UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

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Obsolescence tuning tool Gen3

Tesis en torno a una hipótesis o problema de investigación y su contrastación

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Obsolescence tuning tool Gen3

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DEDICATORIA

MI FAMILIA, MI MAMA, MI PAPÁ Y MI HERMANA.

AGRADECIMIENTOS

Sincere appreciation and thanks to my supervisor Willy Portier who provided assistance in this project and knowledge enrichment in my professional career and development. In addition, special thanks to Patrick Monselet and all the team in Continental Automotive France I get to meet, whose knowledge, personality, friendship and professionalism contributed to a perfect working ambiance.

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RESUMEN

El siguiente proyecto fue desarrollado para la empresa Continental Corporation Automotive France con el fin de resolver la problemática relacionada con la herramienta de calibración utilizada para calibrar la cobertura de la llave de acceso manos libres, actualmente se utiliza la tecnología Gen3 para la generación 3, que ha caído en desuso debido a la incompatibilidad con el software más reciente y al mal uso de las funciones obsoletas que consumen memoria que aún se incluyen. En las tecnologías actuales, las pruebas de calibración de la cobertura se siguen realizando con el mismo principio, por lo que es necesario proporcionar una herramienta de ajuste mejor, compatible y actualizada. El objetivo es desarrollar e implementar una interfaz completa back-end y front-end, la migración del medio ambiente para actualizar las funciones generales de la herramienta de calibración, así como la implementación y mejora de nuevas características, con una guía de usuario en inglés.

Palabras clave: manos libres, llave, radiofrecuencia, antenas, banco de pruebas, llavero, BCM, ECU.

ABSTRACT

The following project was developed for Continental Corporation Automotive France in order to solve the problem related to the calibration tool used to calibrate the coverage of the hands-free access key, currently using Gen3 technology for generation 3, which has fallen into disuse due to incompatibility with the latest software and misuse of obsolete memory-consuming functions still included. In today's technologies, coverage calibration tests are still performed on the same principle, so there is a need to provide a better, compatible and up-to-date tuning tool. The goal is to develop and implement a complete back-end and front-end interface, migrating the environment to update the general functions of the tuning tool, as well as implementing and improving new features, with a user guide in English.

Key words: hands-free, key, radiofrequency, antennas, test bench, key fob, BCM, ECU.

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INTRODUCTION

In order to solve the problematic concerned to the tuning tool used to calibrate the hands free key coverage, currently using technology Gen3 for generation 3, that has fallen into desuetude due to incompatibly with newer software and misused for obsolete memory consuming functions the following document describes the project which objective was to develop and implement an interface based on the procedural programming CAPL (Communication Access Programming Language), an automotive oriented language. In order to make a tool for testing and calibrating hands-free access systems on vehicles more accessible.

Also, it required an environment migration to update the general functions of the tuning tool into a software interface CANoe current version, to be used in new laptops as well as the implementation and improvement of new features, with a user guide in English.

The tuning tool implemented is used to calibrate the wireless key fob to adjust the coverage ranges of the magnetic field surrounding the according to the different shape of the car and the needs of the final user. With the specifications and limitations of car antennas UHF frequency used in North America division of 315 MHz and for the European division 434MHz.

As well as the test development using a software tool to perform automatized test results in the new application.

Objectives

- The general objective of the project is to develop and implement a simpler calibration tuning tool.

- It is required an update of the tuning tool, considering unused internal and external features.
- Also, an analysis and study of the ongoing technology used in key fob in order to get rid of nonessential and memory consuming data.
- Therefore, is necessary to find starting values or reference values to provide as an input.
- For the amelioration of the present tuning tool the configuration of a simpler interactive user environment must be provided
- And finally perform and evaluate ongoing calibration automotive tests.

STATE OF THE ART

Antenna principle

The basic principle of the car antennas is that they emit electromagnetic waves to the environment and senses reflections. The antennas will receive and transmit information in terms of bit codes related to radiofrequency identification applications RFID. The key fob uses PKE passive keyless entry system, that refers to the communication between the transmitter antenna inside the key and the allocated antennas placed in crucial parts of the vehicle. Inside the key there is also a receiver, therefore it is considered a trans receiver or a radio. These antennas are the physical interface for the electronic devices to the electromagnetic waves. The transmission of the information between the antenna allocated inside the car and the one inside the key is conducted by electromagnetic induction.

This principle will be used to describe the location of the key fob, inside/outside and the functions to be performed lock/unlock, actions performed wireless and hands-free, without the active intervention of the user, reason to be called PKE.

Through the years there have been some variations and technology improvement in the mounted antennas concerned to power, size and current consumption, this work considers the average performance for a generalized calibration and in particular the coil loop antennas.

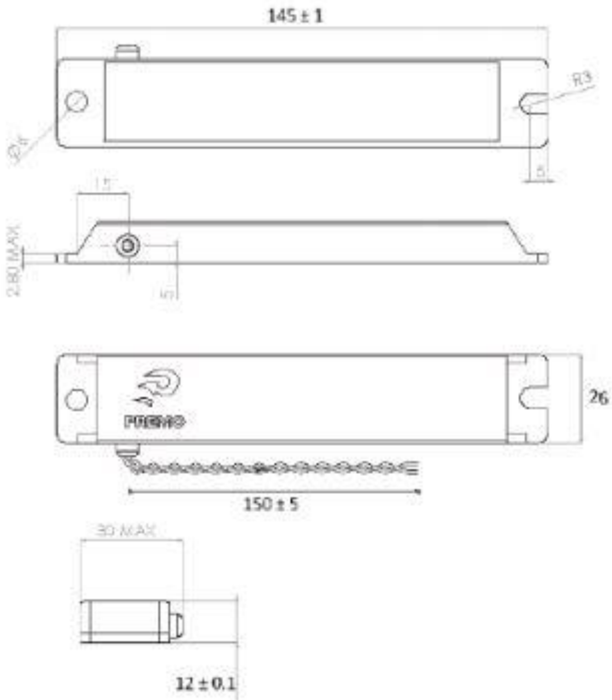


Figure 1. Car door mounted antenna

The electrical circuit for the loop antenna is simple and is as showed in the figure

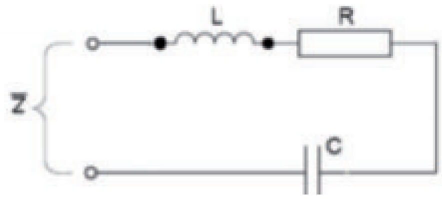


Figure 2. Car door antenna electrical diagram

The equivalent small loop antenna circuit portrays the simplicity including two resistors and an inductor, a radiation resistance and a loss resistance.

Some useful equations are taken into account based in the Matching Small Loop Antennas microchip datasheet for the 434 MHz frequency.

Radiation resistance

$$Rrad = 31171\left(\frac{A^2}{\lambda^4}\right)$$

A= Area of the loop [m2]

λ= wavelength [m]

$$Rrad = 31171\left(\frac{(0.03 \times 0.015)^2}{0.691^4}\right) = 0.0277\ \Omega$$

Loss resistance

$$Rloss = \frac{l}{2w}\sqrt{\frac{\pi f \mu}{\sigma}}$$

Considering the conductivity of the copper (Siemens per meter)

σ=5.7x107 S/m

μ= 4πx10-7

l= perimeter or circumference[m]

f=radiation frequency in [H]

w= width of the PCB track [m]

$$Rloss = \frac{2.25 \times 10^{-4}}{2(0.015)}\sqrt{\frac{\pi \times 434 \times 10^6 \times 4\pi \times 10^{-7}}{5.7\text{x}10^7}}$$

$$Rloss = 7.5 \times 10^{-3}\sqrt{1730} = 0.3119\Omega$$

Inductance

$$L = \frac{\mu}{2\pi} \times l \times \ln\left(\frac{8A}{l \times w}\right)$$

$$L = \frac{4\pi \times 10^{-7}}{2\pi} \times l \times \ln\left(\frac{8(0.03 \times 0.015)}{2.25 \times 10^{-4} \times 0.015}\right)$$

$$L = 4.5 \times 10^{-11} \times 6.972 = 31.37nH$$

The radiation resistance is 0,0277 Ω and the loss resistance is 0,3119Ω. Therefore a loop resistance of 339,6 k Ω.

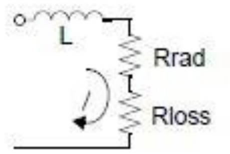


Figure 3. Equivalent loop antenna circuit

As a first approach the perimeter p for a loop antenna is very weak as the actual operating frequency used for the European region is 434 and 315 North America.

$$p < \frac{\lambda}{2\pi}$$

λ=wavelength at operating frequency

For (434 MHz)

$$p < \frac{\dfrac{3 \times 10^{8}\,\frac{m}{s}}{434 \times 10^{6}\,\frac{1}{s}}}{2\pi} = \frac{0.691m}{2\pi} = 0.11m$$

For (315 MHz)

$$p < \frac{\dfrac{3 \times 10^{8}\,\frac{m}{s}}{315 \times 10^{6}\,\frac{1}{s}}}{2\pi} = \frac{0.949m}{2\pi} = 0.15m$$

This perimeter is useful to consider the mounting of the antenna to avoid crosstalk. Also this value is considered for the minimum nearest range detection established as 20cm.

In order for the magnetic field produced around the antenna region to be uniform and strong enough to detect the signal from the transmitter in the key, it has to maintain the same current along the loop with a constant magnitude and must be in-phase.

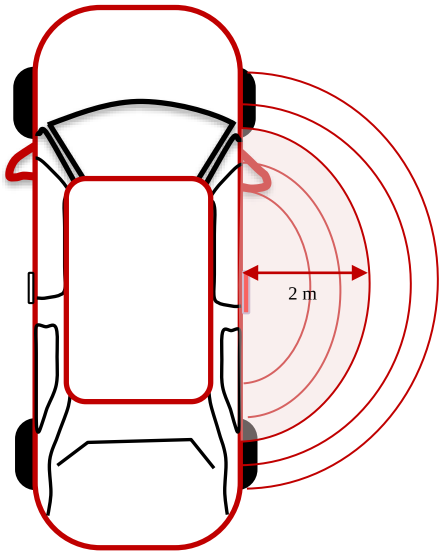


Figure 4. Car coverage magnetic field

The design of this antenna varies depending model, technology and region of the vehicle, it is not a concern in this work as the need of a generalized technology must be the approach. For a segmented antenna the perimeter is around 3meters. Considering vehicle manuals and general datasheets for this type of car antennas, the perimeter and farthest detection field will be 2 meters. The key must perform lock functions as it will no longer be detected.

The frequency of the transmitted signal is the same frequency of the applied voltage signal. The PKE system uses LF low frequency resulting in longer wavelengths for the far field and UHF for the near field applications.

The length of the antenna depends on the wavelength and perfect transmission is half of the wavelength, the wavelength in air is

$$\lambda_{air} = \frac{c}{f_{air}}$$

$$\lambda = \frac{3 \times 10^8 \frac{m}{s}}{433.92 \times 10^6 \frac{1}{s}} = 0.691m$$

So ideal length for the $\frac{\lambda}{2}$ antenna is

$$L = \frac{\lambda}{2}$$

$$L = \frac{0.6913}{2} = 0.345m$$

This means the antenna length should be the half of the wavelength, for the cars therefore 34 centimeters. This is the worst case scenario to be considered when any wrong detection of a signal is presented during a calibration. But nevertheless the length antenna is constrained by the case box it might be mounted. Therefore, the actual length of the antenna will be disregarded and only consider the value for the nearest field detection.

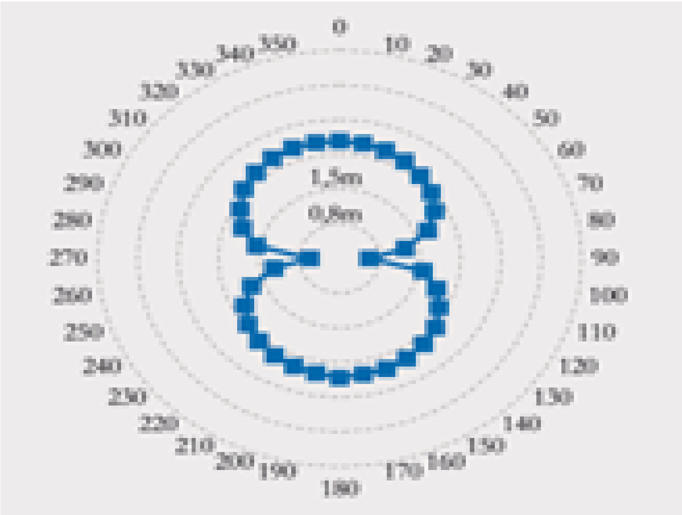


Figure 5. Antenna phase. (Reference image)

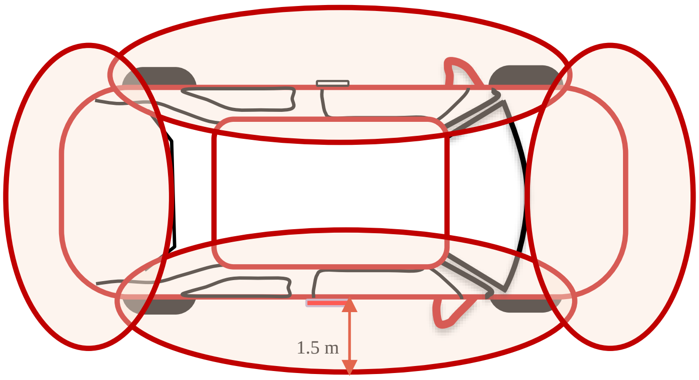


Figure 6. Mounted antenna coverage

From the previous image it is important to regard the phase as the selection in the calibration test will vary its shape slightly but can include the inversion of the phases for appropriate limitations depending on the model.

PKES Passive keyless entry system

The passive keyless entry system refers to the use of the key as a remote access system that does not require manually activating the buttons or any other input from the user. To perform the unlock mode the key must be in close range and lock when it no longer detect the signal. The coverage will depend on the magnetically pair linked radiofrequency signal. This is not an isolated communication, it will also exchange information with the electronic control module ECU to decide and conclude when an action is requested as well as the device it originated from.

The radio frequency identification works with the low frequency LF and also the ultrahigh frequency UHF. The LF is used to determine if the key is inside the detection region the low frequency channel will be used with the closest approximation to the car of 20 cm passive and for the active mode it is possible 2 meters. Also, the LF has a special concern as the hands free key concentrates in the passive system and also to detect if the key is inside the car or outside as some basic actions are strictly dependent like start engine. The UHF channel will be actioned for farther distances starting at 10 m. In this band the propagation and transfer of data between reader and key are based in electromagnetic waves.

The car is sending a constant LF signal in wake up mode. If the identification system RFID recognizes the device, the encrypted unique key authentication data, within the coverage range it will send back the correct ID to the be processed with a modulated radiofrequency signal, both frequency shift keying FSK are commonly used for car key and tire pressure system.

The FSK is a digital modulation 0 or 1, two different frequencies transmitted modulated to a carrier. The car must be on wake up state, if not it will send a wake up LF signal triggered by proximity to the vehicle, pull or touch the handle. This will correspond with and ID communication check, the key fob responds transmitting a UHF signal to the environment that will be recognized as a presence if in range. If the ID is authenticated the key with send the binary data to the car that will send the info to the ECU in order to process information and perform the logic of lock or unlock referring of the constraints of near presence far presence, inside, outside or previous active input data. Therefore, allowing or not the access to the car. The lock unlock is performed in 300 ms perceived as instantly for the user. The key will only transmit for few seconds as it is power consuming

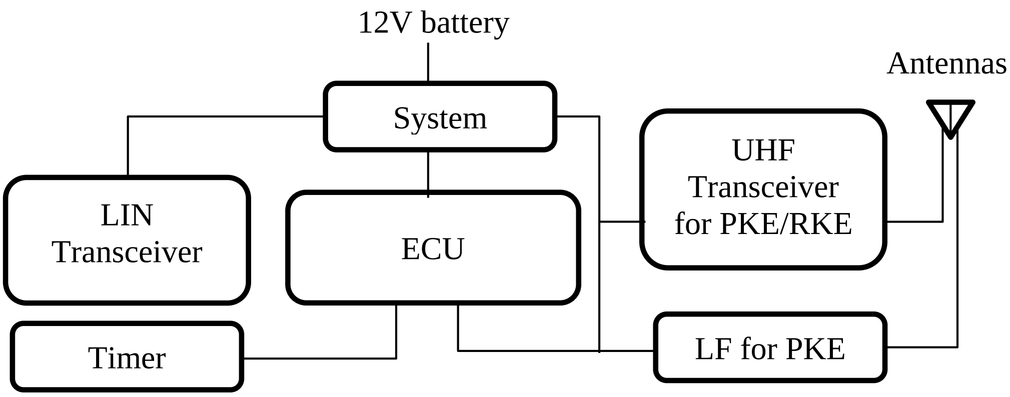


Figure 7. Car side schematic

Key fob notions

The key fob is a wireless key access that emits a radiofrequency signal that allows the user to lock or unlock the door, at the same time be able to start the engine only when the driver has the key inside, and determine if the user is leaving or approaching the car to avoid unwanted lock of the keys inside the car without the driver. This is based on the PASE that is the passive start and entry system, passive means that there is no input from the user, like pushing buttons. The key fob may also be called the identification device as it contains a unique access code to the car it is linked. In order to determine the position of the key fob relative to the vehicle environs it is necessary to get the information that it is sending to the antennas located in the different sections of the car. The value will be measured in nanotesla (nT) that is the electromagnetic unit for the magnetic induction, equivalent to 10-9 Weber per square meter (Wb/m2). Inside the key fob there is a gyroscope that provides the information in the three axes, this average position will be shown as the final output. The value will determine the proximity of the key to the triggered antenna. This will help to determine if it is inside or outside and will help determine whether it is approaching or moving away for the lock and unlock functions. The frequency of the keys in the cars considered will communicate at 433,92 MHz, the ranges will include lower frequencies such as 125kHz, these are for short range devices, between 1-100 m. There is a high penetration and the reflections will be small; meanwhile the wavelength will be larger higher than $\lambda>2000$m. There should be a full coverage of the vehicle surroundings, but the ranges should be meet, the proximity for the automatic lock far approach is around 2 meters and for the closest nearest detection around 20cm. This is the purpose of the tuning, to calibrate the detection of this key fob according to the shape of the car keeping in mind the coverage that the antennas possess.

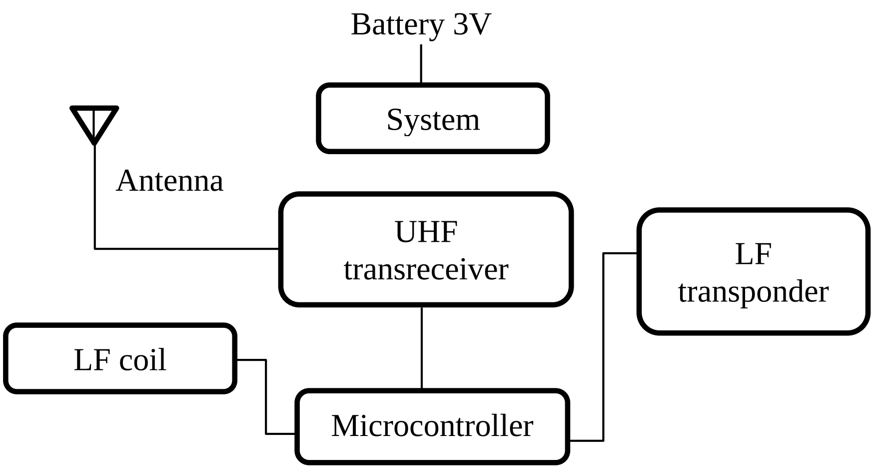


Figure 8. Key fob schematic

Automobile standards and authentication

CAN communication

The Controller Area Network CAN bus communication enables the information exchange between various electronic devices involved in the car function. CAN bus allows the signal of the key fob, the engine control, lights, ECU, brake system to perform a parallel function and data transfer without stopping of interfering with one or another. The actual car require more simultaneous performance of actions therefore CAN protocol is essential in the automotive performance because they will send signals from actuators, sensors, cameras and other elements for basic car functions. It is not essential to have a main computer for the derived systems due to the fact that they will have a separated ECU.

The reliability of this protocol remains on the fact that the messages are in priority order, crucial functionalities like ABS are in a higher hierarchy than those coming from the automatic transmission. This information is transmitted in binary code, in sections and encapsulated separately. CAN modes can be activated, deactivated or erased as they are not essential for the general interconnection.

The CAN bus dispatches data through a Can cable bus composed by two intertwined cables CAN high and CAN low, resistances, CAN controller between the ECU and trans receiver, CAN trans receiver.

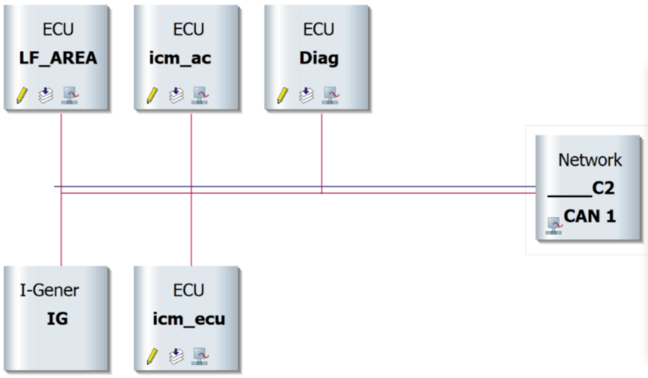


Figure 9. CAN connection Vector interface

The possible logic sates for the CAN communication protocol is centered on two possibilities: The leading bits for sequence is 0 and the receding 1or leading. The CAN intertwine cable has CAN low, CAN high, Ground, voltage, LIN lines and one for specialized functions.

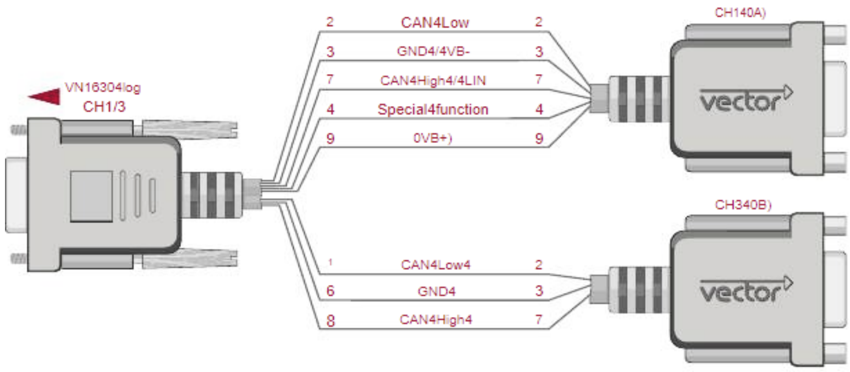


Figure 10. CAN cable

The CAN bus lengths also affects the data transmission. The twisted pair will transmit with a constant rate for longitudes less than 40 meters. The data is transferred rate is about

1Mbps. The intertwined cable is the most common used for automobile applications, further bus lengths can be achieved with other mediums like coaxial cable or fiber.

This protocol uses content based addressing, it has an ID for each message and this will be introduced in the branches direction and decoded in the units that are connected to a channel.

Identifier 11 bit	Control 4 bits	Data field 0 to 8 bits	Redundancy check 15 bits

Figure 11. CAN standard bit frame

The priority does follow a structure of mediation to assign which information is more important or should be attended first. It is content in the 11-bit or 29-bit identifier. The recessive will be overlooked when there is dominant bit and in the node the lower identifier has higher priority in access.

The ECU units connected can be eliminated without affecting the hardware or the operation of the software because the units don't have an address reserved. All units work at the same message speed depending of the network.

This protocol has a type of error trigger when executed for diagnosis that helps the order the priority and decrementing the importance of a unit that will continually be sending errors and prevent it from interfering and obstruct the communication of units with normal behavior. The CAN bus can turn off units or disconnect them from the channel when a persistent error is detected, to avoid a general bus error perform. Network that is generally does not carry noise.

Unified Diagnostic Services (UDS)

The unified diagnostic service is another communication system used in car analysis this works also to interpret the data that is executed in the electronic control unit. The CAN protocol and UDS can work together. It must be established that the communication is CAN in the way that the data is received parallel and act separated but the diagnosis can be interpreted by an UDS as it will be used for the user of the software an easier display to find the requested code. This are based on CAN standards.

The UDS accepts all the electronic control units for different models of vehicle. Necessary to use for calibration tests. As it is a bus based request layer and to select it can be implement or selected later in the feature.

After executing the tests, the results from the analysis are indicated as positive or negative responses with a code that helps realize the parameter that is producing the conflict in the acquirement of the signals.

Negative response codes NRC have 3 ranges that provide statistics to be interpreted by the final user. The meaning of this ranges are in hexadecimal from 0 to 255, 0 to FF.

Positive response:

0x00: Internal implementation parameter value for server

Negative response:

0x01 – 0x7F: codes for communication related negative response codes,

0x80 – 0xFF: used for specific conditions. These are the ones that not corrected at the same time when the request is received by the server.

There are also conditions that are not corrected that will show up in the negative response 1 to 255 responses. The not correct condition is the 34 in hexadecimal 0x22 and will be validated as valid and will be showed in the report as a flag and listed to specify the reason that the requested action is not possible to be done.

METHODOLOGY AND INVESTIGATION

General project overview

Vehicles status

The tuning can be performed for the exterior and the other one for the internal part. For the ranges in the outside the worst-case scenario will be considered, that is a distance from the car to the key fob around 1.10 at 2 meters it will be detected as it has left the reaching ranges. The fact that the car acknowledges the key inside or outside is based to the condition that the car is a metal housing box indicating the existence or not of the key.

For the car that was taken for the test calibration some predetermined values are taken into account. The event of unlock height considers a range of 0.3 m and 1.5m with a far field of 0.8 m. However, in newer models this range was updated for a further coverage, 2m. The case of a roller bag still an issue therefore calibration options in the tool will be more permissive due to the fact this varies more depending the structure of the vehicle.

Customer targets are following:

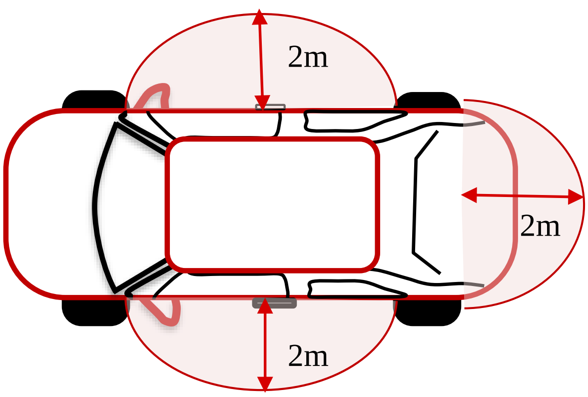


Figure 12. Side view customer target key fob

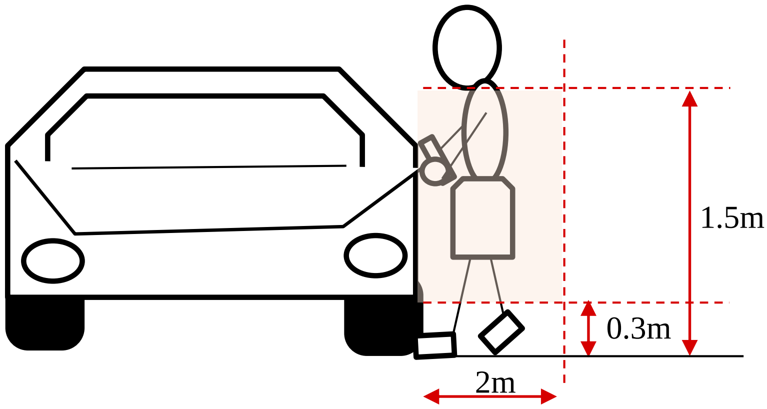


Figure 13. Front view customer target

A calibration is performed following some considerations. For example, in the tuning for exterior part, the selected power for the antennas should be the maximum. At the driver and the passenger door antenna the maximum value is 22 Vpp, for the trunk at the back of the car will be 28Vpp. The values that will be recovered are the fields strength measured in nT. When using the tuning mode, the RSSI value will be 0. These are the ones indicated in the table and for the threshold to be set. The destroy bit is around 5 V, it can also be adjusted if the crosstalk still present. For the blinking mode the ranges will be checked, this allows to know the distances and heights limits.

Position of antennas

The antennas areas outside cover the following:

– Driver door

Location: usually located inside or closer to the handles in the side where the driver will be getting inside the car, the steering wheel side.

– Passenger door

Location: mostly found inside or closer to the handles of the opposite side of the driver’s door. The passenger door may include the doors in the back seats, depending on the model there may be more than one. This is referred mostly like the assistant door.

- Trunk

Location: this refers to the door that opens the trunk. This is mostly located in the back of the car, the bumper. This is the luggage compartment.

The antennas areas inside cover the following:

- Front room

Location: The antenna is allocated in the frontal panel are to make a coverage of the internal part of the vehicle

- Central console

Location: The central console the major part of the vehicle as it is in the middle central part of the car.

- Rear room

Location: This refers to the back inside part of the car, not the trunk door.

A visual aid is provided in the tool for a better selection of the antenna area selection. There is selection of the same areas with the same antennas as a backup configuration. Can be used to create a different signal shape from the signals emitted from the antennas.

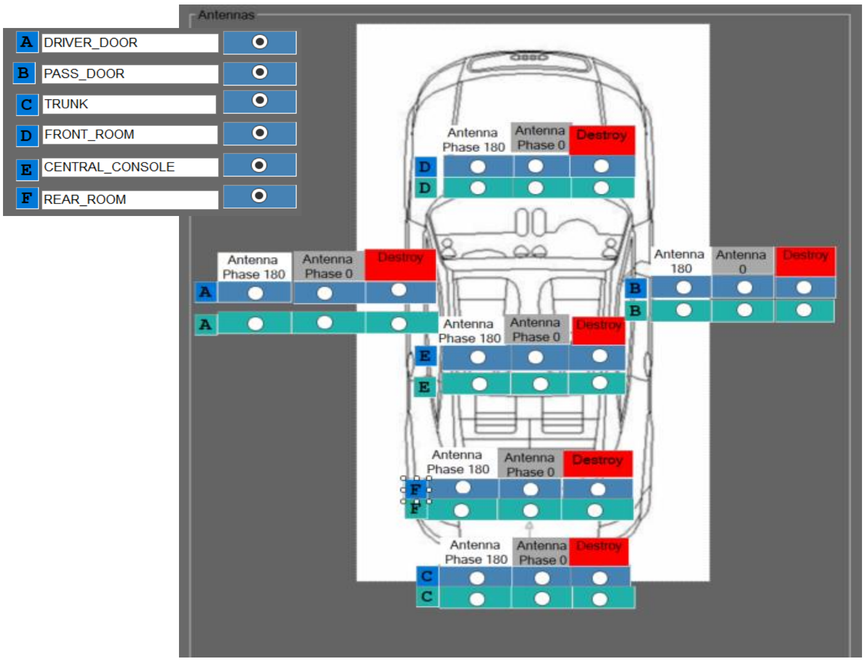


Figure 14.Antenna panel configuration

Reference of antennas

Some verifications related to the antennas should be performed when doing the tuning. To perform the verification in the vehicle, the first step will be the antenna power check.

Table 1. Antenna voltage and configuration

Antenna	Atic64 outputs configuration	Vpp Atic
Driver door	2 half	28V
Assistant door	2 half	28V
Bumper/Trunk	Half	28V
Room1	Half	28V
Room2	Half	28V
Trunk	Half	28V

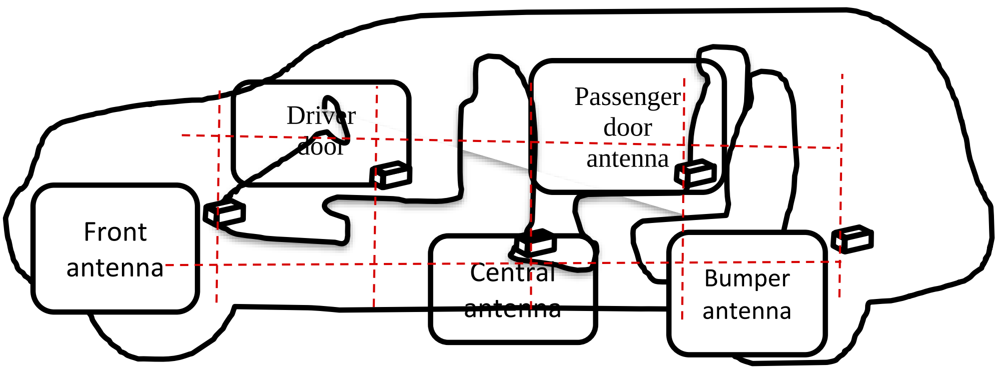


Figure 15. Side view, antenna position

It is important to verify that the antennas are mounted as expected, this includes that the phases of this ones are correctly selected in order to cover all the surroundings.

The selection of these phases is to from 0° to an opposite of 180° in order to be able to play with the shape of the field surrounding the car. For instance, for the activation of the interior antennas it is recommended to perform the actions in pairs. For example, to be able to see the field effect from the phases it would be useful to select the front and central antenna with the same phase and a low power. Then change the phase from the central antenna and measure the field. This allow to choose the configuration with the highest field. This will be repeated for the central and trunk. The phases can be selected in diphase to be able to get a higher internal coverage.

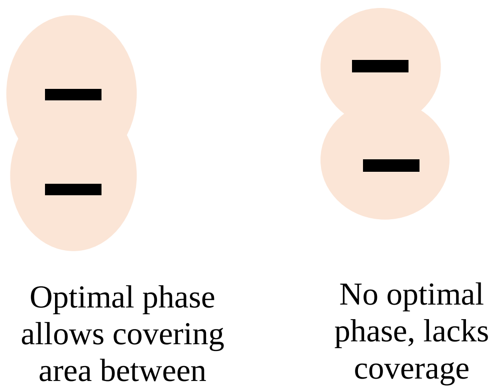


Figure 16. Phase coverage

If the key is not detected the phases may be inverted to get the full coverage, the position and range is previously established and depends of the car model, for the calibration and data on the software it is required to adjust angles inverting the phase. The optimal phase will be reached by changing the phase or the threshold values inside the program.

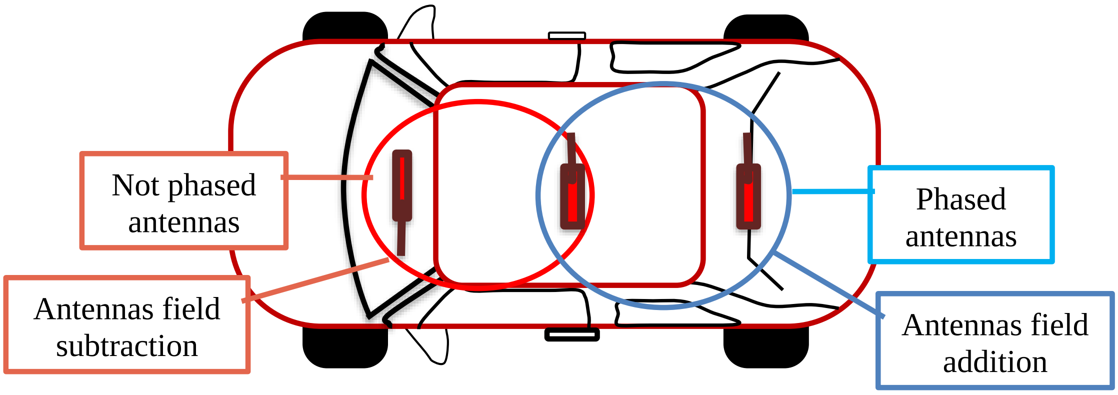


Figure 17. Antenna phase

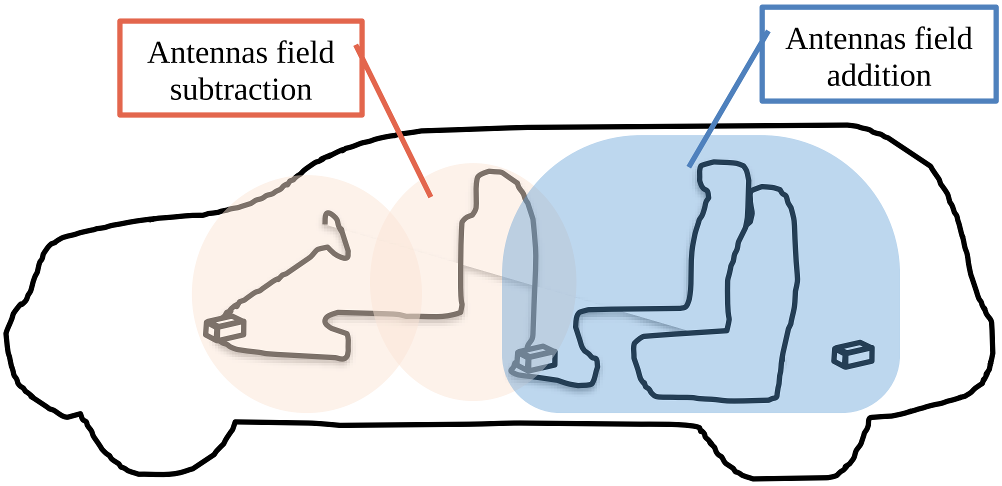


Figure 18. Antenna subtraction and addition

This can also be performed with the external antennas. Activating by pairs first the antenna corresponding to the driver door and the trunk, then changing the phase from the driver door, and with this getting the highest measured field. The phase from the trunk is import s it will be kept while the phase with the passenger and other doors may change. This should be especially careful seeing the fields from the corners.

Voltage values received

The values of power sent to the antennas will include the data for the power from the antenna, the next value to be inserted is the RSSI received signal strength indicator that is related to the power level transmission at the receiver end, labeled CW current value as it was established before. The previous label was left in order to avoid confusion. Some start values are 27 for the data and 24 for CW

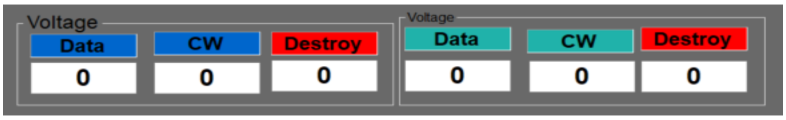


Figure 19. Voltage, data input panel

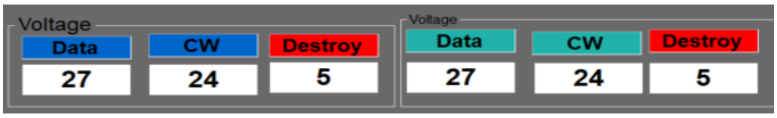


Figure 20. Voltage common inputs

Destroy bit

This is a bit sent to eliminate the undesired crosstalk (proximity of cables) that can be caused by antennas not fired in the proximity of the area selected. The transferred energy from the other cables causing electromagnetic interference interpreted as signal frames 0 and 1. In this case Front area and Central console antennas are fired:

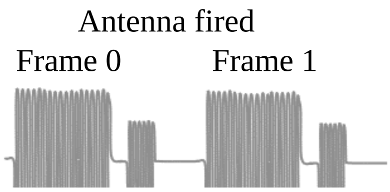


Figure 21. Fired antenna message

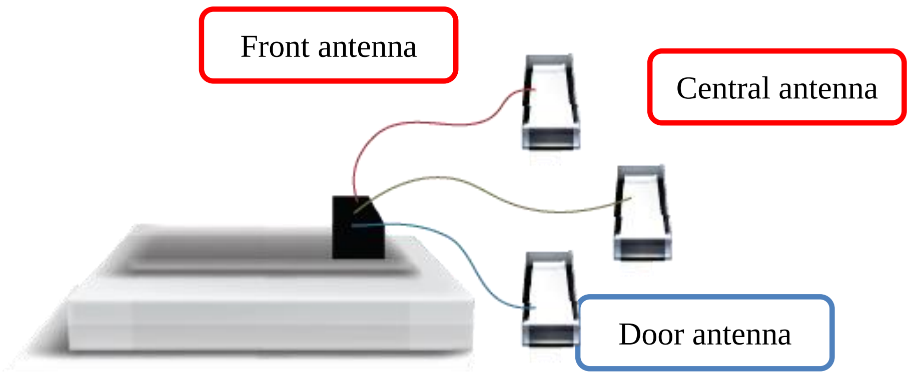


Figure 22. Antenna connection

When an antenna that is in the range is not fired, like door antenna in this case, to avoid the incorrect response from the key and the unique response from the key to the desired antennas, a destroy bit is sent. This signal will be interpreted as an overshoot and a signal that won't be able to be read, for this reason the message from the antenna not fired will be eliminated or killed.

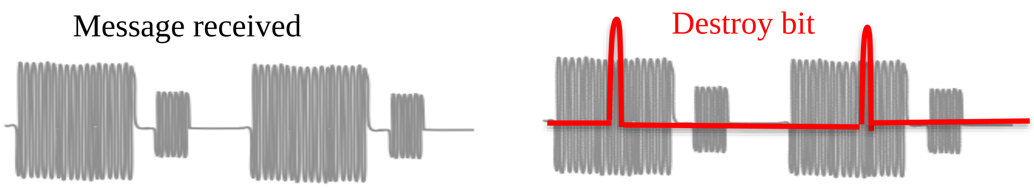


Figure 23 Message from antenna

Range detection

In order to get the coverage, range usually there is a display of the plots of power gain radiation in function of the azimuth angle using 90° and 180° degrees. The radiation patterns are established for absolute gain. This values were already pre-established in db. Inside the program this data will not be changed but the table related to the nanotesla. The values are used in the hexadecimal system and these are previously converted in an inside feature that can also provide decimal numbers.

The electromagnetic field must be measured in means of electromagnetic flux, the calibration performed before allowed to confirm and avoid future measurements with a flux meter. The average value is showed in the screen and therefore the new configuration proved the following graphic input.

There are two functions when performing the calibration tuning and blinking mode. The tuning will provide ranges that are used in the key fob for data unlock/lock entry. And the other mode is blinking mode this provides values outside the configured tables used when the coverage is not inside the table seen as a reset for a distance to value measure in order to set a new starting point by the calibration measurement.

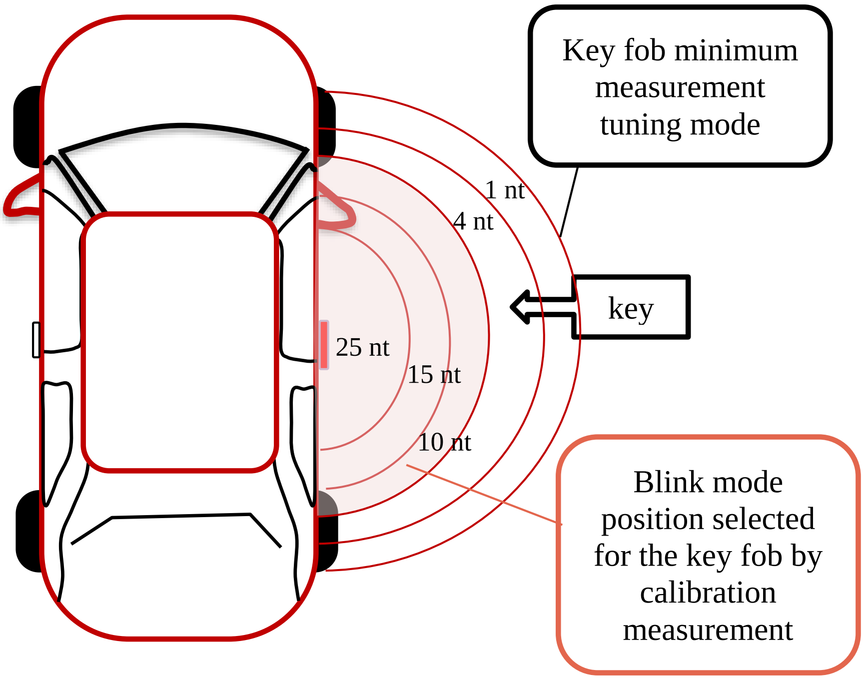


Figure 24. Coverage range modes

ANALISIS AND RESULTS

General configuration

The general configuration to edit the program will include a CAPL browser with the main panels. In the left side there will be a panel for the events, the right part when editing will include the global variables, and event procedure. In the lower part there is useful messages for the compiler.

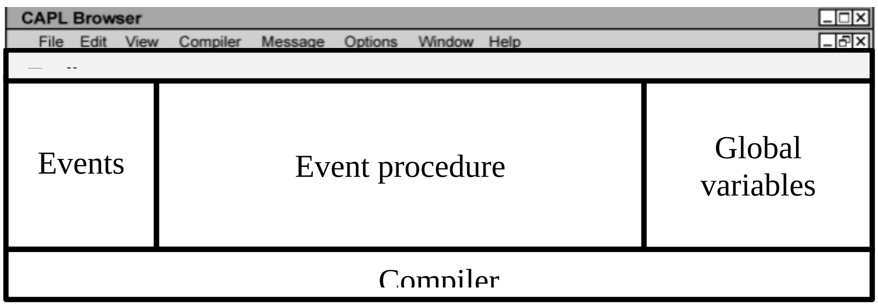
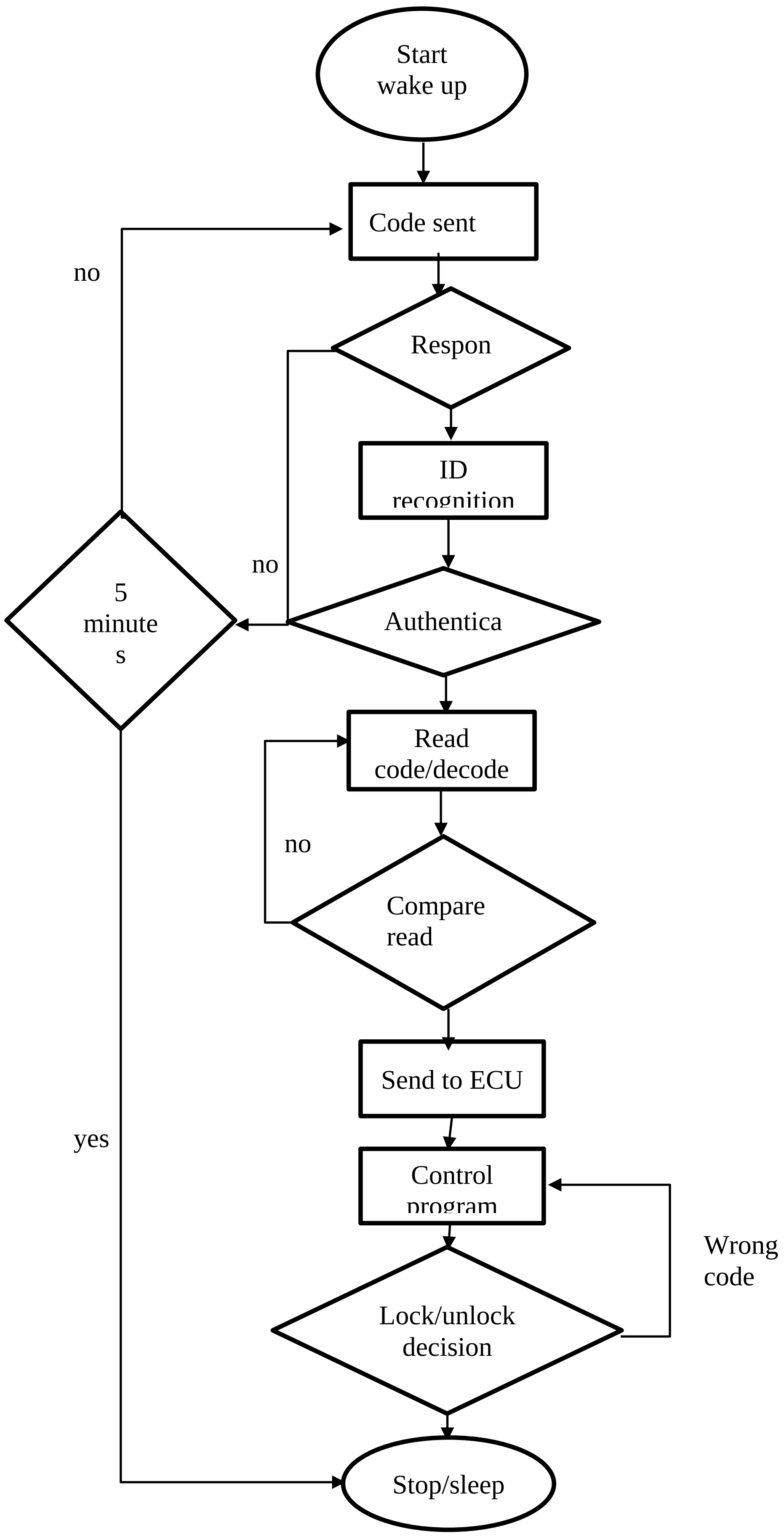


Figure 25. CAPL browser window


Start
wake up
Code sent
no
Respon
ID
recognition
no
5
minute
s
Authentica
Read
code/decode
no
Compare
read
Send to ECU
yes
Control
program
Wrong
code
Lock/unlock
decision
Stop/sleep

Setup

Other panels that might open when a previous configuration is setup. The CAN bus shows the transmitting channels. IG interactive generator to show user interaction buttons, LF antenna related to the key fob configuration data essential to change the values data table. Icm AC and Icm ECU. The DIAG will send data to stop start sending when it comes or goes after the comparison in a table, this are parallel functions so it will not be waiting for an action but constantly sending signal if it is not the value from the comparison table this will continue performing dialogue request to the user or the ECU unit so some garbage data ca be collected.

Next to this window there is the measurement window that allows real time test or an off test, this allows to enter filters that pass only in high or low mode depending the request test and this will be stored in a final CANoe1 file after logging. It is showing different branches that can show and store the graphic display also.

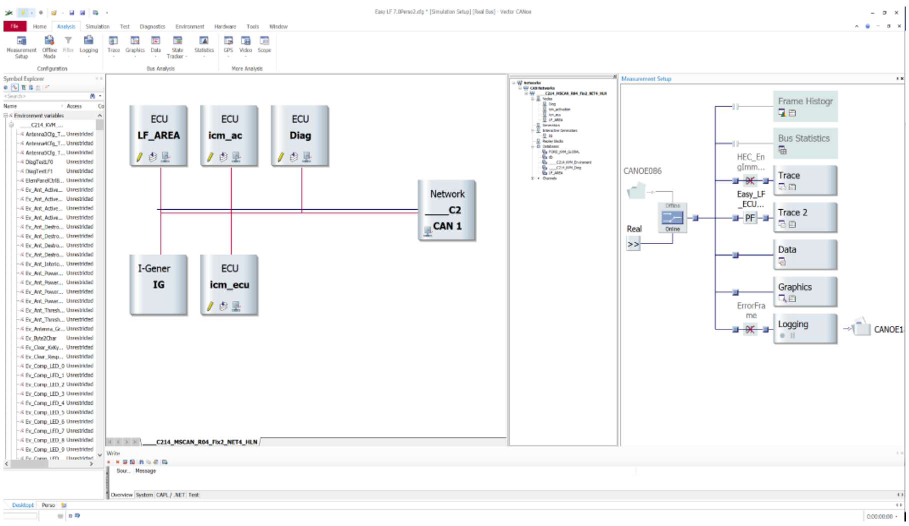


Figure 26.CAN channel and measurement setup

There is an extensive test that can be performed, for the key fob calibration some useful modules to show are RKE and PASE to indicate if the indicated key is in range. The rest can or not be activated and the ones in DIVA will act as automation test files to be stored.

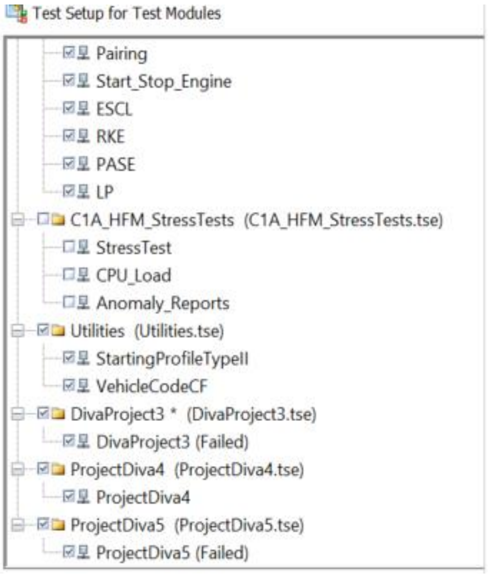


Figure 27.Setup test module

Schematic

The key fob side has a receiver and a transmitter the general configuration may vary depending on the type of vehicle and model but the general elements to function in both sides the car and the key are listed, antenna receiver, transmitter, microcontroller and respective demodulator and modulator, with an addition of actuator from the side of the car to perform actions of lock and unlock following the logic. Priority entry levels were removed and ranges modified. No physical hardware configuration was changes

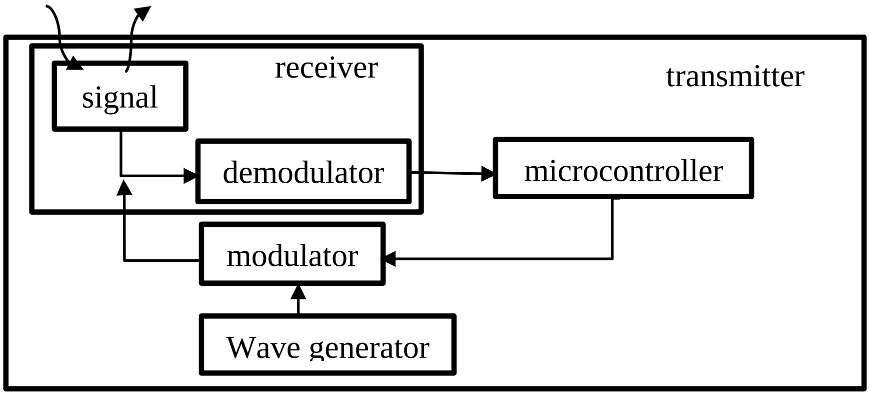


Figure 28. Key side schematic

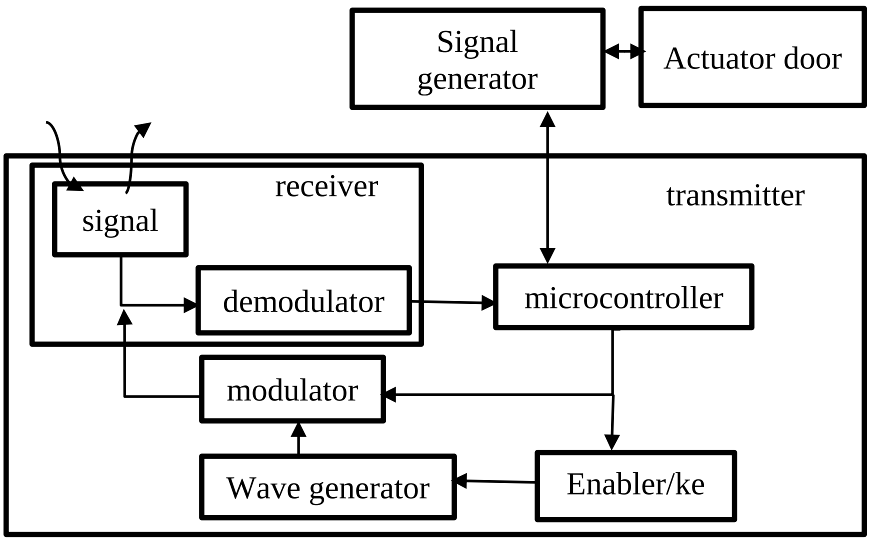


Figure 29.Car side schematic

Measurement

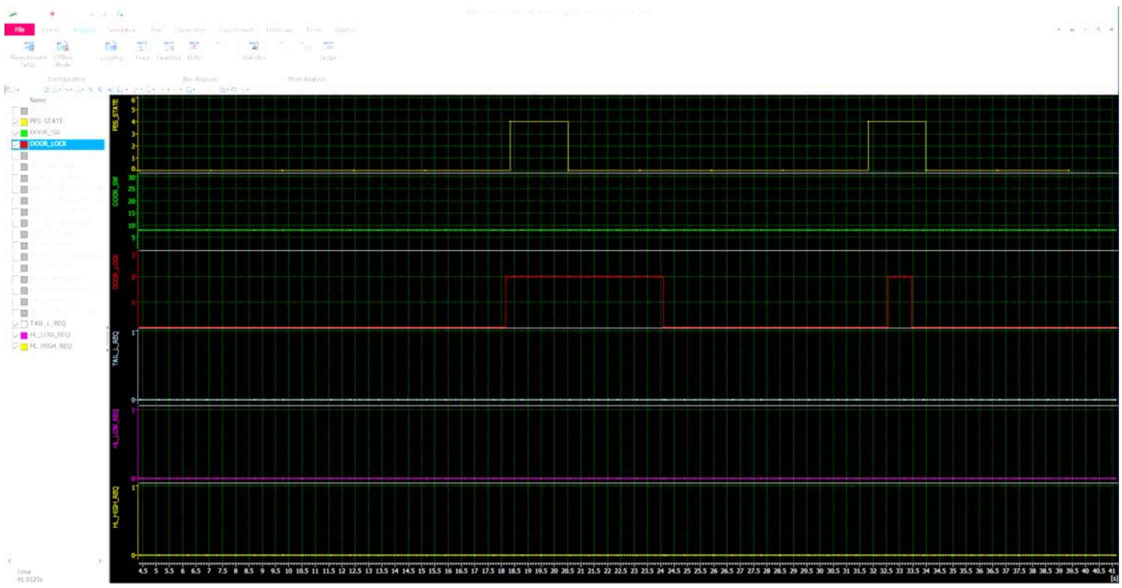


Figure 30. Signal voltage response

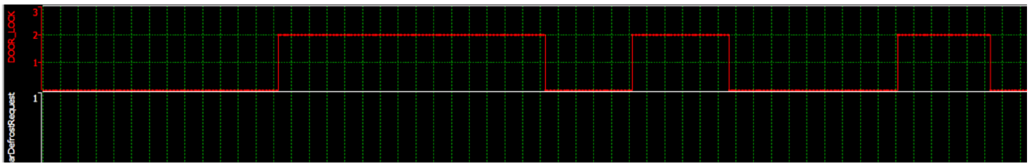


Figure 31. Lock/unlock signals

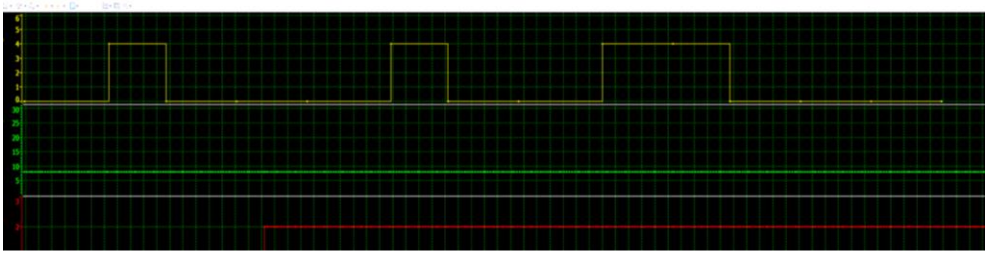


Figure 32. Passive entry state response

To initiate the data acquisition a security access for the key entry request an ID. If there is a mistake there would be display an error inside not been able to acquire or recognize the key that is been selected. Previous to any measurement the pairing or ID identification must be established and in a way learnt by the BCM that will be tested on. This is the specification for keys to perform the lock and unlock features.

As seen below

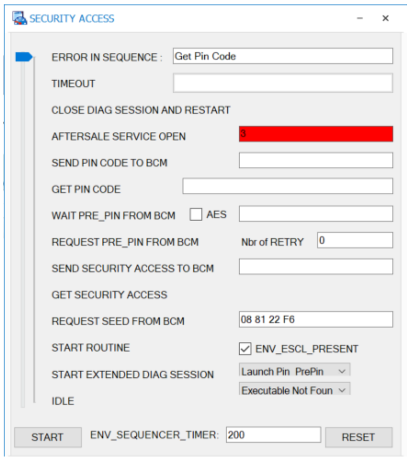


Figure 33. Identification refuse

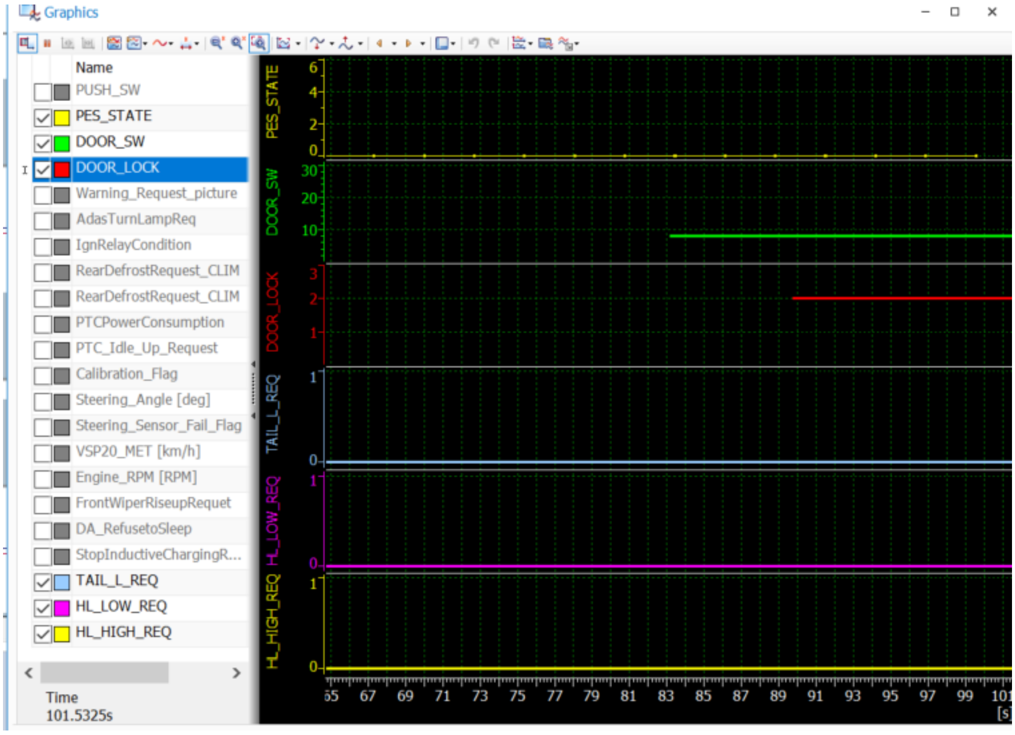


Figure 34. Response signal voltage, time

When the permission is granted the key recognized and the approapiate signal sent, the security access will allows the signals like the passive entry system to be activated. This is the signal that disregard the value will be interpreted as active or inactive in binary logic. The bus allows transmits various options from the concerned Passive entry state and door lock, as well as other test request that will not be activated when performing the key calibration. The x axis with time main show timing of less than 2 seconds in active and the transmission is 300 ms.

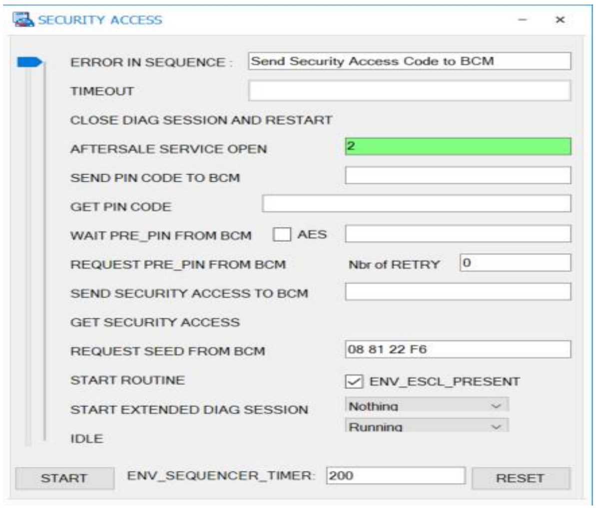


Figure 35. Security access granted

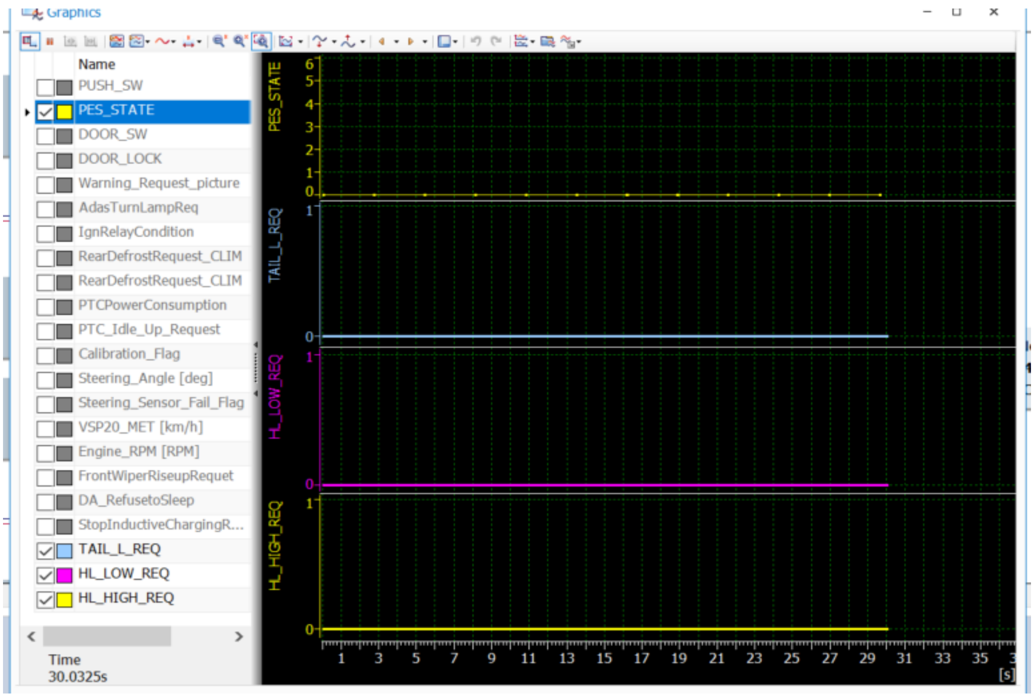


Figure 36.Signal response PES

Panels

There main functions requested remain as follows other non-essential data has been removed, the update configuration button will send the new antenna and threshold selection to a memory file to update the data from selected table compare to the sent stored and send the value display for coverage.

This panel also includes gap time that is time between two scenarios TX/Rx-Rx/Tx or constant sent transmission from the car. For more antenna options it will enter a different panel that was removed but left in memory as this could be used when antenna output is not in range not connected or not operating. RF refers to radiofrequency wavelengths adjustments and other further tests not related in this calibration process. The power options act for a wake up mode to send active mode to the ECU. Diagnostic will be used to perform connection tests. The configuration or selected antennas and phase are saved or loaded in a file that can be opened in CANoe.

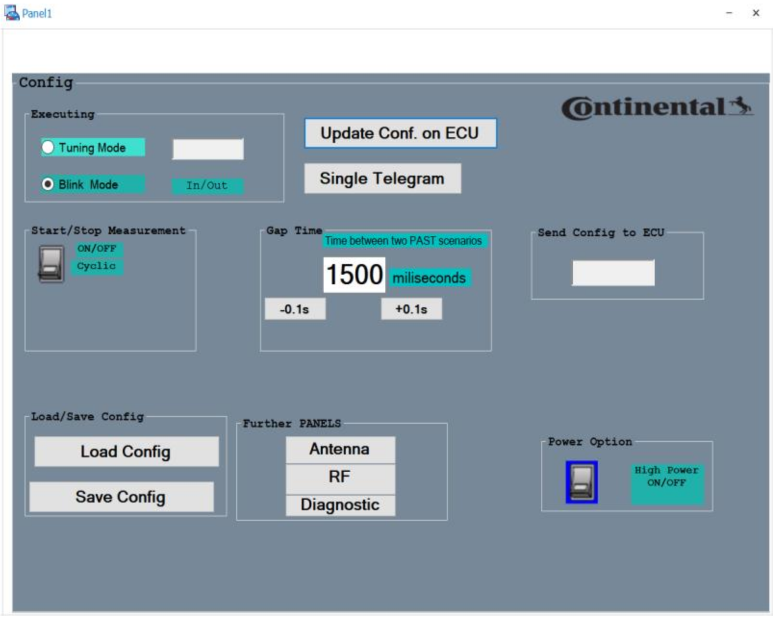


Figure 37. Panel control input

The main panel contents data antenna selection to trigger the signal at the correct configuration this will allow to get the value in nanotesla in the visible output by the output gate that varies depending on the proximity of the subject.

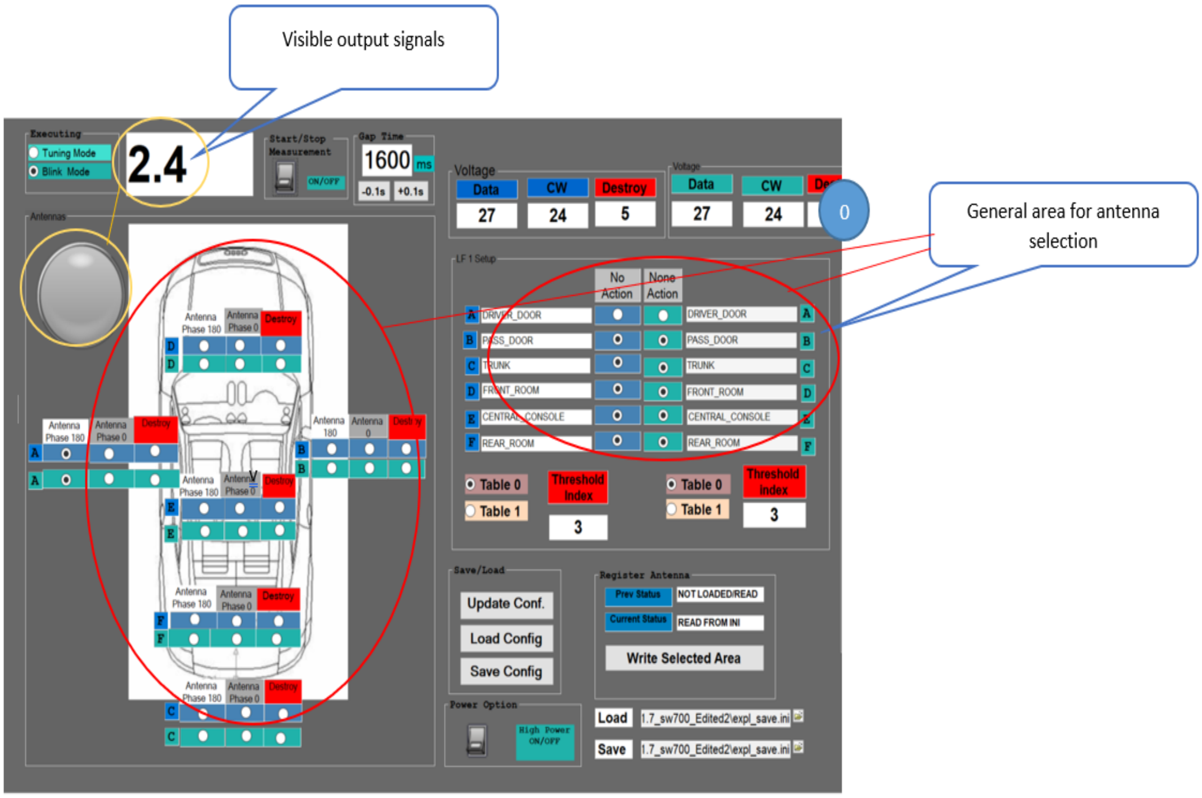


Figure 38. Main panel configuration

Data acquisition and values

The y axis represents voltages that will be applied vs the timing in yellow is the passive entry state in red the unlock performance the timings. For trusting it will be introduced inside vehicle configuration switch cases HEC_VehicleConfig name of the variable in hexadecimal to 0 or 1. Frame data will not collide as different bus is used.

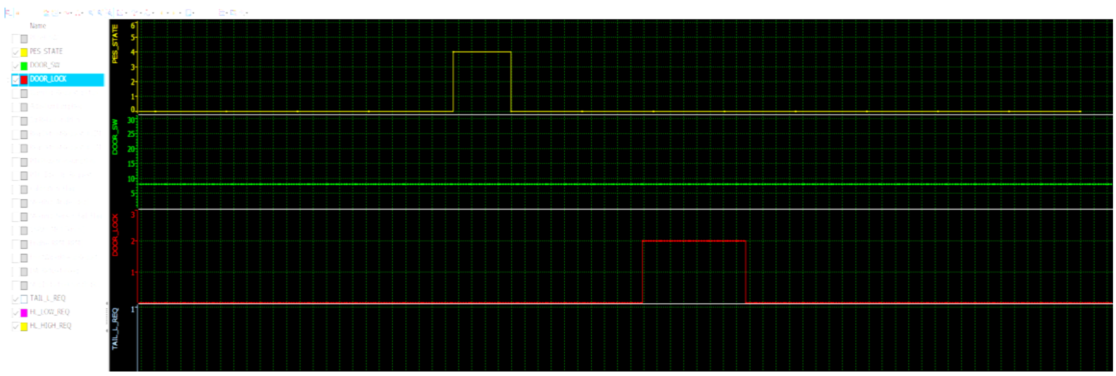


Figure 39. Acquisition voltage unlock pulse

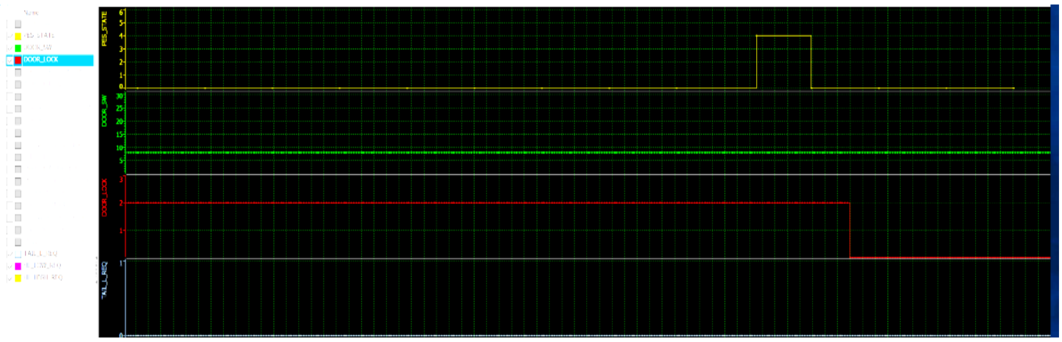


Figure 40. Active unlock signal response

Values for the threshold coverage obtained and introduced into the program are showed in nanotesla ad decimal numbers in the panel although inside they are in hexadecimal. The table 0 includes ranges that are from 4.5 to 15 in the first one including 0 for the calibration distance reset. And for lower values table 1 needs to be used, this includes also 0 and values of 15 to ensure on and off coverage.

Table 0

	nTp	Dec		nTp	Dec
0	0.00	0.00	9	9.00	3692.00
1	4.50	708.00	10	10.00	4701.67
2	5.00	871.67	11	11.00	5833.67
3	5.50	1117.67	12	12.00	7087.67
4	6.00	1393.67	13	13.00	8463.33
5	6.50	1700.67	14	14.00	9961.33
6	7.00	2038.00	15	15.00	11581.00
7	7.50	2405.67	16	15.00	11581.00
8	8.00	2804.33	17	15.00	11581.00

Table 1

	nTp	Dec		nTp	Dec
0	0.00	0.00	9	1.75	102.00
1	0.50	6.67	10	2.00	135.00
2	0.60	10.33	11	2.25	172.33
3	0.70	15.00	12	2.50	213.67
4	0.80	19.67	13	3.00	310.00
5	0.90	25.33	14	3.50	425.00
6	1.00	31.33	15	4.00	557.33
7	1.25	51.00	16	15.00	11581.00
8	1.50	74.00	17	15.00	11581.00

Figure 41. Table coverage in nanotesla

Performance

The test software automation performed by the side tool DIVA allows the selection of specific features and configuration of the requested data to be sent to the car BCM in order to acquire the correct data that will be interpreted as bit data and can be shown in a graphic interface. For the automation of the tests it could be used the capture and replay method performed in side software tools. The actual method is to select pieces and essential functions, to replay the tests.

This options are configuration of CANoe program that will be open, it must enter in ECU the appropriate program first to open the dialog box where it can be assigned to a CAN, the default for testing ABS system is shown below. There is a possibility to select the CAN bus directed as there can be more than acting in the memory of the unit.

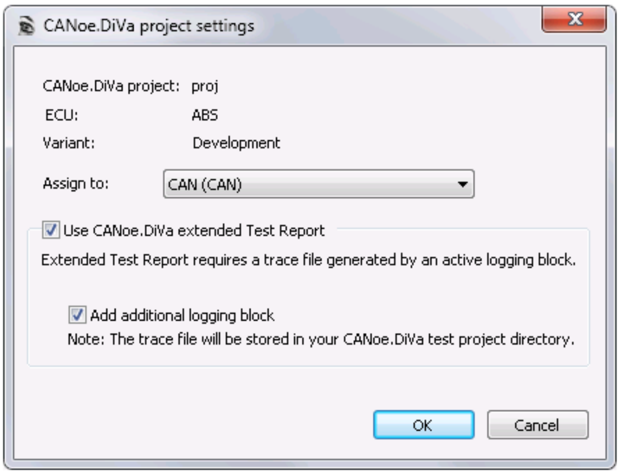


Figure 42. Diva import window for CANoe

The proposed automation remains on basic test configuration where the BCM data and timing is acquired in order to send with a signal generator the appropriate activation until the comparison no longer activates the start of the next test.

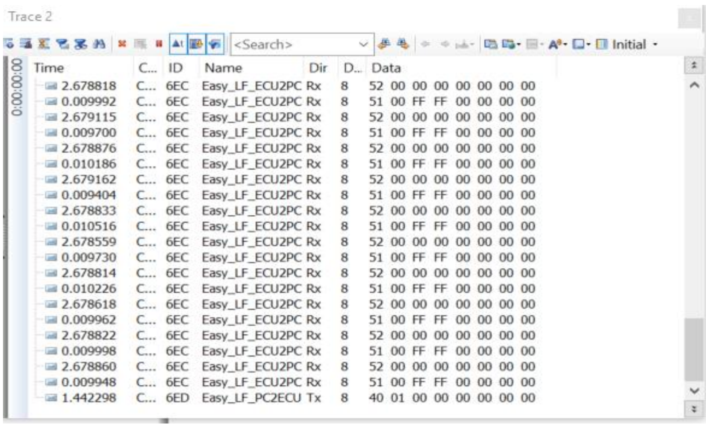


Figure 43. BCM data UDS code

A good performance is showed before where the appropriate data is sent during the period the signal is sent and then it changes to another data indicating transmission mode will start. The test is passed without errors as long as it does not encounter a flag activation for an alert in the data to be checked.

Inside the automation feature after importing with appropriate timing and selected an ECU the tests must be ticked or checked. The measurement is stooped automatically below 5 minutes

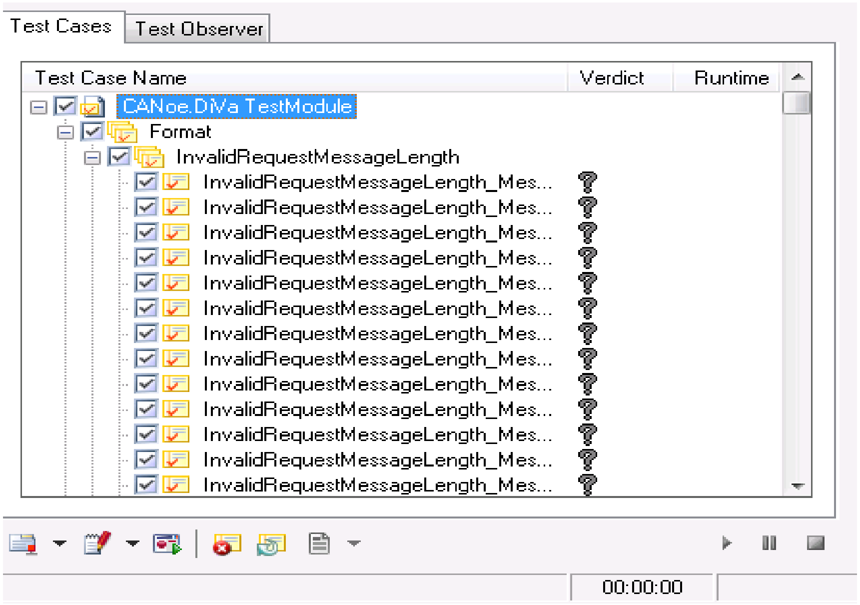


Figure 44. Test selection for automatic test pass

The data will be sent in red when power 12 volts is not connected or BCM or inversed resistance previously searched to be for the loop antenna around the 300-400kΩ.

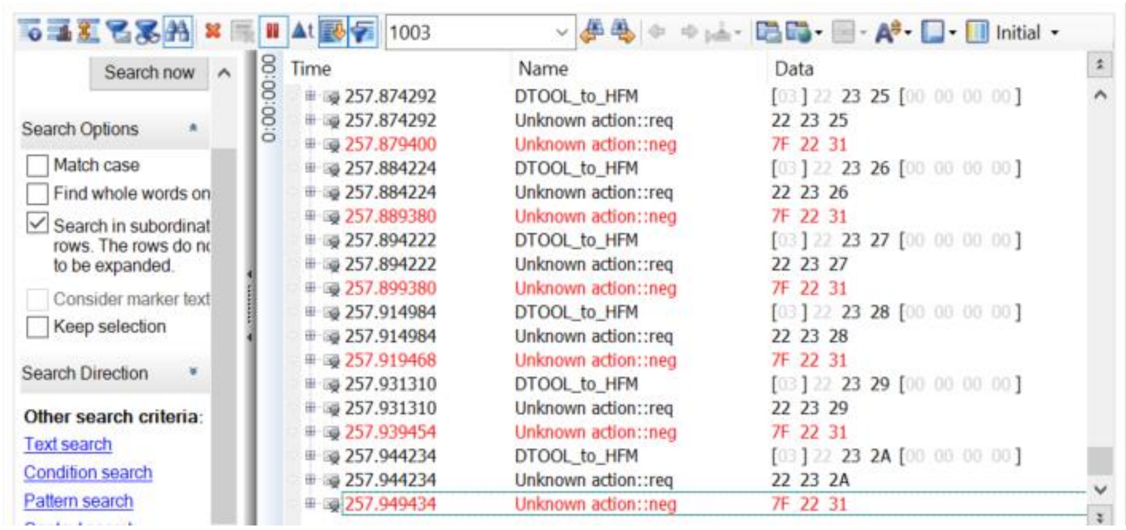


Figure 45. Data ECU communication

If the BCM is recognized data framed will be passes with the first bits or authentication and the others to ensure a communication of the changing values.

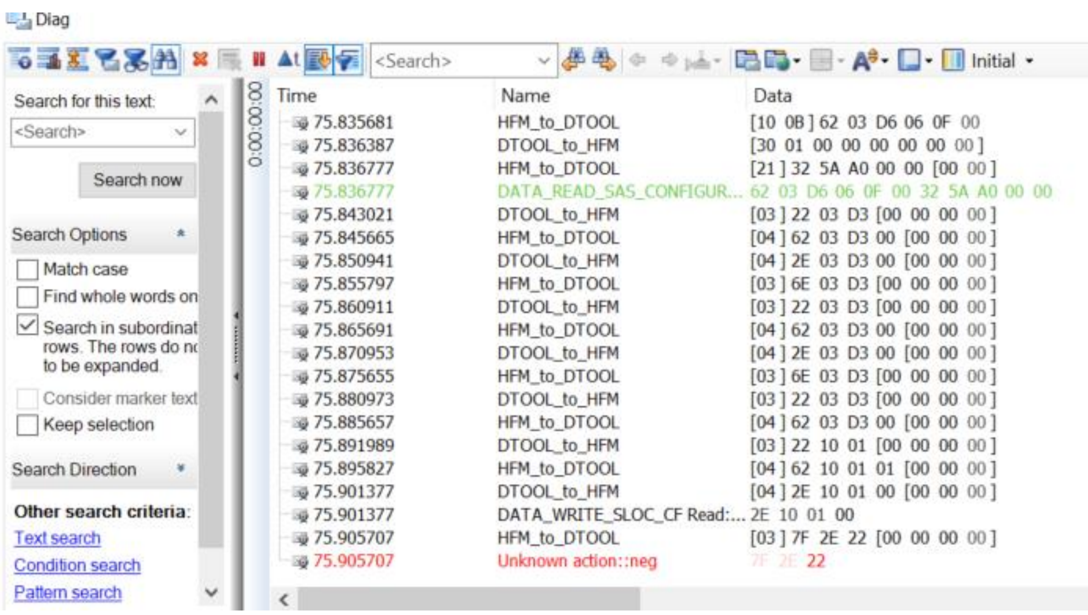


Figure 46. Data ECU communication

For the test configuration export to perform in Canoe Values for identification should be entered in hexadecimal this are dependent on the average value already provided 31 for identifier and can vary in tens.

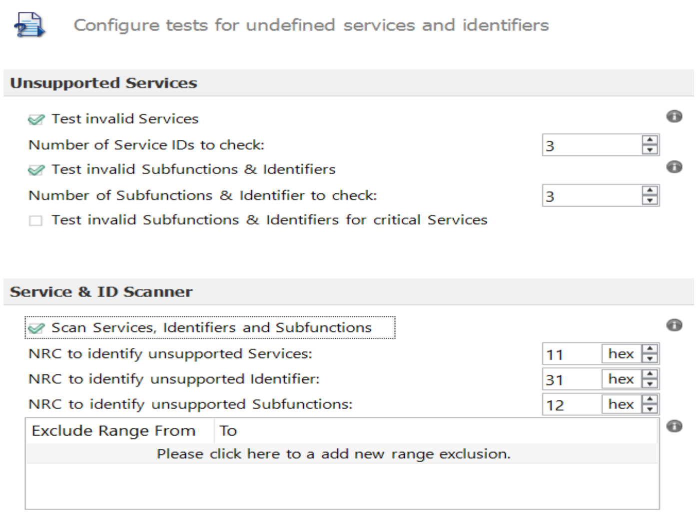


Figure 47.Test configuration ID

The timing adjustments are for the entry of the key must be taken into account but are around 130 ms as the time for response once the data is transmitted will follow the logic of highest value comparison. In simple words the fail or pass test will exit the loop after 180 ms or the selected in this part of the configuration for the tests.

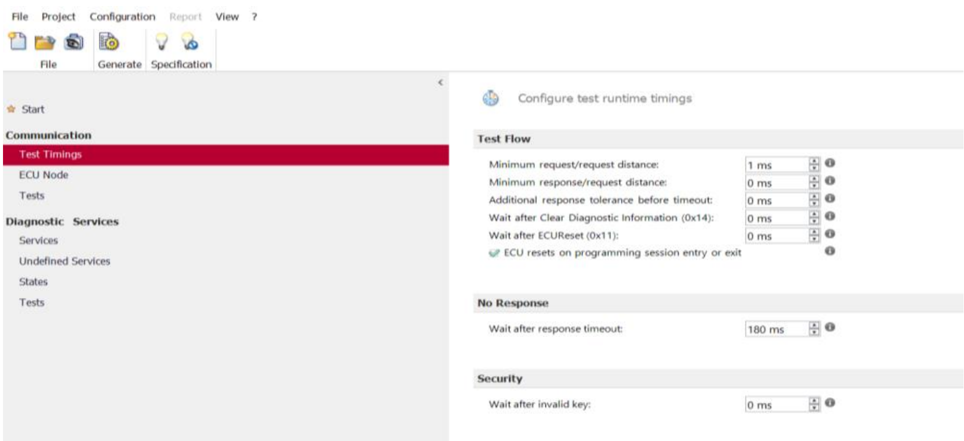


Figure 48.Test configuration

Finally, after the tests are executed information summary with the passed and failed sectors are sent. The focus must be on the failed tests as it indicates that some signal is not synchronized, the communication is not sent because of an interference, the voltage is not being sent, another antenna has been fired or any data reception from the key or remote devices have been corrupted.

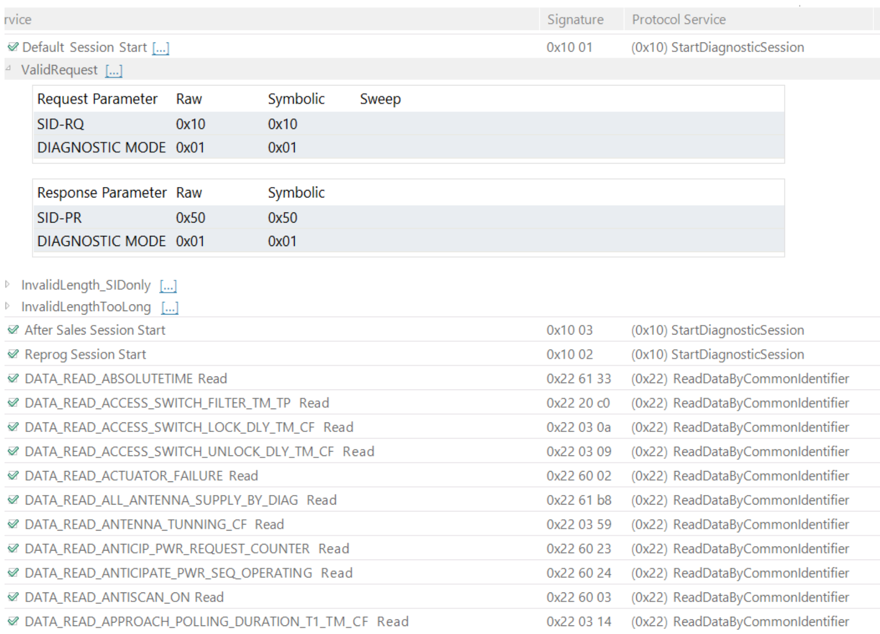


Figure 50.DIVA test selection

CONCLUSIONS

Conclusions and highlights

- The objective was achieved by developing a new calibration tool compatible with the new software, limiting and removing previous unused ranges.

- There is no need of a flux meter to perform the calibration in situ as the actual implemented tool provides a table with correct ranges for hands free key fob and this values are used to translate in the programing as detection access for the unlock or lock.

- The values found for the magnetic field covered by the antennas has an average of 4.5 nt for the lowest detection value, with varying ranges from 0 to 15 nt.

- There was a need to include values below 4.5nt in another table with varying ranges from 0 to 4 because they are used to perform other type of near field calibration.

- Changes in the key fob antennas sizes and reach range requires the need of manual input from the user performing the test, therefore t was implemented an automatic setup for the reference used voltages are 25V and 2000 ms for the gap time with possibility of changing ranges. This values are an average of the values commonly used from previous past data.

- The tuning test for calibration found for the executed calibration a required output from 8 to 13 in threshold meaning the approximation coverage for the magnetic flux is an average of 13 nt at a reference 2 m distance from the car.

- A visual panel with for the reach ranges was provided because the configuration of the antennas position in the car needed a visual aid for the selection when performing measurements for the calibration of the key.

- Predetermined values where introduced in the internal code to interpret the voltages and data received in the CAN bus.

- One of the objectives was to evaluate the new feature in the testing tool, this feature DIVA used that provided automated selection of the entries. The most relevant contribution of it is better timing. It proved to be more efficient with times in the normal test of less than 5 minutes while without it the test will require manual selection and average time of 20 minutes due to the need of discrimination of not required data.

Recommendations and future work

- The hand free key system configuration related to size and trans receiver are in continue development, a range of around 1 nanotesla should always be left to expect new changes

- Ancient technology is still in circulation and also new cars key fobs are based on the same principle as the previous ones, therefore a table ranges should be provided periodically in order to keep up to date.

- The test automation performed could implement sonorous alarms in order to avoid the need of a monitor

- For the future work there is a requirement of an update in other automotive test like engine start, electronic automatic lighting related to a friendlier user introduction of parameters related to range calibration and signal reproduction.

- The evaluated feature DIVA has a similar environment as the one in actual use, some other actions that could be configured, if a new actualization must be done it is recommended to acquire the tool for faster tests performances but the downside is the high cost and limited market.

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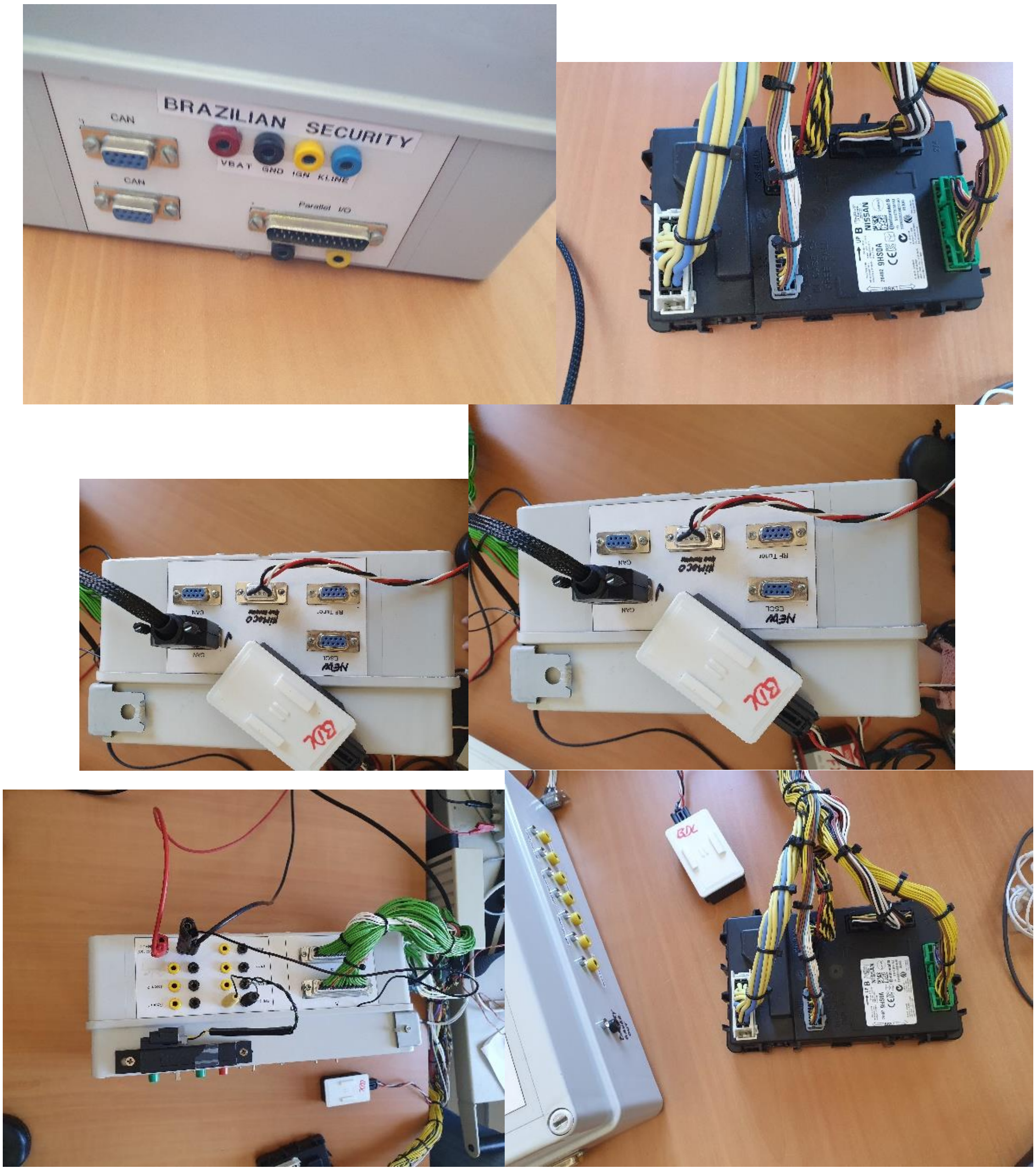
van Niekerk, J. (2002). Matching Small Loop Antennas to rfPIC™ Devices. Application Note AN831, 5.

ÍNDICE DE ANEXOS

ANEXO A: TEST BENCH EQUIPMENT



ANEXO B: USER GUIDE

EasyTuning Tool

MANUAL

System:

Vehicle key fob calibration

June 2020

Revision Sheet

Release No.	Date	Revision Description
Rev. 0	09/01/2020	User’s Manual

User’s Manual
Easy tuning

The following manual is used to describe the general functions of the tuning tool and how to use it. This one is used to perform the calibration of the wireless key fob to adjust the reaching ranges according to the different shape of the car and the needs of the user.

DATE 2020

USER'S MANUAL

TABLE OF CONTENTS

Page #

1.0 GENERAL INFORMATION

A. GENERAL INFORMATION

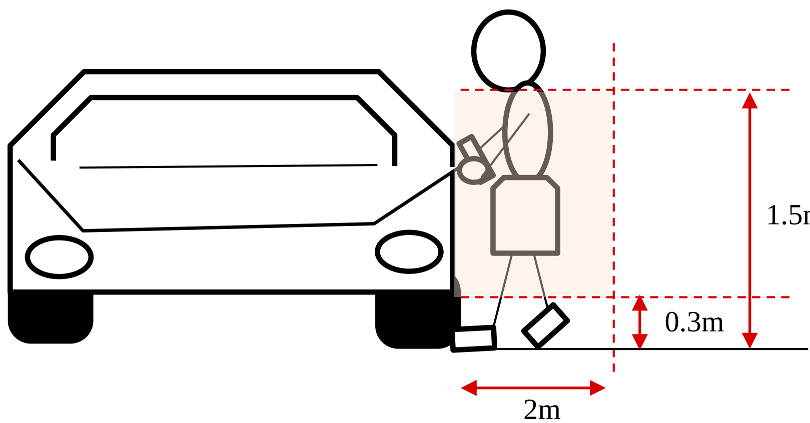
1.1 System Overview

Easy tuning tool is based in the program CANoe/CANanalyzer, therefore the communication is based in a Controller Area Network bus that helps communicate the microcontroller and devices like the ECU (electronic control unit) mounted inside the car in order to get the exchange of information between the antennas and the hand free key fob. These antennas are mounted on the vehicle and evenly distributed inside and outside the perimeter in order to make a full coverage of the surroundings, emitting a radiofrequency signal that will communicate with the passive wireless electronic device, the key fob.

1.2 Method

The tuning can be performed for the exterior and the other one for the internal part.
For the ranges in the outside the worst-case scenario will be considered, that is a distance from the car to the key fob around 1.10 at 2 meters it will be detected as it has left the reaching ranges.

Customer targets are following:



A calibration is performed following some considerations. For example, in the tuning for exterior part, the selected power for the antennas should be the maximum. At the driver and the passenger door antenna the maximum value is 22 Vpp, for the trunk at the back of the car will be 28Vpp. The values that will be recovered are the fields strength measured in nT. When using the tuning mode, the RSSI value will be 0. These are the ones indicated in the table and for the threshold to be set. The destroy bit is around 5 V, it can also be adjusted if the crosstalk still present. For the blinking mode the ranges will be checked, this allows to know the distances and heights limits.

1.4 Vehicles status

1.4.1 Position of the antennas

The antennas areas outside cover the following:

- Driver door
  - *Location:* usually located inside or closer to the handles in the side where the driver will be getting inside the car, the steering wheel side.
- Passenger door
  - *Location:* mostly found inside or closer to the handles of the opposite side of the driver's door. The passenger door may include the doors in the back seats, depending on the model there may be more than one. This is referred mostly like the assistant door.
- Trunk
  - *Location:* this refers to the door that opens the trunk. This is mostly located in the back of the car, the bumper. This is the luggage compartment.

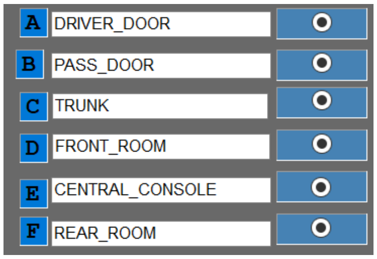
The antennas areas inside cover the following:

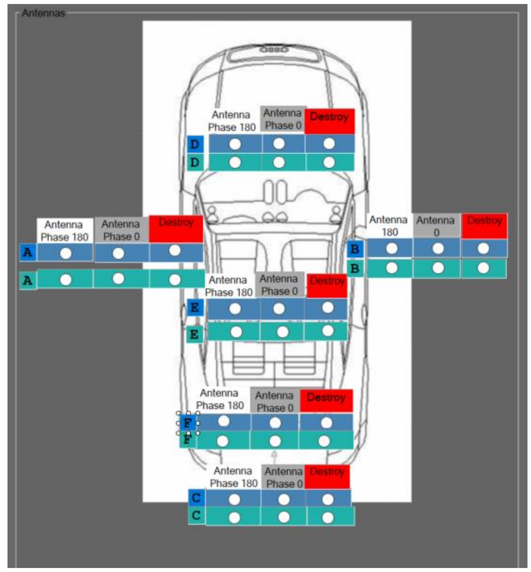
- Front room
  - *Location:* The antenna is allocated in the frontal panel are to make a coverage of the internal part of the vehicle

- Central console
  - *Location:* The central console the major part of the vehicle as it is in the middle central part of the car.

- Rear room
  - *Location:* This refers to the back inside part of the car, not the trunk door.

A visual aid is provided in the tool for a better selection of the antenna area selection. There is selection of the same areas with the same antennas as a backup configuration. Can be used to create a different signal shape from the signals emitted from the antennas.





1.4.2 Reference of antennas

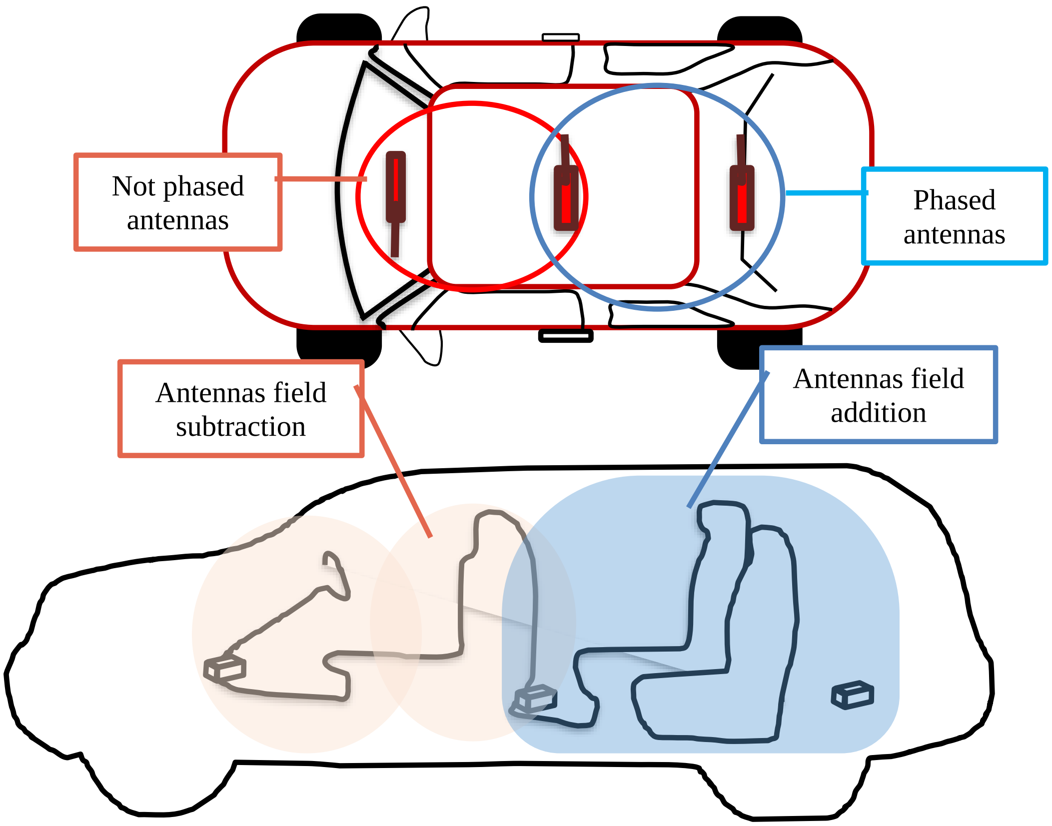
Some verifications related to the antennas should be performed when doing the tuning. To perform the verification in the vehicle, the first step will be the antenna power check.

Antenna	Atic64 outputs configuration	Vpp Atic
Driver door	2 half bridges in //	28V
Assistant door	2 half bridges in //	28V
Bumper	Half	28V
Room1	Half	28V
Room2	Half	28V
Trunk	Half	28V

1.4.3 Antenna phases

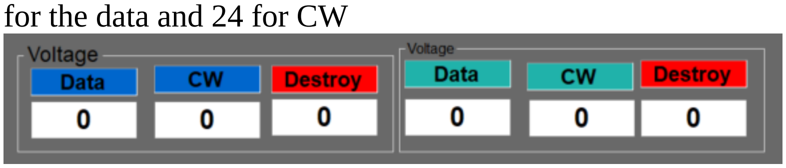
It is important to verify that the antennas are mounted as expected, this includes that the phases of this ones are correctly selected in order to cover all the surroundings.
The selection of these phases is to from 0° to an opposite of 180° in order to be able to play with the shape of the field surrounding the car. For instance, for the activation of the interior antennas it is recommended to perform the actions in pairs. For example, to be able to see the field effect from the phases it would be useful to select the front and central antenna with the same phase and a low power. Then change the phase from the central antenna and measure the field. This allow to choose the configuration with the highest field. This will be repeated for the central and trunk. The phases can be selected in diphase to be able to get a higher internal coverage.

This can also be performed with the external antennas. Activating by pairs first the antenna corresponding to the driver door and the trunk, then changing the phase from the driver door, and with this getting the highest measured field. The phase from the trunk is import s it will be kept while the phase with the passenger and other doors may change. This should be especially careful seeing the fields from the corners.



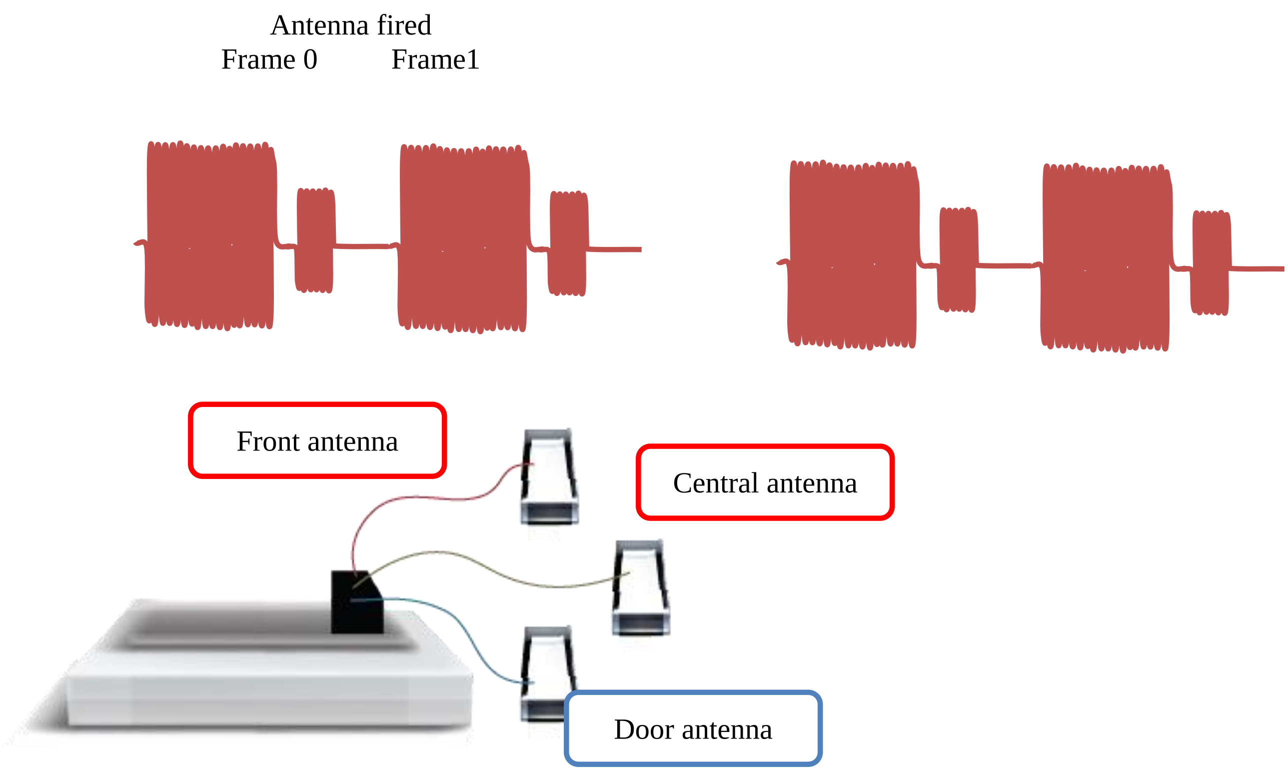
1.4.4 Power received by the antennas

The values of power sent to the antennas will include the data for the power from the antenna, the next value to be inserted is the RSSI received signal strength indicator that is related to the power level transmission at the receiver end, labeled CW current value. Some start values are 27 for the data and 24 for CW



1.4.5 Destroy bit

This is a bit sent to eliminate the undesired crosstalk (proximity of cables) that can be caused by antennas not fired in the proximity of the area selected.
In this case Front area and Central console antennas are fired:



1.6 Acronyms and Abbreviations

Some useful acronyms used

CAN: controller area network
ECU: electronic control unit
EMR electromagnetic radiation
BCM: body control module
RSSI: received signal strength
RF: radio frequency
RX: receiver/ receive
TX: transmit/ transmitter

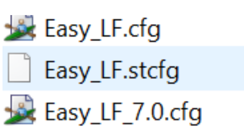
2.0 GETTING STARTED

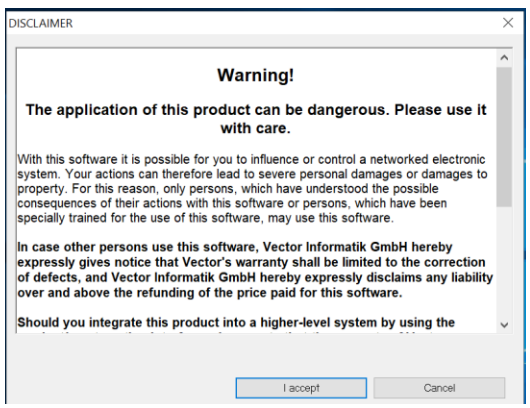
B. GETTING STARTED

Previously requirements include installation of CANoe/CANalyzer tool with a programmable version, hardware connection (Vector). Test bench (test bench the provided voltage is 12V) or real test communication with the car BCM (body control module). This may include the car key fob, antenna, NIMOCO (antenna communication), ECU (electronic communication unit), valid key fobs.

2.1 Starting Program

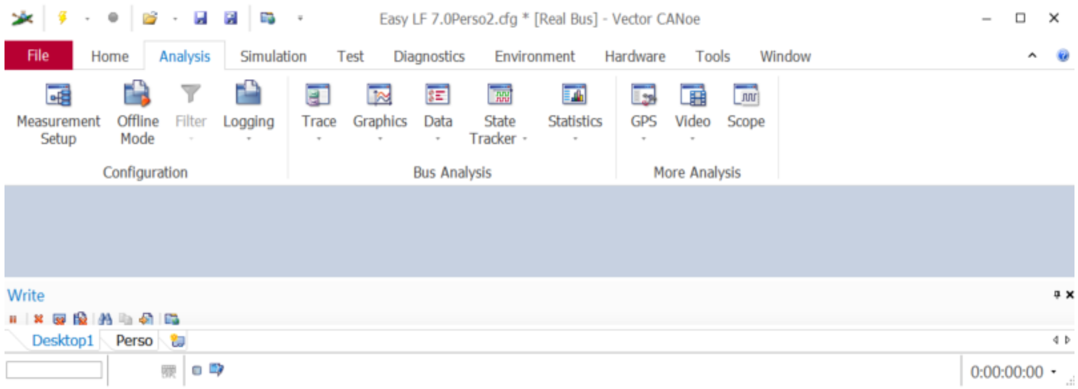
Initialize tool, open the file with .cfg extension. This is the configuration file that will automatically open the main screen and the panels with the tool to be tested. The program will initialize with a disclaimer of the use of the program as it will change crucial information related to the car electronic components and its configuration.



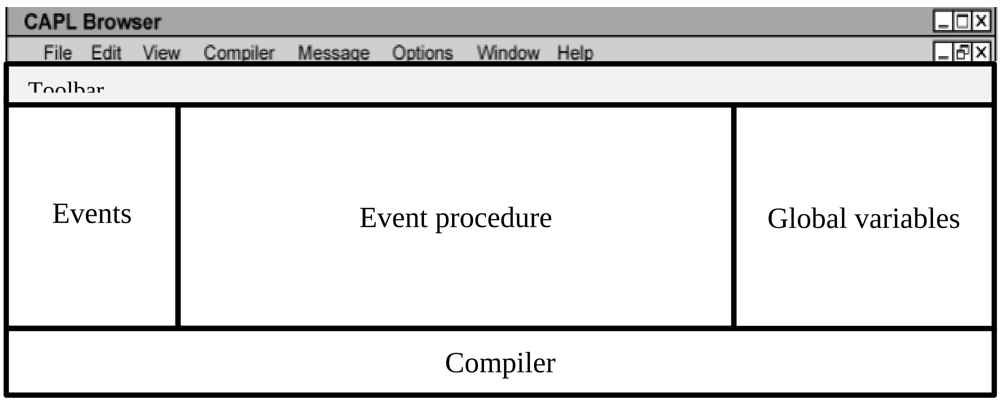


2.2 Default browser

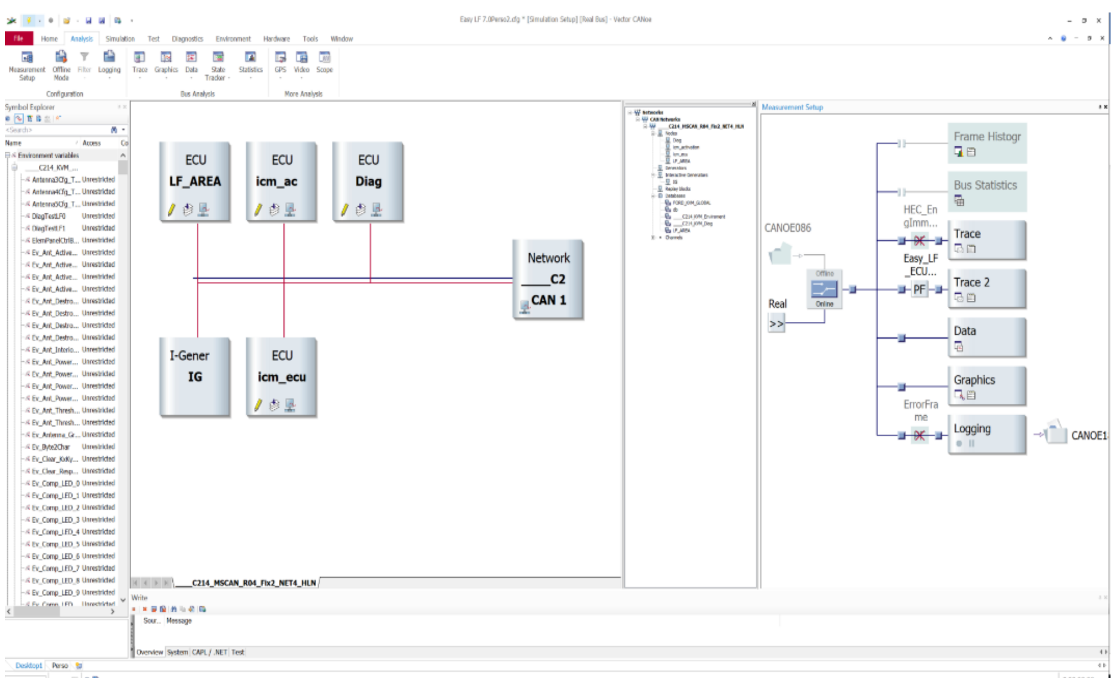
The default menu window will not show more open windows in the main body, although if it has been previously modified it will show some added windows in the main body, like the measurement setup and the CAN configuration.



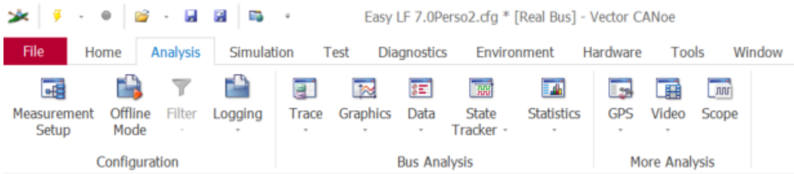
The general configuration to edit the program will include a CAPL browser with the main panels. In the left side there will be a panel for the events, the right part when editing will include the global variables, and event procedure. In the lower part there is useful messages for the compiler.



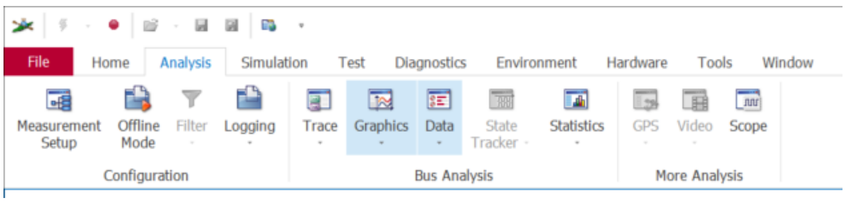
Other panels that might open when a previous configuration is setup



2.2.1 Useful buttons from start window



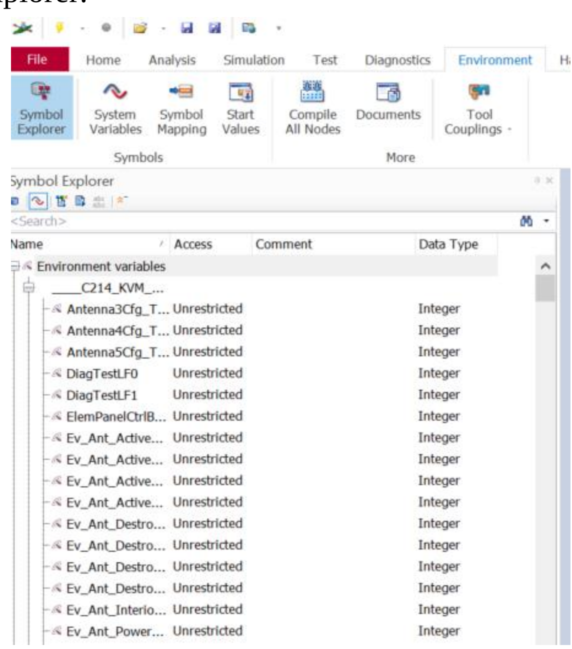
Some useful buttons include the start lighting icon, next to it is a button that stops the simulation or the test. Must be pushed every time a new configuration is realized.

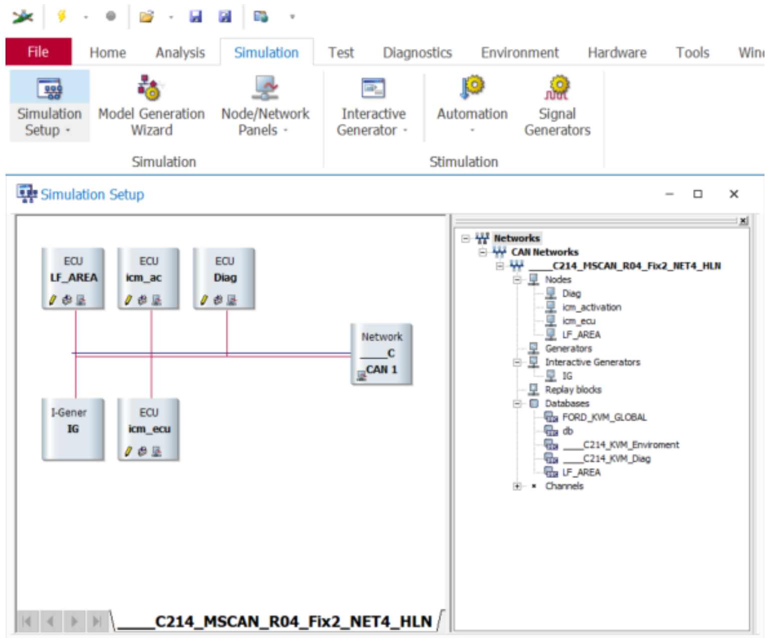


Other useful panels to get visual idea of the CAN configuration are the measurement setup, the simulation setup, the symbol explorer to the left the trace in the lower part.
The trace window shows a list of all bus activities, messages, warning, errors and further values is required.
The graphic window will display the values over a time axis with real-time tests.

To open some useful panels, go to the tabs at the top of the window.

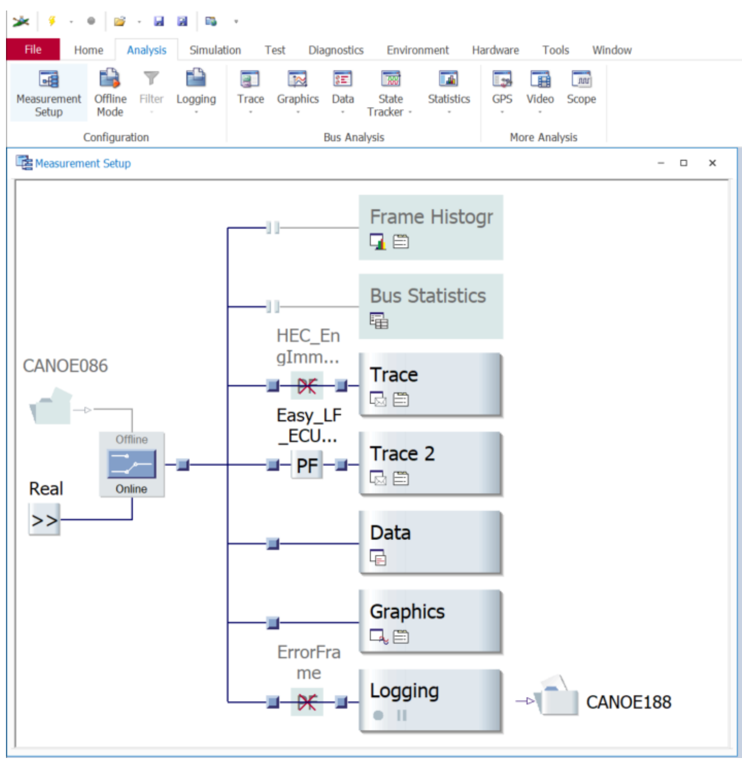
To open the symbol explorer related to the variables used thought out the program go to environment, symbol explorer.





To open the simulation setup, go to Simulation and click in the simulation setup icon.

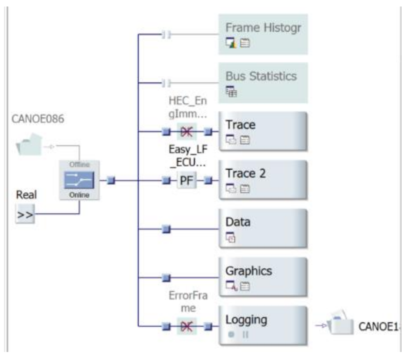
To open the measurement setup, go to Analysis, Measurement setup.



This panels are useful to display the connections and dependencies of the bus configuration

2.3 Measurement setup

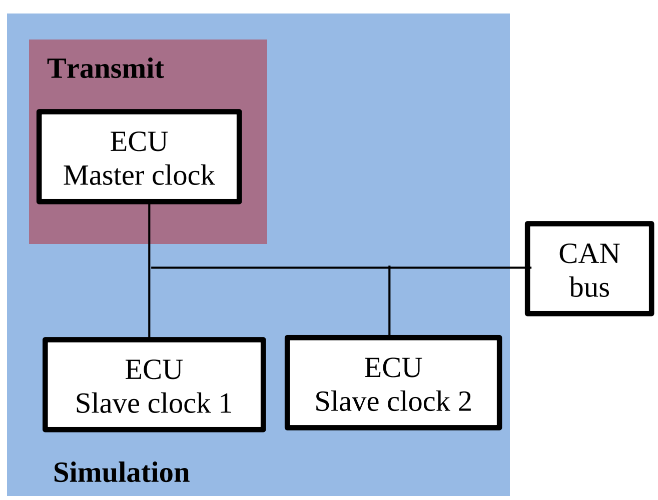
For graphical display and parameterization of function blocks and evaluation functions
Sign into the Web Interface.
Click Settings at the top of the main page, and open the Accounts and Import tab.
Click on Account settings.
In the new window, click Change password under the Personal information option.
Enter your current password and your new password.



2.4 Simulation setup

The panel simulation setup shows a summary of the stablished communication structure. This environment allows more than one node at the time. The division into individual nodes provides a reusable system.

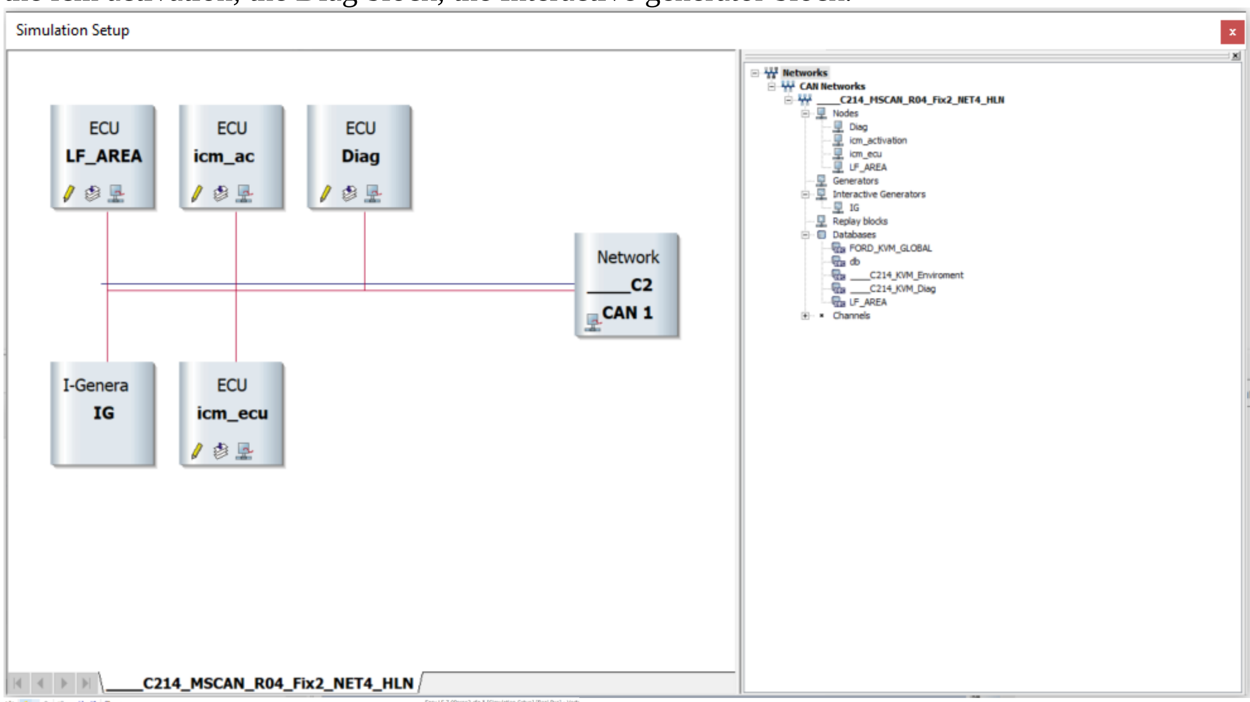
The general configuration of the network can be organized into blocks, the Transmit Branch to Simulation Branch and the CAN bus.

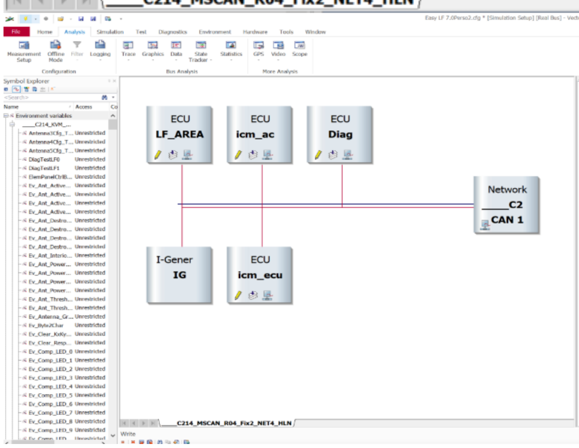


This distribution is possible because this program supports multiple CAN network system simulations. On a vehicle it would usually be useful to simulate various CAN networks at the same time.

Moreover, it can be used as a gateway for sharing data from different networks when node simulations are not necessary.

In this particular configuration for the simulation setup, it is divided in 5 blocks. The LF_AREA, the icm activation, the Diag block, the Interactive generator block.





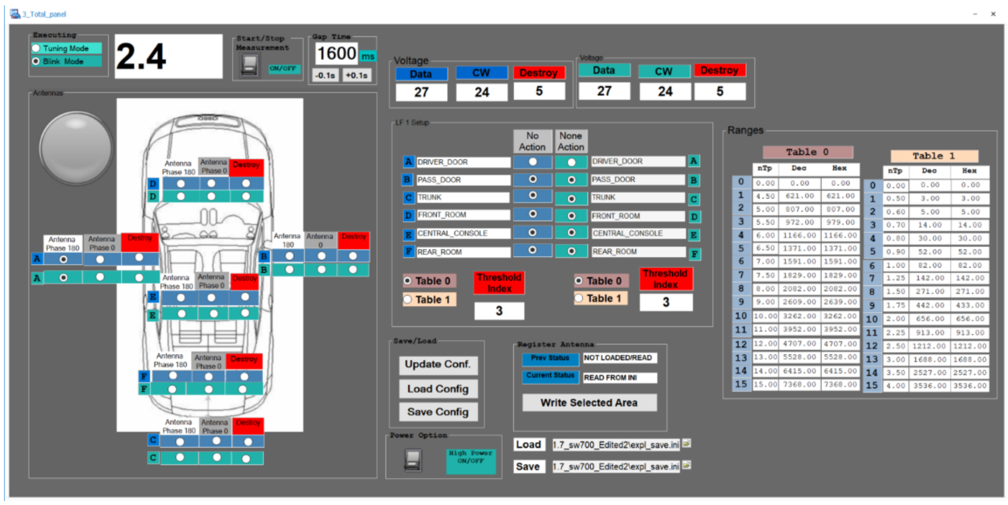
In this window the display of the Can communication can set

2.5 Initialization

Connect the hardware to the computer, start the simulation and use the interactive panel.

2.5.1 Panel calibration

The following panel displays all the functions to be used when performing the calibration, this provides a summary and interactive view of the antennas, voltages, threshold tables and file options to save data.



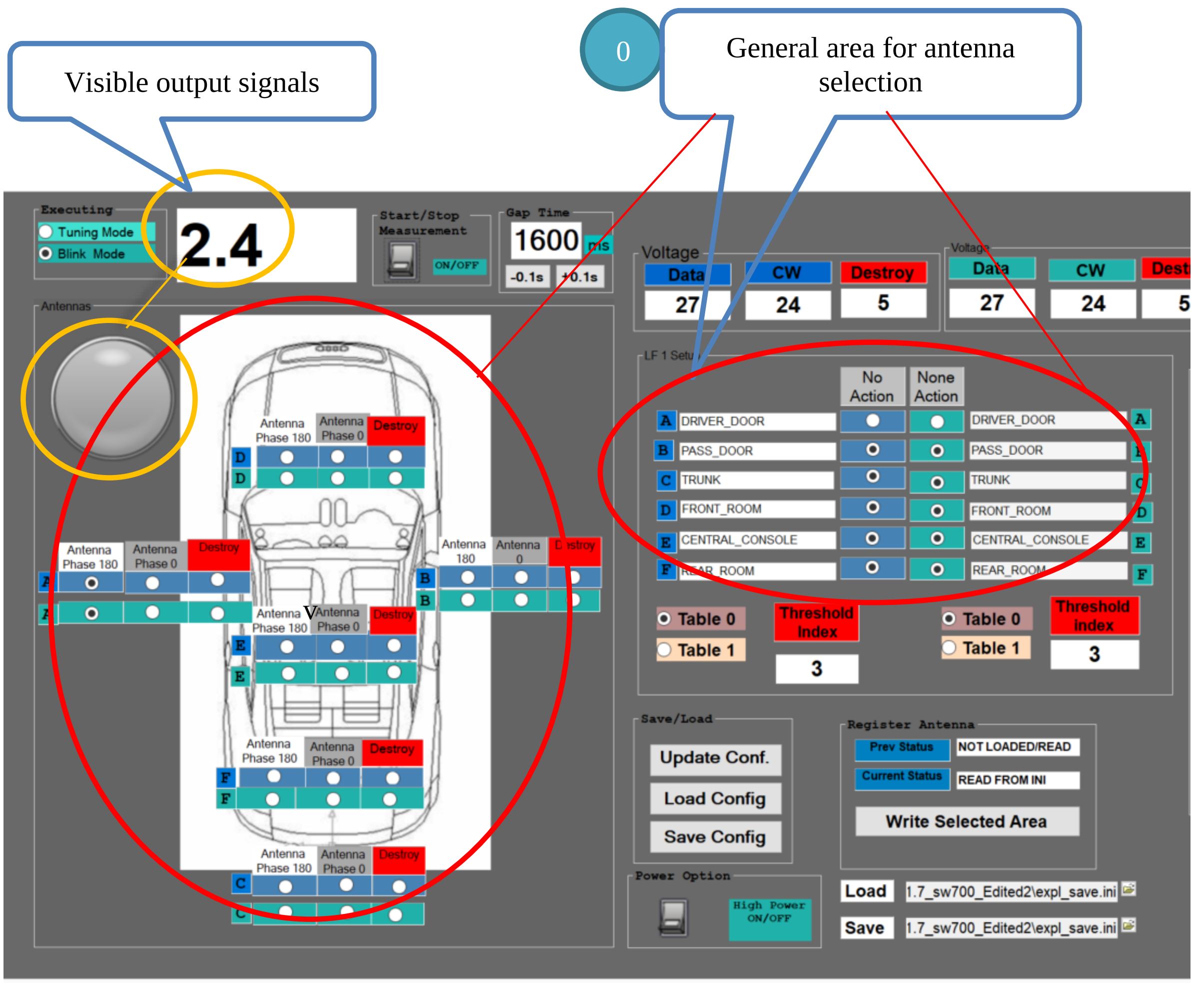
3.0 USING THE TOOL WITH THE MAIN PANEL

This panel consists of various sub windows that will help in the realization of the calibration for the key fobs.

C. STEPS FOR TUNNING

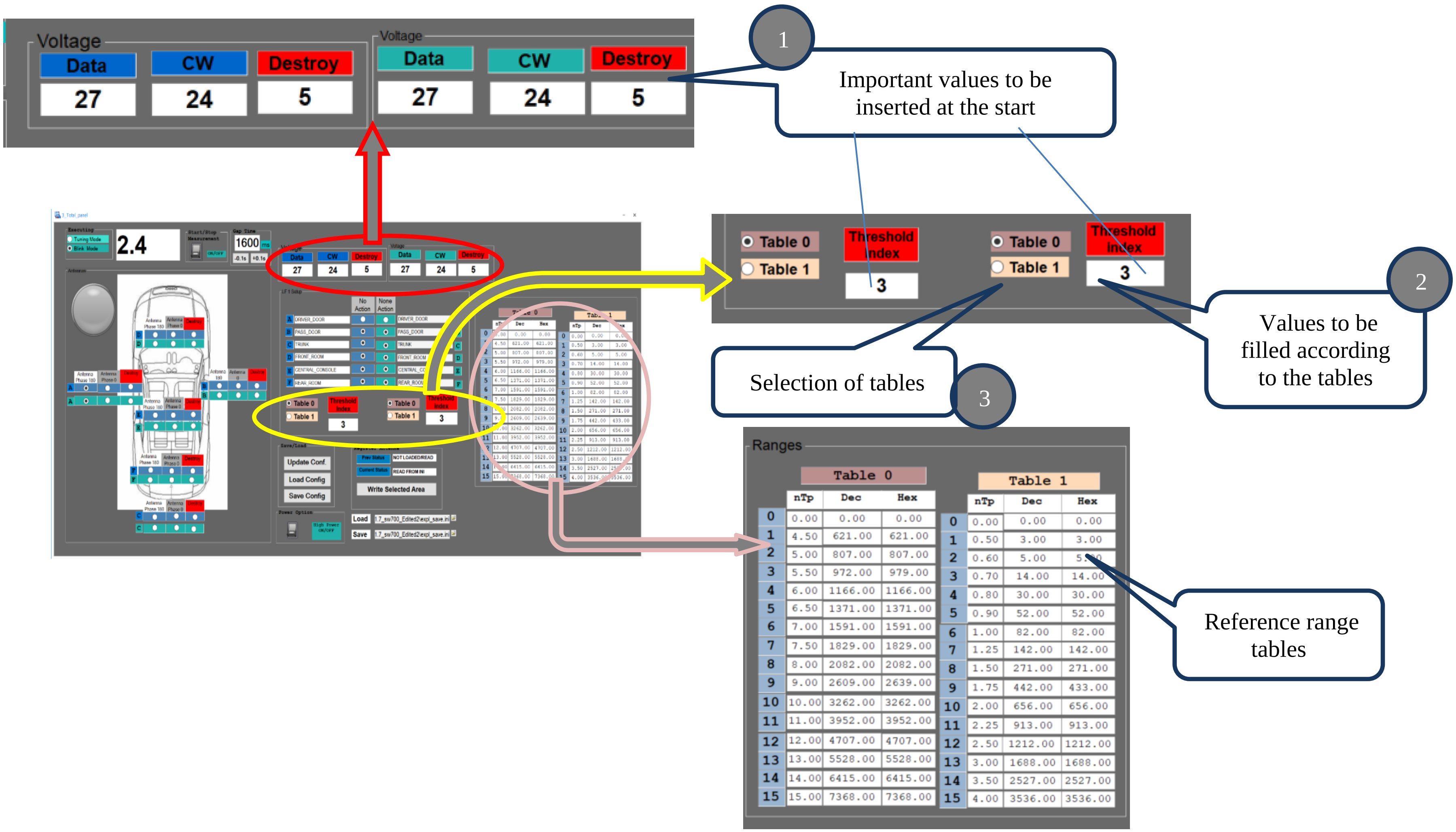
The first general step is to select the antennas that will take part in the tuning tests. An intuitive graphic has been added to show the position of the antennas in order to select them. There are two phases for the antenna that will intervene in the general shape of the radius of coverage from the electromagnetic signal that surrounds the car. The full coverage should be obtained by varying these parameters depending on the needs. Also, the selection of the antennas includes a destroy bit to avoid the diaphone of the closest antennas that would not like to intervene in the measurement.

3.1 Configuration



3.2 Values insertion

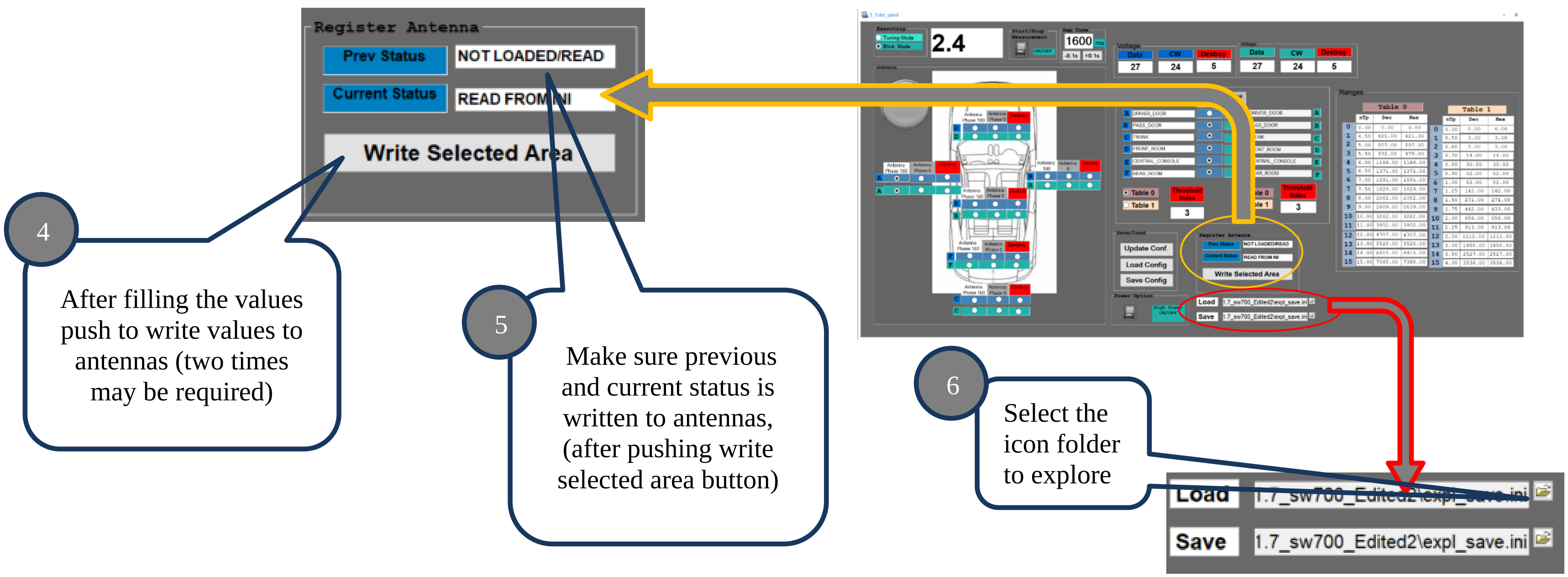
Data value shows the value introduced for voltage, the CW is the RSSI and Destroy refers to the value sent for the destroy bit. The index threshold must be chosen according to the tables showed.



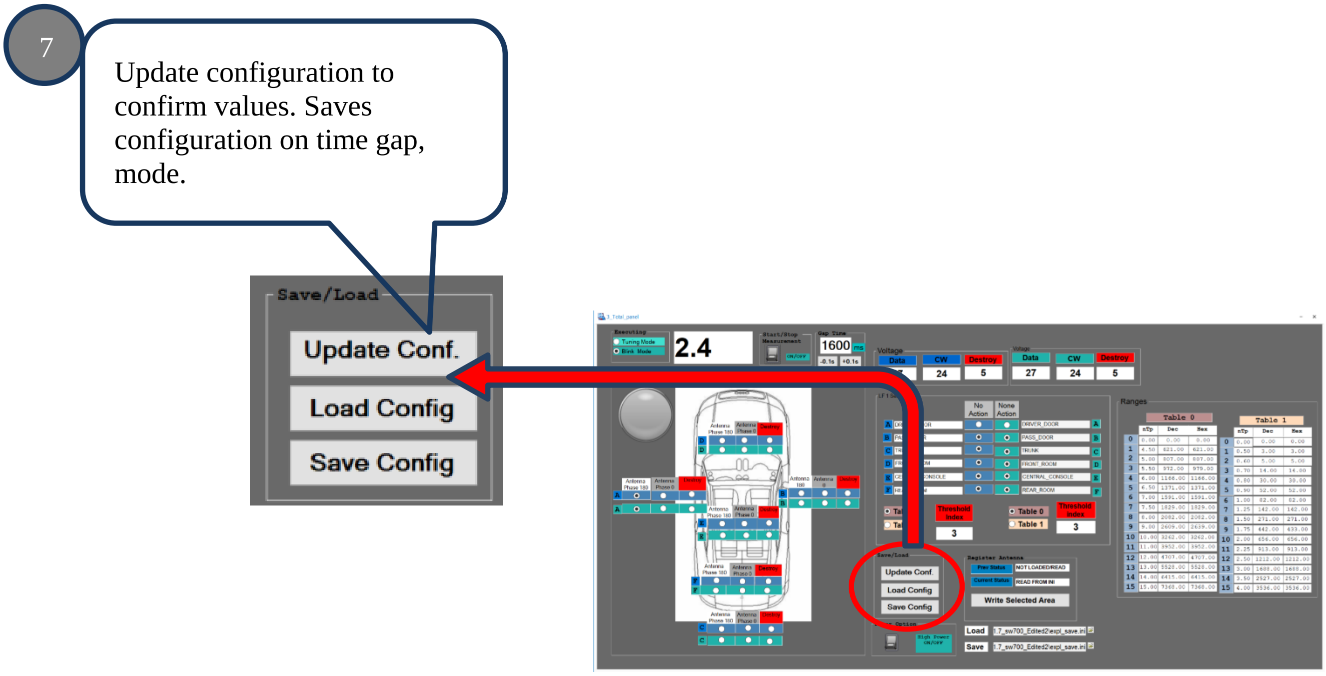
3.3 Saving, Writing, Loading options

3.3.1 Saving, loading, update configuration

In order to register the configuration and write the information to the antennas selected in the first steps it is required to push the write button, the first time it will show the current status as written, push another time so that the previous and current status is written.
There is the option of saving and loading the current information of the selected antennas to be tested as document with a .ini extension. The name and destination can be chosen by the user. The configuration will return to its default values when stopped, therefore, to initialize with a previous configuration select in load the file previously saved.

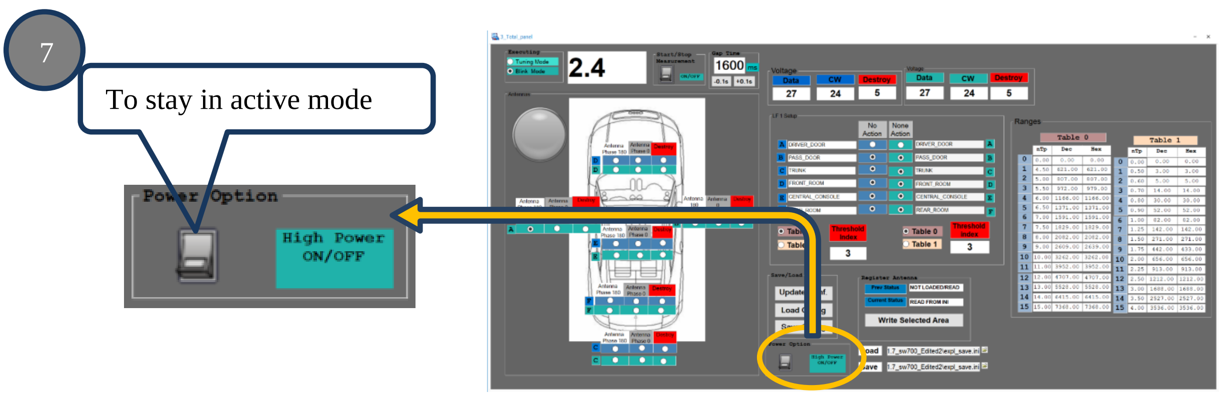


To save the values in the gap time and the selected mode, tuning or blink mode use the buttons save and load config.
In order to confirm the configuration selected or to make sure the values where written to the antenna, use the update config button.



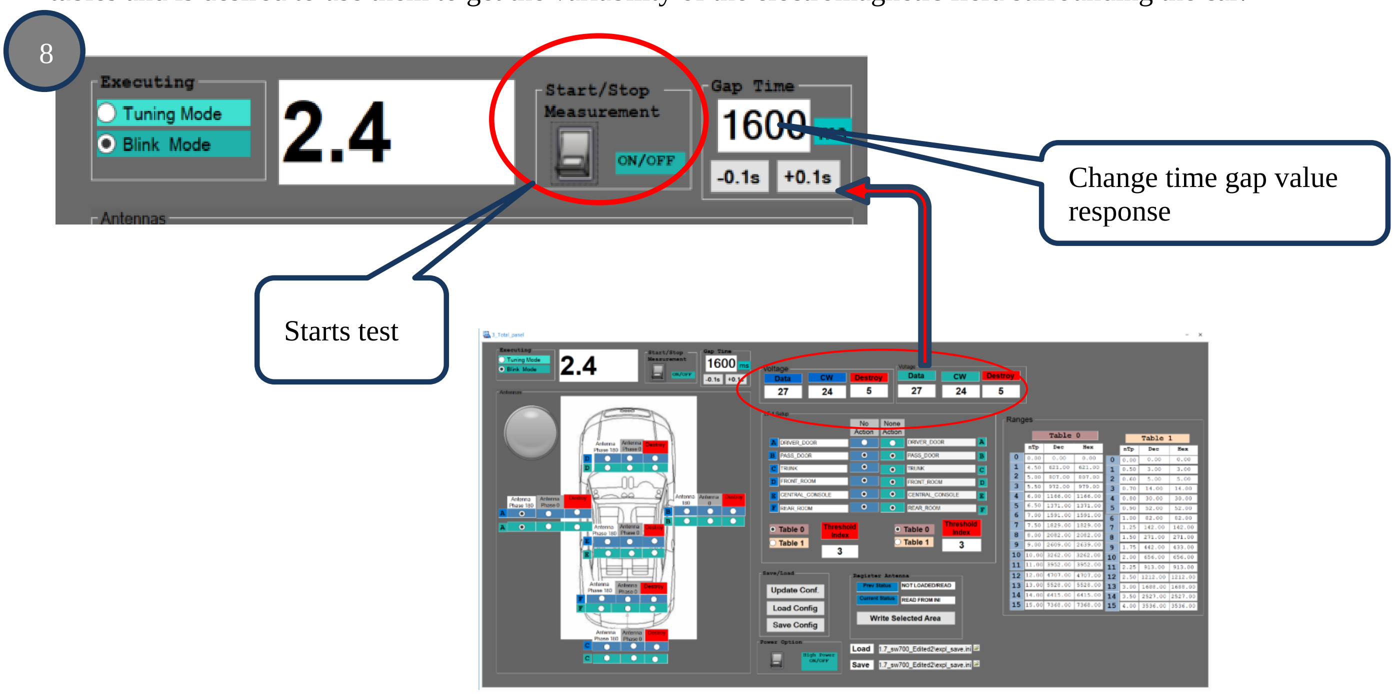
4.3 Power options

If active mode is required, choose turn on this button.



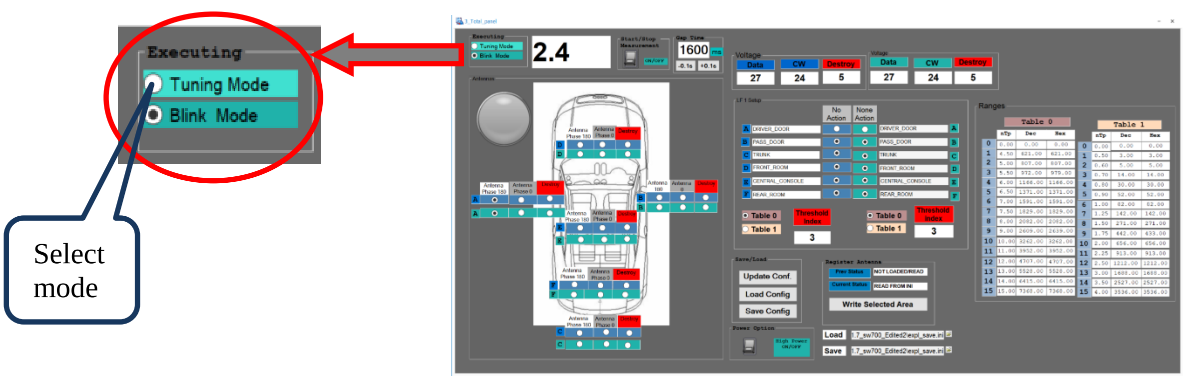
.4 Executing, gap time

The gap time could be reduced or augmented according to the frequency in which the visual signal wants to be seen, is the elapsed time between two PASE (passive start and entry system) events. Contrary to the common RKE where the user intervenes actively in the decision of lock or unlock, start or no the engine. The options of tuning or blinking mode can be selected, the tuning mode will start with values of zero not following the values of the tables; the blinking mode would be used when the value is known from the tables and is desired to use them to get the variability of the electromagnetic field surrounding the car.



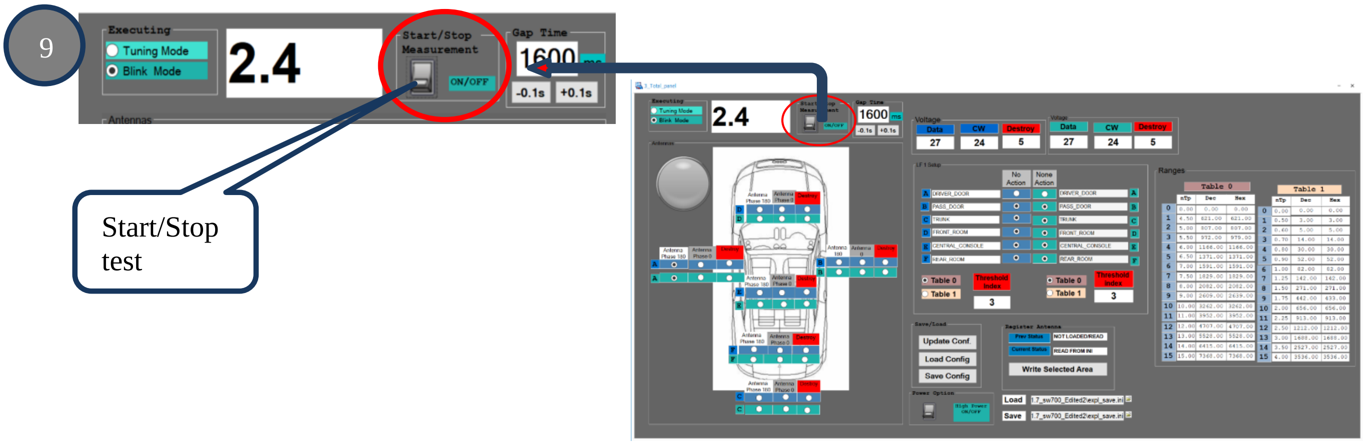
4.5 Tuning/Blinking Mode

The selection of this modes can be realized at the start or the end of the configuration. The tuning mode will be used when the calibration ranges will be required to be displayed. The blinking mode will be used to verify multiple test of the key fob proximity.



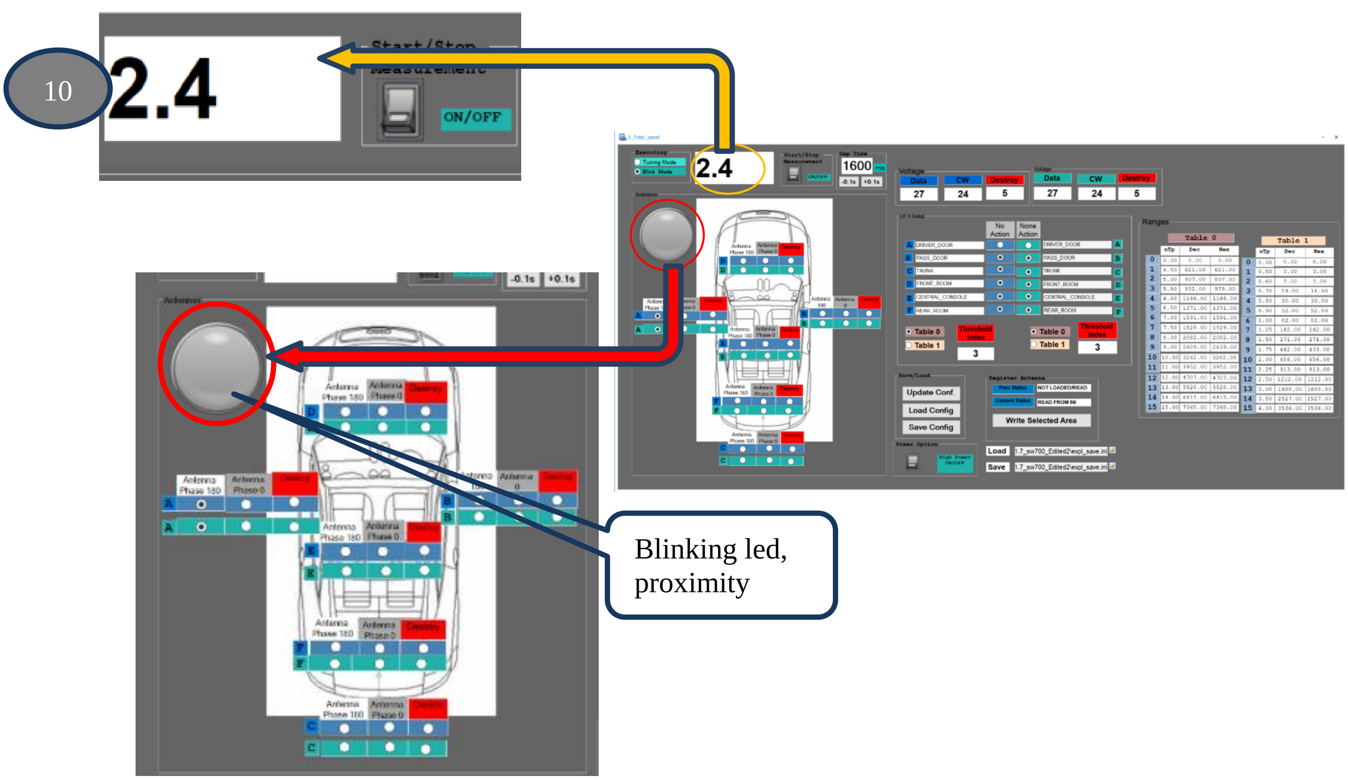
4.6 Start/ Stop Tuning test

The on/off switch will be used to start or stop the test.



4.7 Visual display

The output will be displayed as visual aids that are the blinking led in red next to the antenna car selection image and the numerical value that indicates the position of the key fob. This is an average value position from the 3 general coordinate, this is the output that would be the one used for the tuning



4.0 APPENDIX

A. APPENDIX

Test bench connection