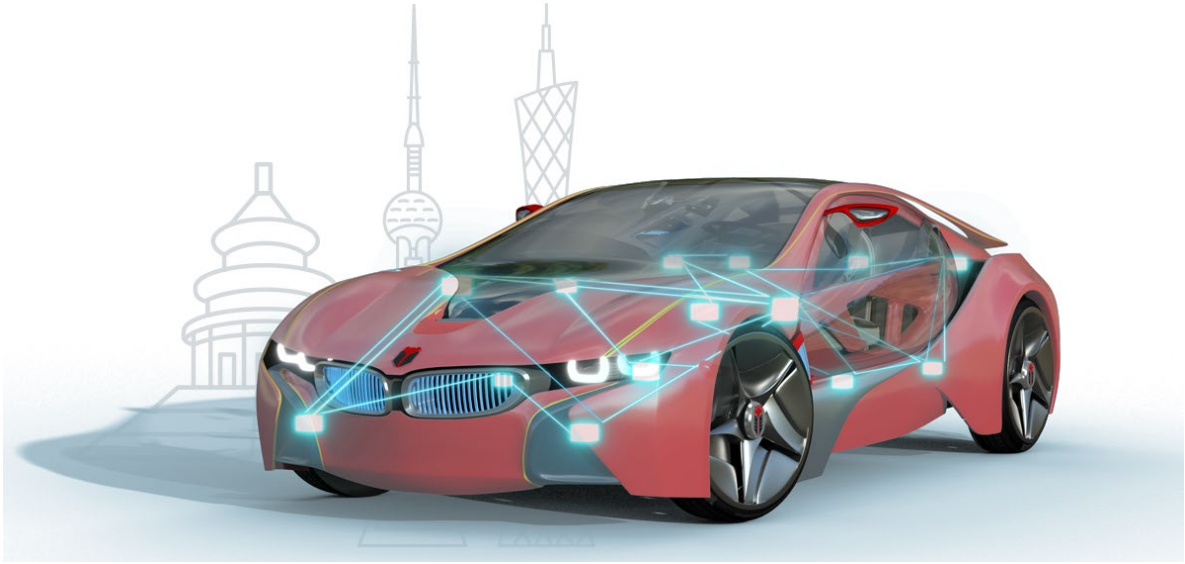
知从青龙 TC3XX A/B SWAP 刷写介绍

ZC.QingLong AB SWAP Pragramming Based on Infineon TC3xx

知从青龙 BootLoader

ZC.QingLong BootLoader



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1 开发背景 DEVELOPMENT BACKGROUND

在汽车智能化发展过程中，尽管软件的重要性及占比不断提升，但整车研发周期却在无形中缩短，因此由于软件漏洞引发汽车召回的风险持续攀升。目前高端汽车的整车代码量已经突破 1 亿行，即使按照 CMMI（Capability Maturity Model Integration，能力成熟度集成模型）5 级的最高软件标准进行控制，代码缺陷率仍为 0.32‰，潜在问题的规模不容小觑。而召回事件，需要整车厂付出巨大的直接和间接成本。

In the process of automotive intelligence development, although the importance and proportion of software continue to increase, the research and development cycle of the whole vehicle is invisibly shortened, so the risk of car recalls caused by software vulnerabilities continues to rise. At present, the total code amount of high-end cars has exceeded 100 million lines. Even if controlled according to the highest software standard of CMMI (Capability Maturity Model Integration) level 5, the code defect rate is still 0.32‰, and the scale of potential problems is not to be underestimated. Recall events require car manufacturers to pay huge direct and indirect costs.

对于处在发展中的行业而言，面对智能汽车行业发展大趋势，类似于特斯拉一样的系统更新功能必将成为行业可持续发展的前提和基础，FOTA（Firmware Over-The-Air，移动终端空中下载软件升级）也就成为解决软件漏洞、进行智能汽车配件升级的最佳解决方案之一。

For industries in development, facing the major trend of the development of smart cars, system update functions similar to those of Tesla will inevitably become the premise and foundation for the sustainable development of the industry. FOTA (Firmware Over-The-Air) has thus become one of the best solutions for addressing software vulnerabilities and upgrading smart car components.

FOTA 无线升级，是指通过云端为具有连网功能的终端设备提供固件升级服务，用户使用网络以按需、易扩展的方式获取智能终端系统升级包，并通过 FOTA 进行云端升级，完成系统修复和优化。汽车制造商和供应商通过 FOTA 专业的升级方案，能方便快捷地实现汽车 ECU、

系统版本等迭代，保证系统安全、快速升级，让用户在不更换硬件设备的前提下，体验新功能。

FOTA wireless upgrades refer to providing firmware upgrade services for terminal devices with networking capabilities through the cloud. Users use the network to obtain smart terminal system upgrade packages on demand and in an easy-to-expand manner, and upgrade through FOTA to complete system repairs and optimizations. Car manufacturers and suppliers can quickly and conveniently achieve iterations of car ECUs, system versions, etc., through professional FOTA upgrade plans, ensuring system security and rapid upgrades, allowing users to experience new functions without replacing hardware equipment.

目前，FOTA 已逐渐被认可，并发展成为影响 OEM（Original Equipment Manufacturer，原始设备制造商）和 TSP（Telematics Service Provider，汽车远程服务提供商）决策的车联网新趋势，也是汽车厂商提升用户体验的创新尝试和趋势之一。

At present, FOTA has gradually been recognized and has developed into a new trend of the Internet of Vehicles that affects the decisions of OEMs (Original Equipment Manufacturers) and TSPs (Telematics Service Providers). It is also one of the innovative attempts and trends for car manufacturers to improve user experience.

2 OTA 方案介绍 OTA SOLUTION INTRODUCTION

目前整车 OTA 刷写方案较为统一，主要是通过云端使用以太网将更新数据发送给车端，整车端接收数据后按照 OTA 信息进行数据更新。以下为整车 OTA 执行的主要步骤：

1. 需要执行 OTA 时，OEM OTA 云端通过以太网将待更新的数据发送给整车端。
2. 整车端的 T-Box 识别接收以太网传输的 OTA 数据后透传给网关。
3. 网关作为升级主节点来管理控制车内所有的 ECU 升级：
   a) 对于具备自更新能力的 ECU，它可以直接将数据发送至目标 ECU，只需要负责收集反馈更新结果
   b) 对于不具备更新能力的 ECU，网关还需要充当升级 Master 阶段，待升级 ECU 作为 Slave，双方通过 UDS 完成升级。

At present, the whole vehicle OTA brushing program is relatively unified, mainly through the cloud using Ethernet to send the updated data to the vehicle end, the whole vehicle end to receive the data in accordance with the OTA information to update the data. The following are the main steps of OTA execution for the whole vehicle:

1. When it is necessary to execute OTA, the OEM OTA cloud sends the data to be updated to the vehicle end via Ethernet.
2. The T-Box on the vehicle side recognizes the OTA data transmitted over Ethernet and transmits it to the gateway.
3. The gateway acts as the update master node to manage and control all ECU updates in the vehicle:
   a) For ECUs with self-updating capability, it can send the data directly to the target ECU, and is only responsible for collecting feedback on the update results.
   b) For ECUs that do not have the ability to update, the gateway also needs to act as the upgrade Master stage, the ECU to be upgraded as Slave, and both parties complete the upgrade through UDS.

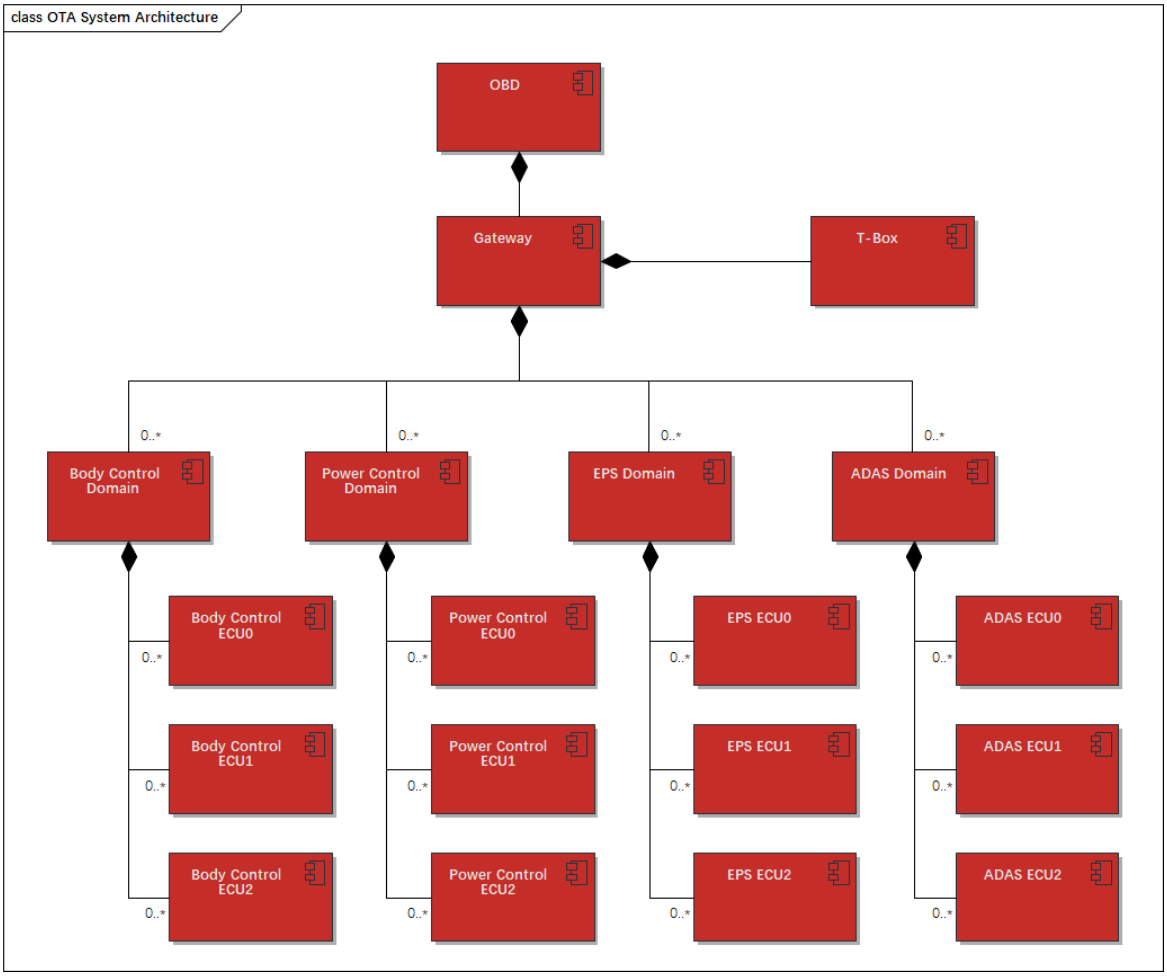

图 2 - 1 知从青龙 OTA 系统架构

FIGURE 2 - 2 ZC.QINGLONG OTA SYSTEM ARCHITECTURE

随着芯片技术和 OEM OTA 规范的不断升级，OTA 的使用场景也在不断扩大，根据实际使用场景， OTA 实现方案可以分为以下几类：

With the continuous upgrading of chip technology and OEM OTA specifications, the use of OTA scenarios are also expanding, according to the actual use of scenarios, OTA implementation programs can be divided into the following categories:

OTA 解决方案 OTA Solution	描述 Description
等待 OTA **Wait OTA**	在车辆停止时将更新程序下载并写入闪存。 Download and write the update program to the flash memory when the vehicle is stopped.
半非等待 OTA **Semi-non wait OTA**	在车辆运行期间或停止时，将需要更新的数据下载到外部闪存，并在车辆停止时将更新程序写入内部闪存。

	During vehicle operation or when it stops, downloads the data to be updated to the external flash memory and writes the update program to the internal flash memory when the vehicle stops.
非等待 OTA **Non wait OTA**	在车辆运行期间或停止时，将更新程序写入非活动区内存，并在车辆停止时将运行程序切换到非活动区。 Writes the update program to the inactive zone memory during vehicle operation or when the vehicle is stopped, and switches the running program to the inactive zone when the vehicle is stopped.

表 2 - 1 OTA 解决方案

TABLE 2 - 1 OTA SOLUTION

3 AB SWAP 功能介绍 AB SWAP FUNCTION INTRODUCTION

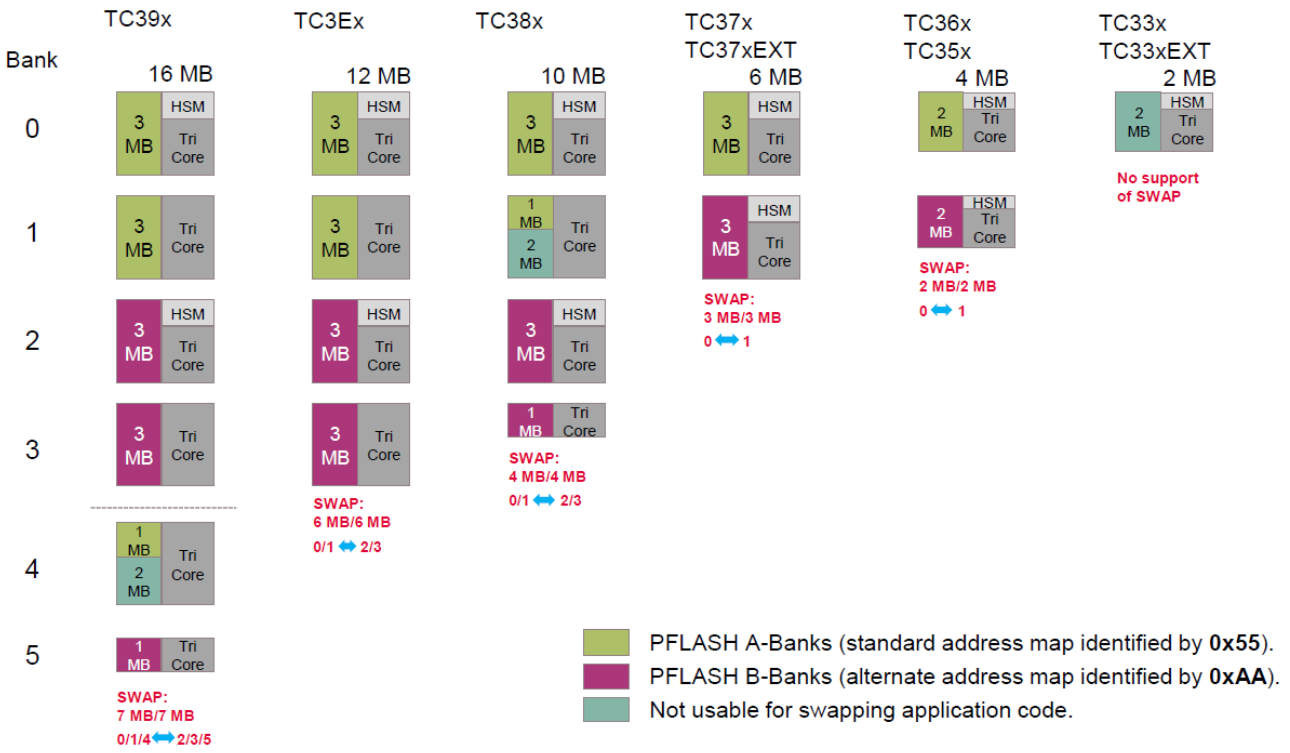

图 3 - 1 TC3XX AB 分区分配

FIGURE 3 - 1 TC3XX AB BANK ASSIGNMENT

为了适配 OTA 功能以及其他使用场景需求，大部分芯片添加支持地址映射功能。除 TC33x 和 TC33xED 外，所有 TC3xx 芯片都具备将 PFLASH 分为 A 和 B 两组存储库的功能。在标准地址映射中处于活动状态的组称为“A”，在备用地址映射中处于活动状态的组称为“B”。一组 PFLASH 存储体将映射到 CPU 可执行地址空间（定义为“活动”存储体），另一组将映射到一组允许读写的地址（定义为“非活动”存储体）。当 OTA 更新完成后，库被交换时，只有地址映射会发生变化，即无需复制数据，执行时的地址范围也始终保持不变。

In order to adapt to OTA function and other usage scenarios, most of the chips add support for address mapping function. With the exception of TC33x and TC33xED, all TC3xx chips have the ability to separate PFLASH into two groups of banks, A and B. The address mapping is called “A” in standard address mapping and “B” in alternate address mapping. The group that is active in standard address mapping is called “A” and the group that is active in alternate address mapping is called “B”. One group of PFLASH banks will map to the CPU executable address space (defined as the “active” banks), and the other group will map to a set of addresses that allow reads and writes (defined as the “inactive” banks). When the libraries are swapped after the OTA

update is complete, only the address mappings will change, i.e., there is no need to copy the data, and the address ranges will always remain the same at execution time.

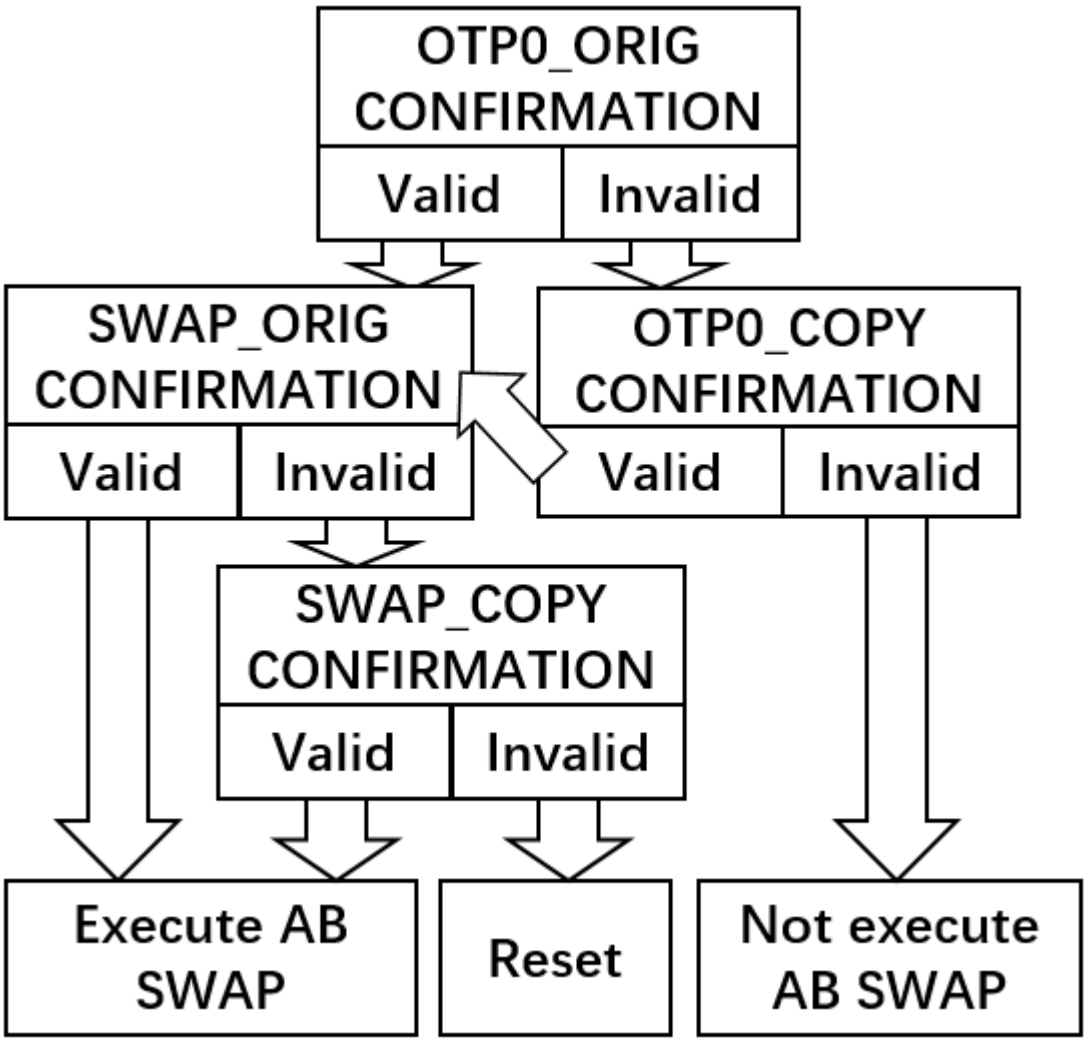

图 3 - 2 TC3XX AB SWAP 启动判断流程图

FIGURE 3 - 2 TC3XX AB SWAP STARTUP JUDGMENT FLOWCHART

TC3xx 的 AB Swap 功能通过 UCB 寄存器组 OTPx_ORIG、OTPx_COPY、SWAP_ORIG 和 SWAP_COPY 进行控制。若 UCB 相关寄存器的使能标志位未置起，或者 CONFIRMATIONLx 和 CONFIRMATIONHx 寄存器位数据不为有效状态，则 AB Swap 功能不会启用。上图为 AB Swap 启动判断的流程图。

The AB Swap function of the TC3xx is controlled through the UCB registers groups OTPx_ORIG, OTPx_COPY, SWAP_ORIG and SWAP_COPY. The AB Swap function will not be enabled if the enable flag bit of the UCB related register is not set, or the CONFIRMATIONLx and CONFIRMATIONHx register bit data is not valid. The above figure shows the flowchart of AB Swap startup judgment.

TC3xx 通过 UCB 寄存器组 SWAP_ORIG 和 SWAP_COPY 判断执行 AB 区切换，在进行判断时，TC3xx 优先按照上图逻辑进行判断，若有多组符合判断标准的寄存器配置，则会按照最新一组的寄存器配置进行判断。

The TC3xx performs AB Swap by judging the UCB registers groups SWAP_ORIG and SWAP_COPY. When making judgments, the TC3xx prioritizes the judgments in accordance with the logic in the above figure, and if there are multiple register configurations that meet the judging criteria, the judgment will be made in accordance with the latest set of register configurations.

UCB 寄存器组 SWAP_ORIG 和 SWAP_COPY 中一共包含 16 组寄存器配置，各寄存器功能如下表所示：

The UCB register groups SWAP_ORIG and SWAP_COPY contain a total of 16 register configurations, and the functions of each register are shown in the following table:

Register	Description
MARKERLx	Determines the system address map to be used by the running application. **ERASED -> 0x00000000** **STD (selects standard address map / groups of banks A) -> 0x00000055** **ALT (selects alternate address map / groups of banks B) -> 0x000000AA**
MARKERHx	For validation and for safety purposes this is checked by the startup software before the address map is installed. **ERASED -> 0x00000000** **VALID -> Address of MARKERLx of the corresponding UCB**
CONFIRMATIONLx	Holds the confirmation code of the address map configured in MARKERLx. A valid code indicates that the address map configuration can be installed. **ERASED -> 0x00000000** **UNLOCKED -> 0x43211234** **VALID -> 0x57B5327F** **ERRORED –> Others**
CONFIRMATIONHx	Acts as validation code for CONFIRMATIONLx. **ERASED -> 0x00000000** **VALID -> Address of CONFIRMATIONLxof the corresponding UCB**
PW0-7	A password set, allows only authorized access and modifications if the UCB Confirmation Code is CONFIRMED.

表 3 - 1 SWAP_ORIG 和 SWAP_COPY 寄存器组介绍

TABLE 3 - 1 INTRODUCTION TO THE SWAP_ORIG AND SWAP_COPY REGISTER SETS

在实际使用过程中，FOTA 软件需要在每次完成软件更新后，判断 AB Swap 功能是否启用以及 AB Swap 功能是否执行 AB 区交换，并根据实际情况开启 AB Swap 功能并切换分区，使

ECU 在复位后从更新程序的分区进行启动。以下为 FOTA 执行过程中，UCB 寄存器组 SWAP_ORIG 和 SWAP_COPY 的参考配置情况：

In actual use, the FOTA software needs to determine whether the AB Swap function is enabled or not and whether the AB Swap function performs AB Bank swapping or not after each completion of the software update, and turn on the AB Swap function and switch the partition according to the actual situation, so that the ECU can start from the partition of the update program after reset. The following is the reference configuration of UCB register groups SWAP_ORIG and SWAP_COPY during FOTA execution:

Group ID	MARKERLx	MARKERHx	CONFIRMATIONLx	CONFIRMATIONHx
0	0x00000055	0xAF402E00	0xFFFFFFFF	0xFFFFFFFF
1	0x000000AA	0xAF402E10	0xFFFFFFFF	0xFFFFFFFF
2	0x00000055	0xAF402E20	0xFFFFFFFF	0xFFFFFFFF
3	0x000000AA	0xAF402E30	0x57B5327F	0xAF402E38
4	0x00000000	0x00000000	0x00000000	0x00000000
…	…	…	…	…
15	0x00000000	0x00000000	0x00000000	0x00000000

表 3 - 2 SWAP_ORIG 寄存器组参考配置

TABLE 3 - 2 SWAP_ORIG REGISTER SET REFERENCE CONFIGURATION

Group ID	MARKERLx	MARKERHx	CONFIRMATIONLx	CONFIRMATIONHx
0	0x00000055	0xAF403E00	0xFFFFFFFF	0xFFFFFFFF
1	0x000000AA	0xAF403E10	0xFFFFFFFF	0xFFFFFFFF
2	0x00000055	0xAF403E20	0xFFFFFFFF	0xFFFFFFFF
3	0x000000AA	0xAF403E30	0x57B5327F	0xAF403E38
4	0x00000000	0x00000000	0x00000000	0x00000000
…	…	…	…	…
15	0x00000000	0x00000000	0x00000000	0x00000000

表 3 - 3 SWAP_COPY 寄存器组参考

TABLE 3 - 3 SWAP_COPY REGISTER SET REFERENCE CONFIGURATION

4 知从青龙 FOTA 介绍 ZC.QINGLONG INTRODUCTION

知从青龙 FOTA 通过与应用程序集成，实现无等待 OTA 功能。车辆应用软件通过版本对比、获取升级任务、并自动完成下载，在应用软件运行的过程中下载最新软件数据。应用软件在完成下载后，将最新软件数据安装到 B 系统。整个下载安装过程都是在车辆运行时执行完成的。最后，车辆重新上电时，设备执行 AB 区切换，这一过程是激活过程，这一过程是能感知到的过程。对具备无等待 OTA 的设备升流程而言，用户能感知到的过程，仅为新软件系统“激活”的过程。耗时可能达数十分钟的 B 系统切换，在无等待 OTA 情况下，可以大大缩短集成了复杂功能的域控设备的车辆用户可感知的升级时间，减小了驻车升级时对车辆电量的消耗、缩短了客户的车辆不可用时间，也保证了系统本身始终的可用性。

ZC.Qinglong FOTA realizes the non-wait OTA function by integrating with the application program. The vehicle application software downloads the latest software data while the application software is running by comparing versions, obtaining upgrade tasks, and completing the download automatically. After completing the download, the application software installs the latest software data into the B system. The entire download and installation process is performed while the vehicle is running. Finally, when the vehicle is re-powered, the device performs AB swapping, which is an activation process that can be sensed. For equipment upgrades with non-wait OTA, the only process that is perceived by the user is the “activation” of the new software system. The B-system switchover, which can take up to tens of minutes, can be greatly reduced in the case of non-wait OTA, which can greatly reduce the upgrade time perceivable by the user of the vehicle integrating the complex functions of the domain control equipment, reduce the consumption of vehicle power during the parked upgrade, shorten the time of unavailability of the customer's vehicle, and ensure the availability of the system itself at all times.

下图为知从青龙 FOTA 基于 TC397 执行刷写和 AB 切换的刷写流程图：

The following figure shows the flowchart of programming and AB Swap based on TC397 performed by ZC.QingLong FOTA:

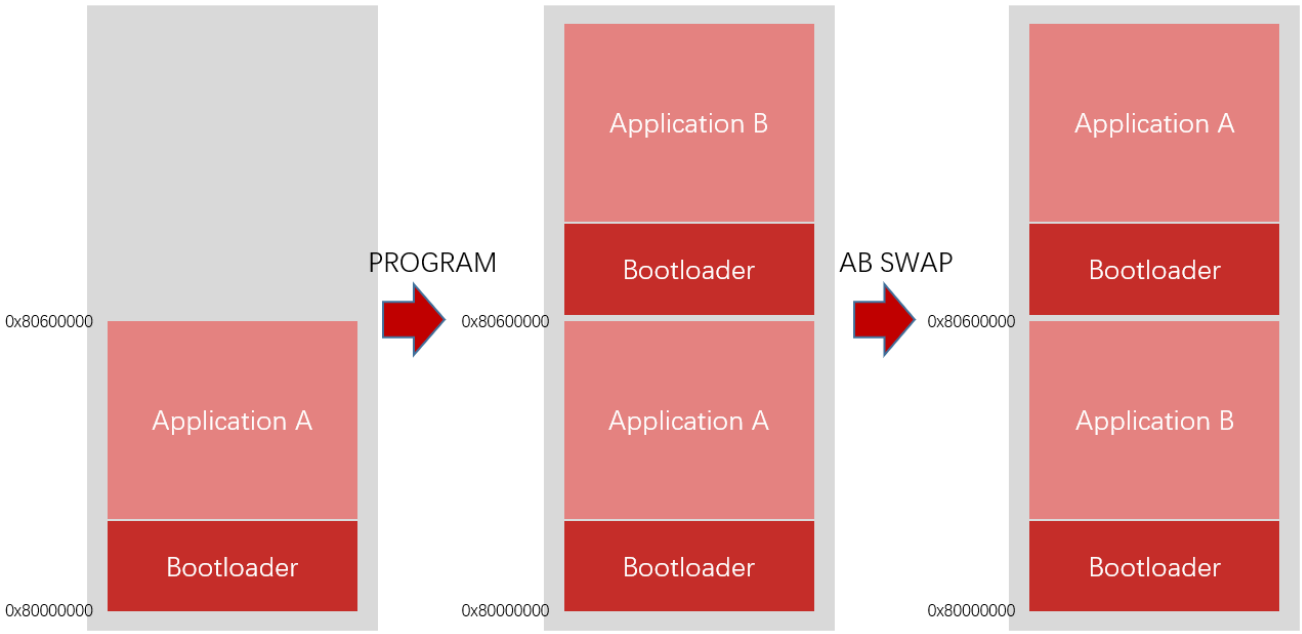

图 4- 1 知从青龙 FOTA AB SWAP 刷写流程

FIGURE 4 - 1 ZC.QINGLONG AB SWAP PROGRAMMING SQUENCE

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成为全球领先的汽车基础软件公司
To Be the Global Leading Automotive Basic Software Company