PEPS keyless entry system-traditional PEPS and digital key system

Table of contents

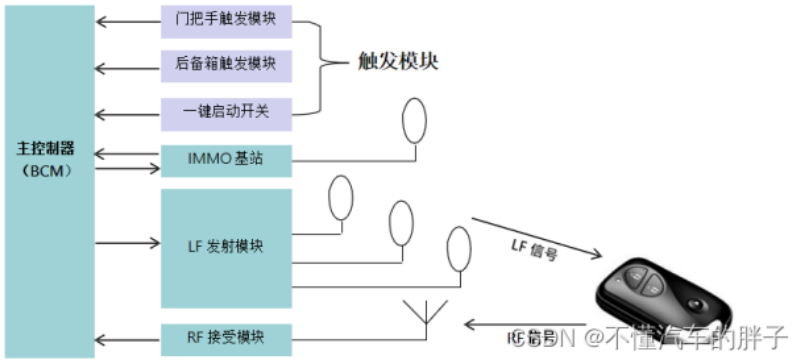
1. What is PEPS?

The keyless entry and start system is referred to as the PEPS (Passive Entry Passive Start) system, which consists of a controller, a radio frequency (RF) transmitter in the smart key, a receiver on the car side, an LF drive antenna, a start switch, etc. When the key is within the effective range, the owner pulls the door or presses the one-button start switch, and the corresponding module sends a terminal signal to wake up the main controller and start the entire communication process. The whole process does not require the use of a key to open the door or start the engine.

要钥匙在有效范围内，车辆会自动检测钥匙并完成身份认证

1. **Traditional PEPS**

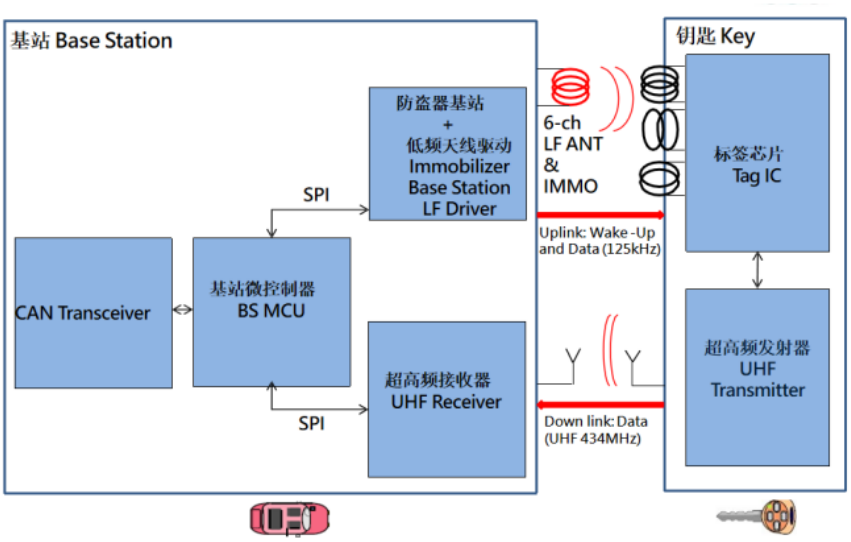
2.1 PEPS system architecture diagram



PEPS System Components :

1. PEPS system controller: responsible for function logic processing, key positioning, LF antenna drive, RF signal reception, ESCL control
2. Electronic key: responsible for sending remote control commands and location signals
3. LF antenna: responsible for sending LF signals (125KHz/134KHz)
4. Start switch: responsible for triggering the start ignition signal, IMMO certified
5. Door handle: responsible for triggering the unlock signal and sending the LF signal
6. ESCL: Lock steering column, anti-theft

2.2 PEPS Hardware Block Diagram



2.3 PEPS Controller MCU Selection Reference (NXP)

There are many references for MCU selection. The following is only a reference for NXP brand selection. I did not receive advertising fees from NXP, but I was too lazy to organize more comparisons. The following other chip selection references are also

Items	S32K116	S32K118	S32K142	S32K144	S32K146	S32K148
CPU	ARM Cortex-M0+		ARM Cortex-M4F			
Frequency	48MHz		80MHz or 112MHz			
Flash/RAM	128KB / 17KB	256KB/25KB	256KB/32KB	512KB/64KB	1MB/128KB	2MB/256KB
LPSPI	1x	2x	2x	3x		
LPUART/LIN	2x		2x	3x		
FlexCAN	1x (1x with FD)		2x (1x with FD)	3x (1x with FD)	3x (2x with FD)	3x (3x with FD)
GPIO	up to 43	up to 58	up to 89		up to 128	up to 156
Operating voltage (Vcc)	2.7~5.5V		2.7~5.5V			
Temperature range	-40℃ to + 105℃ / +125℃		-40℃ to + 105℃ / +125℃			
Function Safety	capable up to ASIL-B		capable up to ASIL-B			
Packages	32-pin QFN 48-pin LQFP	48-pin LQFP 64-pin LQFP	48-pin LQFP 64-pin LQFP 100-pin LQFP	48-pin LQFP 64-pin LQFP 100-pin LQFP 100-pin MAPBGA	64-pin LQFP 100-pin LQFP 144-pin LQFP 100-pin MAPBGA	100-pin LQFP 144-pin LQFP 176-pin LQFP 100-pin MAPBGA

2.4 LF Driver (NXP)

The main brands of LF Driver include NXP, ATMEL, TI and other solutions. The following is a reference for NXP brand selection. Other brands are not listed, such as ATMEL ATA5291 ATA5279; TI TPIC84125, TRF4140, etc.

Items	PCF7991	NJJ29C0	NJJ29C2
Communication	SPI	SPI	SPI
Operating frequency	125kHz	125kHz	125kHz
Operating voltage (Min) (V)	4.5	5	5
Operating Voltage (Max) (V)	5.5	28	28
LF driver channel count	1	6	5-9
Security Level	AEC-Q100	AEC-Q100	AEC-Q100
Temperature range(C)	-40~85℃	-40~105℃	-40~105℃
Encapsulation	SO14	HVQFN56	HVQFN56
Remark	1 x REAL	1 x REAL	2 x IMMO with High Power Mode

2.5 UHF Receiver

There are many common brands of UHF receiver, such as TI, NXP, INFINEON, ATMEL, etc. The following is a list of NXP brands. Other brands have not been sorted out and are not listed. Common brands include ATMEL ATA5781; INFINEON TDA5235, etc.

Items	NCK2910	NCK2912	NCK2913	NCK2983
Communication	SPI	SPI / UART	SPI / UART	SPI / UART
Receiving frequency	310~928MHz	310~960MHz	310~960MHz	315~950MHz
Supply voltage (Min) (V)	2.85	1.9	2.1	2.1
Supply voltage (Max) (V)	5.5	5.5	5.5	5.5
Security Level	AEC-Q100-005	AEC-Q100-005	AEC-Q100-005	AEC-Q100-005
Operating temperature(C)	-40~125℃	-40~125℃	-40~125℃	-40~125℃
Encapsulation	HVQFN32	HVQFN48	HVQFN48	HVQFN48
RX / TX Channels	1 / 0	1 / 0	3 / 0	3 / 1
Remark		P2P		

2.6 Key-side Application Chip

Items	NCF29A1	NCF29A7	NCF2953
Communication	SPI	SPI	SPI
Vehicle grade	AEC-Q100	AEC-Q100	AEC-Q100
Supply voltage (V)	1.8-3.6	2.0-3.6	2.0-3.6
Encryption Algorithm	HT2-E, HT3, HT-AES or HT-Pro2 based transponder emulations	HT2-E, HT3, HT-AES or HT-Pro2 based transponder emulations	HT2-E, HT3, HT-AES or HT-Pro2 based transponder emulations
Temperature range(C)	-40~85℃	-40~85℃	-40~85℃
Encapsulation	HVQFN32	HVQFN32/HVQFN40	HVQFN32
Operating frequency	125kHz	125 kHz	125kHz
High frequency transceiver	UHF transmitter (310 MHz to 447 MHz)	UHF transmitter (310 MHz to 447 MHz)	Interface for external UHF transceiver (e.g. I way RF communication)
Remark	NCF29A7 has better LF field strength effect than NCF29A1, can sense field strength changes at a longer distance, and ha accuracy		

Key-end application chips include integrated (LF&RF) and discrete ones, such as TI RF430, CC1101, INFINEON TDK5101, ATMEL ATA5749, MICROCHIP MICRF112, etc. The following is a comparison of NXP brands:

1. **PEPS system features**

3.1 PE function (keyless entry)

3.1.1 PKE unlocking

The user presses the door handle button (or touch sensor switch), triggering the PEPS controller to drive the LF antenna to transmit a low-profile wireless signal to find the car key. The car key transmits an RF signal and feeds it back to the RF receiving module of the PEPS controller. If the car key is the car key, the PEPS controller sends an unlock command to the BCM via the CAN bus.

3.1.2 PKE window raising function

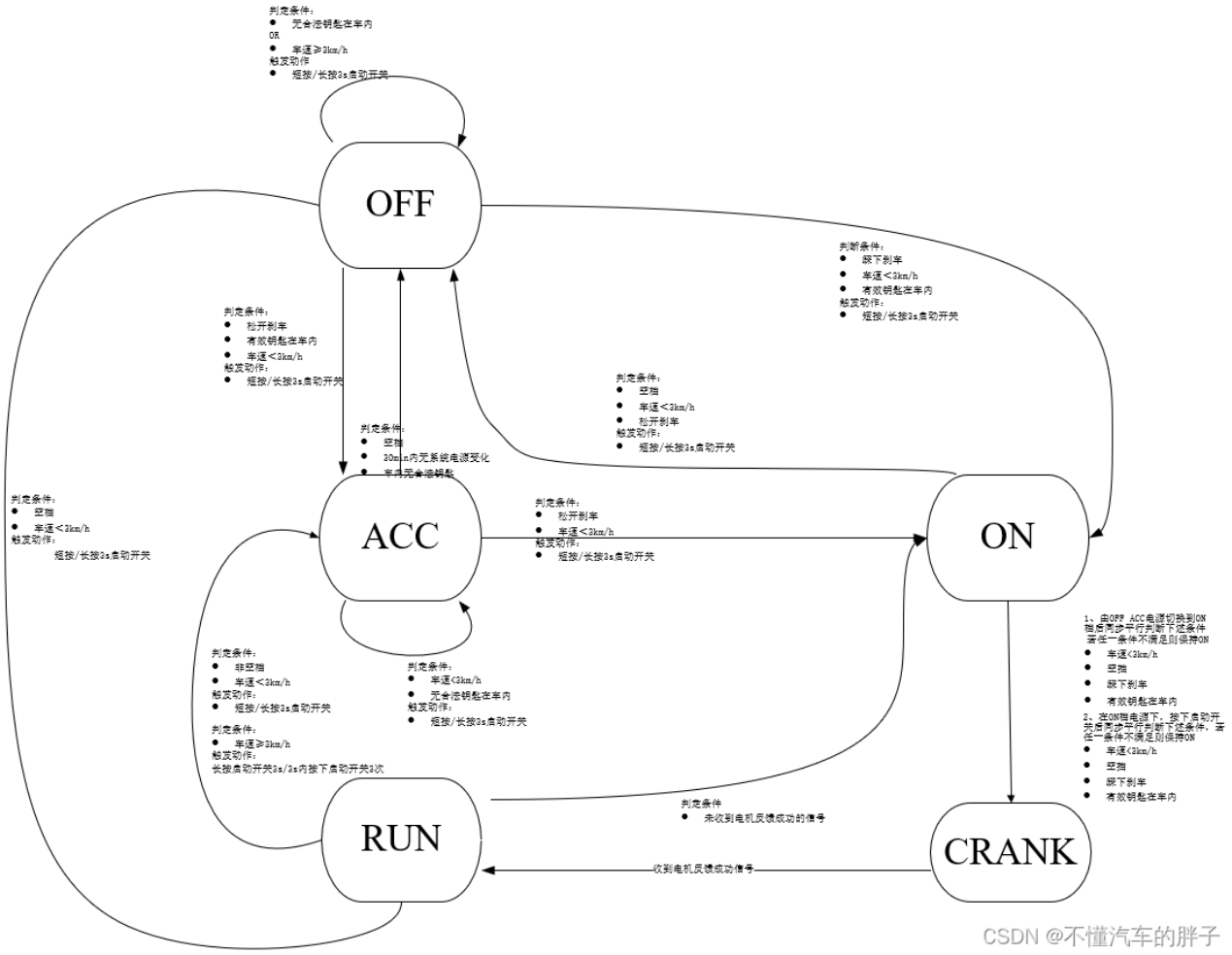
When the vehicle is off and the door is closed, long press the door handle micro switch, and the valid key is within the detection range, the PKE window raising action will be executed

3.2 PS function (keyless start)

3.2.1 Normal startup

When the user presses the one-button start switch in the car, the PEPS controller is triggered to drive the LF antenna to transmit a low-profile wireless signal to find the car key. The car key transmits an RF signal to the RF receiving module of the PEPS controller. If the car key is the car key, the PEPS controller drives the power management relay to close (IGN1, IGN2, ACC, ST four relays, the number of relays varies according to the actual car). To control which relays to close, other certain conditions must be judged: current power gear, vehicle speed, gear position, brake, clutch and other signals.

Power Mode	Relay Status
OFF	All relays disconnected
ACC	ACC relay energized
ON	IGN1, ACC relay is energized, motor is stopped
CRANK	IGN1 is energized, ACC relay is disconnected, and VCU request signal is issued
RUN	IGN1, ACC relay is closed, motor running status



A clear and editable VISIO version is available at the following path:

PEPS power management flow chart

https://download.csdn.net/download/ChrisKKC/85390513

3.2.2 Emergency start

When the vehicle suddenly stalls during operation, the power gear is switched from RUN to ACC. At this time, the start switch can be pressed to start the vehicle without checking whether the key is in the vehicle.

3.2.3 Backup startup

When the smart key battery is out of power, the PEPS controller cannot locate the smart key through the low-frequency antenna and can only authenticate the key through the backup antenna IMMO function. The legitimate key needs to be brought within the effective range of the backup antenna for authentication and ignition.

3.2.4 Normal shutdown

See the power level flow chart for details.

3.2.5 Emergency shutdown

When the vehicle is driving and needs to be shut down urgently due to brake failure or other faults, press and hold the start switch for 3 seconds or press it three times within 3 seconds, the power will switch to ACC and the engine will shut down. It will take 3 seconds before you can restart the engine.

3.2.6 Timeout shutdown

When the system power is in ACC gear, in order to avoid battery consumption, if there is no power gear change within 30 minutes and no valid car key is detected, the power will be switched to OFF after 30 minutes.

3.3 RKE Function

3.3.1 RKE Unlock

Within the RKE remote control range, press the smart key unlock button to unlock the door

3.3.2 RKE Lockout

Within the RKE remote control range, press the smart key lock button to lock the door

3.3.3 RKE Car Search

Within the RKE remote control range, press the smart key car search button to turn on the remote control car search function.

3.3.4 RKE window lowering

Within the RKE remote control range, press and hold the smart key unlock button for more than 2 seconds to execute the window lowering function.

3.3.5 RKE window raising

Within the RKE remote control range, press and hold the smart key lock button for more than 2 seconds to execute the window raising function.

3.4 Start switch LED indication

Generally, the green LED lights up to indicate that a legal key is found in the car.

The green LED is always on when the power is in RUN mode

The yellow or red light is on, indicating that the power is not OFF.

The yellow or red light flashes if the legal key is not found.

3.5 Remote Function

PEPS can realize remote unlocking, ignition, shutdown, air conditioning and other functions according to the remote command of T-BOX.

3.6 Alarm prompt

3.6.1 Key not detected reminder

During normal startup, if other preconditions are met and the start switch is pressed, if the smart key is not in the car, a message indicating that the key is not detected is sent.

3.6.2 Key not in car reminder

In non-OFF gear (OFF means engine off), the last door is closed, PEPS searches for the smart key in the car. If the smart key is not in the car, a key not in the car prompt message is sent.

3.6.3 Reminder for not shifting into neutral gear

When you step on the brake to start the ignition, if the gear is not in neutral and there is a valid key in the car, a message "Please shift to neutral to start" will be sent.

3.6.4 Please step on the brake to start the prompt

If the vehicle is not started within 60 seconds after the OFF→ACC→ON→OFF cycle, a message "Please press the brake to start the vehicle" will be sent.

3.6.5 Low key battery warning

When the smart key battery low indication is received 10 times in a row, PEPS sends a key battery low indication message

3.6.6 Start button failure prompt

When the start switch button is detected to be stuck, that is, the hard line signal is valid for more than 40 seconds, PEPS sends a start button failure prompt message

1. **Digital key system (BLE + NFC + UWB)**

The digital key is a new product of the improvement of automobile technology. Its function is that car owners can use smart phones, electronic bracelets, electronic watches and other devices as car keys, which can realize operations such as unlocking the car, starting the car, and controlling the temperature inside the car without a physical key.

Digital key is a smart device that replaces the car key, which can unlock the vehicle, start the engine, monitor the number of times your car is opened, and send the real-time status of the car to your mobile phone.

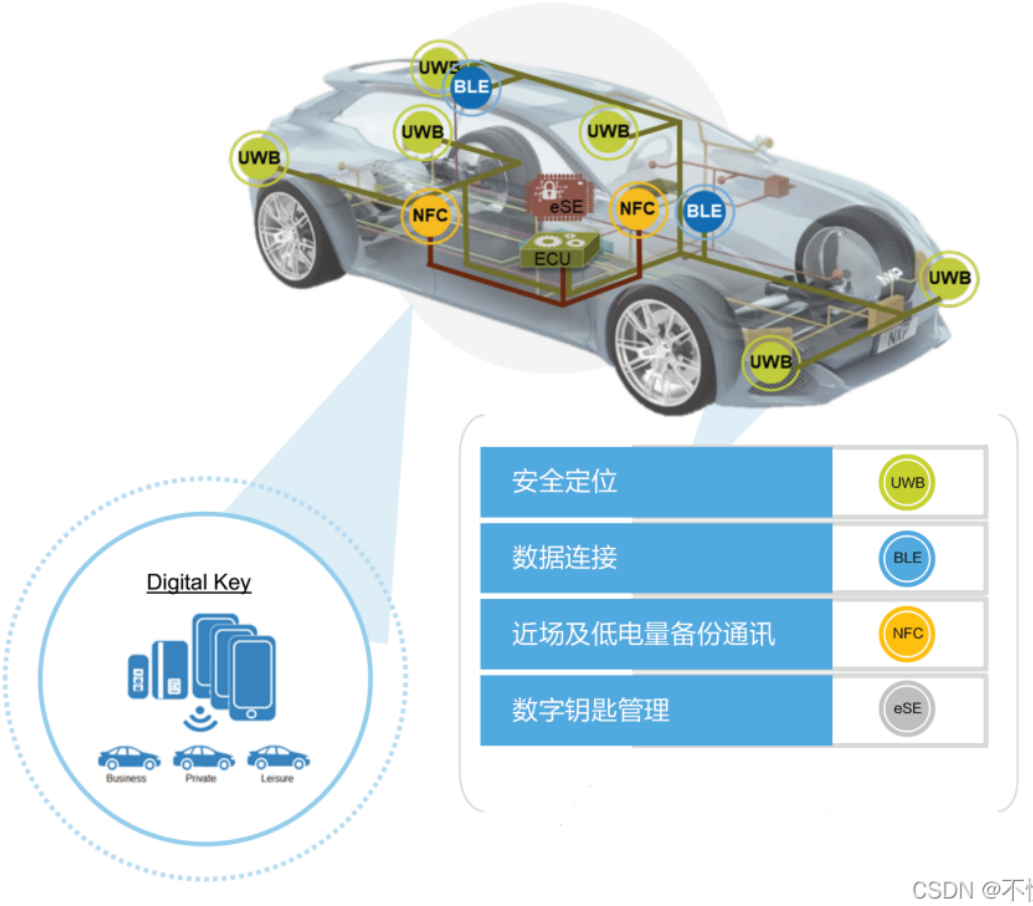
You can even give the digital key's unlocking and driving permissions to your relatives and friends, and it can also be operated with a physical key.

4.0.1 Digital Key System Performance Parameters

Serial No. 号 NO.	Item	Specifications
1	Normal operating range	9V ~ 16V
2	CAN bus operating voltage	6.5V ~ 18V
3	Normal operating temperature	-40℃ ~ +85℃
4	Storage temperature	-40℃ ~ +85℃
5	Quiescent Current	≤3mA
6	Working current	≤200mA
7	connect	Only the master Bluetooth connection is required, and the slave Bluetooth uses frequency hopping monitoring
8	Key signal forwarding success rate	100%
9	Bluetooth protocol version	Bluetooth 5.0 (backward compatible with 4.2, 4.0)
10	Operating frequency	Bluetooth 2.4GHz, UWB 5~10GHZ
11	Bluetooth receiving sensitivity	-97db (not more than 5db of RF chip sensitivity)
12	BLE end field strength RSSI (BLE mobile phone)	1M -50 to -74db; 5M -68 to -79db; 10M -69 to -85db; 15M -79 to -92db. (Adjusted according to actual calibration)
13	Transmit power P	5dBm
14	Success rate of Bluetooth signal conversion to CAN signal	100%

15	BLE compatible mobile phone capabilities	Compatible with the top 30 mainstream mobile phones
16	Connection success rate (single)	> 90%
17	Connection success rate (maximum 3 reconnections allowed)	> 99%
18	Authentication success rate	> 99%
19	Authentication time-consuming	≤500ms
20	Connection time	5 meters distance < 2000ms 10 meters distance < 4000ms
21	Bluetooth remote control distance (single unit)	≥50 meters (open space)
22	Bluetooth remote control distance (actual car)	≥50 meters (open space)
23	Polling distance	≥30m
24	Luggage PE	Centered on the antenna, there is no blind spot within 1.5 meters
25	Detection accuracy (window overflow)	≤50cm (Bluetooth)
26	UWB connection distance (single unit)	≥50 meters (open space)
27	UWB connection distance (actual vehicle)	≥30 meters (open space)
28	UWB positioning accuracy (within 10m)	≤20cm (no obstruction outside the vehicle) ≤30cm (obstruction by backpack outside the vehicle)
29	UWB compatible mobile phone capabilities	Compatible with the top 30 CCC/ICCE protocol mobile phones of the year
30	Success rate of UWB signal conversion to CAN signal	100%

4.0.2 Digital Key Vehicle Layout



2 NFC modules: NFC vehicle entry module is responsible for NFC card entry (when the phone is out of power)

The NFC in-car start module is responsible for NFC card swiping to start (if the card is not started within 10 minutes outside the car, you need to swipe the NFC again to start

move)

2 Bluetooth modules: responsible for long-distance (80m) mobile phone and vehicle communication and waking up the UWB system

4-6 UWB modules: responsible for accurate positioning of keys (mobile phones), communication distance 10m