Table of Content

1 General Information

In this document the Keyless GO and Start System is introduced.

Keyless Entry Systems are the consequent development of well-known Remote Keyless Entry Systems (RKE), the usage of the key fob with button pressing is still possible, but not necessary anymore to enter the vehicle or to start it.

With the Hella Components UID, LF antennas and **Keyless Start ECU** it's possible to equip a vehicle with only a few components and realize this very convenient and luxury feature.

The ECU is built together with Continental Corporation Germany.

Hella is the Engineering Distributer AND Designer for the **part that is to be approved.**

The Model Name of the described ECU is:

MARS Keyless

2 LF- Performance in Typical Application

In the MARS EIS ECU the Hella LF Driver Part is connected with Hella LF Antennas.

A UID – also manufactured from Hella – is to be found inside or outside the vehicle, whether a special occasion happens.

Here are some examples:

- Passive Entry / Exit

A Person with the UID **nears** to the locked vehicle.
If he grabs the door handle capacitive unlock sensor is activated and the complete Keyless Entry Protocol is started. The side LF antenna is transmitting LF data and a carrier signal, which can be recognized and judged by quantity (RSSI-measurement) by the UID.

The measured field strength is sent to the ECU and is judged.

If the magnetic field strength is high enough (a certain border is reached). The doors will unlock.

The additional LF communication guaranties the functionality, that only the valid key OUTSIDE the vehicle authenticates the system to unlock the car passively.

If the magnetic field strength is not high enough (e.g. the UID is too far away from the vehicle, the border is not reached), the UID shuts down again and waits for the next LF Data. The vehicle is still locked.

A Person with the UID **is leaving** the vehicle. If he touches the capacitive lock sensor at the door handle, the complete Keyless Exit Protocol is started:
The side LF antenna is transmitting LF data and a carrier signal, which can be recognized and judged by quantity (RSSI-measurement) by the UID.

The measured field strength is sent to the ECU and is judged.

If the magnetic field strength is high enough (a certain border is reached). The doors will lock.

The additional LF communication guaranties the functionality, that only the valid key OUTSIDE the vehicle authenticates the system lock the car passively. If the UID is left inside the car, the car won't lock.

If the magnetic field strength is not high enough (e.g. the UID is too far away from the vehicle, the border is not reached), the UID shuts down again and waits for the next LF Data. The vehicle is still open.

- Passive Start

A Person with the UID inside of the vehicle is pressing the Start-Stop-Switch. The Start-Stop-Switch activates the complete Keyless Start protocol:

The interior antenna is transmitting the LF Data and a carrier signal, which can be recognized and judged by quantity (RSSI-measurement) by the UID.

The other two interior antennas IN1 and IN2 transmit two additional carrier signals sequential.
If the magnetic field strength of one of these transmits is high enough (a certain border is reached) then the UID authenticates the system to start the vehicle.

If the magnetic field strength of all antenna transmits are too low (the field strength border is not reached, maybe the UID is laying outside or is held 10cm outside the vehicle) the car won't start.

2.1 LF Antenna Positions in Vehicle

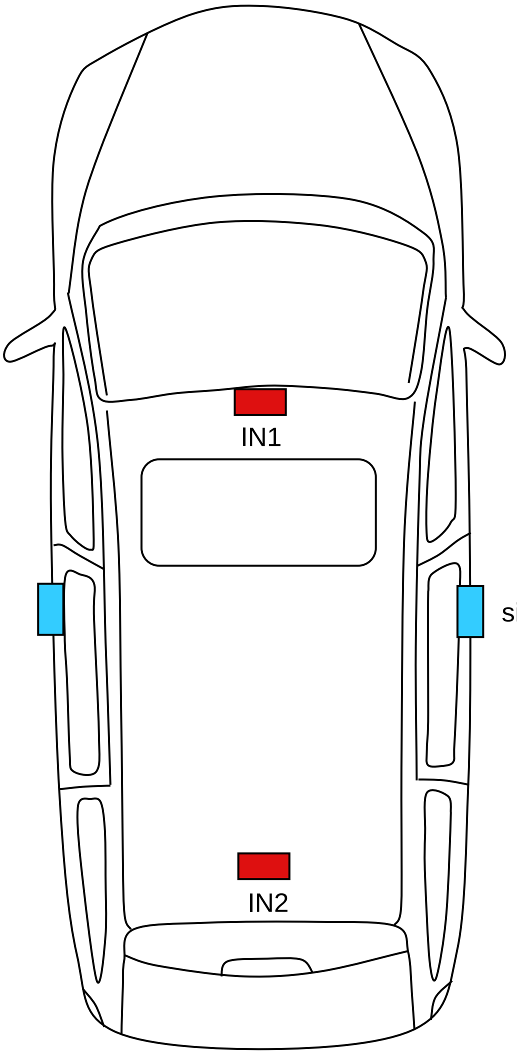

Fig. 1 Antenna Positions at a Keyless Entry / Keyless Start Vehicle

2.2 Authentication Ranges Inside and Outside the Vehicle

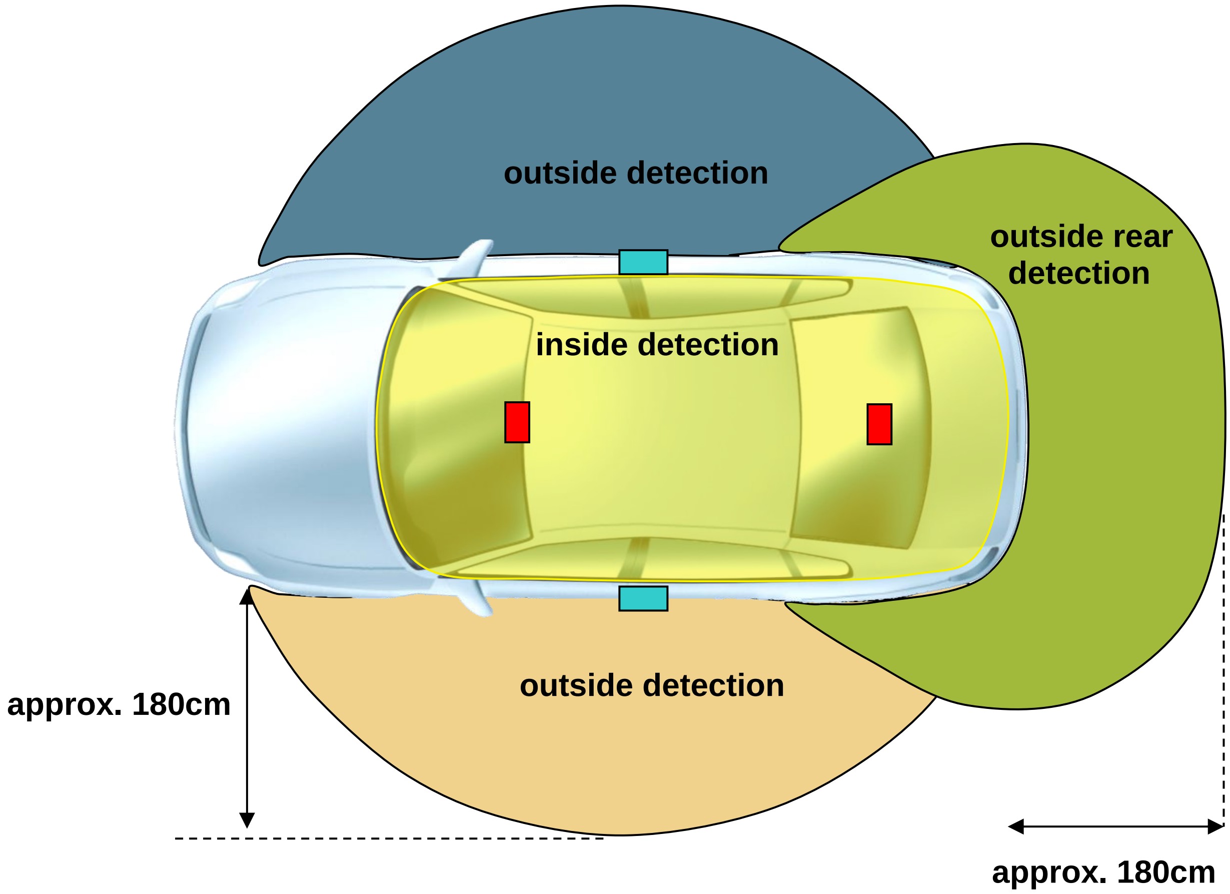

Fig. 2 Principle of Magnetic Field Detection Areas

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3 HW-Description

3.1 DAIMLER MARS ECU

The main tasks of the MARS EIS ECU are: Entry/Exit functionality with unlock and lock sensor signal analysis, Keyless Go / Keyless Start functionality, LF-Message transmission, Immobilizing functionality communication with other ECU's on CAN by building a gateway.

3.2 ECU Layout

Layer TOP

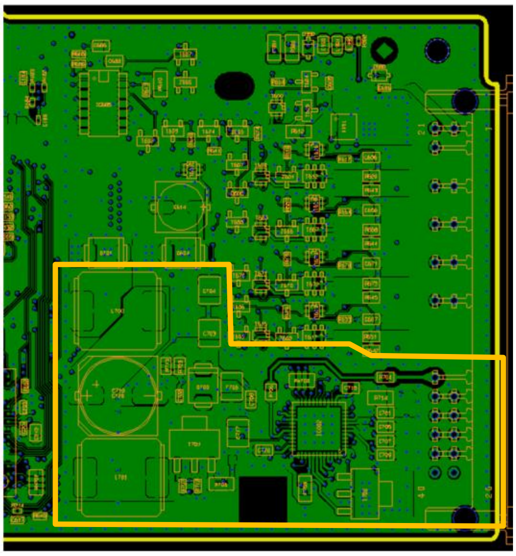


Fig. 3 Layer 1

Layer 2 – incl. Components from Top

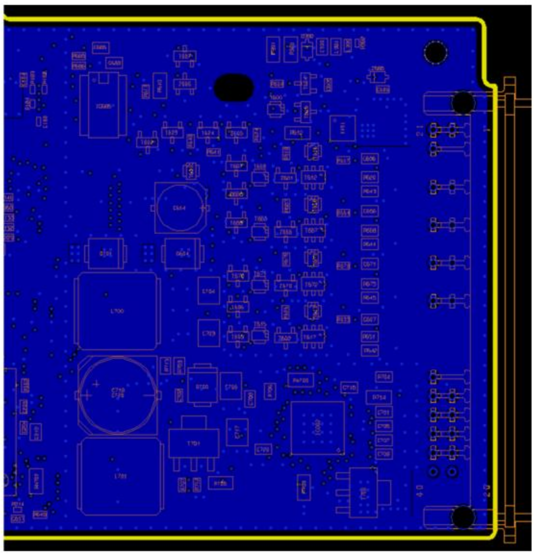


Fig. 4 Layer 2

Layer 3 – incl. Components from Top

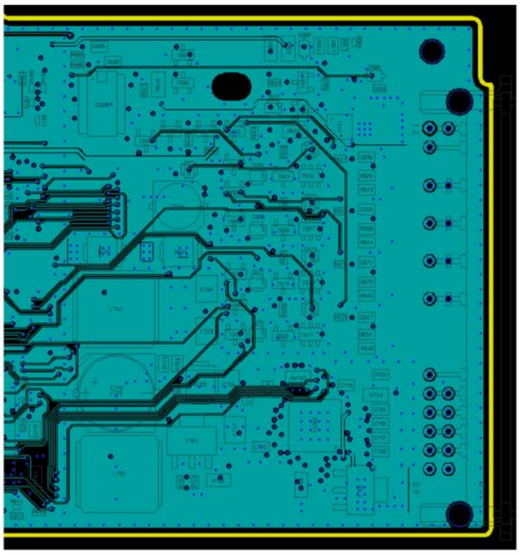


Fig. 5 Layer 3

Layer 4 – incl. Components from Top

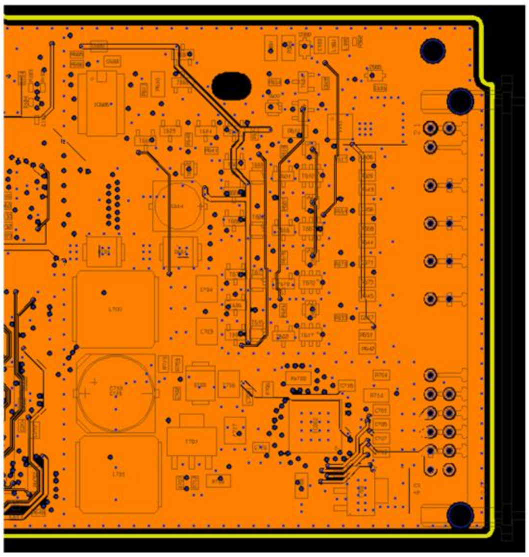
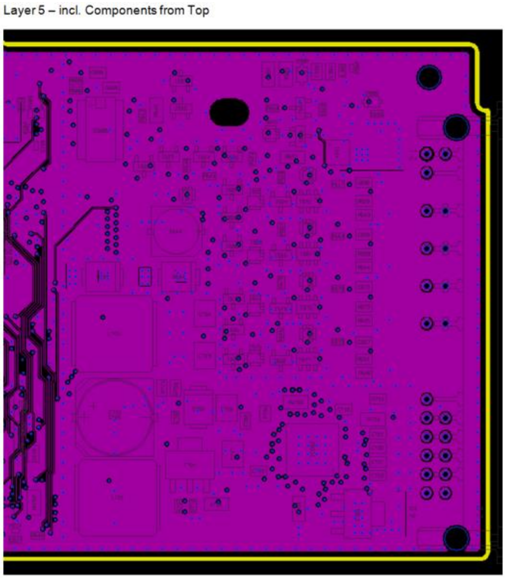


Fig. 6 Layer 4



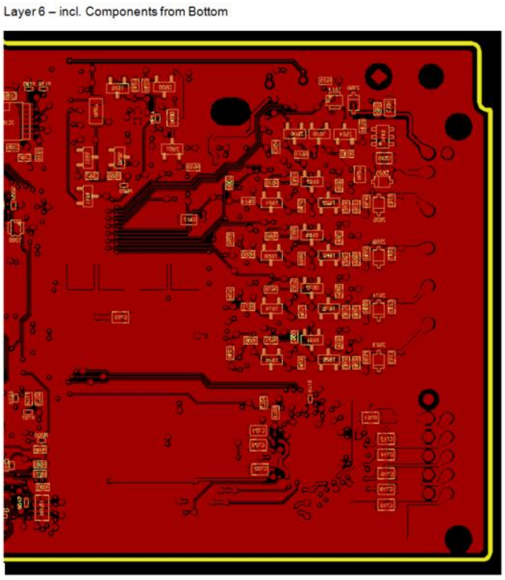


Fig. 7 Layer 5 **Fig. 8 Layer 6**

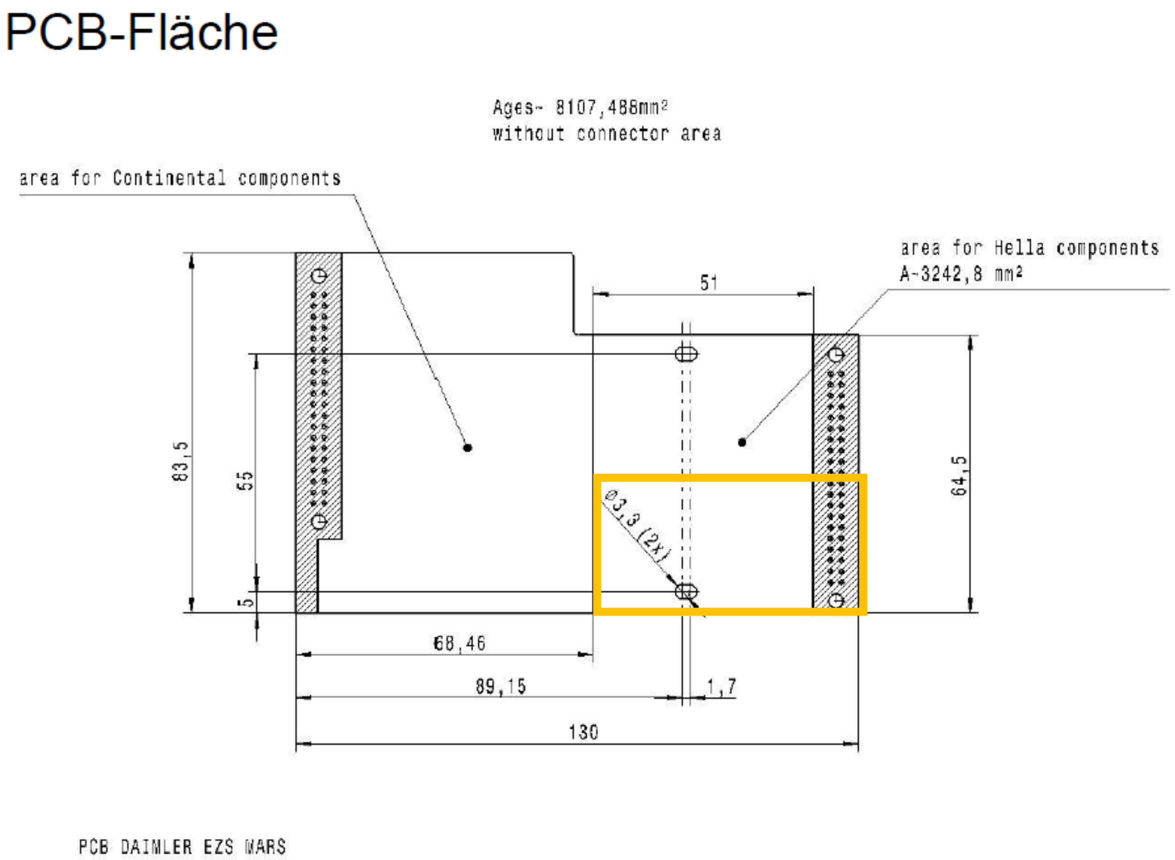


Fig. 9 Layout LF- Driver Part in Detail, marked orange area is to generate f=125kHz-signal

3.3 ECU Schematic

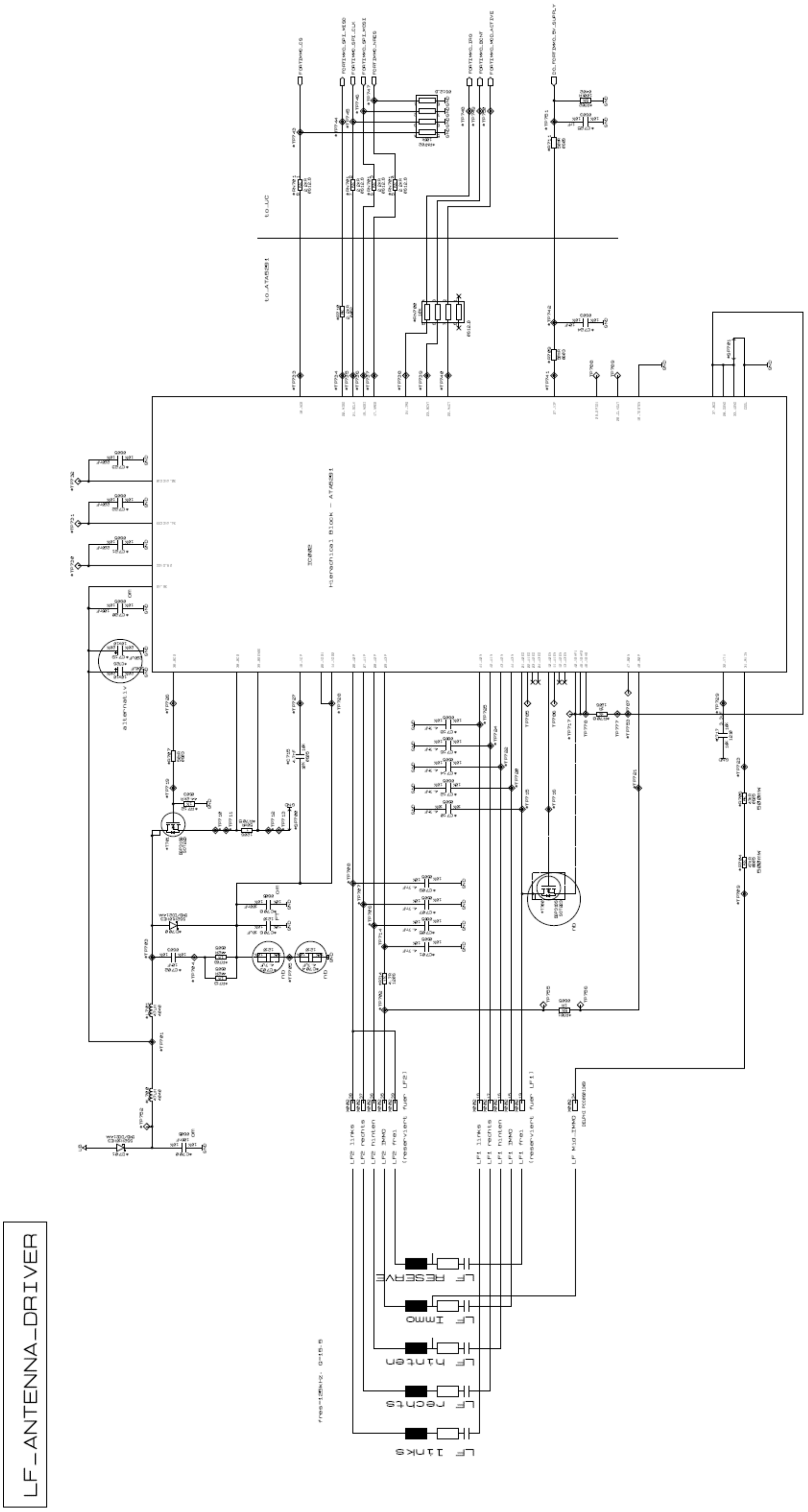


Fig. 10 Schematic of LF Driver Part of MARS EIS ECU

3.4 BOM (Populated Parts) of Hella Part

C600		D670		R664	

C601		D685		R665	
C602		D700	SS2H10HE3	R666	
C603		D701	SS2H10HE3	R667	
C604		IC002	ATA5291	R670	
C605		IC685		R671	
C606		L700	47u	R672	
C607		L701	47u	R673	
C608		R600		R674	
C609		R601		R675	
C610		R602		R676	
C611		R603		R677	
C612		R604		R678	
C613		R605		R679	
C614		R606		R680	
C615		R607		R681	
C616		R608		R682	
C617		R609		R683	
C655		R610		R685	
C656		R611		R686	
C657		R612		R687	
C658		R613		R688	
C659		R614		R689	
C670		R615		R690	
C671		R616		R701	1
C672		R617		R702	100k
C673		R618		R703	442
C674		R619		R704	47k
C685		R620		R705	50m
C686		R621		R706	47k
C687		R622		R707	50m
C688		R623		R708	1
C700	100n	R624		R709	50m
C701	4.7n	R625		R710	2.2k
C702	10n	R626		R711	50m
C703	4.7u	R627		R712	44.2k
C704	4.7u	R628		R713	442
C705	4.7n	R629		R714	4,7
C706	10u	R630		RN700	10k
C707	4.7n	R631		RN701	2.2k
C708	100n	R632		RN702	100k
C709	4.7n	R633		T600	
C710	4.7n	R634		T601	
C712	4.7n	R635		T602	
C714	4.7n	R636		T603	
C715	4.7n	R637		T604	
C716	4.7n	R638		T605	
C717	3.3u	R639		T606	
C718	4.7n	R640		T607	
C719	220u	R641		T608	
C720	100n	R642		T609	
C721	220n	R643		T610	
C722	220n	R644		T611	
C723	220n	R645		T612	
C724	10n	R647		T613	
C725	1n	R648		T614	
C726	330u	R655		T615	
D600		R656		T616	
D601		R657		T617	
D602		R658		T618	
D603		R659		T619	
D604		R660		T620	
D605		R661		T621	
D655		R662		T622	
D656		R663		T623	

Parts used in Hella schematic part that is to be approved.

T624	
T655	
T656	
T657	
T658	
T659	
T660	
T670	
T671	
T672	
T673	
T674	
T675	
T685	
T686	
T687	
T700	BSP318S
T701	BSP318S

Parts used in Hella schematic part that is to be approved.

Table 1 BOM of populated parts

This list is NOT to be shown to third parties!!!

3.5 Block Diagram of Related Functional Modules

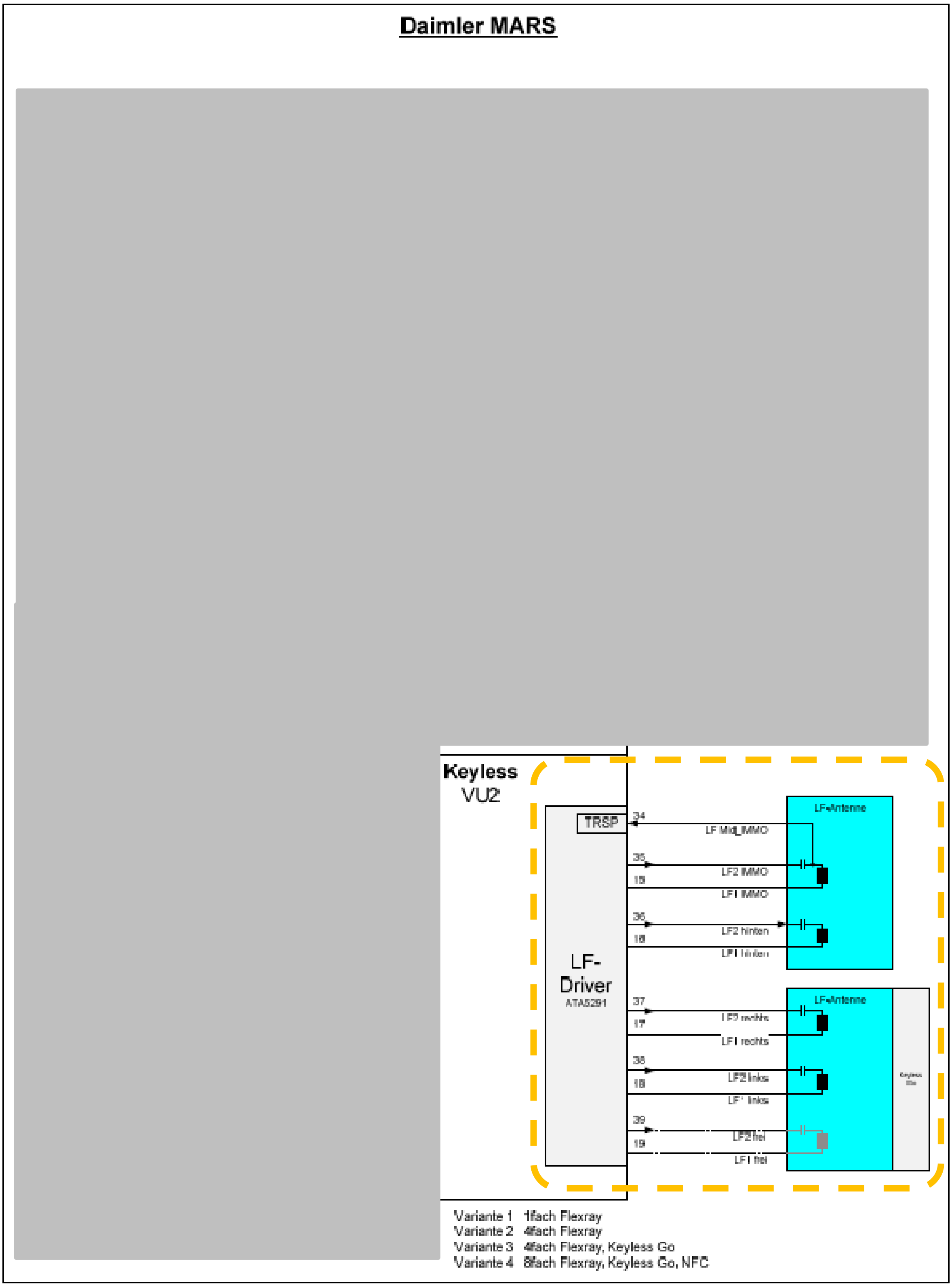


Fig. 11 Block diagram of modules in the ECU, LF driver in orange marked area

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4 LF-Driver Hardware Module with 5291

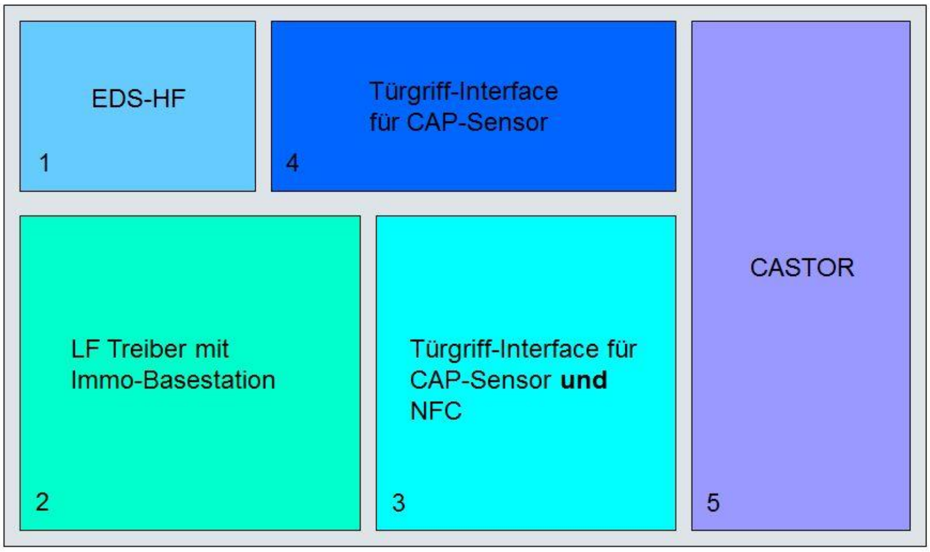

Fig. 12 Block diagram, architecture of Hella part

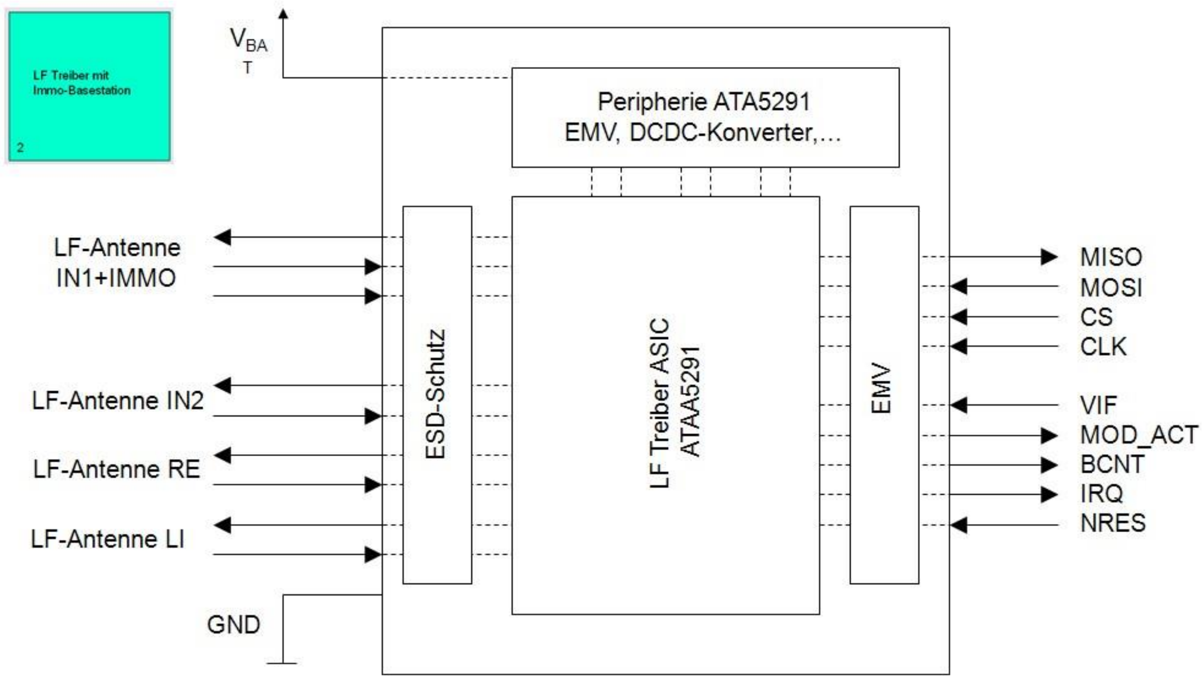

Fig. 13 Block diagram, LF driver module

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4.1 Functional Description

4.1.1 General Function

The ATA5291 is the main part of generating a f=125kHz signal and drive it through four series resonant circuits, called LF antennas.

It is an ASIC with a sine-wave-generation circuitry to avoid noise in the AM-Band.

4.1.2 PEPS Tx Mode

This mode is used for passive entry, passive start (PEPS) data transmission. It is activated by sending the GPP() - "Go to PepsTxMode" SPI command. A 100% modulated carrier with a frequency of 125kHz is transmitted to the key fob. The output power is set by selecting one out of 19 regulated antenna current levels. The antenna current regulation can be carried out by means of an external resistor or an integrated current sensing circuit.

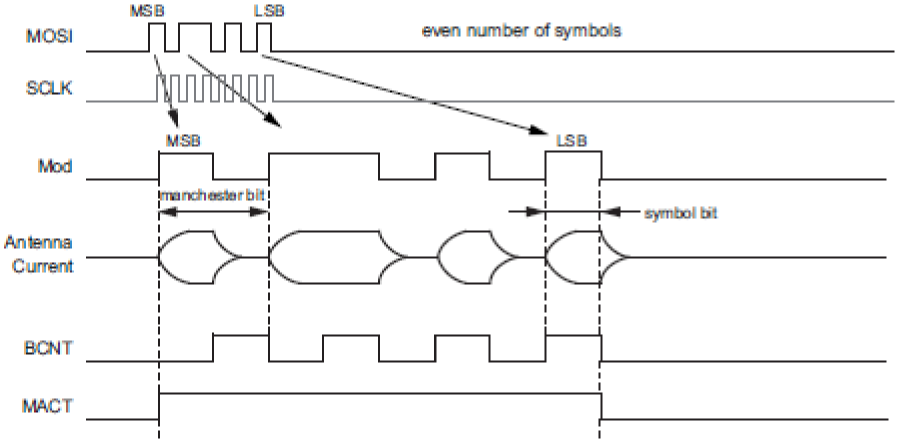
The AVCC18, AVCC33 voltage regulators and the PEPS front-end circuits are active. The booster circuit generates reliable VDS1 and VDS2 voltages even with variable VS input. The PEPS drivers require the VCP voltage to be higher than VDS. An internal charge pump provides the VCP voltage during transmission. The high accuracy oscillator is used as a clock and LF frequency reference. The VDS voltage is switched to VTX to achieve VTX = VDS, allowing the B0P driver to be connected directly to an AXP driver for shared coil applications.

A typical command sequence for PEPS transmission consists of:

- Entering the PEPS mode with the GPP() command
- Configuring the PEPS transmission, such as transmitting carrier and data with the SPC() and SPD() commands
- Returning with GID() to IdleMode after data transmission is completed.

Figure 4-2 shows some signals participating in a buffered PEPS transmission. The data input via SPI is shown on the MOSI and SCLK lines. The data is translated into a modulation signal (Mod) with the selected data rate. The antenna current changes in accordance with the modulation signal in relation to the antenna Q factor. The active data transmission can be monitored using the bit count (BCNT) and modulation active (MACT) output signals.

Figure 4-2. PEPS Transmission Signals



The Atmel® ATA5291 also supports regular autonomous wake-up pattern (WUP) transmission for polling operation. The required data and gap times are written to the TX control block and executed in a loop.

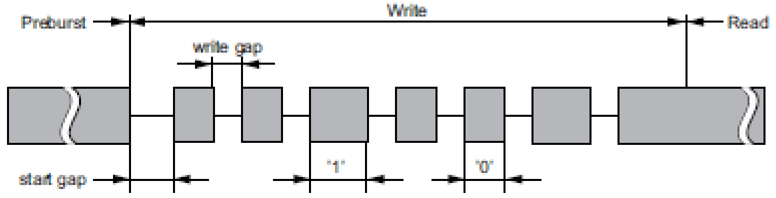
Fig. 14 Extract from Datasheet

4.1.3 Immo TxRx Mode

The ImmoMode is used to communicate with an immobilizer transponder. The AVCC18, AVCC33 voltage regulators and the IMMO front-end circuits are active. The booster circuit generates reliable VDS1 and VDS2 voltages even if the VS input varies. The VTX regulator generates a low noise voltage supply for the immobilizer driver and receiver circuits. The high accuracy oscillator is used as a clock and LF frequency reference.

The ImmoMode is activated by sending the GIM() - "Go to ImmoMode" SPI command to the Atmel ATA5291. A 125kHz carrier is transmitted by default when this mode is active. The energy transmitted by this carrier is used to power up the transponder. Data can be sent by using the SID() - "Send Immobilizer Data" command. The data is encoded in BPLM (binary pulse length modulation) or NRZ format and uses 100% ASK (OOK) modulation (see Figure 4-4). Length of gaps, zeroes and ones can be programmed over a wide range. In this way different transmission timings are possible to optimize power and data transfer simultaneously.

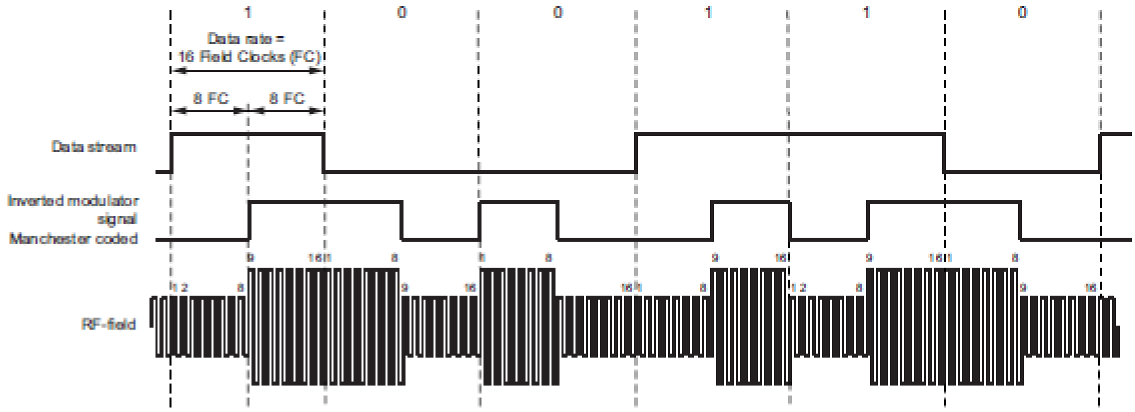
Figure 4-4. Reader to Transponder Write Sequence



The transponder response is expected during the Read phase. Load modulation (see Figure 4-5) with Manchester encoded data is typically used. This type of data transfer is also called full duplex mode (FDX). The Atmel® ATA5291 stores the received data symbol-based in the "Rx Buffer", for example a Manchester '0' in data stream will be stored as '1' and '0' in the "Rx Buffer". A fill level interrupt can be configured to signal a certain amount of received data by setting the IRQ pin to HIGH. The received data can be read out via SPI interface.

The ImmoMode should be activated with the GIS() - "Go to ImmoMode with shared coil" SPI command when one antenna coil is shared for PEPS and immobilizer operation.

Figure 4-5. Example of Transponder to Reader Modulation



Fully transparent transmission and reception operation is also possible with the shared MOSI/DIN and MISO/DOUT pins.

Fig. 15 Extract from Datasheet

5 LF-Antennas

The LF antennas generate the magnetic field that is needed for wireless communication between car electronic components and the UID that is carried with by the end-user.

Each LF antenna that is plugged to the ECU is a LCR resonant circuitry:

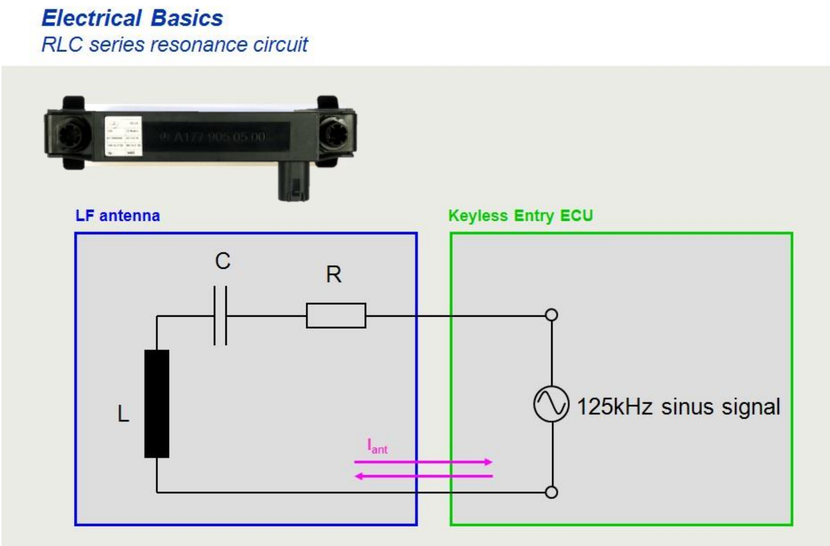


Fig. 16 LF Antenna, RLC resonant circuit

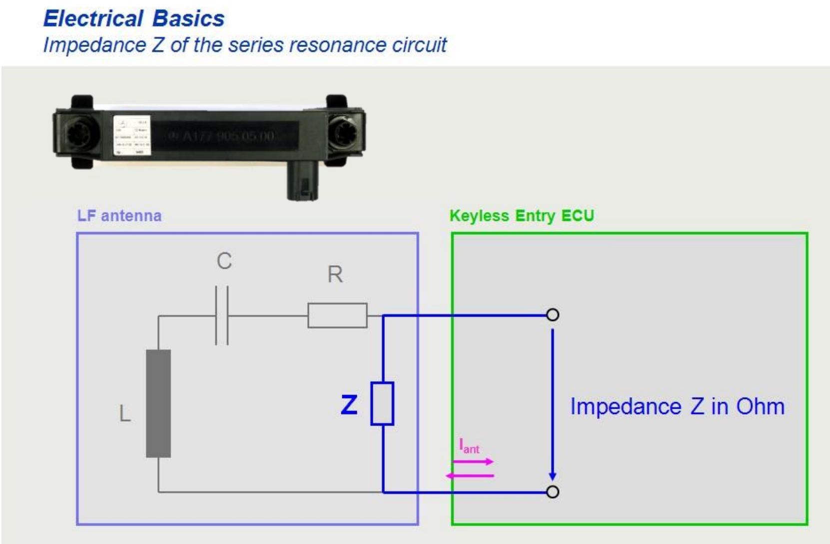


Fig. 17 LF-Antenna, Impedance Z

The LF antennas transmit the LF challenge signals (data) and the LF carrier wave signals. They are activated by the MARS EIS ECU using a controlled current.

ALL LF Antennas have the same efficiency.

The efficiency of all antennas is H_{max}(@l=1m, @I_{ANT}=500mA) =77,5 dBµA/m.

The general measurement of the efficiency of the antennas is shown is this picture:

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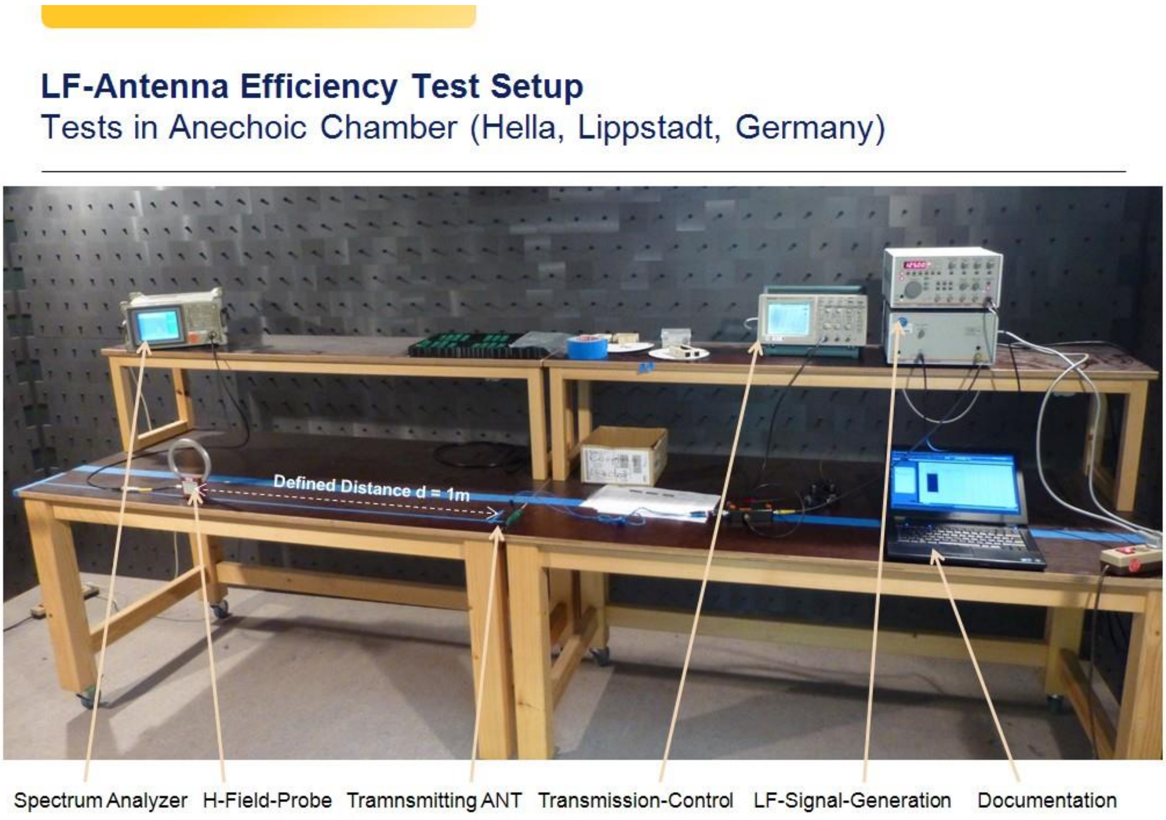


Fig. 18 LF-Antenna Efficiency Test Setup

The used LF antenna for homologation setup (the same as inside the car) has the following typical electrical parameters and is equal to ALL possible antennas in the system:

f_{res} = 125kHz

L = 326µH

R = 8Ohm

Z@125kHz = 12…18 Ohm

5.1 Documentation C2-Sample

5.1.1 Connection Schematic 207.308-00, A167 905 47 00

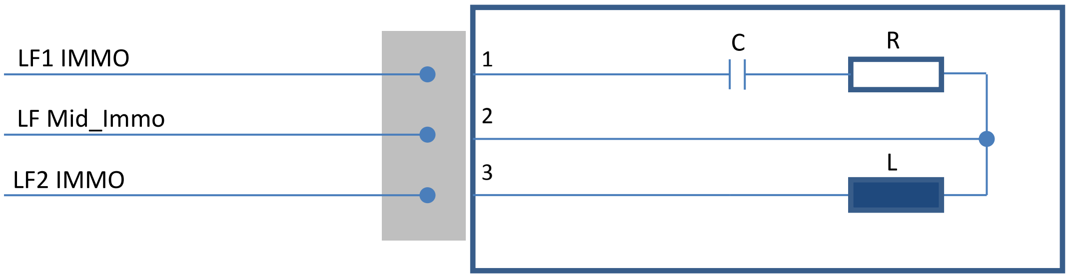
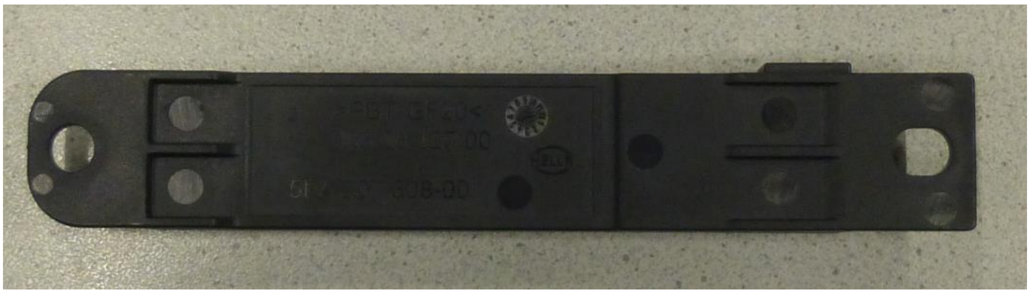


Fig. 19 Antenna Schematic

5.1.2 Picture of the C2-Sample Antenna



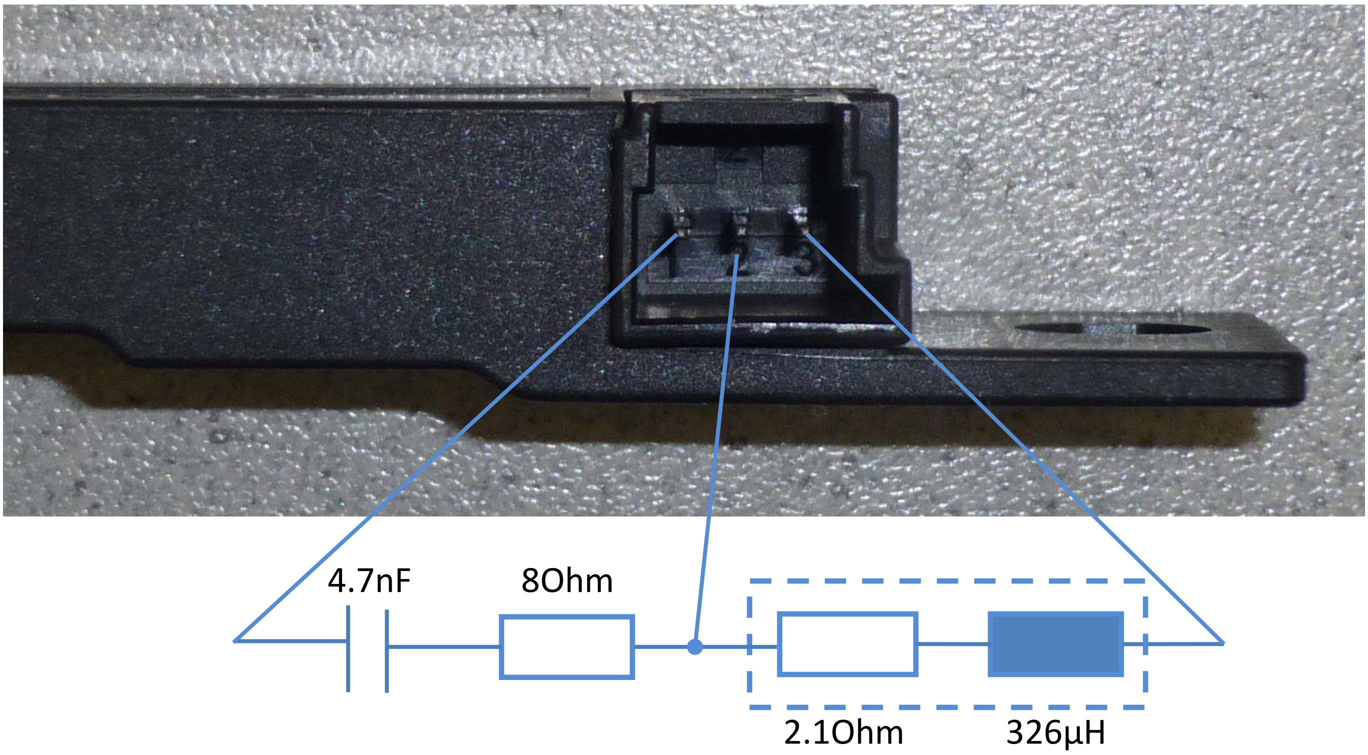


Fig. 20 Antenna housing and pinning

5.1.3 Mechanical Parameter

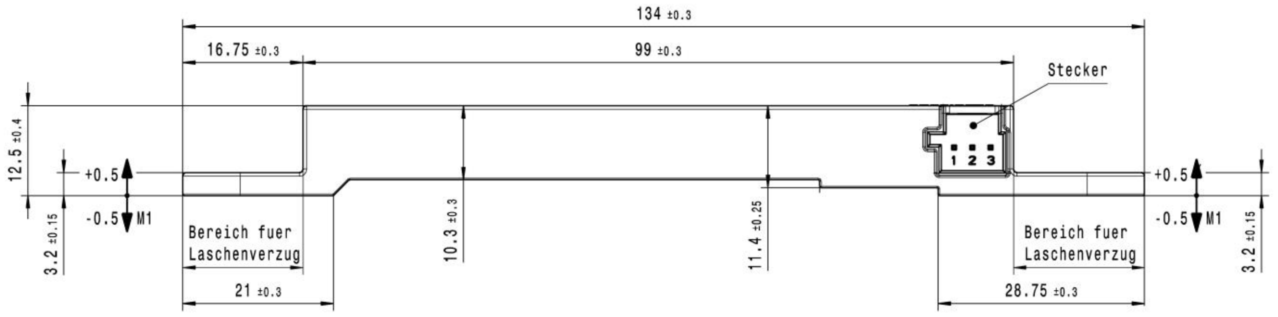


Fig. 21 Extract of the antenna part description

6 Software for LF Transmitter Mode (Data and CW) for Homologation

The LF Transmission for Homologation Purpose is an original LF Scan for a Passive Entry / Passive Exit action.

The LF driver IC is especially made for driving an electric current at f=125kHz with a certain modulation and bit structure. Only short burst shall be sent out at different antennas channels in a certain timing.

It is NOT possible to drive the antennas with a continuous carrier signal. The maximum of carrier (unmodulated) signal length that can be driven – and is driven for magnetic field strength measurement in the UID – is $t_{carrier}$=5,2ms.

The SW of the ECU has two small changes in comparison to the mass production software:
First:
As the setup is connected to the power supply (**V = 12V / I = 5A**) and the lever is set to “Open – LF Mode”, an **LF data scan** is automatically generated on all four antennas with a time gap of 23ms between each antenna and a pause of 273ms after the last antenna.

So, a continuous repetitive scanning is created, that is similar to the system reaction, as if a person is grabbing the door handle to enter the locked vehicle every 370ms with not having the UID in detection range.

Second:
As the setup is connected to the power supply (**V = 12V / I = 5A**) and the lever is set to “GND – IMMO Mode”, an **Immo transponder start** is automatically generated on the IMMO-antenna every 3,25s. After a successful keyfob answer the LED is powered for 100ms.

IMPORTANT NOTE: This **Second functionality** is only allowed to be used **1 Minute** and then a power down of 2 Minutes is needed. Otherwise the protocol won’t finish completely and the LED won’t light up due to warmup of the ECU. In mass production / series such a stress never would occur!

To switch between those two functions simply turn the lever in the designated position and perform a power-on reset.

There are no other SW changes to the mass production software.

The scope-diagrams in the following are taken by a simple AIR-COIL (15 windings, 4cm diameter), which is positioned near to the test setup. This coil is connected to a 150MHz Scope Probe (x10).

With this SW FOUR ANTENNAS are mentioned to the system.

6.1 LF Data Scan

6.1.1 Single Transmission LF Scan

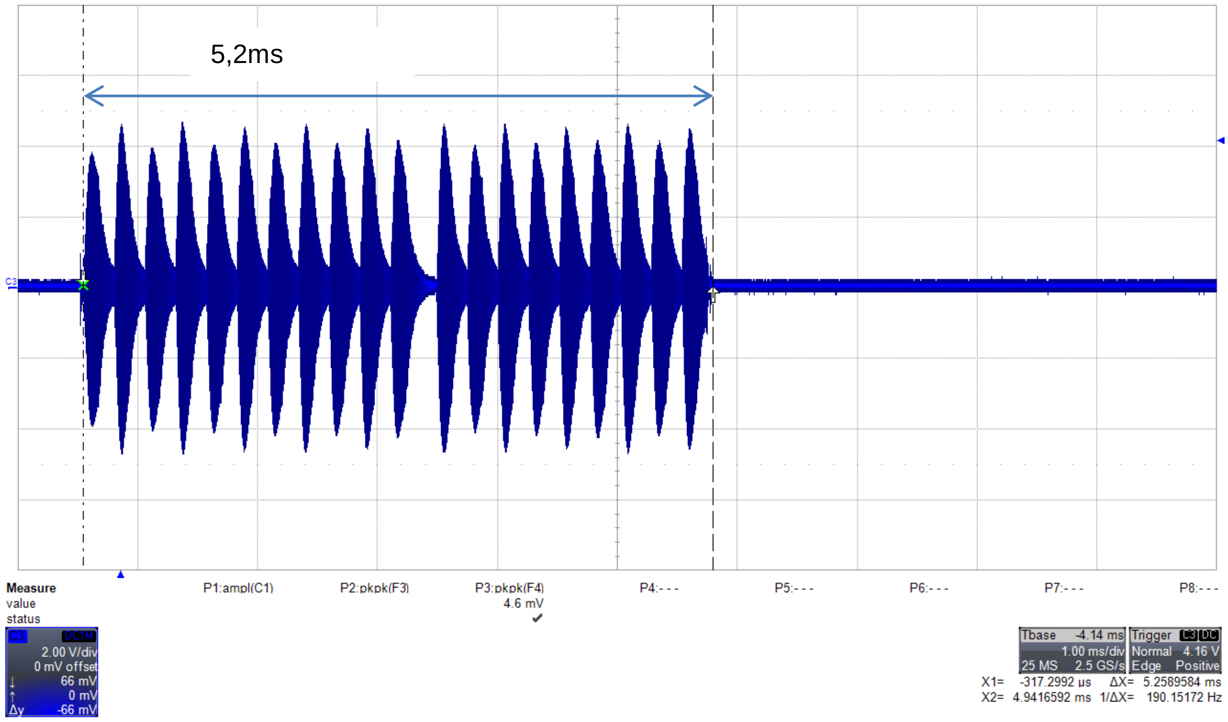


Fig. 22 Scope Shot from complete single LF scan

6.1.2 Single Transmission – f = 125kHz Oscillating Signal

The ECU drives a sinusoidal output signal. The frequency is f=125kHz. The magnetic field as the result is oscillating the same:

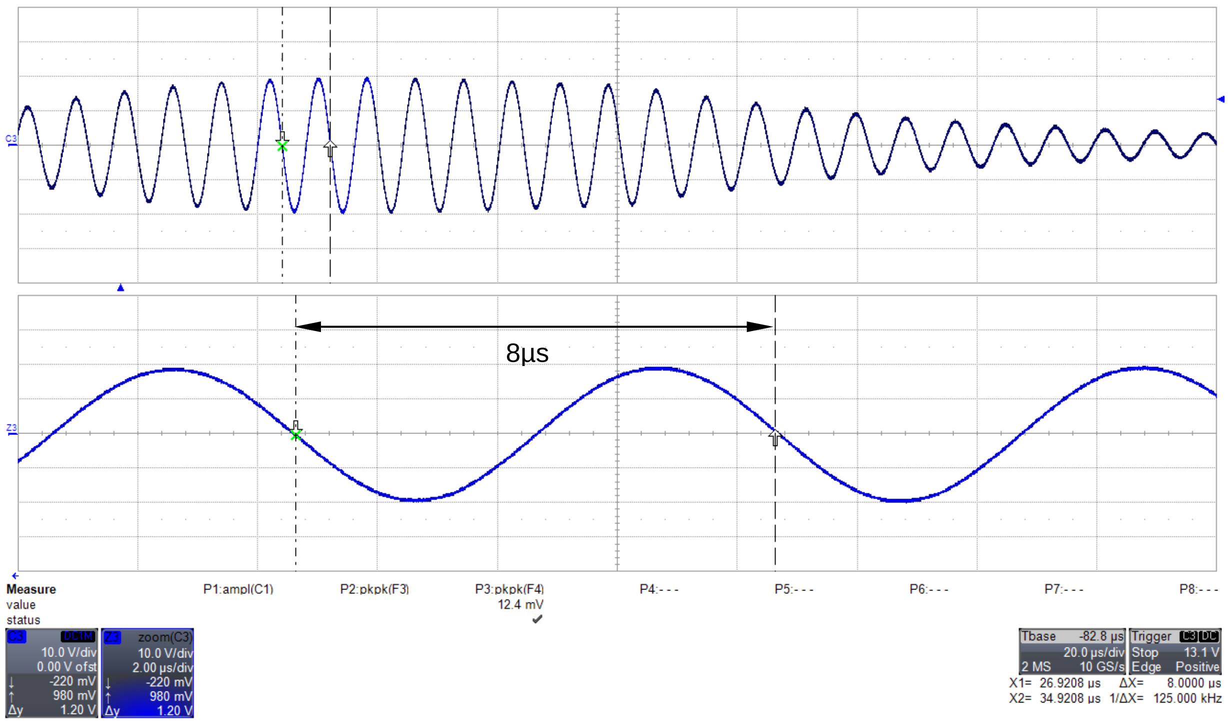


Fig. 23 Oscillating signal at f=125kHz

6.1.3 Repetition of Transmissions

All four LF-antennas are powered and the LF scan is repeated frequently due to homologation purpose:

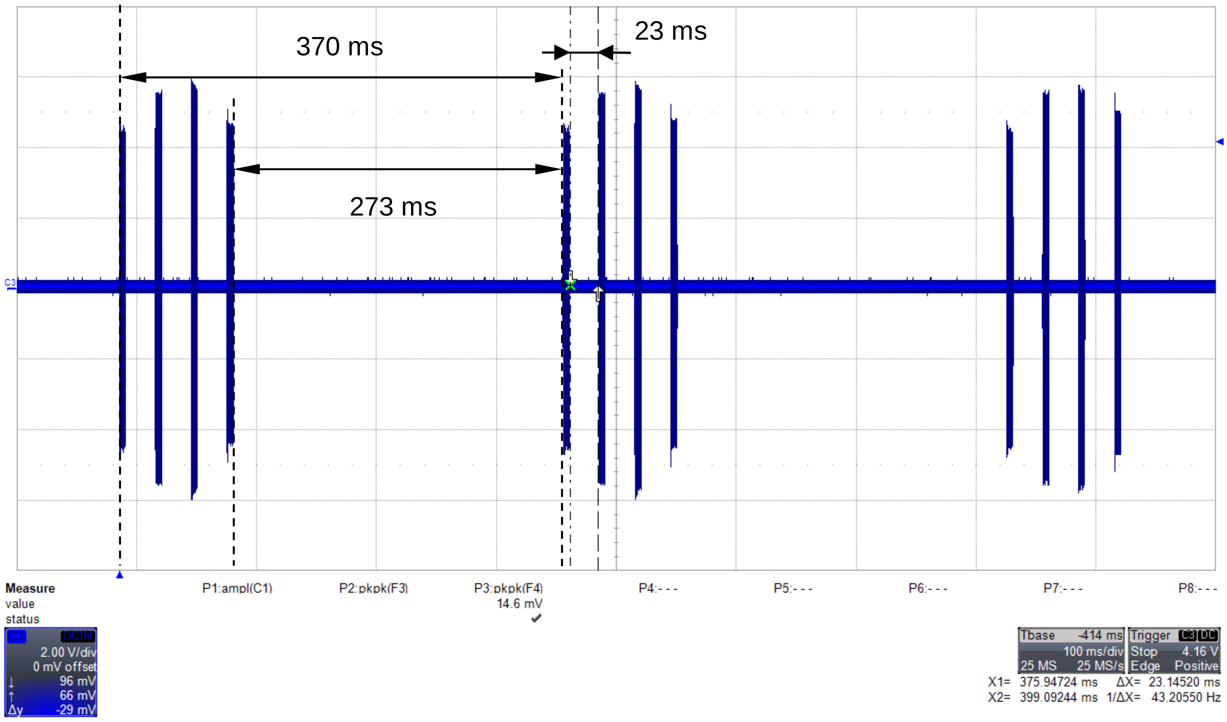


Fig. 24 LF-Signal repetition

6.2 IMMO Transponder Start

6.2.1 Single Transponder Start and Repetition of Transmissions

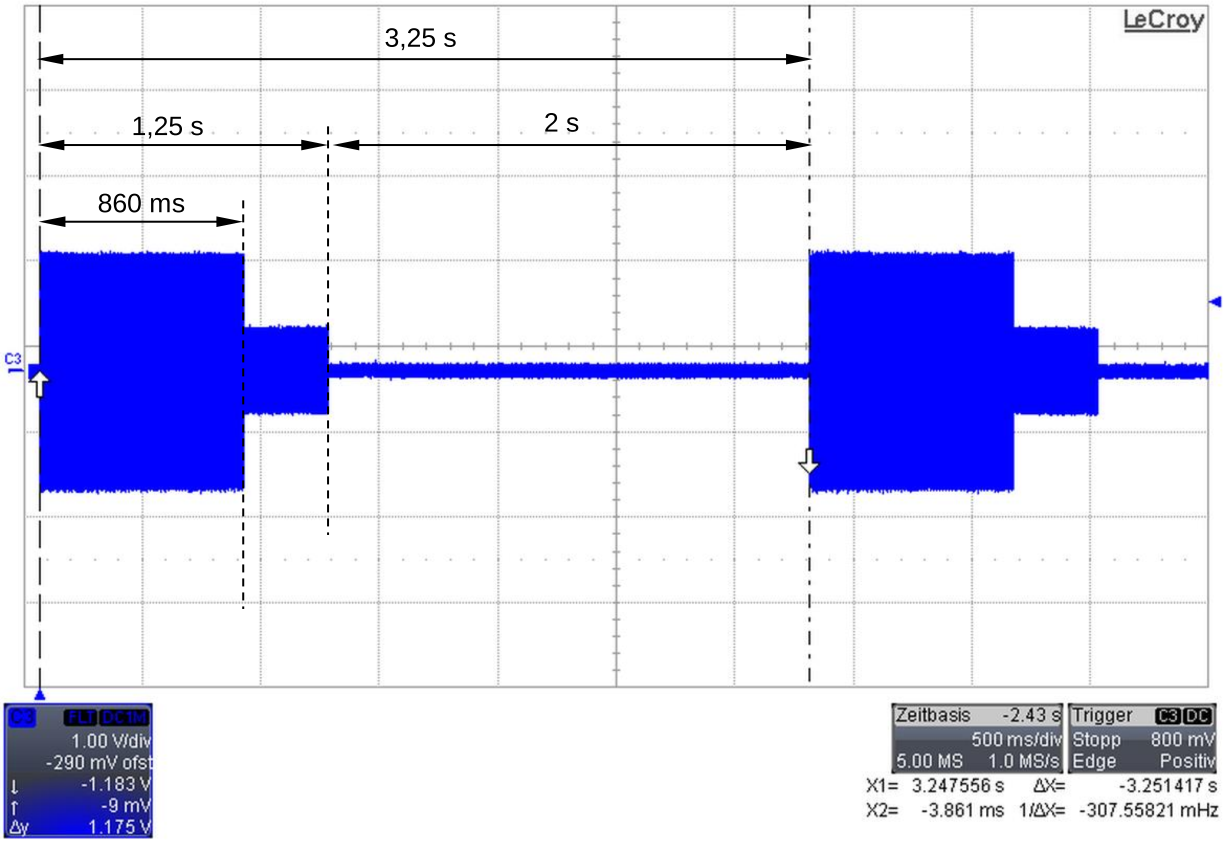


Fig. 25 Scope Shot of Transponder Transmission

6.2.2 Data Transmission

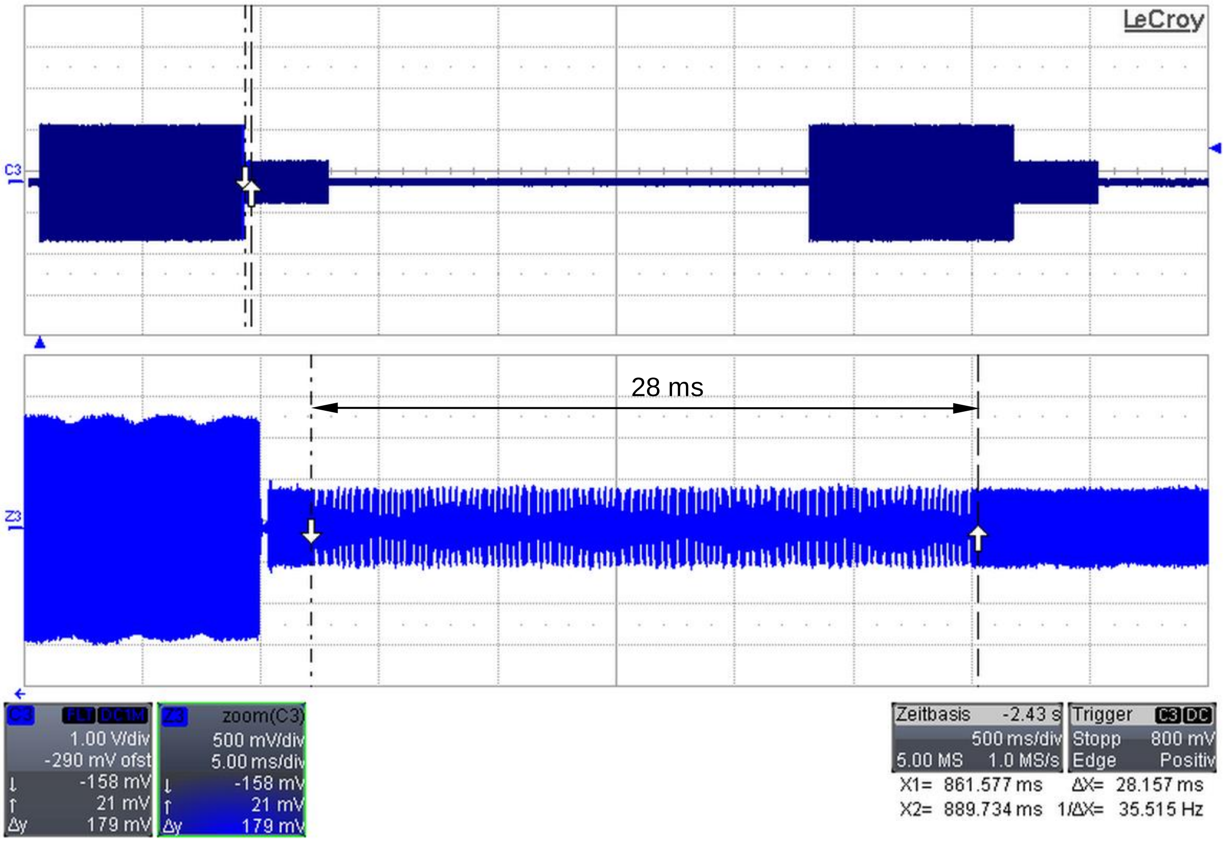


Fig. 26 Scope Shot of Data Transmission in in the Transponder Protocol

7 Test Set Up for Homologation

7.1 Setup in Block Diagram View

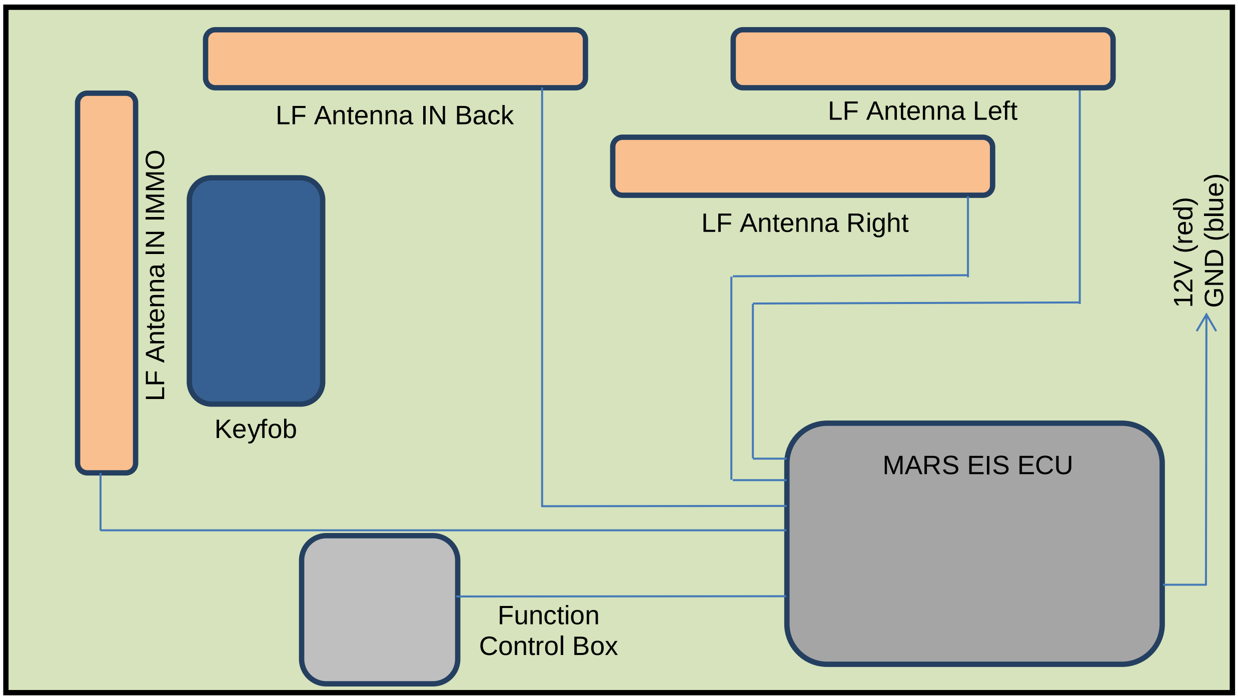
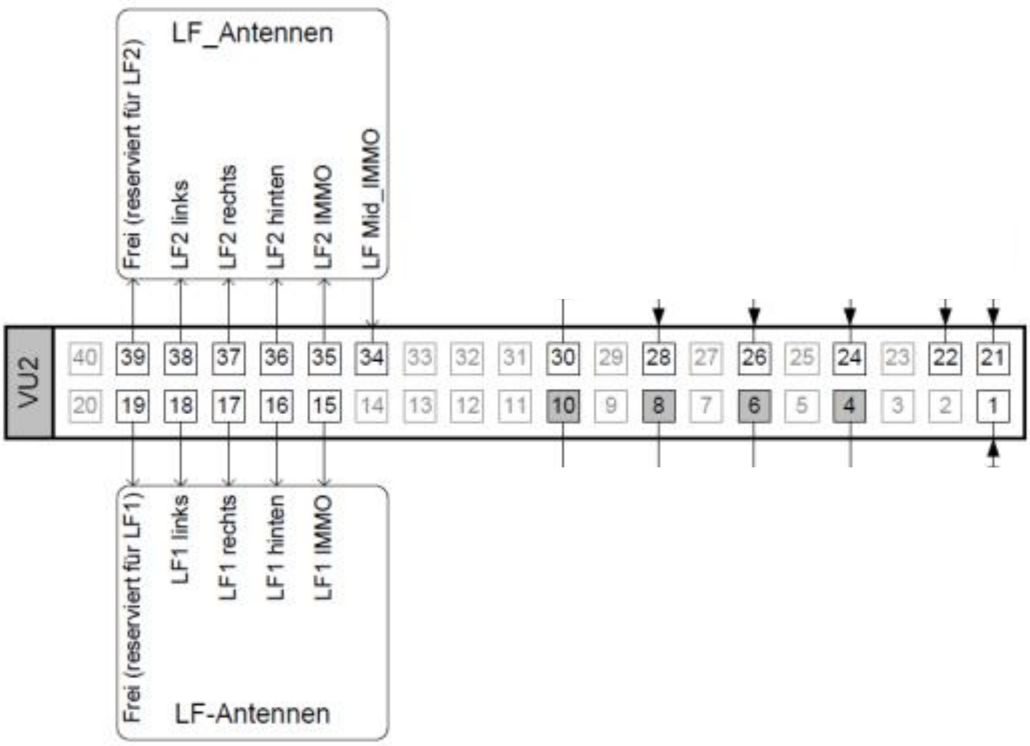


Fig. 27 Block diagram of the Test Setup

7.2 ECU and Connector Pinning for Hella design part



Connector Name	**PIN** (inside)	**PIN** (outside)	**Connector name**
	21	1	
	22	2	
	23	3	
	24	4	
	25	5	
	26	6	
	27	7	
	28	8	
	29	9	
	30	10	
	31	11	
	32	12	
	33	13	
LF Mid_IMMO	34	14	
LF2 IMMO	35	15	LF1 IMMO
LF2 hinten	36	16	LF1 hinten
LF2 rechts	37	17	LF1 rechts
LF2 links	38	18	LF1 links
free (reserved for LF2)	39	19	free (reserved for LF1)
	40	20	

7.3 Components on Setup

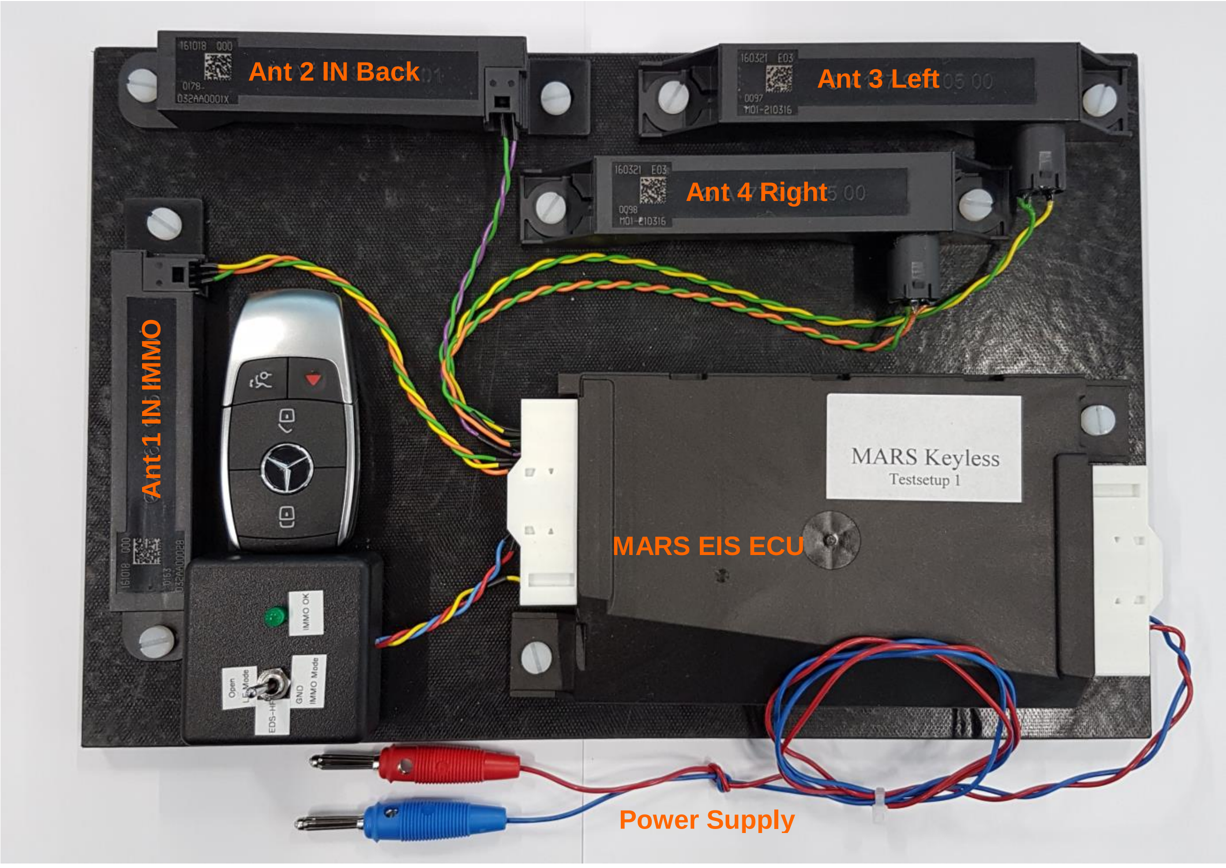
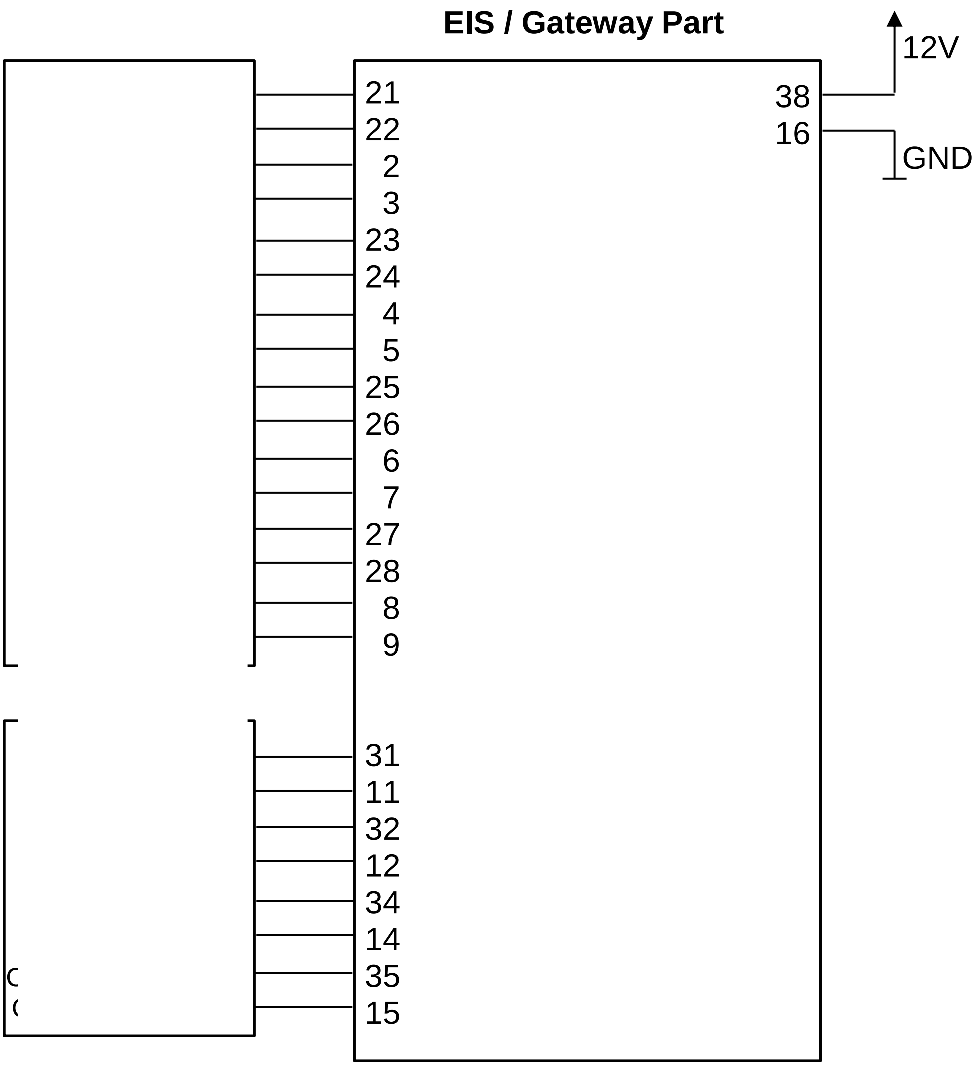
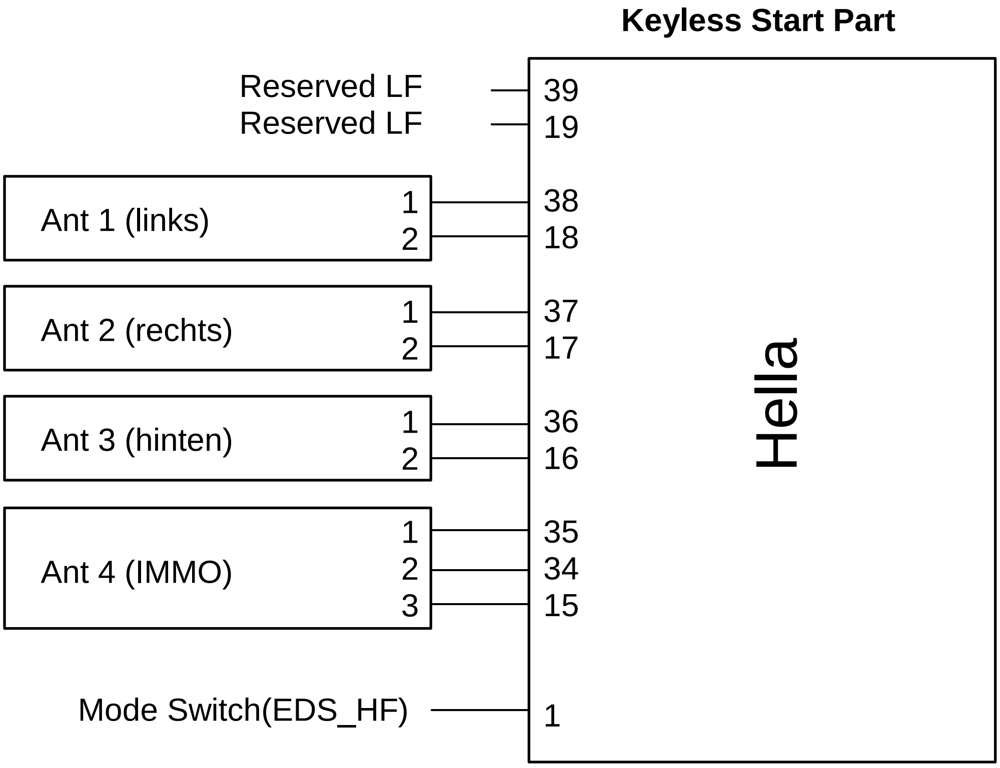


Fig. 28 Components on setup

7.4 Schematic





8 Housing views including Label

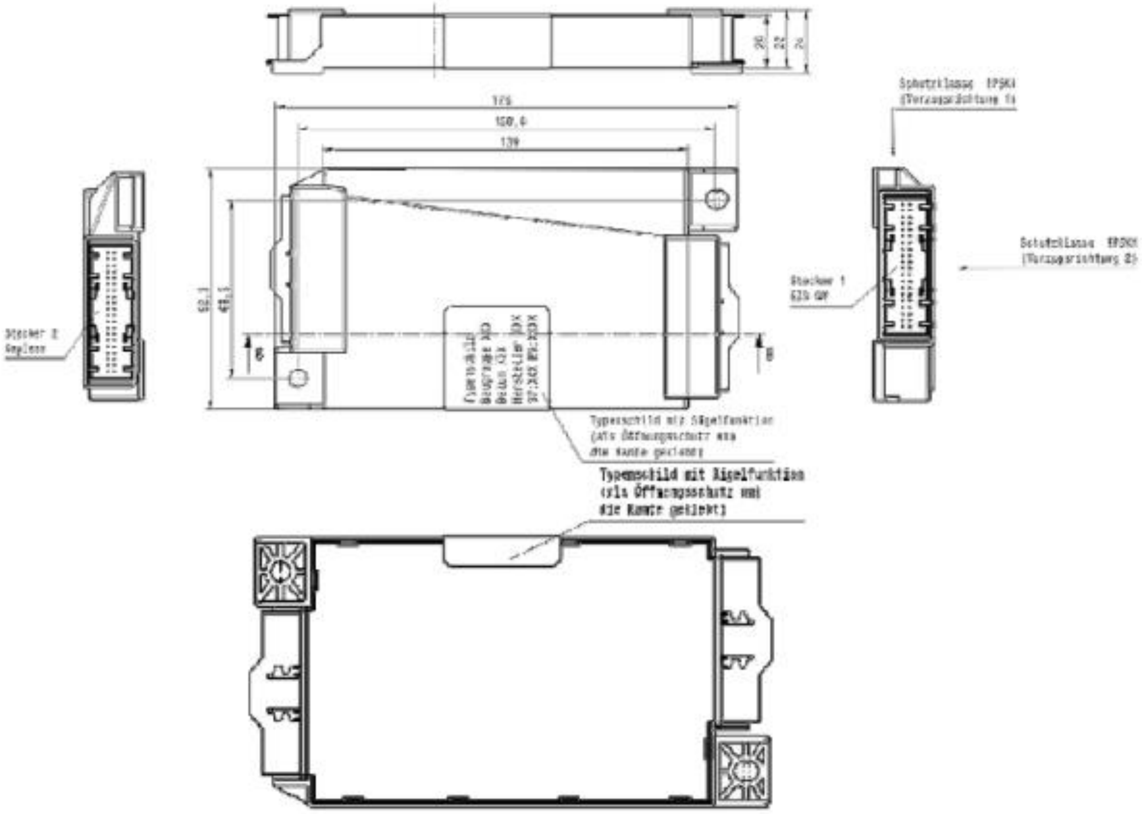


Fig. 29 Housing Top view (1) with details (2D)

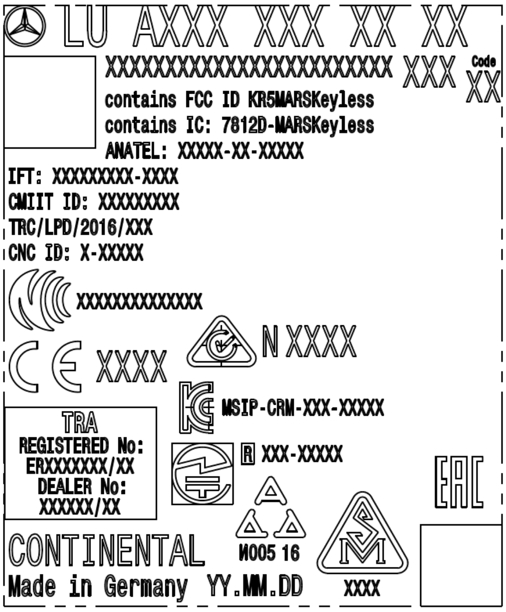


Fig. 30 Label (2D)

9 FCC Compliance statements

FCC § 15.19 Labelling requirements
This device complies with part 15 of the FCC Rules and Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and
(2) This device must accept any interference received, including interference that may cause undesired operation.

FCC § 15.21 Information to user
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

10 PHOTOS

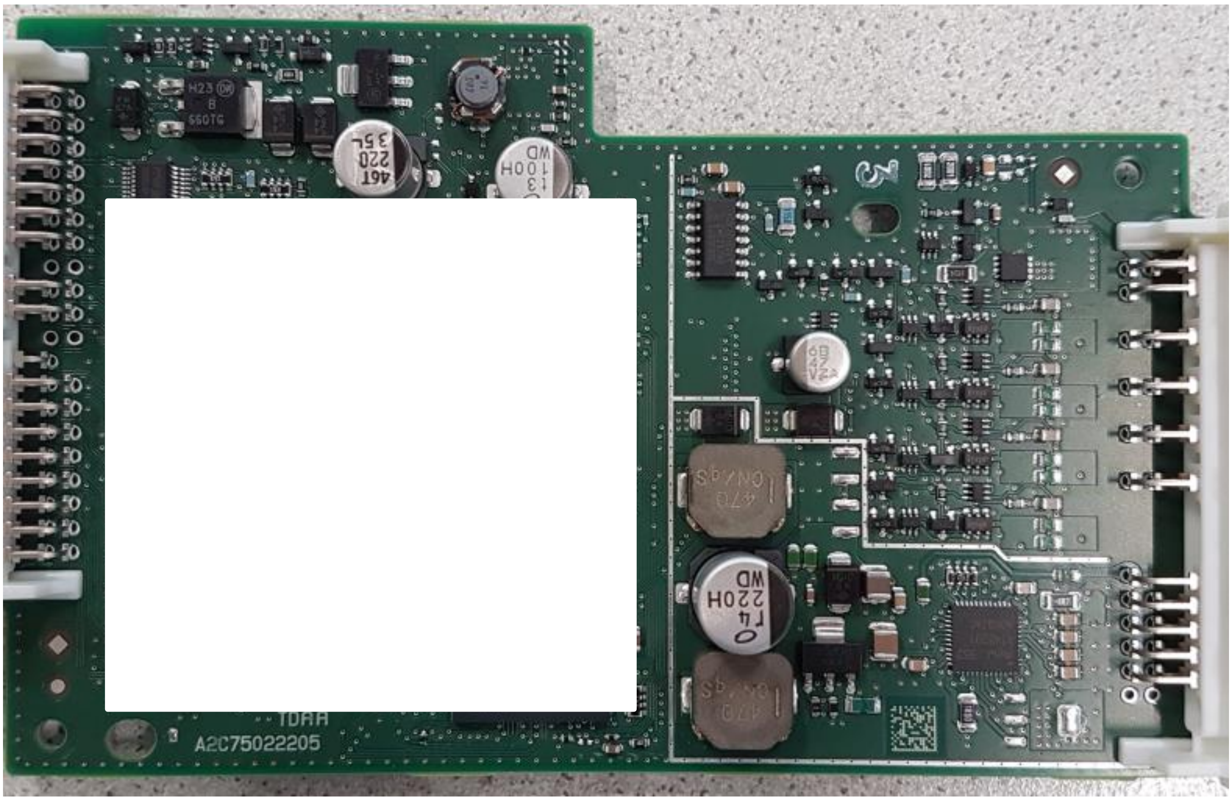


Fig. 31 MARS EIS ECU PCBA Top View

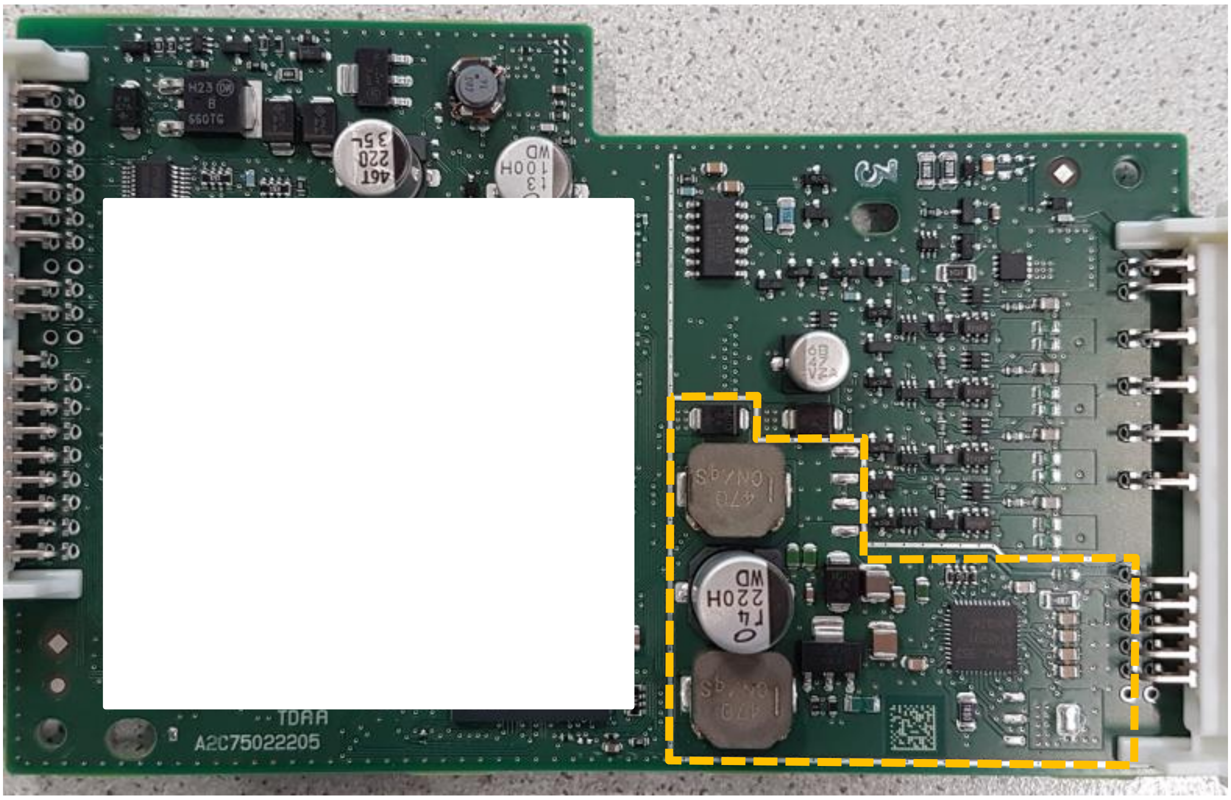


Fig. 32 MARS EIS ECU PCBA Top View with important module marked

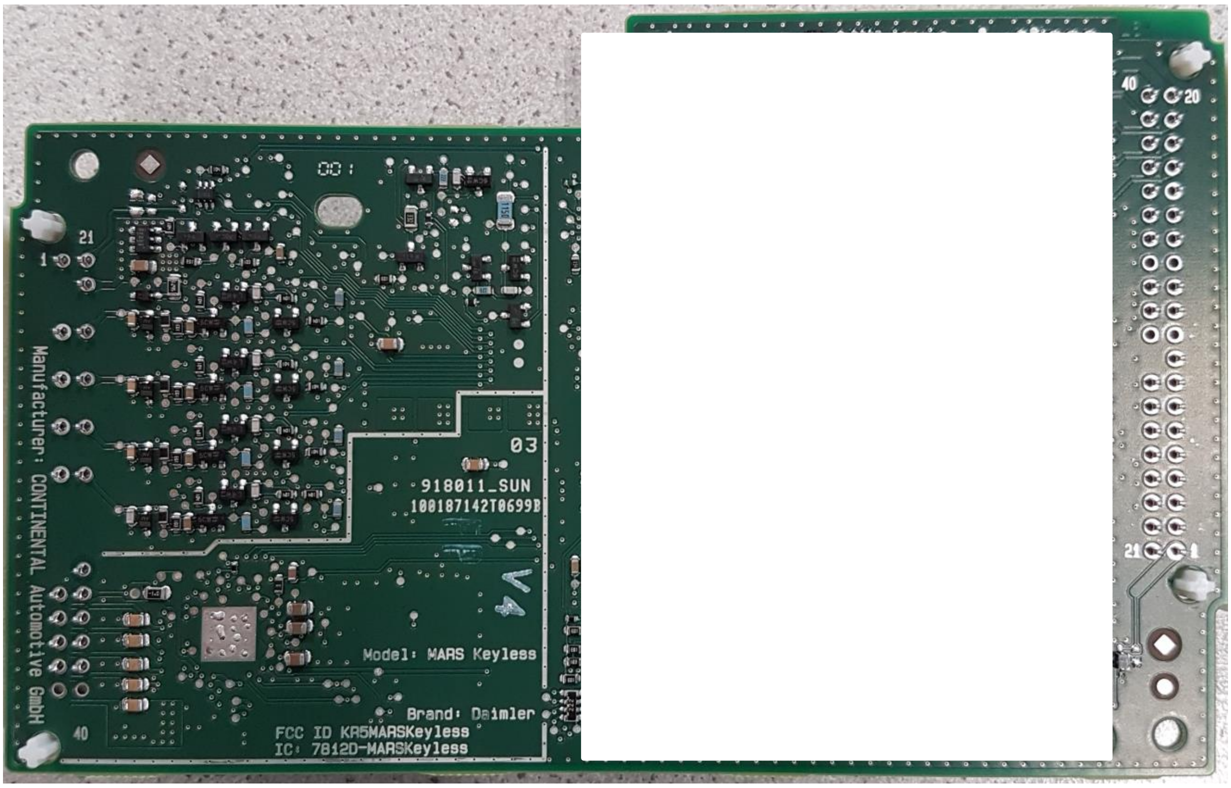


Fig. 33 MARS EIS ECU PCBA Bottom View

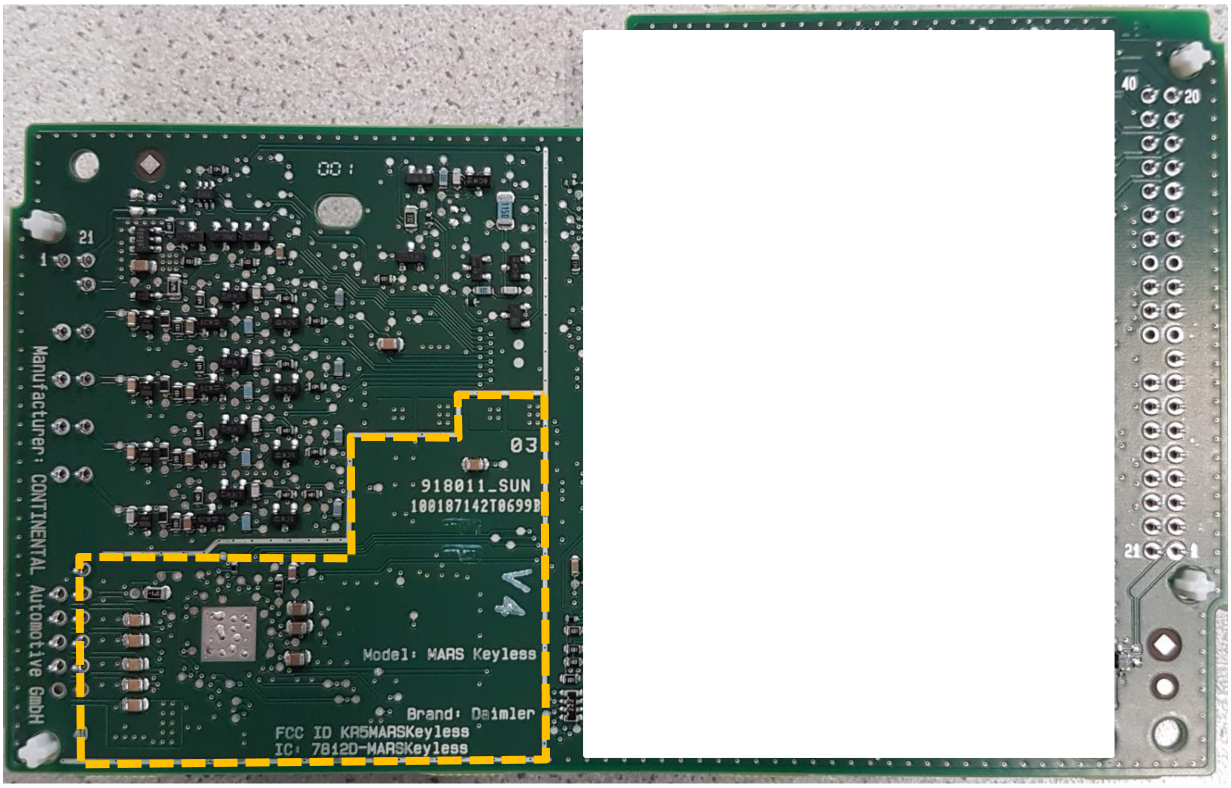


Fig. 34 MARS EIS ECU PCBA Bottom View with important module marked