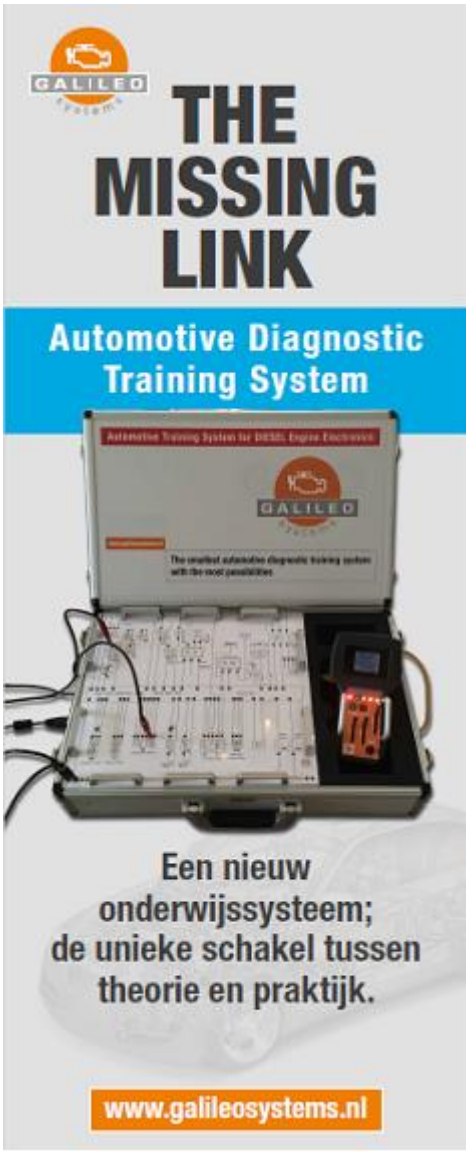
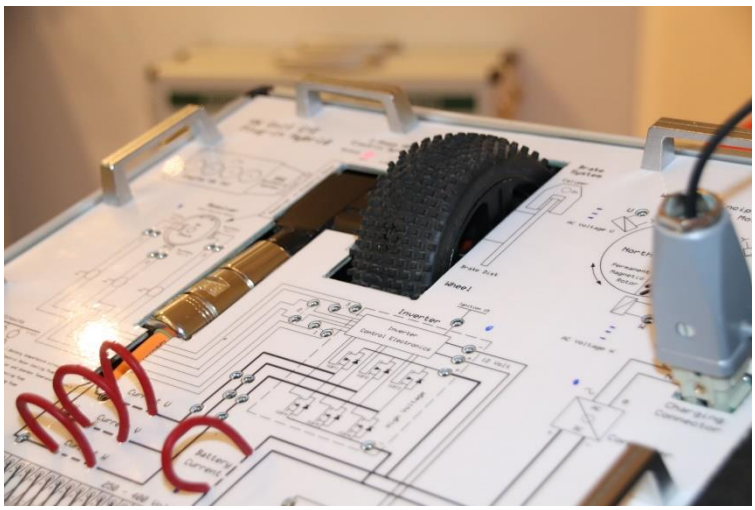
GALILEO VW Golf GTE System Description

The Galileo training system was developed out of the need to get as high a return as possible from Automotive (Diagnostic) Trainings with as few resources as possible.



The Galileo system is ideal for gathering the right basic knowledge on levels 2, 3 and 4 as effectively as possible but also for finding the very difficult problems in the electronic control systems during the Diagnosis Specialist training.



V1.04

Training purpuse of this Hybrid simulator

Clarifying the operating principle of hybrid cars. In addition to a Stand-Alone application, the software is made suitable for directly connecting the Hybrid case with the existing Galileo gasoline simulator (Golf TSI).

With this combination, the exact and complete operation of a plug-in hybrid vehicle can be understood under all conceivable operating situations. It is therefore possible to "drive" with this simulator as a real Hybrid, which provides a good insight into the complete operation and possibilities.

These operating situations are:

1 / Electric driving (measuring voltages and currents).

2 / More power due to "jump in" of the fuel engine at full power situation.

3 / Regeneration of the braking energy (measuring voltages and currents).

4 / Mechanical (additional) braking with faster braking or an emergency stop.

4 / Only fuel engine operation with empty battery.

5 / Recharge during fuel engine operation.

6 / Plug charging (measuring voltage currents).

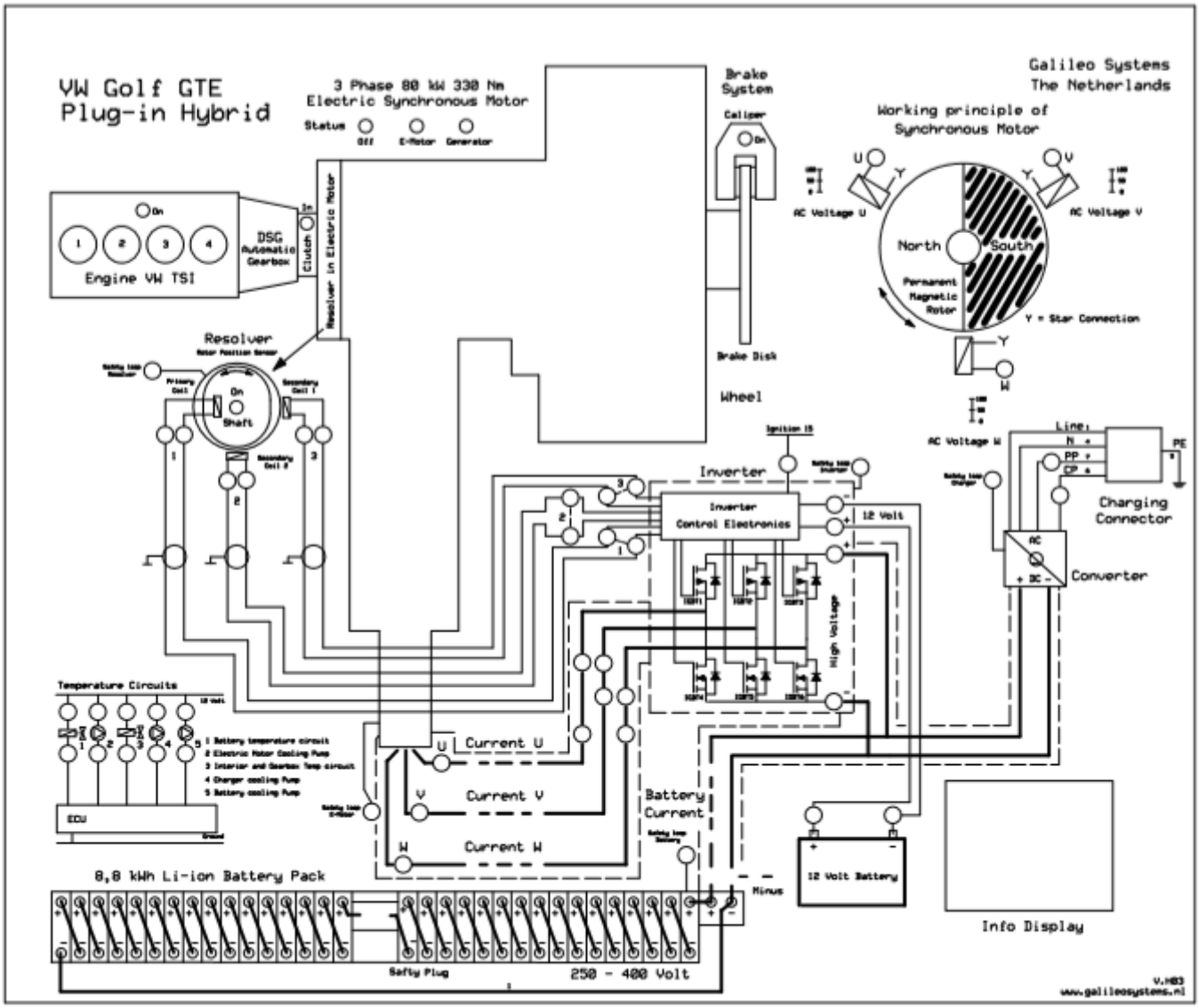
7 / Securing the battery.

8 / Cooling systems.

9 / Info display in dash board.

The Hybrid System

The top plate



This VW Golf GTE is designed as a Plug-In Hybrid. From a structural point of view, the applied layout is slightly different from the actual situation. Normally the electric motor is located between the engine and gearbox. The gearbox is therefore also used in only electric motor operation. In this situation we cannot realize a "real mechanical" gearbox, which is why the electric motor is placed in a different position and drives the wheels directly. The principle operation is also the same in terms of DSG automatic transmission, acceleration and braking. So the switching can be seen in electrical engineering only as in electrical in combination with fuel engine operation.

Up-to-date to fully electric car

This setup is also necessary because with an update of this suitcase (only other top plate) a full EV can also be realized. A big cost saving when switching to an EV car.

DSG Gearbox

The gearbox is simulated as a DSG automatic. This gearbox automatically selects the correct gear if only electrically driven. This is necessary in order to be able to deliver the right power and flexibility immediately in the event of switching over to petrol engine (Galileo Systems version).

Power supply and safety

The power supply is an external 24 Volt unit. The entire electric motor system has exactly the same characteristics and the same design as the electric motor in the Golf GTE including the position sensor (resolver). The difference is really only in the voltage of the battery. In the real Golf GTE the battery voltage is between 250 and 400 volts.

In addition, the driven wheel is connected to a slip coupling to the electric motor. If the wheel is accidentally touched or stopped by something or by hand, this will not cause physical injury (wheel stop immediately).

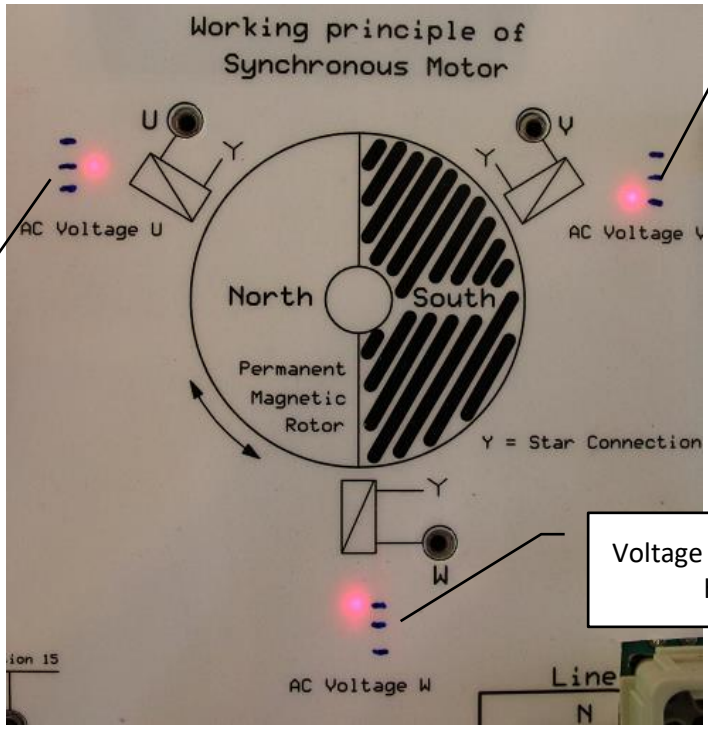
This simulator system is therefore completely safe on all sides. With "real" hybrid cars, there may still be doubts about safety during measurement and rightly so.

Driving the electric motor (battery capacity above 20%)

Drive away

Turn the ignition on., Apply the brake, then set the automatic selector to B / D, release the brake and accelerate.

The LEDs next to the wheel at the right of the electric motor image clearly indicate the variation in voltages and the phase shifts between the three phase. The following figure clearly shows these differences in control.



Voltage on coil V is low

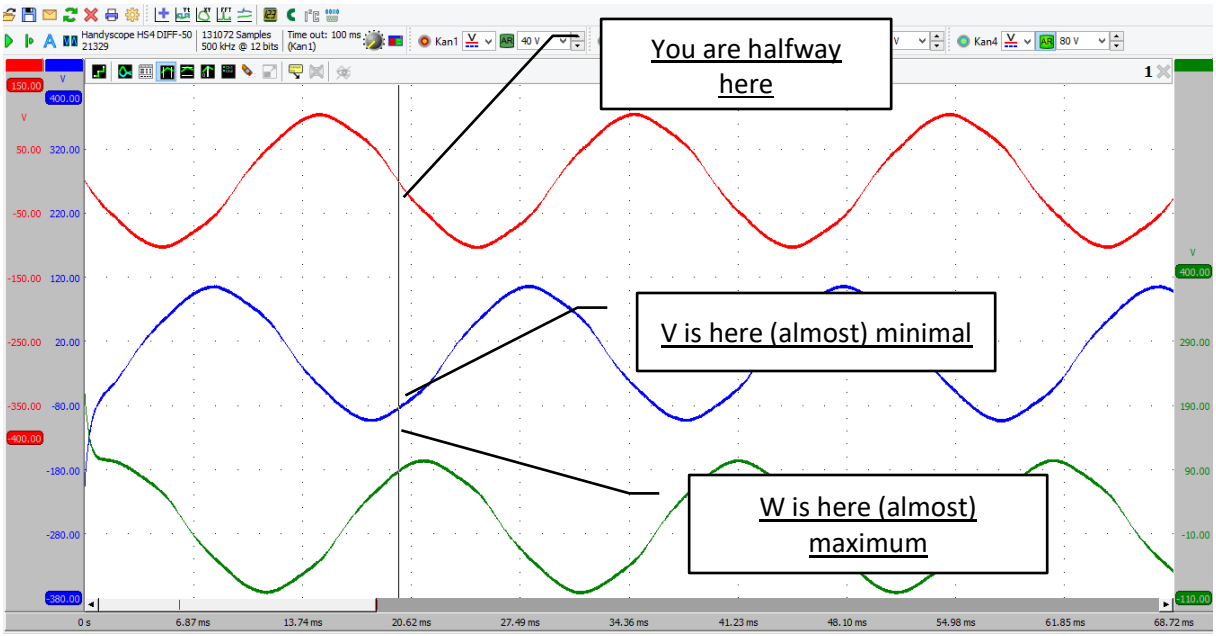
Voltage on coil U is halfway

Voltage on coil W is high

AC voltage and the controls

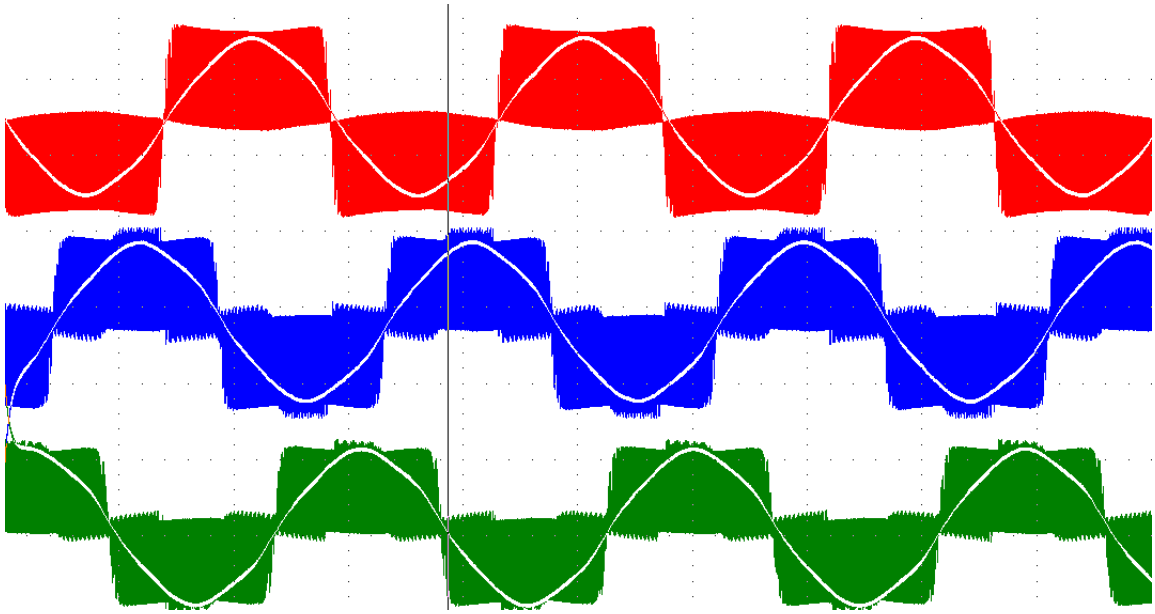
In the following image the voltages between the 3 phases are measured and brought to a nice, clearly visible and understandable 3 phase alternating voltage by means of a software filter (500 Hz). The situation shown in the previous image is shown at the point of the cross-thread.

U / Half
V / Low
W / High

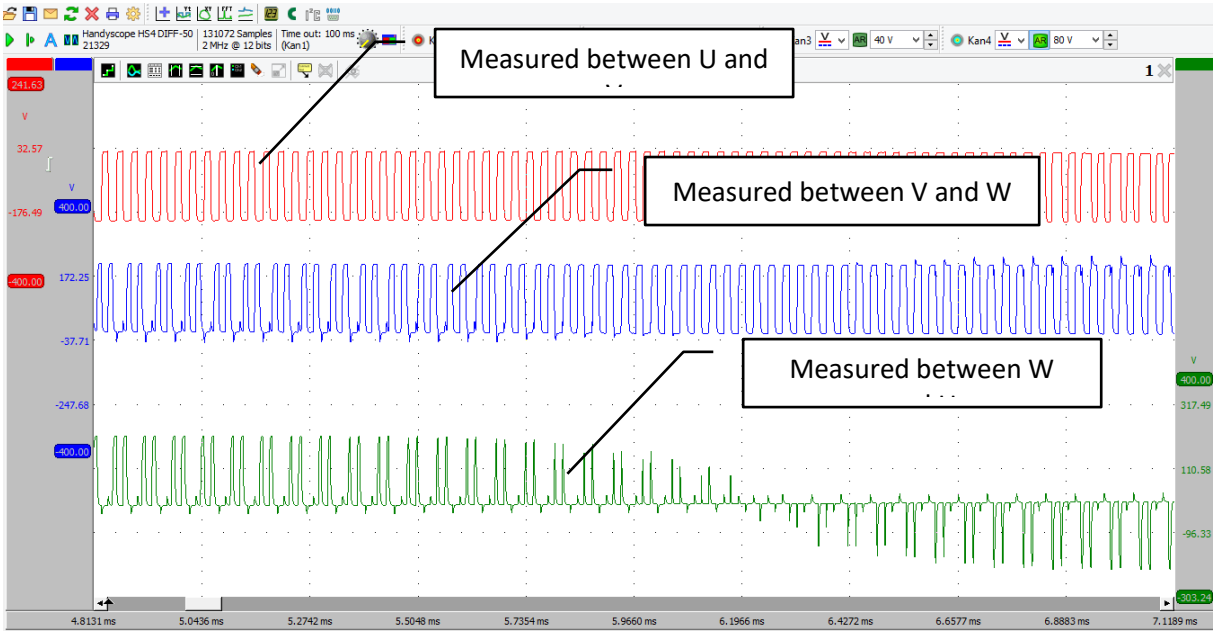


The measuring probes have an amplification factor of 10. The actual measured voltage will not exceed 24 Volts, but with this probe factor 10 setting the scale indicates 240 Volts. That is reasonably close to the actual voltage of 250 - 400 Volts of the applied battery.

As mentioned, the voltage measured with a (software) filter switched on. Basically, the 3 phases are created by means of a pulsating duty-cycle voltage. In the following figure, the same measurement is done without and with the filter switched on.



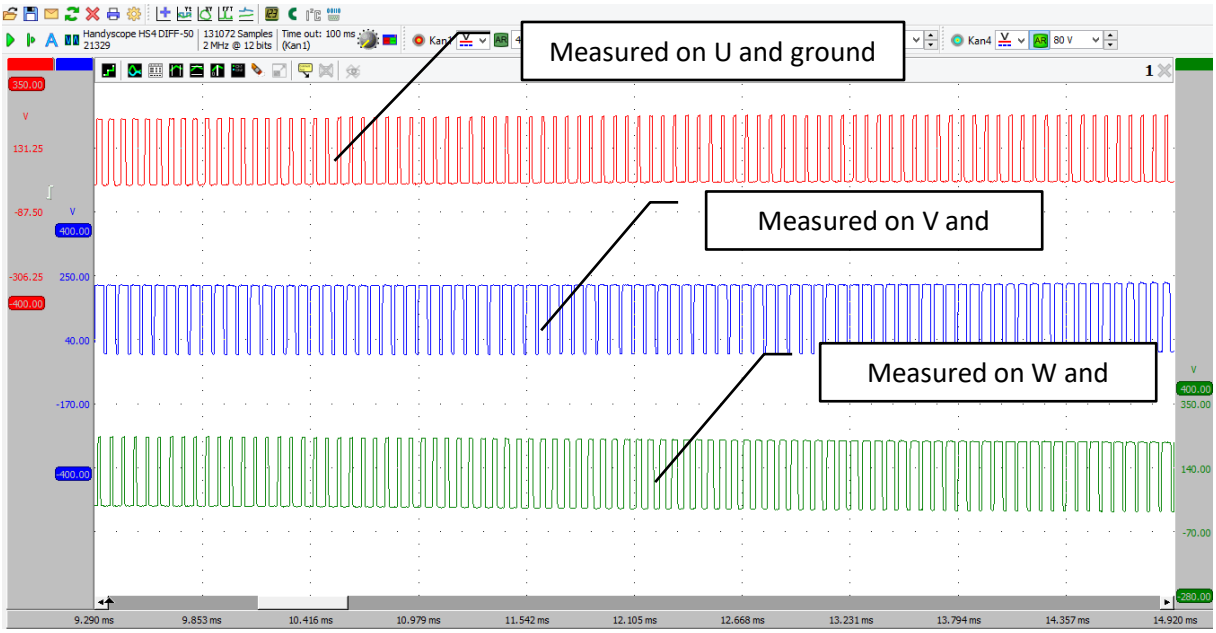
After magnification on the signals, a variable duty cycle is clearly visible.



It can clearly be seen that W switches from positive to negative. That is of course not the case because there is no negative voltage present in the car. This is because another phase then becomes higher than this. Note that the phase has been measured here BETWEEN the phase.

Measure against the ground of the battery

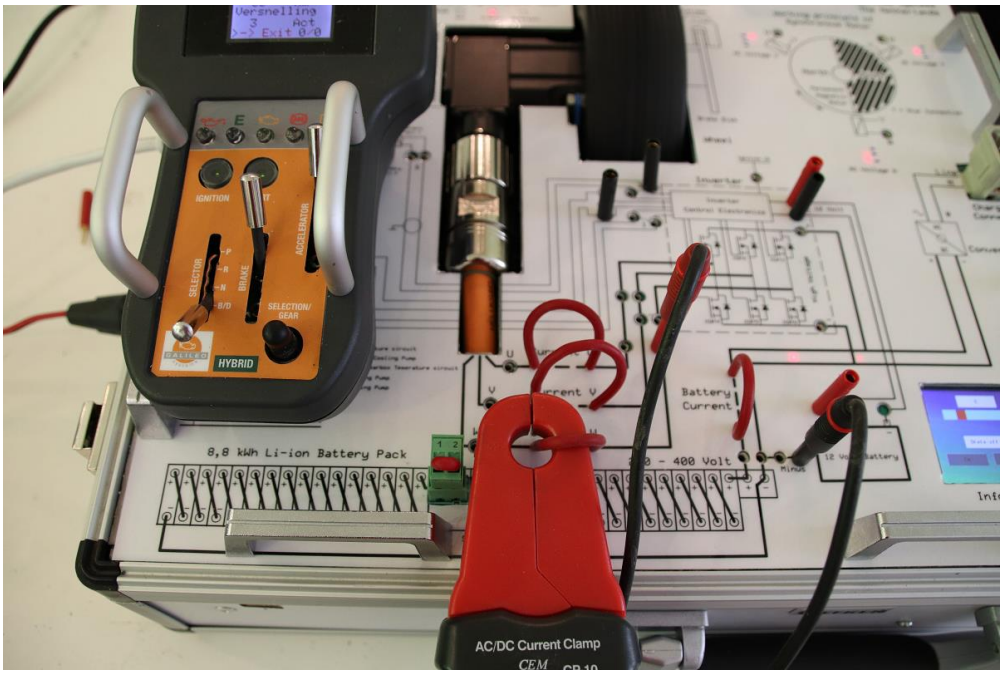
If there is a measurement on the 3 phase (3 channel measurement) relative to the minus of the battery you get the following scope image.



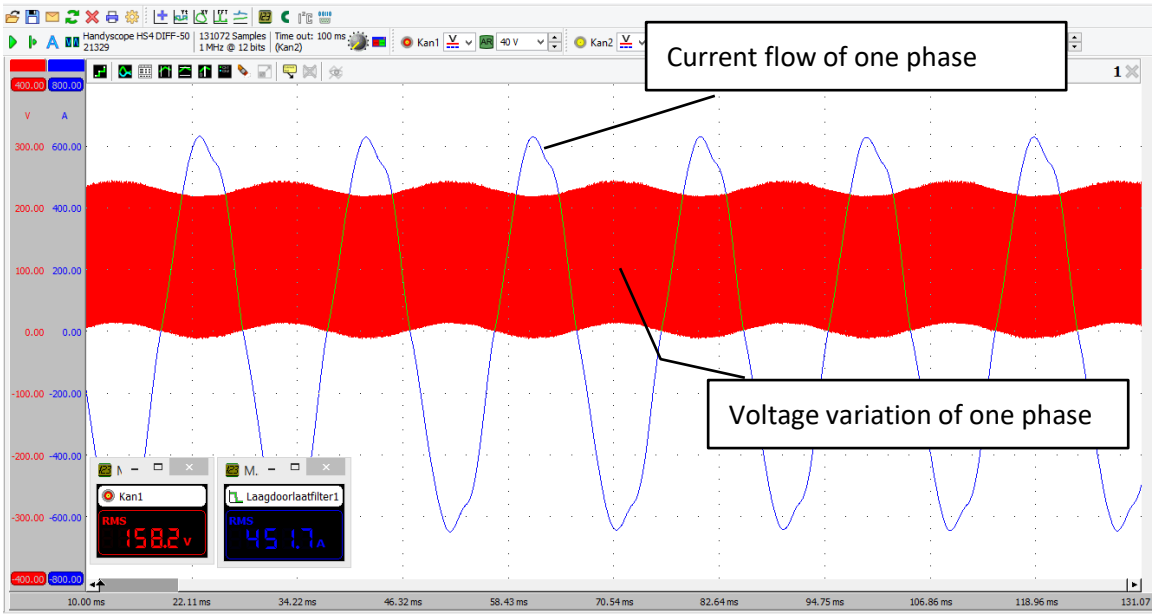
You can clearly see that the pulse width is constantly changing. With a broad pulse there is a relatively long voltage on the coil concerned and the current will also be high and the associated magnetic field will also be.

Measuring voltage and the associated current

The following illustration shows the arrangement of the current and voltage measurement in the phase wire W.

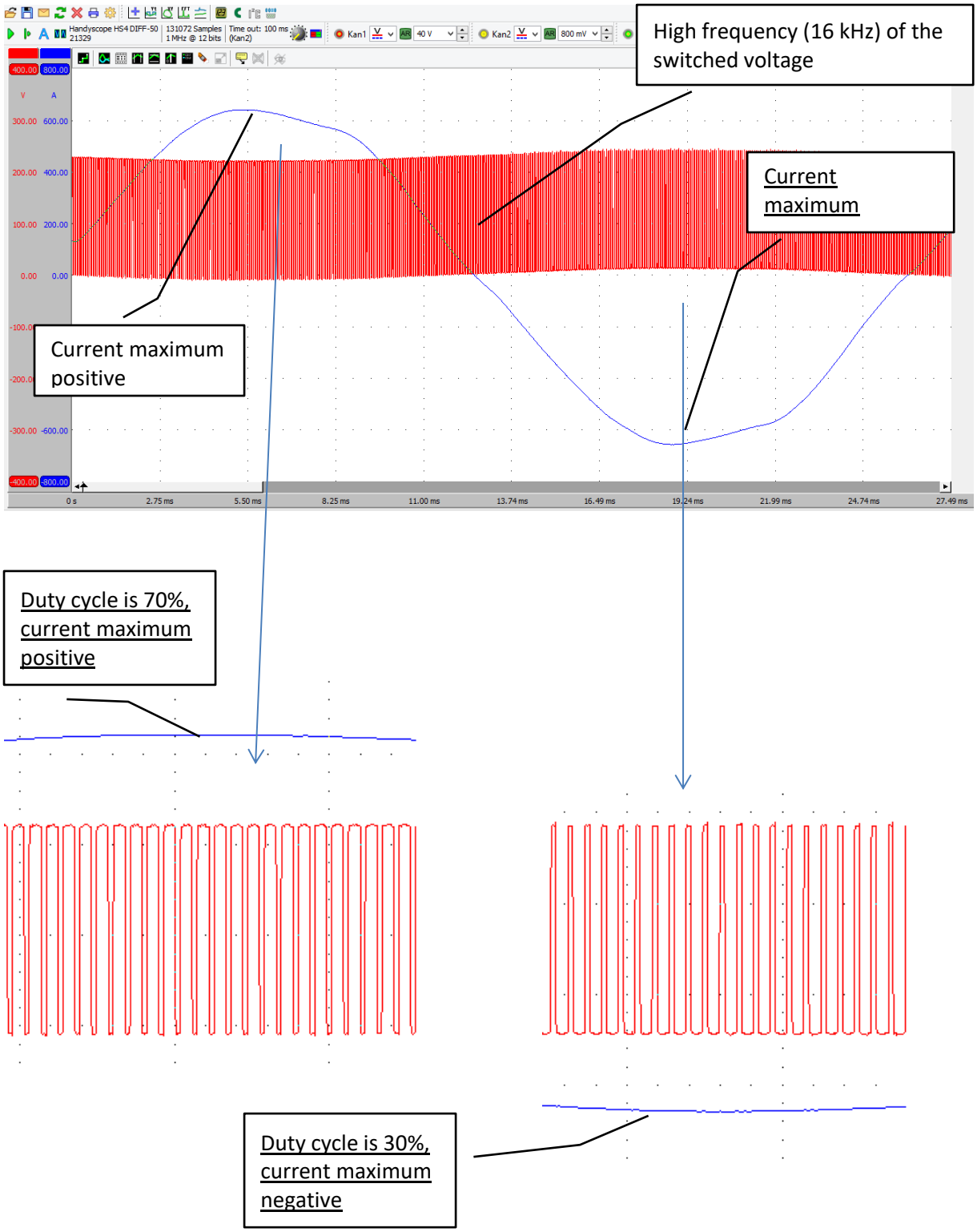


In this measurement, one phase was measured with the corresponding current. Probe settings: voltage probe x10, current probe x1000 (100mV / A).



The voltage is switched by the Inverter via a high frequency (16 kHz). To get a good understanding of the voltage pulses, zooming is required.

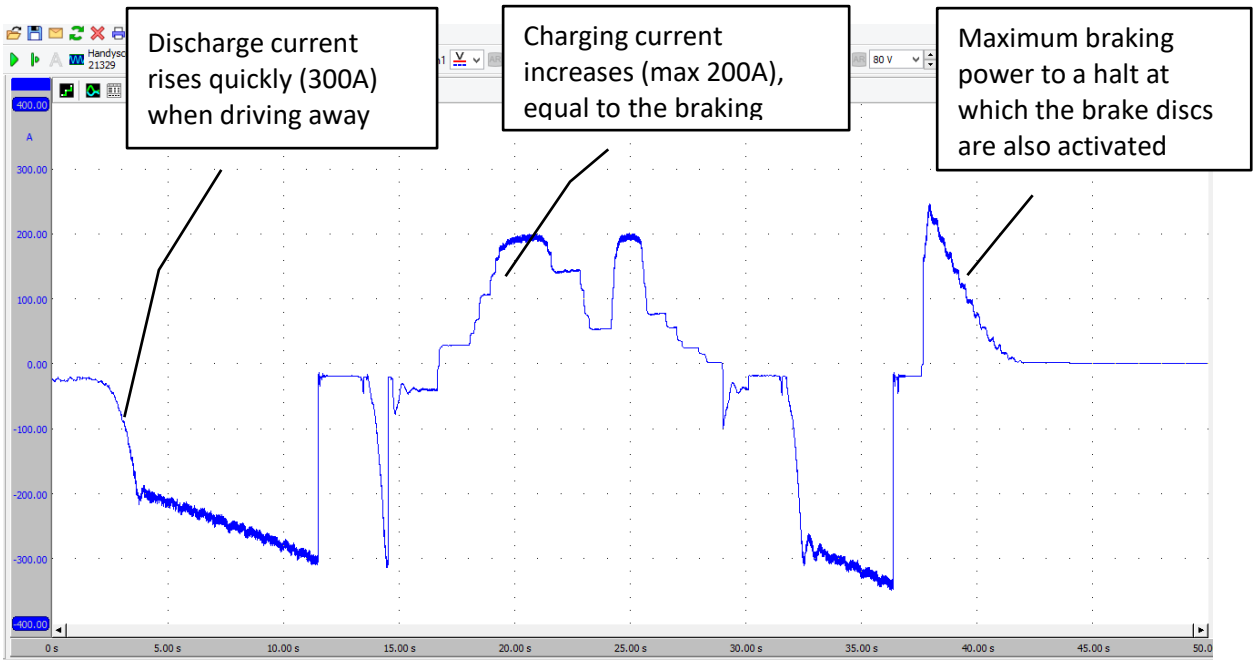
After enlarging one flow cycle, we get the following scope image.



After further magnification at the highest and lowest flow point, the difference in duty cycle can clearly be seen (see above)

Brakes with regeneration

The electric motor is switched to generator mode during braking. Depending on the braking force, more or less energy is supplied to the battery. This energy (current) can be measured with a current clamp in the plus line of this battery (wire loop in plus line). Clamp the clamp to the wire in the correct direction. Current and charge the battery "in" positive, the battery "negative" current and then discharged.



The property of an electric motor is that the maximum torque is present very quickly. There is some construction to prevent slipping. The correct probe setting shows the currents that are reasonably true to nature. Discharge currents run up to 300A and the regeneration current can be a maximum of 210A. In reality, the currents are 3A and 2.1A, respectively.

Plug charging

The plug charging is available with this simulator system. This is a single-phase charging plug that is only active if the engine is switched off and the automatic selector is in the P position. In addition, there are two security and control wires present in the charging plug indicated by PP and CP. If the charging plug is connected to the car, it cannot be started or run on an electric drive.

PP/ Proximity Pilot

CP/ Control Pilot

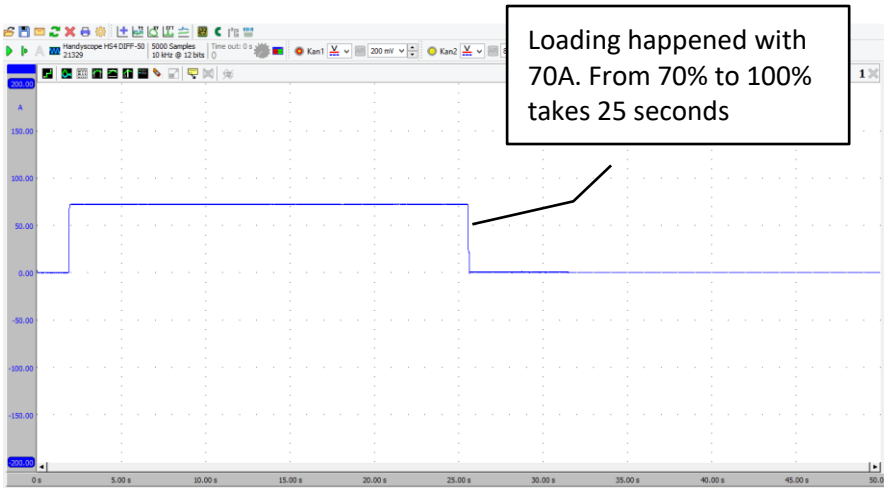
The PP wire shows if the charging plug is connected to the car and charging station. In addition, the height of the voltage indicates the charging modes in which the system is located. The relevant status is shown in the table below.

Status A	Standby	12V	
Status B	Car gedetecteerd	9V	
Status C	Cherging		6V
Status D	With ventilation		3V
Status E	No Power	0V	
Status F	Error	-12V	

The CP wire is connected to an electronic system that indicates how much can be loaded. A voltage with a switching frequency of 1 kHz is present on this wire. The duty cycle of this voltage indicates how much can be charged. The table below shows the agreement between Duty Cycle and charging current.

DC	Current continu
50%	30A
40%	24A
30%	18A
25%	15A
16%	9,6A
10%	6A

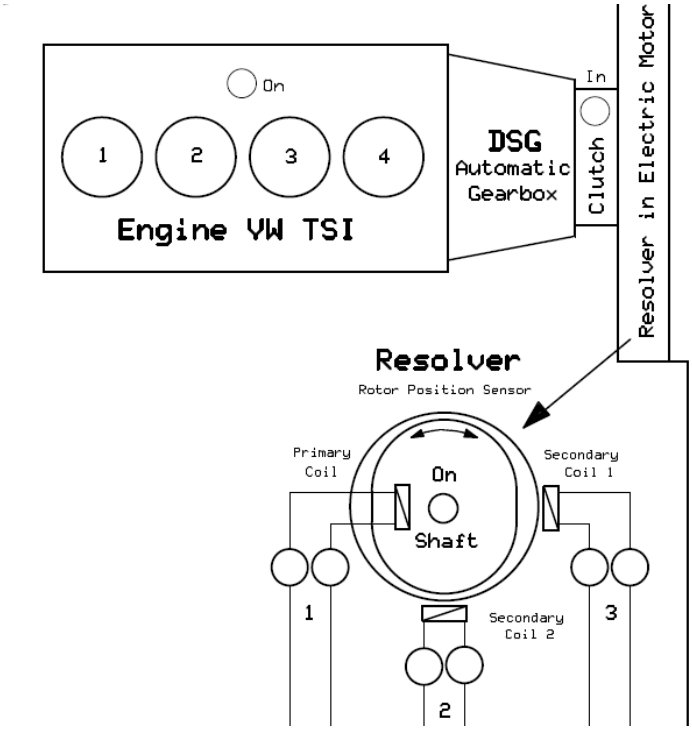
Below a charging cycle from 70% battery charge to 100%. The charging and discharging times are programmed with this simulator to avoid having to wait too long for an empty battery (20%) or full battery (100%).



Resolver

The resolver is a coil sensor that precisely transmits the position of the electric motor rotor to the inverter. The inverter ensures that the 3-phase rotating field is not too much ahead of the magnetic poles of the permanent rotor. If the rotating field goes too fast, a situation may arise that suddenly the rotor wants to turn in the other direction. With these forces, that can be disastrous for the mechanical transmission or components.

The resolver is shown in the following figure.

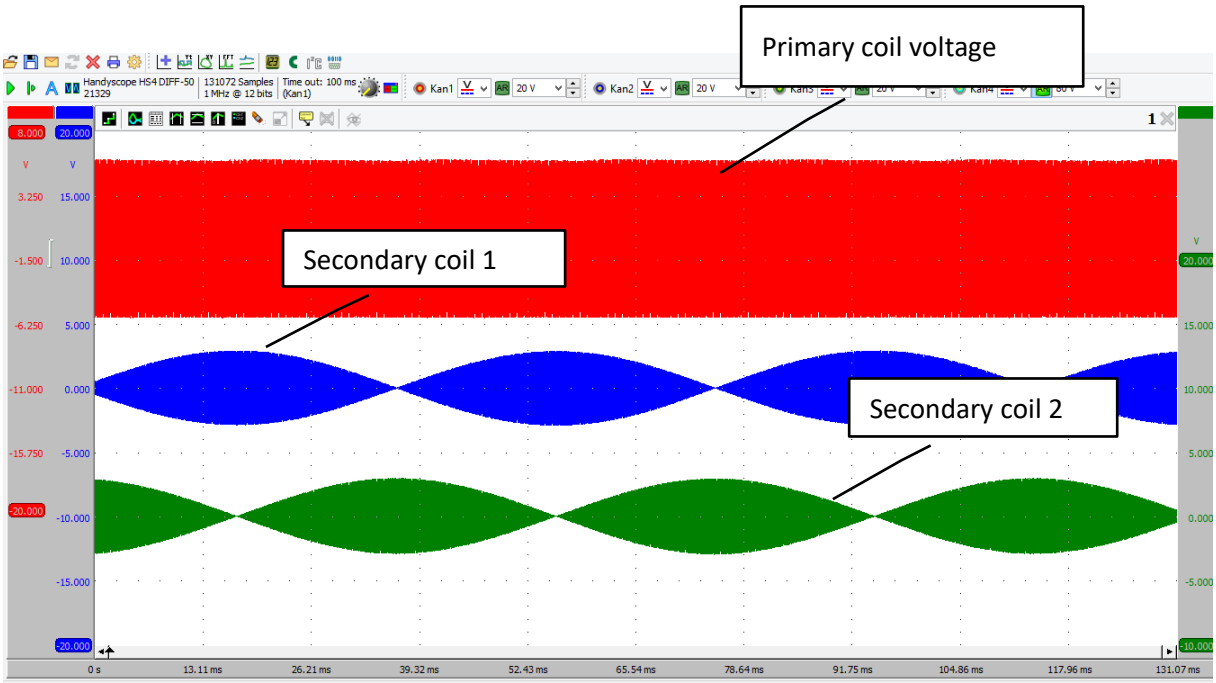


The resolver is mounted in the electric motor and consists of 3 coils

There is a primary coil and 2 sensor coils that are 90 degrees apart. There is a fixed alternating voltage on the primary coil that makes the rotating rotor sensor magnetic. This sensor is therefore a type of transformer with two secondary coils.

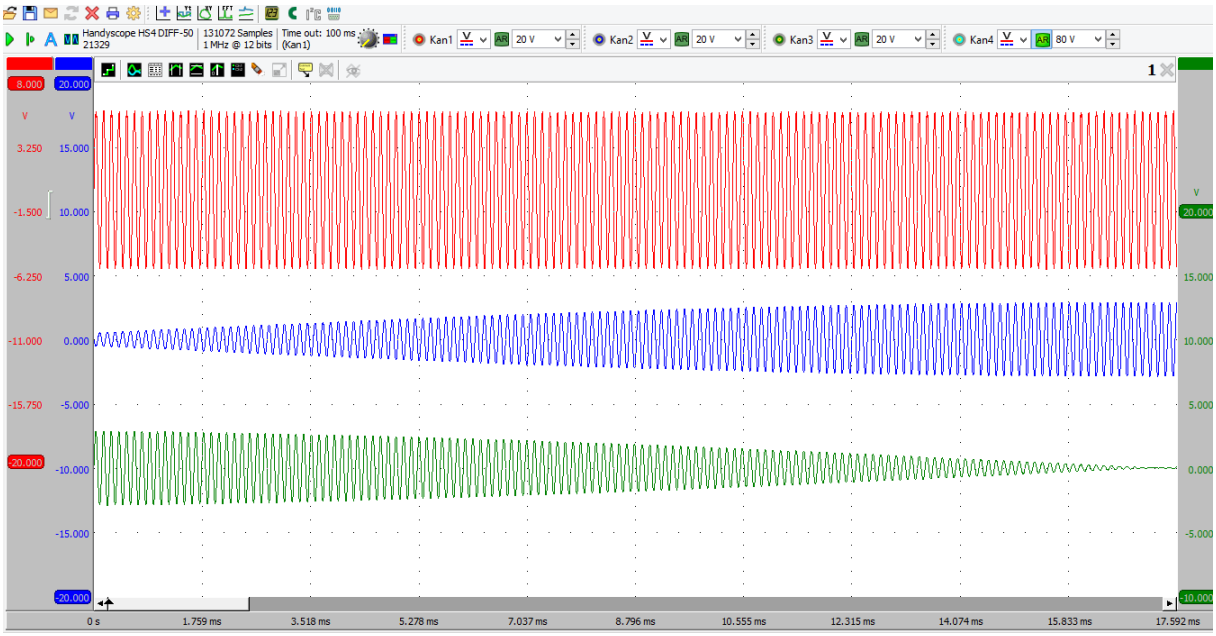
This rotor sensor is not completely round but has two larger air gaps. The sensor coils are alternately brought under more or less magnetic field. This results in an alternating voltage that is variable in height on the secondary coils.

The three voltages were measured in the following scope image.



The upper signal is the alternating voltage of the primary coil. The two lower signals are Coil 1 and coil 2, respectively. It can clearly be seen that the height of the voltage generated from the secondary coils is shifted by 90 degrees. The Inverter can precisely trace the position of the rotor from these two signals.

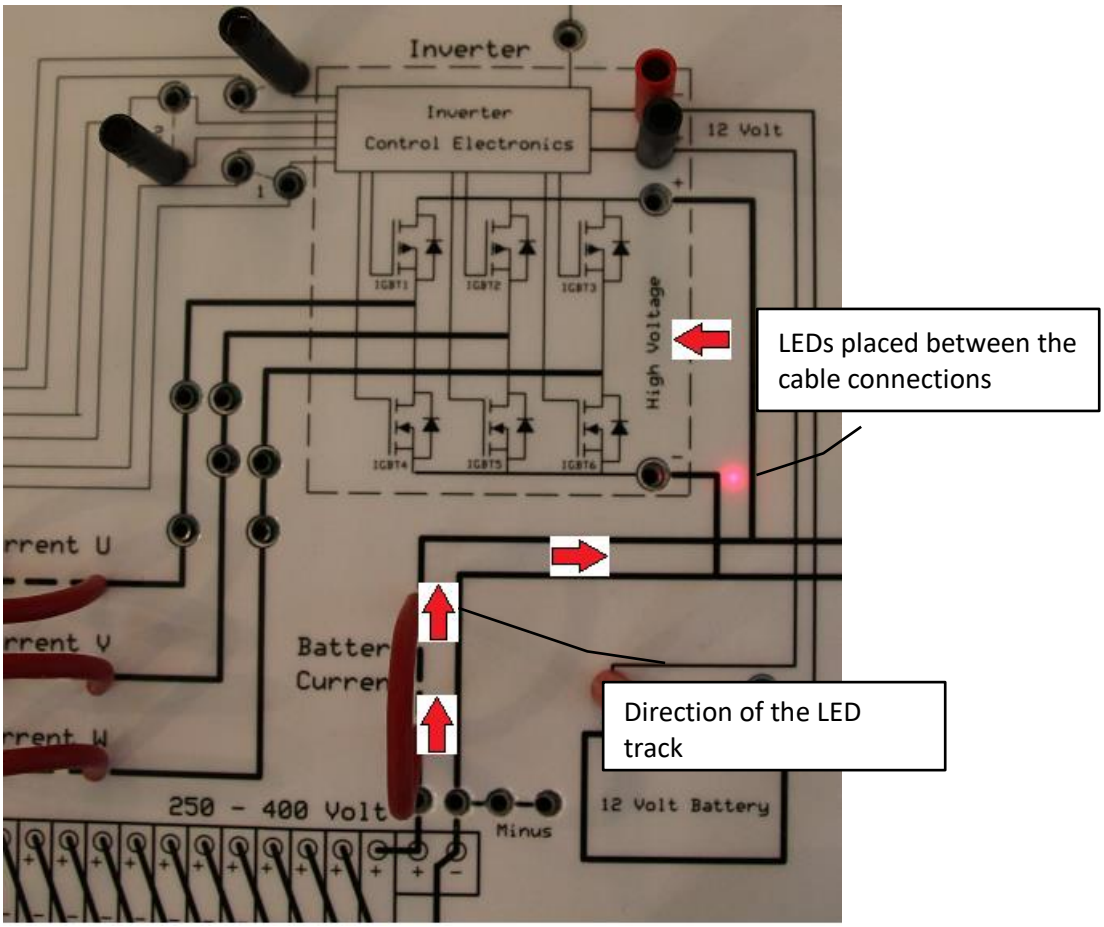
The following zoomed-in scope image shows that this is an alternating voltage.



Energy flows

The Hybrid simulator is equipped with LED light paths that make the energy flows visible. For example, a light path will appear from the battery to the Inverter during electrical operation. The same light path, but the other way in the direction of the battery. And a light path when charging via the plug.

The light paths will vary in speed as the energy flow increases or decreases. It certainly indicates how it all works. This energy flow can be seen in the following figure.



Safty plug

The safty plug is not officially present in the Golf GTE. Yet we have thought to place it in the battery pack because many Hybrid cars have this plug and thus clarify the procedures around this phenomenon. When Safty Plug is removed, the car cannot drive and the relevant battery voltages can be measured (2 x 12 Volt battery packs)

Safety Loop

A Safety Loop has been installed throughout the system (fictional). This means that if a part or cables are disconnected from the Hybrid system, a loop is interrupted. This results in a blocking of the entire system with the associated defect code and readout.

Charging during fuel engine operation

Via the info-display you can choose whether the fuel engine recharges the battery in addition to the regeneration during braking. This gives a higher fuel consumption and is therefore a driver's choice.

Cooling systems

In this Golf there are a number of cooling systems active such as cooling the battery, inverter, converter and electric motor. These controls can be measured on the simulator in the form of valve controls and duty cycle controls.

Faults (under construction, ready February 2020)

About 15 faults are built into this Hybrid system and can be selected via the display in the control console.

Live data (under construction, ready February 2020)

All relevant live data is readable via the menu in the control console.

The Galileo Team