bottom of the PCB:

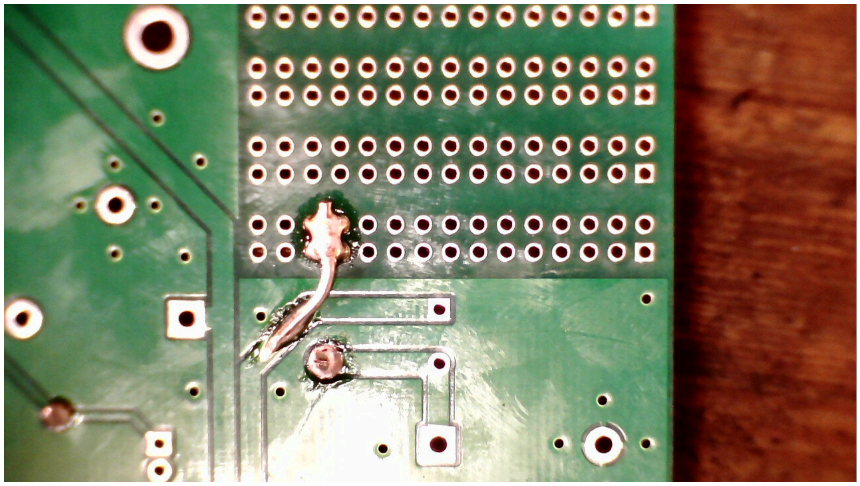


This can be done by piggy-backing the extra diodes on top of the three existing diodes (after mounting these, of course) and connecting them to a few holes in the experimental part of the PCB:



A bit hard to solder, since because of the thick wires it's hard to heat up, but doable.

At the bottom of the PCB, a connection from the 4 holes to the CAP_BANK trace must subsequently be made:



3. Testing (step 4)

- Documenting test results
-

4. Operating (step 5)

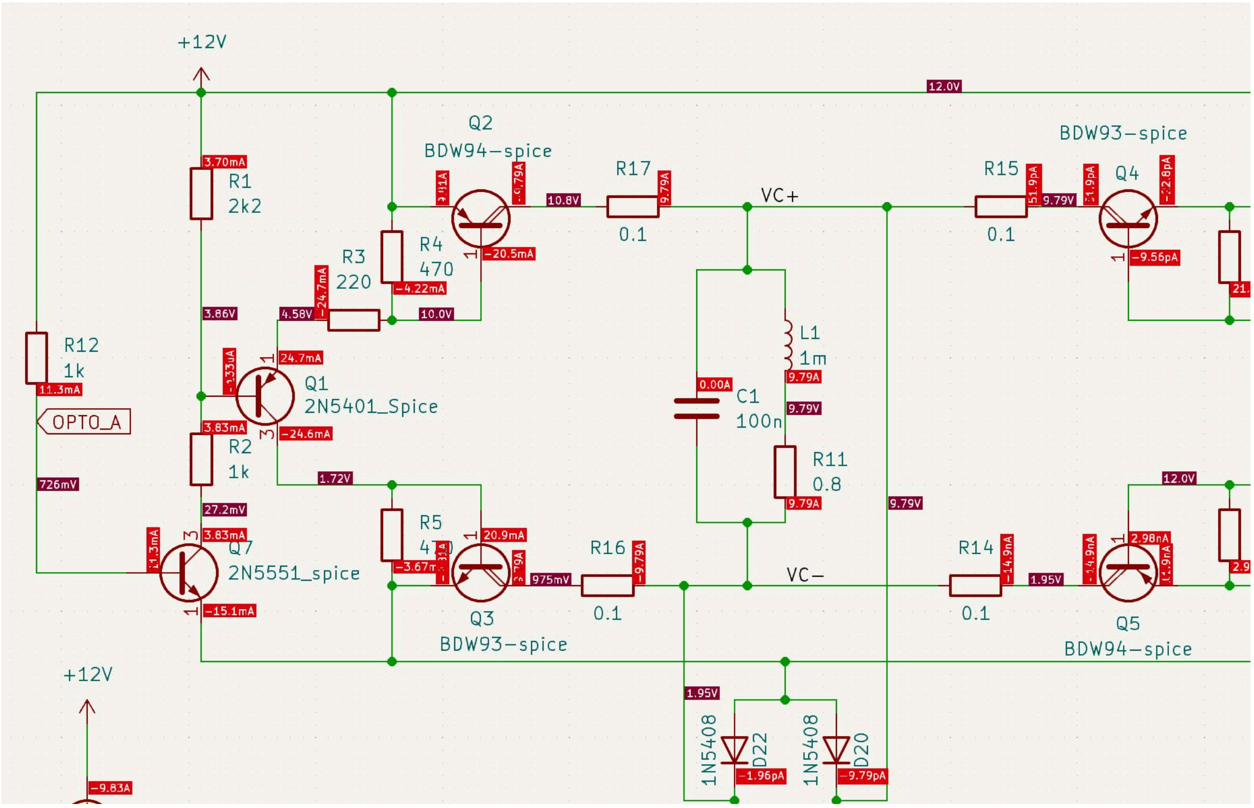
- Operating instruction
-

5. Simulation (step 6)

- Simulation in Kicad using Spice.
- First simulation to establish DC operating point of the control circuit has been done and can be opened with KiCad: https://github.com/l4m4re/H_Bridge_BLDC/tree/main/KiCad/Bridge_Simulation
- The motor itself could be simulated using FEMM https://www.femm.info/wiki/HomePage , like in this video: https://www.youtube.com/watch?v=4qe8HzIg0B8

A Spice simulation of the basic circuit has been done to determine the DC setpoints of the circuit:

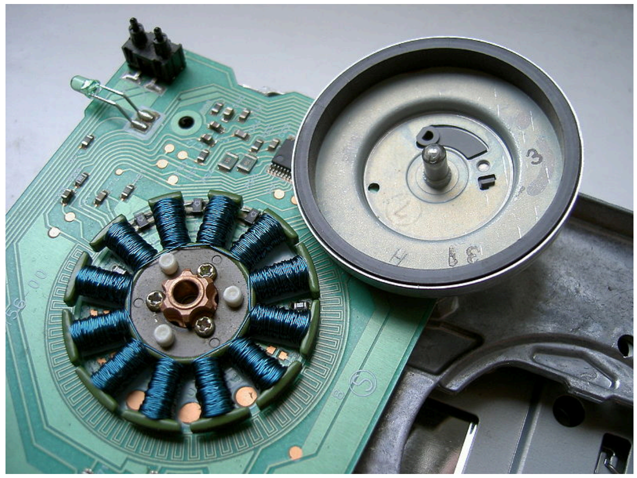
https://github.com/l4m4re/H_Bridge_BLDC/blob/main/Img/DC-Setpoint.jpg



According to the simulation, the 220 and 470 Ohm resistors steering the power transistors do not dissipate much power, but in Friedrich's version of the schematic 2 W resistors were specified, which is why the resistors in the current schematic are 2 W. It is probably because of the use of Darlington transistors that the resistor power dissipation is much less than in the original, so probably ¼ W resistors are sufficient in the current schematic.

6. Scaling up (step 7)

- If the principle can be shown to work with a small BLDC motor, pretty much any BLDC motor with magnets rotating around a star shaped stator with coils can be used, in principle, ranging from small motors such as in a floppy drive to an electric bicycle motor up to a motor in an electric car and beyond. The principal design of a suitable motor for upscaling is illustrated in this picture from a floppy drive motor:



Note the three hall sensors needed for timing information in between the coils at the upper part of the stator.

- The same design can be found in e-bikes:
  How to open an eBike hub motor on an electric bicycle
- And bigger motors like this 35kw outrunner motor :
  High efficiency 35kW Brushless motor.
- Or in washing machines:
  220V DC Motor from Washing Machine upto 600W DIY - Salvage Outrunner BLD…
- This rather interesting video show a tear-down of a small BLDC motor:
  Episode 20: Teardown of a brushless outrunner motor