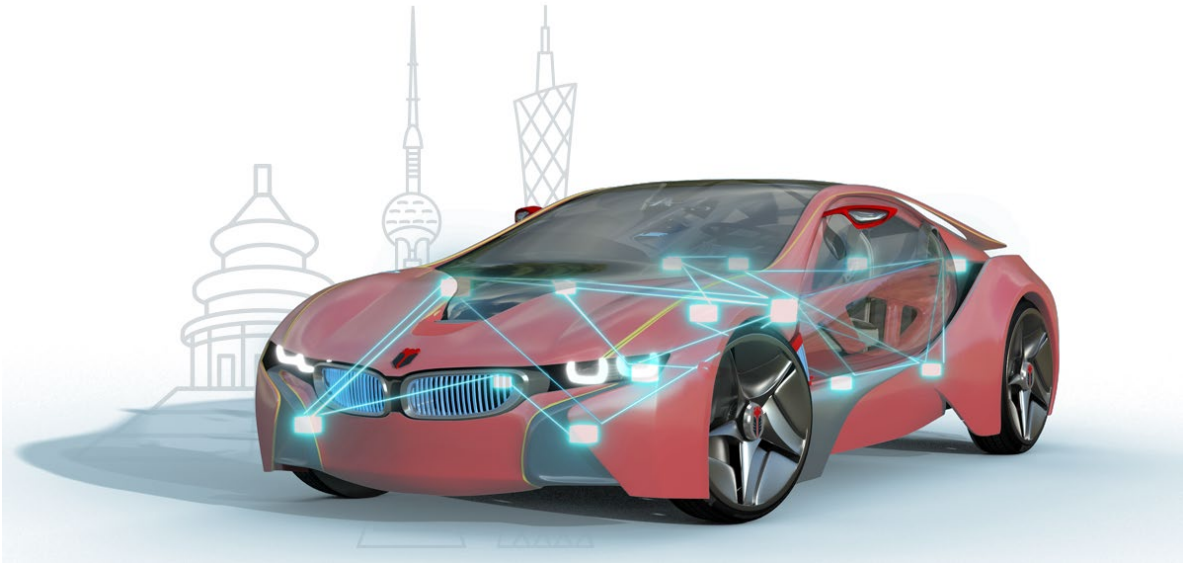
知从青龙 SPI OTA 英飞凌 TC397 产品手册

ZC.QINGLONG SPI OTA PRODUCT MANUAL

BASED ON INFINEON TC397

知从青龙 BootLoader

ZC.QingLong BootLoader



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1 功能概述 FUNCTIONAL OVERVIEW

知从青龙 BootLoader 是由知从科技自主研发的程序刷新软件(BootLoader)。使用知从青龙 BootLoader 的控制器，可以通过 CAN、LIN、SPI、UART 等通信方式实现应用程序的更新功能。知从青龙 BootLoader 支持 NXP、Infineon、Renesas、ST 等多家芯片，并且支持多家整车厂程序刷新规范，可提供定制开发服务。

ZC.QingLong BootLoader is a self-developed program refreshing software (BootLoader) by ZhiCong Technology. Controllers using ZC.QingLong BootLoader can achieve the update function of the application program through communication methods such as CAN, LIN, SPI, and UART. ZC.QingLong BootLoader supports chips from NXP, Infineon, Renesas, ST, and other manufacturers, and also supports the program refreshing standards of many car manufacturers, offering customized development services

在知从青龙 BootLoader 的基础上，知从青龙 SPI OTA 基于 Infineon TC397 平台，结合 SPI 诊断协议与 SOTA 功能实现了 SPI OTA 功能，控制器可以通过 SPI 通信方式执行 OTA 刷新，AB 备份，断点重传，回滚等功能，提高了程序刷新的效率和安全性。知从青龙 SPI OTA 同样支持多家整车厂的 OTA 规范，并提供定制开发服务。

Based on ZC.QingLong BootLoader, ZC.QingLong SPI OTA, built on the Infineon TC397 platform, combines the SPI diagnostic protocol with the SOTA function to implement SPI OTA capabilities. The controller can perform OTA updates, AB backup, breakpoint resumption, rollback, and other functions through the SPI communication method, enhancing the efficiency and security of program updates. ZC.QingLong SPI OTA also supports the OTA specifications of various car manufacturers and provides customized development services.

2 应用领域 APPLICATION DOMAINS

知从青龙 SPI OTA 可应用于基于 TC397 系列芯片的控制器程序刷新功能。支持的控制器包括:

ZC.QingLong SPI OTA can be applied to the controller program refreshing function based on the TC397 series chips. The supported controllers include:

- 车身系统 Body Systems Vehicle

车身控制器、空调控制器、车门控制器、网关等

body controllers, air conditioning controllers, door controllers, gateways, etc

- 动力系统 Power Systems

发动机控制器、电池管理系统、电机控制器、整车控制器等

Engine controllers, battery management systems, motor controllers, whole vehicle controllers, Auxiliary Control Module， etc

- 底盘系统 Chassis Systems

电动助力转向系统、制动防抱死系统、电气稳定系统等

Electric power steering systems, anti-lock braking systems, electronic stability systems, etc

- ADAS 系统 ADAS System

雷达、摄像头系统等

Radar, camera systems, etc

3 配置环境 CONFIGURATION ENVIRONMENT

配置环境 Configuration Environment	
Hardware (Chip)	TC397
Compilers Supported	Tasking 6.3r1
Debugger	Lauterbach (Trace32 R.2020.02) Isystem (IC5700)

4 开发背景 DEVELOPMENT BACKGROUND

智能化和网联化是未来汽车的发展方向。智能汽车的快速发展，改变了汽车的价值，伴随着用户体验需求的攀升，系统软件变得愈发重要，软件定义汽车成为不可逆转的趋势。软件定义汽车（Software Defined Vehicles，简称 SDV）核心思想是：决定未来汽车的是以人工智能为核心的软件技术，而不再是汽车的马力大小、是否真皮座椅、机械性能好坏，而这也将成为汽车行业普遍的发展趋势。汽车行业的产业结构构建正重走电脑和手机行业的发展路径，将来衡量汽车优劣的标准将从“硬件”水平转化为智能化水平的高低和软件服务的好坏。

Intelligent and connected vehicles are the future direction of the automotive industry. The rapid development of smart cars has changed the value of cars. With the rise of user experience needs, system software has become increasingly important, and the trend of software-defined vehicles has become irreversible.The core idea of Software Defined Vehicles (SDV) is that the future of cars will be determined by software technology centered on artificial intelligence, rather than the size of the car's horsepower, whether it has genuine leather seats, or the quality of its mechanical performance. This will become a common development trend in the automotive industry. The industrial structure of the automotive industry is following the development path of the computer and mobile phone industries, and the standard for measuring the quality of cars will shift from the "hardware" level to the level of intelligence and the quality of software services.

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.

5 功能描述 FUNCTIONAL DESCRIPTION

5.1 产品特点 Product Features

- 使用 SPI 协议传输数据，符合 ISO14229 规范

  Uses SPI protocol for data transmission, compliant with the ISO 14229 standard.

- 适用于多家整车厂的程序更新规范

Adaptable to the program update specifications of various car manufacturers

- 支持多重加密机制，保证数据的安全可靠

Supports multiple encryption mechanisms to ensure the security and reliability of data

- 支持应用程序和数据的更新功能

Offers update capabilities for both applications and data

- 支持 SOTA AB 分区 SWAP 功能，保证升级过程数据的完整性

Supports SOTA AB partition SWAP functionality to ensure the integrity of data during the upgrade process.

- 支持断点续传、智能还原、可回溯的安全机制，保证升级过程安全稳定

Features safe and stable upgrade processes with mechanisms such as breakpoint resumption, intelligent restoration, and traceability

- 支持差分还原技术，比普通升级时间提速 90%

Supports differential restoration technology, which can speed up the upgrade process by 90% compared to standard upgrades

- 支持整包升级，提供更多的安全保障

Supports full package upgrades for enhanced security

- 适配知从玄武程序更新工具，提供完整的程序更新解决方案

Compatible with ZC.Xuanwu program update tools, providing a comprehensive solution for program updates

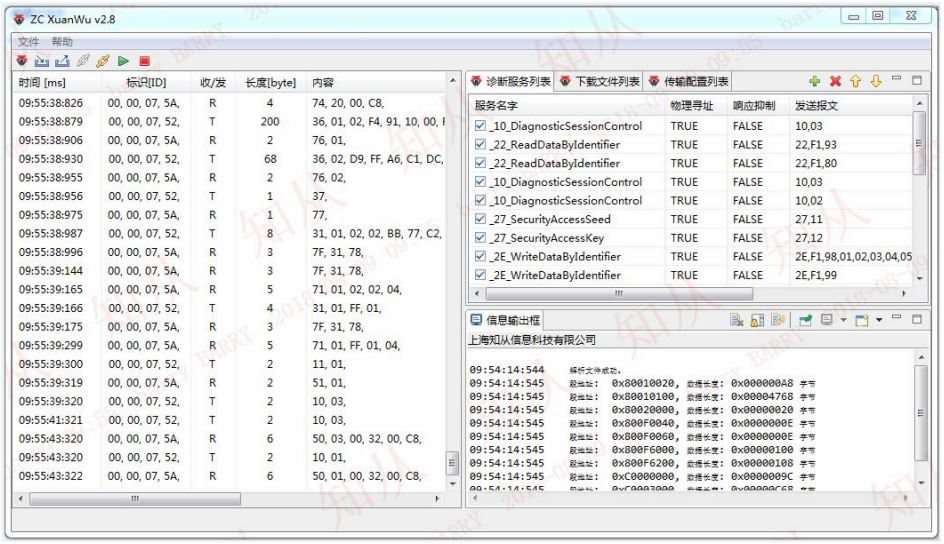
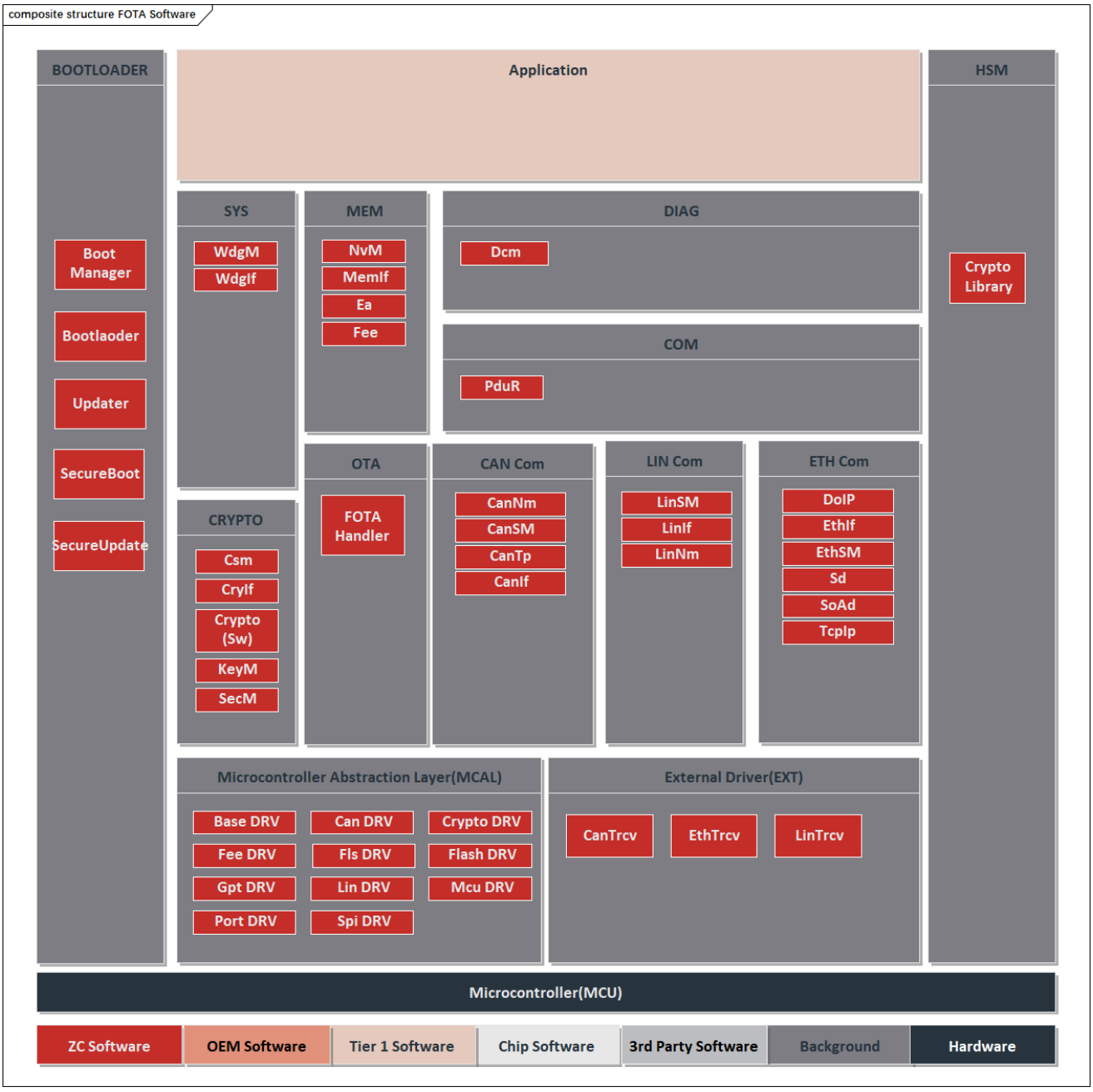


图 5 - 1 知从玄武--程序更新工具

FIGURE 5 - 2 ZC.XUANWU-- PROGRAM UPDATE TOOL

5.2 系统架构 System Architecture



FOTA 系统架构
FOTA SYSTEM ARCHITECTURE

知从青龙 FOTA 系统架构支持 CAN、LIN、SPI、Ethernet 通信场景下的 FOTA 功能，通过 Dcm 模块实现 UDS 报文解析和诊断刷写，并通过适配 Crypto Library 实现各 OEM 规范的信息安全需求。以下为各模块的功能描述：

- Bootloader

  BootManager 模块提供 FOTA 启动管理功能，支持适配软硬件 SecureBoot 功能，通过烧录和刷写存储 Bootloader 和 Application 的期望 MAC 值，启动阶段 SecureBoot 通过计算比较 Bootloader 和 Application 的 MAC 执行软件完整性校验，保证软件安全需求。

- Can Com

  Can 模块支持 CAN、CANFD 通信功能。

- Spi Com

  Spi 模块支持主从刷写功能，通过适配 5、6、7 线硬件配置，可支持多种 SPI 通信刷写模式。

- Ethernet Com

  DoIP 模块基于 TCP/IP 协议实现 Ethernet 通信收发功能，满足 ISO 13400 标准定义。通过车辆识别、路由激活、诊断消息功能实现 UDS 刷写流程，实现 Ethernet OTA 功能。

- Dcm

  Dcm 模块基于通信模块支持实现诊断功能，满足 ISO 14229 以及 ISO 15765 标准定义。

- Crypto、HSM

  Ethernet OTA 支持适配木牛加密库功能，支持非对称加密算法和加密算法结合实现安全刷写功能，适配证书认证功能满足安全诊断功能，适配 HSM 提高信息安全功能的稳定性和校验速度。

The Qinglong Ethernet FOTA system architecture supports the FOTA function in communication scenarios such as CAN, LIN, SPI, and Ethernet. It realizes the parsing of UDS messages and diagnostic programming through the Dcm module, and meets the information security requirements of various OEM specifications by adapting to the Crypto Library. The following are the functional descriptions of each module:

- Bootloader

  The BootManager module provides FOTA startup management functions and supports the adaptation of hardware and software SecureBoot functions. It stores the expected MAC values of the Bootloader and Application through programming and flashing. During the startup phase, SecureBoot performs software integrity verification by calculating and comparing the MACs of the Bootloader and Application to ensure software security requirements.

- Can Com

  The Can module supports CAN and CANFD communication functions.

- Spi Com

The Spi module supports the master-slave programming function. By adapting to the hardware configurations of 5, 6, and 7 wires, it can support multiple SPI communication programming modes.

- Ethernet Com

The DoIP module realizes the Ethernet communication sending and receiving functions based on the TCP/IP protocol, meeting the definition of the ISO 13400 standard. It implements the UDS flashing process through vehicle identification, routing activation, and diagnostic message functions, thereby achieving the Ethernet OTA function.

- Dcm

The Dcm module realizes the diagnostic function based on the support of the communication module, meeting the definitions of ISO 14229 and ISO 15765 standards.

- Crypto, HSM

The Ethernet OTA supports the adaptation of the Muniu Crypto Library functions. It combines asymmetric encryption algorithms with other encryption algorithms to achieve the secure flashing function. It adapts to the certificate authentication function to meet the security diagnostic requirements and adapts to the HSM to improve the stability and verification speed of the Cybersecurity function.

5.3 部署模式 Deployment Modes

知从青龙 SPI OTA 需要从节点芯片支持 AB SWAP，以下为 SPI OTA 的部署模式

ZC Qinglong SPI OTA requires support for AB SWAP from the node chip. Below is the deployment mode for SPI OTA.

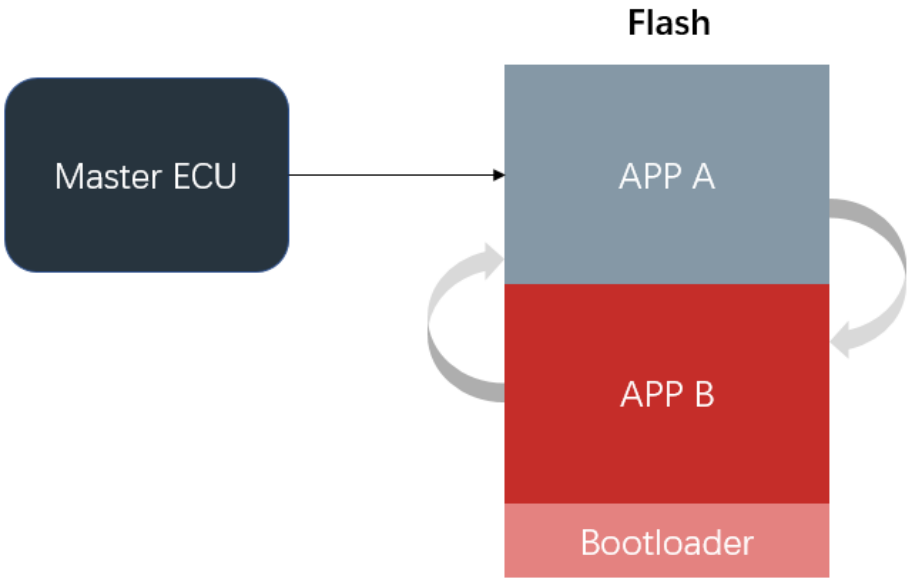


图 5 - 3 SPI OTA 方案
FIGURE 5-3 SPI OTA SOLUTION

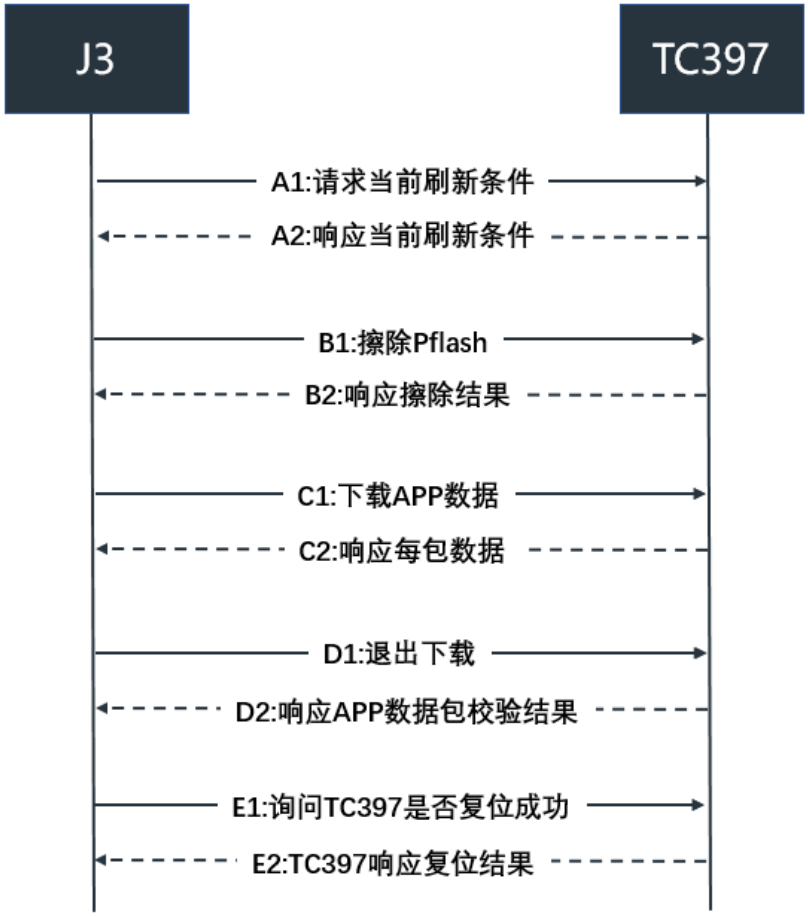
在 Flash 中划分出两块相同大小的区域，分为 A 区和 B 区，都用来存放 APP，但同一时间下只有一个区的 APP 是有效的。初始状态下先将 APP 写入 A 区，更新的时候，将新的 APP 写入 B 区，并切换 AB 区 APP 的有效位。Bootloader 通过标志位判断哪个区的 APP 有效，在启动时将对应 APP 的数据通过 SOAT 功能映射到虚拟地址，Bootloader 跳转并执行虚拟地址中的 APP 程序。这种方法不需要重复拷贝 APP 数据，并通过地址映射功能保证软件数据地址的统一性。

Two regions of equal size are partitioned in the Flash, designated as Area A and Area B, both used to store the APP, but only one area's APP is active at any given time. Initially, the APP is written to Area A. When updating, the new APP is written to Area B, and the active bit for the AB areas' APPs is switched. The Bootloader determines which area's APP is active based on a flag bit, and at startup, it maps the corresponding APP's data to a virtual address through the SOTA function. The Bootloader then jumps and executes the APP program at the virtual address. This method avoids the need to duplicate APP data and ensures the uniformity of software data addresses through address mapping functionality.

5.4 通信方案 Communication Scheme

知从青龙 SPI OTA 遵循标准的 UDS 诊断通信规范，通过 UDS 报文控制从节点的 FOTA 功能运行。下图为基于 J3 和 TC397 的 SPI OTA 诊断交互逻辑图：

ZC Qinglong SPI OTA adheres to the standard UDS diagnostic communication specification, controlling the FOTA (Firmware Over-The-Air) functionality of the slave node through UDS messages. The following diagram illustrates the SPI OTA diagnostic interaction logic based on J3 and TC397:



知从青龙 SPI OTA 通过使用主节点向从节点依次发送请求刷新、擦除数据、刷写数据、校验数据、执行复位的指令，完成对从节点软件数据的更新以及 AB 区切换。

ZC Qinglong SPI OTA completes the update of the slave node's software data and the AB partition switching by sequentially sending instructions to the slave node from the master node, including requests to refresh, erase data, flash data, verify data, and execute a reset.

6 过程文档 PROCESS DOCUMENTATION

开发流程 Development Process	文档描述 Document Description
需求收集 Development Process	顾客的需求文档 Document Description
软件需求分析 Requirement Collection	需求分析 Requirement Analysis
	需求分析规格书 Requirement Analysis Specification
	软件需求追踪表 Software Requirement Traceability Matrix
	客户的问题沟通表 Customer Issue Communication Form
软件架构设计 Software Architecture Design	软件架构说明书 Software Architecture Manual
	软件架构的追踪表 Software Architecture Traceability Table
软件详细设计和单元设计 Software Detailed Design and Unit Design	FOTA 详细设计说明书 FOTA Detailed Design Manual
	配置工具设计 Configuration Tool Design
	软件详细设计追踪表 Software Detailed Design Traceability Table
	FOTA 详细设计评审 FOTA Detailed Design Review
软件单元测试 Software Unit Testing	QAC 分析报告 QAC Analysis Report
	Tessy 测试报告 Tessy Test Report
	软件单元验证策略 Software Unit Verification Strategy
软件集成和集成测试	集成策略 Integration Strategy
	集成手册 Integration Manual

开发流程 Development Process	文档描述 Document Description
Software Integration and Integration Testing	集成测试策略 Integration Test Strategy
	集成测试报告 Integration Test Report
	资源分析报告 Resource Analysis Report
软件认可测试 Software System Testing	FOTA 软件测试报告 FOTA Software Test Report
	FOTA 软件测试报告评审 FOTA Software Test Report Review
发布 Release	发布文档 Release