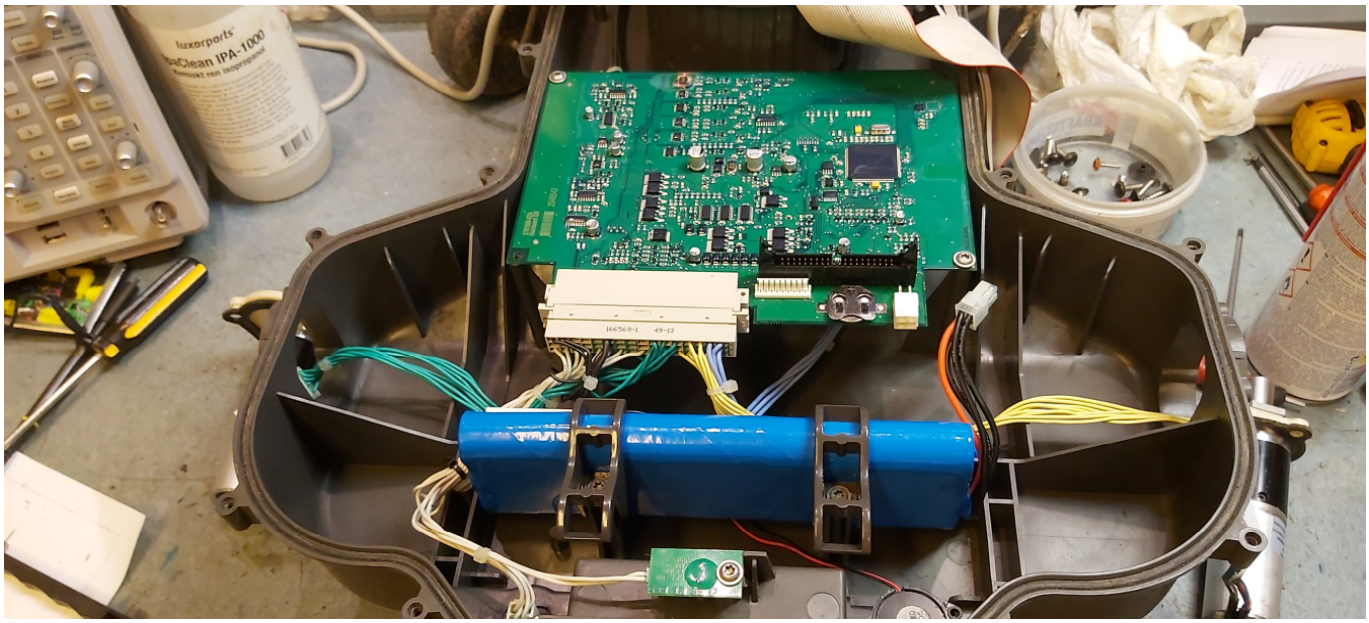
Automower Wheel Fault

My Automower 220AC did stop with the error message "right wheel motor blocked" In Swedish the message was "Höger hjulmotor blockerad". The following is my notes on how I rectified the problem and did bring the machine back to "life" again.

My Automower 220AC suddenly stopped with the error code "Right Wheel Motor Blocked" and refused to move. I tried different ways to reset the machine including disconnect the battery and reconnect it again. Nothing helped.

I contacted a local Husqvarna authorized dealer to get an opinion about the problem and an estimate of the repair cost. The repair shop said that it was most likely the CPU mother board that was faulty and needed to be replaced. The total cost for the repair including the spare parts would be in the order of 6000 – 7000:- (SEK). This is about 600 to 700 US dollars. Expensive!

I therefore dissembled the machine to take a closer look at the problem. To help me in the process I found and downloaded manuals and documentation for the Automower 220AC. Se reference section. I followed the guide lines in the manuals and the disassembled machine can be seen in the figure below.



Diagnostic Tools

There are built in diagnostic "tools" into the firmware of the Automower 220 AC. Normally they are not shown and have to be activated to show up. I had quite a bit of problem to do this activation due to an error in the described procedure in the Technical Manual for 220AC. As can be seen in the figure below it says that you should "place the cursor on the **settings** and then press **Yes**, thereafter press **Home, 4, 3** buttons". That didn't work. I tried it repeatedly without any success.

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2.4 The Tools Menu

Over and above the menus described in the operator's manual for Automower, there is another menu called *Tools*. This is found on the *Expert* user info level. The menu *Tools* contains, among others, the possibility to test components of a mower and information about different operating data.

To show the *Tools* menu:

1. Place the cursor on *Settings* and press **YES**.
2. Press the **Home**, **4** and **3** buttons simultaneously, i.e. at the same time but in the stated order.

Tools is shown at the bottom and *EXP* is stated on the right-hand side of the display.

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Then I discovered this note that is lightly different, see figure below. Here it says that you should: “Place the cursor on the **settings** menu, the press **Home** + **4** + **3** simultaneously and in the stated order. Now finally the “Tools” menu became visible on the menu. The difference is that you should not press “**Yes”** in the settings menu.

Expert mode

In the settings menu: Press **Home** + **4** + **3** simultaneously, but in the stated order.

The *Tools* menu then becomes available in the main menu.

Quick check

In the main menu: Press and hold the **0** key down for 2 seconds. Press **YES** to switch between the different display modes. Press **Arrow back** to exit the quick check function.

Discover the PIN code

In the main menu: Press and hold the **9** key down for 5 seconds.

A combination of letters is displayed. Contact the national service organisation and state the letters.

Now with the tools menu activated we can easily test the wheel motors, see figure below.

When activating the wheel motors the left was running as expected but the right wheel motor didn’t move. If I tried to manually move the right wheel motor I could not move it. It was completely stuck in the same position. However if I disconnected the battery (power) I hand no problem to move and rotate the wheel.

Fault finding

This indicates that there was some electrical problem with the electronic motor driver and the motor itself was ok. To check this I swapped place of the motors and mounted the right motor in the left position. When doing the tools test again for the wheel motors the wheel motor did move normally (now in the left side). Therefore there was no issue with the motor itself and the fault must be localized at the motor driver electronics.

I started to try to find some schematics of the CPU control board without any success despite quite an effort. So the only way seemed to be to do some reverse engineering.

However now a new problem popped up, the control board is coated with some transparent epoxy coat. It is understandable that this is done to protect the electronic components from moister and dust.

Power & Motors (5-2-1)

This part menu contains the following test functions:

Wheel motors

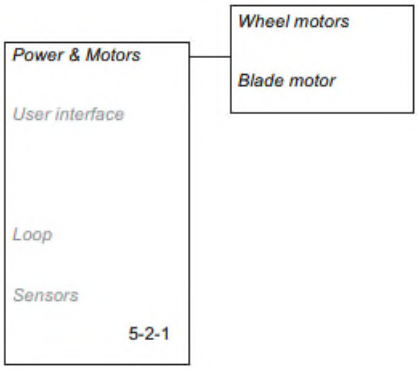
The battery voltage should be at least 18 V when testing the wheel motors.

Place the cursor on *Wheel motors* and press **YES** to start the test. Grip the handle on the underside of the Automower and lift up the rear wheels. The following is shown on the display during the test:

- *Power*: xx %
- *Speed L*: xx cm/s
- *Speed R*: xx cm/s
- *Voltage*: xx.x V

Use **Arrow up** and **Arrow down** to increase respective decrease the wheel force.

- Increase the force to 80% and block respective drive wheels in at least ten different positions over the wheel revolution. Check that the motor starts again once blocking is released.
- Increase the force to 100% and check that the speed of each wheel is at least 60 cm/seconds (45 cm/seconds for 220 AC).



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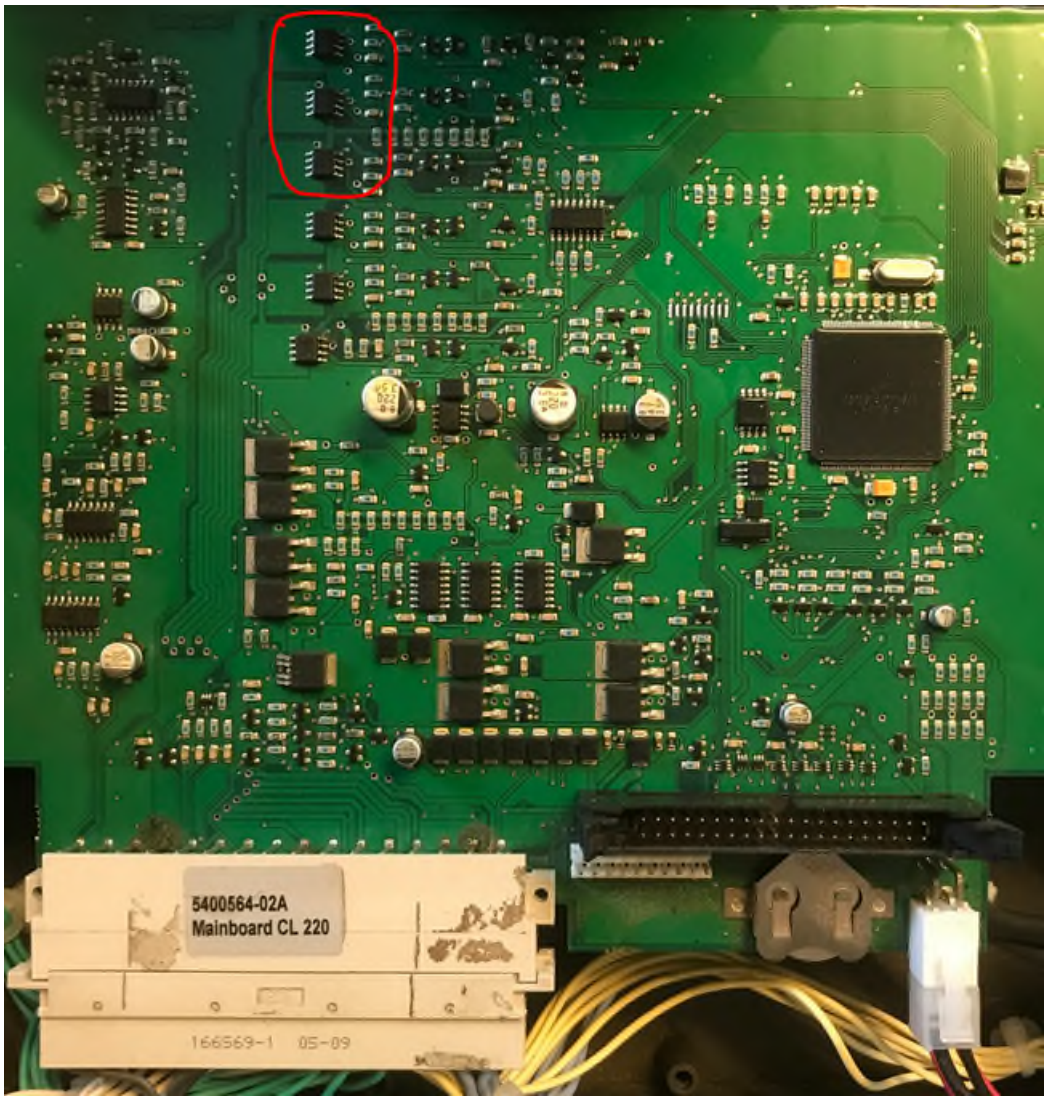
The problem was that this coat was extremely hard and very thick. Also it seems that Husqvarna had removed all the components marking making it difficult to identify the type of components. This was especially true for the IC circuits. I tried to use chemical solvents including acetone without any success whatsoever.

The only solution seemed to be to do a mechanical remove the coting by using a sharp pencil knife and similar tools. The first step was to able to reach tracing points in the circuit to measure pulse train as well as doing Ohm measurements. I did a 3D printing of some adapters to my oscilloscope probes and DMM's with a very sharp tip, see figure below. This sharp tip could penetrate the epoxy coating and made it possible make measurements on the PCB board (control board).

By tracing the connection from the right wheel motor it was an easy task to see witch IC was the driver for the motor. The wheel motor is a three phase BLC motor and the three phases from the motor was connected to the three IC marked with red in the figure below.



By doing an extensive search for the problem with “Wheel Motor Blocked Automower 220AC” as was able to find a forum with information about the problem, see reference section. According to the info on the forum the driver IC would be a STS8C5H30L.

This is a N-channel 30 V, 0.018 Ω typ., 8 A, P-channel 30 V, 0.045 Ω typ., 5 A Power MOSFET in a SO-8 package. See references for more information.

The package and circuit layout of the circuit can be seen in the figure to the right. By checking and do reverse engineering it seemed to be correct. To get a better understanding of the circuit during the reverse engineering I found an application note describing a similar motor driver. The schematic can be found below. See references for more information.

I now had all the information I needed to procced with measurements. I used the tools motor wheel test to continually run the motors and could compare the left and right motor driver pulses using an oscilloscope.

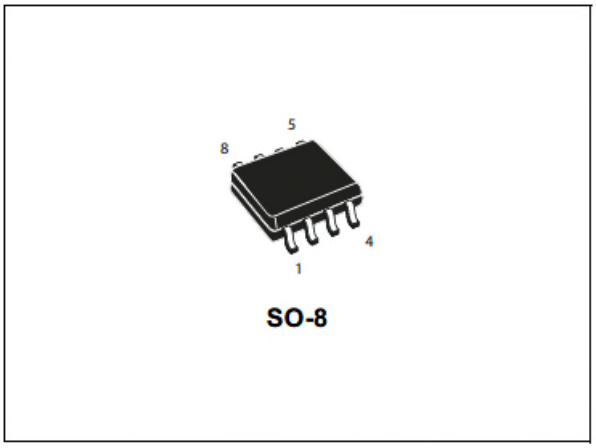


Figure 1. Internal schematic diagram

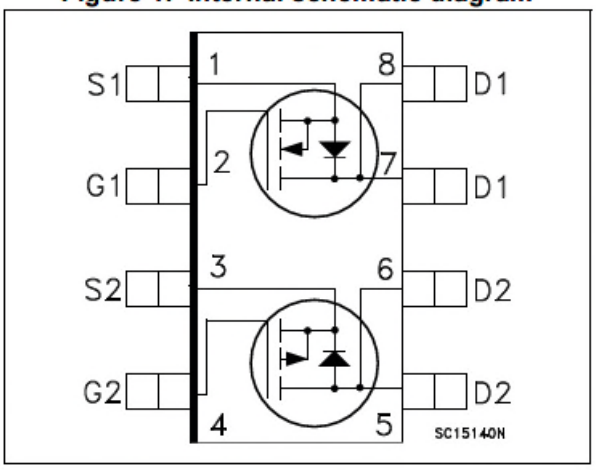
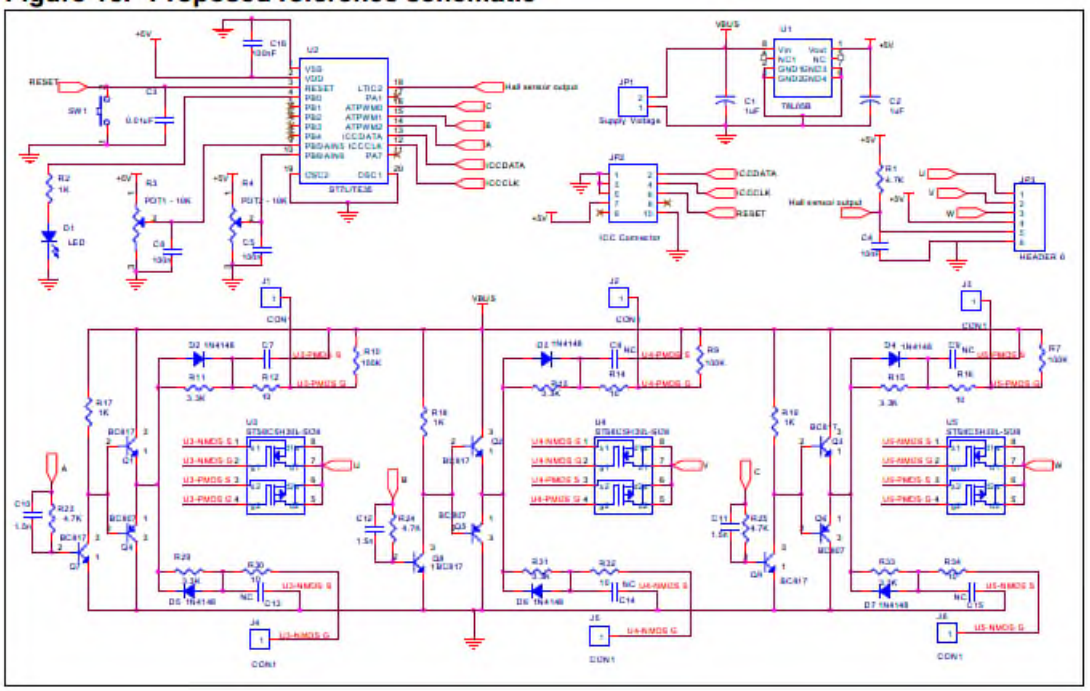


Figure 10. Proposed reference schematic



It was obviously that the wave forms where very similar to the ones showed in the application note for the working left motor. For the right motor there where pulses but they did not reach the NOS-FET driver IC correctly.

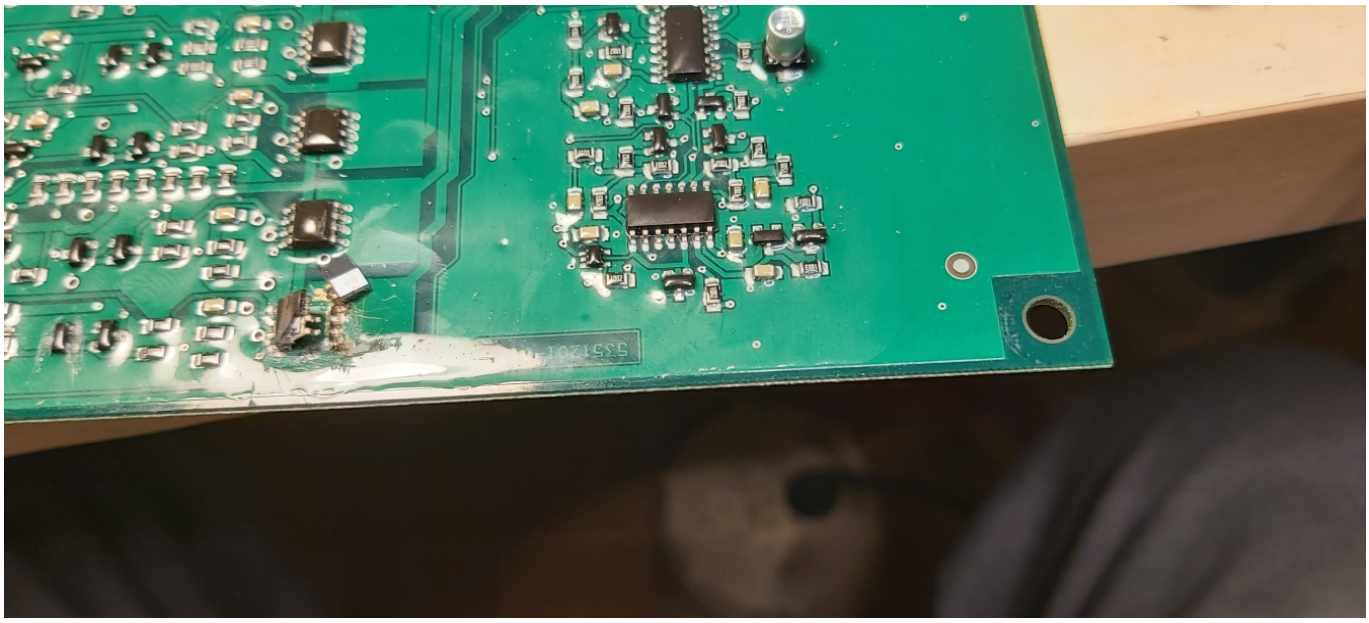
Faulty Component

I the switched over to do ohm (resistance) measurements and could find that the where a short between drain #1

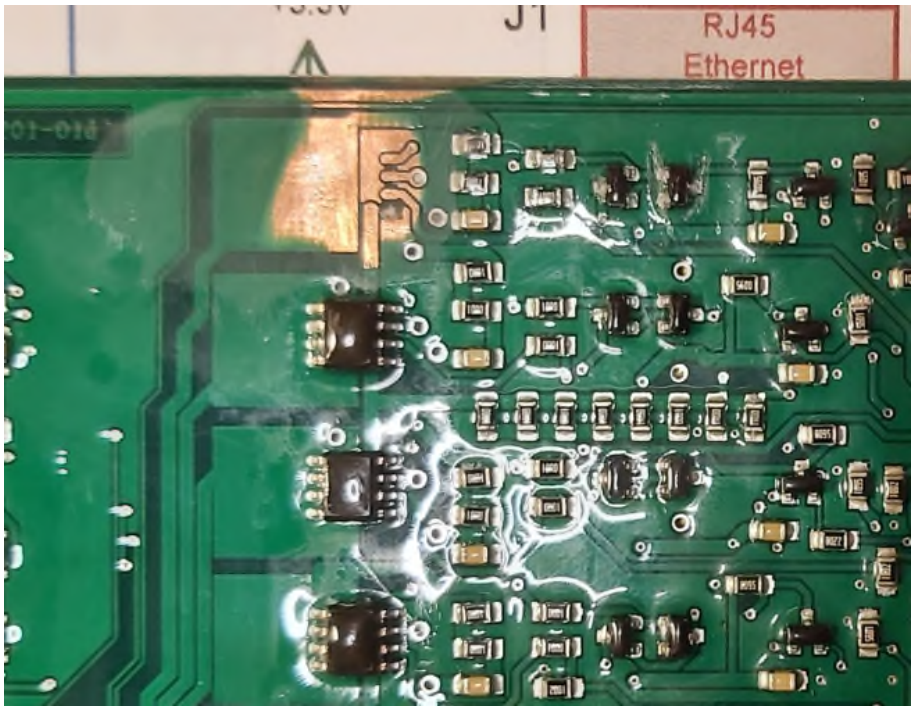
and source #1 of the top IC (the one closes to the board edge). Se the red circled IC in the figure above. I did an extensive number of measurements to see if I could find any more faulty components but everything seemed to be ok. I now did a web search for the STS8C5H30L Power MOSFET. To my disappointment I found out that this IC was “Obsolete and this product is no longer manufactured”. What a disappointment! See references.

However after extensive search I found a Polish site that did have the IC in stock for the price of 0.5 Euro per piece. I made an order for 10 pieces. Four days later they arrived via TNT.

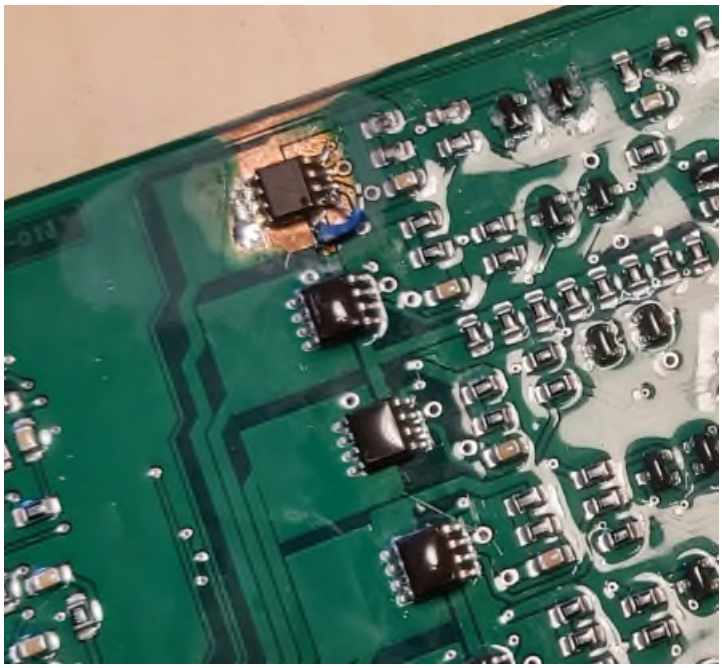
Now the challenge was to unsolder the faulty IC. I used a big solder iron of 150 Watts to do the work. Using some minor force I was able to remove the IC with some difficulty and physical damage. See figure below.



I then proceeded to clean up the board with some sandpaper. The result can be seen in the figure below. Unfortunately I did damage to one of the IC PCP pins (pin 1):



However a fix would be to solder a short wire from pin 1 to the PCB board trace. The result can be seen in the figure below. A coating of Clear Coat was applied to protect the circuit from moister and dust.



Once again the tool test program was run for the wheel motors and now both motors runs smoothly. Test was done from 0 to 100% speed and a test for 5 minutes at 100% worked without problems. The Automower was the assembled and was set back to work again.

So the net effect was going from reparation costing about 600 to 700 US dollars it did cost 0.5 dollars plus a couple of fun hours with fault finding.

Regards

Bo, SM6FIE

References:

1. Husqvarna-Automower-220-Ac, technical manual, link
2. AN2281 Application note Low cost self-synchronizing PMAC motor, link
3. STS8C5H30L, STMicroelectronics, data sheet, link
4. DigiKey STS8C5H30L Obsolete, link
5. In Stock, Micros sp.j. W. Kędra i J. Lic, Distributor of STS8C5H30L STM, link
6. Forum with “Wheel Motor Blocked” (Swedish), link

Dokument info:

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