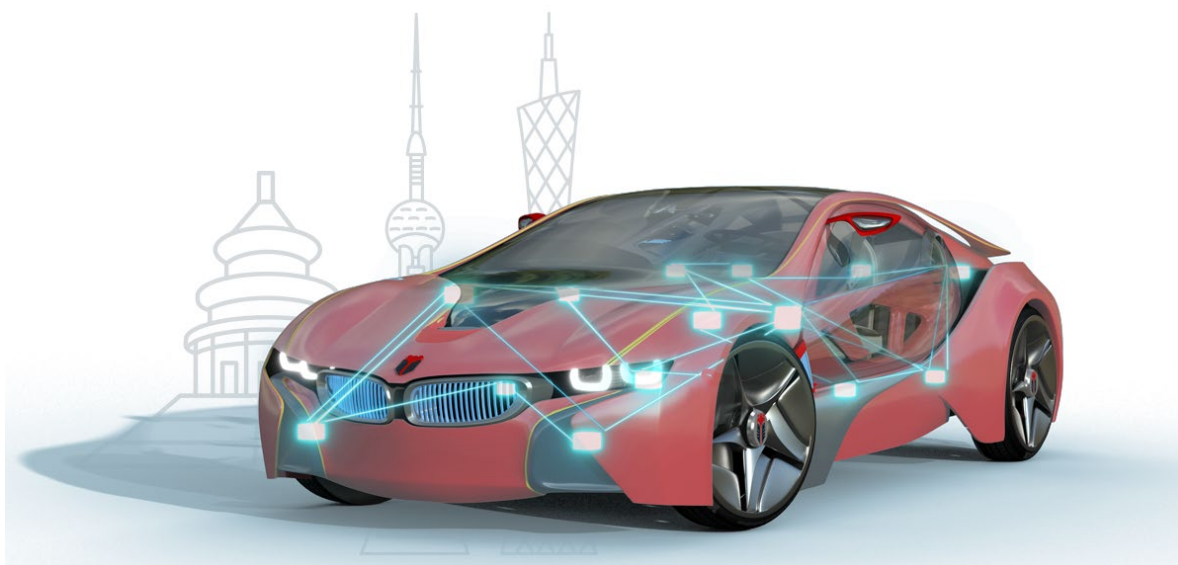




知从青龙 FOTA 英飞凌 TLE9893 产品手册
ZC.QINGLONG FOTA PRODUCT MANUAL
BASED ON INFINEON TLE9893

知从青龙 BootLoader
ZC.QingLong BootLoader



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知从青龙 BootLoader

ZC.QingLong BootLoader

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 flash programming 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 FOTA 基于 Infineon TLE9893 平台，实现了 OTA 功能，控制器可以执行 AB 备份，断点重传，回滚等功能，提高了程序刷新的安全性。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 FOTA, built on the Infineon TC3xx platform, has realized the OTA (Over-The-Air) functionality. The controller can perform A/B backup, breakpoint resumption, rollback, and other functions, enhancing the security of program refreshing. It also supports the OTA standards of many car manufacturers and provides customized development services.

2 应用领域 APPLICATION DOMAINS

知从青龙 FOTA 可应用于基于 TLE9893 系列芯片的控制器程序刷新功能。支持的控制器包括：

ZC.Qinglong FOTA can be applied to the controller program refreshing function based on the TLE9893 series chips. The supported controllers include:

- 动力系统 Power Systems
发动机控制器、电池管理系统、电机控制器等
Engine controllers, battery management systems, motor controllers, etc
- 底盘系统 Chassis Systems
电动助力转向系统等
Electric power steering systems, etc

3 配置环境 CONFIGURATION ENVIRONMENT

| 配置环境 Configuration Environment | |
|-----------------------------------|--|
| Hardware (Chip) | TLE9891 TLE9893 |
| Compilers Supported | Keil μ Vision V5.38.0.0 |
| 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 CAN/LIN 协议传输数据，符合 ISO14229 和 ISO15765 规范

Utilizes the CAN/LIN protocol for data transmission, in compliance with the ISO14229 和 ISO15765 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%

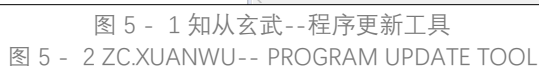
Supports differential restoration technology, which can speed up the upgrade process by 90% compared to standard upgrades

- 支持整包升级，提供更多的安全保障

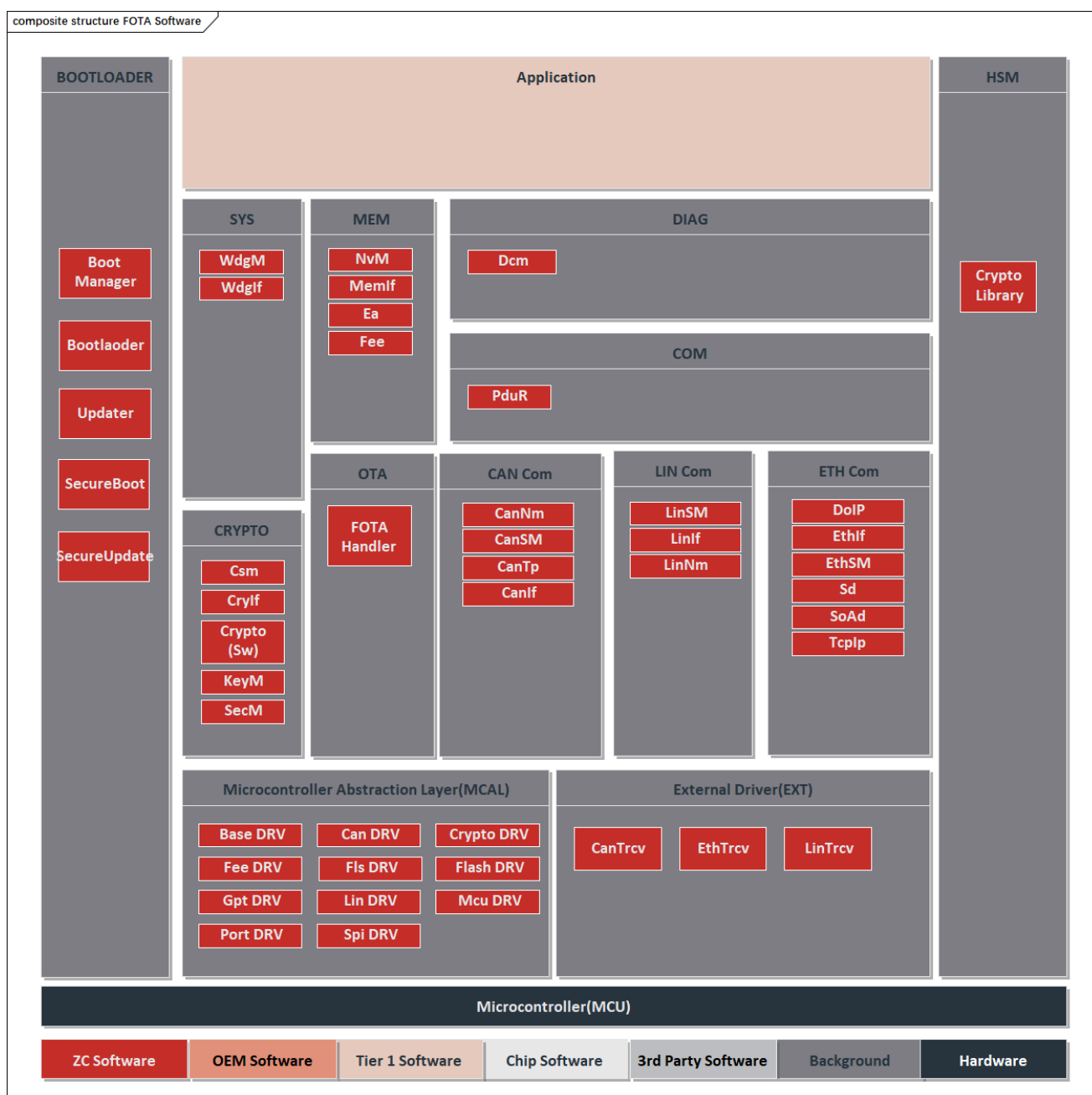
Supports full package upgrades for enhanced security

- 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



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 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。

➤ 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.

➤ 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

TLE989x 不支持硬件地址映射功能，空间资源为 256 KB FLASH1，32 KB RAM 或 128 KB FLASH1，16 KB RAM，不建议适配过多功能以避免出现内存空间不足的问题。以下为 TLE9893 在知从青龙 FOTA 上的内存分配方式：

| Address | Memory/Module in MCU | Block |
|-----------------------|----------------------|---------------|
| 0x11000000-0x11007FFF | NVM0 | Bootloader |
| 0x12000000-0x1203FFFF | NVM1 | Application A |
| 0x12000000-0x1203FFFF | NVM1 | Application B |

表 5 - 1 TLE9893 内存分配

TABLE 5 - 1 TLE9893 MEMORY DISTRIBUTION

基于 TLE989x，知从青龙 FOTA 支持两种软件部署模式，可以为用户提供不同的实现方案。

Based on TLE989x, ZC.Qinglong FOTA supports two software deployment modes, which can provide users with different implementation solutions.

➤ 软件 AB 分区方案：

Software AB Partition Scheme:

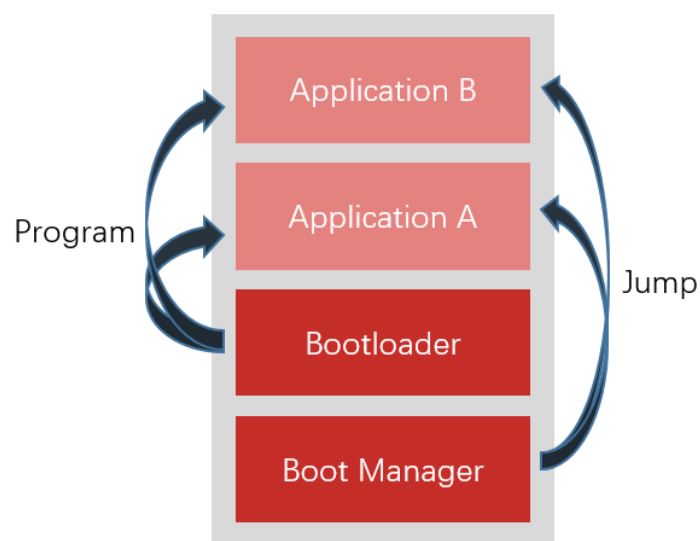


图 5-4 软件 AB 分区方案

FIGURE 5-4 SOFTWARE AB PARTITION SCHEME

如图 5-4 所示，将 Application 区域分为 A 区和 B 区，A 区和 B 区仅有一个激活区，一个非激活区。激活区用于运行 App 软件，非激活区用于供 Bootloader 下载新版本的 App 软件，激活区和非激活区可以自由切换。Boot Manager 会在启动时判断跳转激活区。

As shown in Figure 5-4, the Application area is divided into Area A and Area B, with only one active area and one inactive area. The active area is used to run the App software, while the inactive area is used for the Bootloader to download new versions of the App software, and the active and inactive areas can be freely switched. The Boot Manager will determine which active area to jump to at startup

方案优点：

Advantages of the scheme:

- Application A 和 Application B 互不干扰，能够独立运行
Application A and Application B do not interfere with each other and can run independently.
- 回滚方便，切换激活区并复位即可完成回滚
Rolling back is convenient; simply switch the active area and reset to complete the rollback.
- 不需要硬件支持地址映射功能
No hardware support for address mapping functionality is required.

方案缺点：

Disadvantages of the scheme:

- A、B 分区的地址分配不一致，需要使用两套地址分配生成 Application 软件。
The address allocation for partitions A and B is inconsistent, requiring the use of two sets of address allocations to generate Application software.

➤ 软件备份分区方案：

Software Backup Partition Scheme:

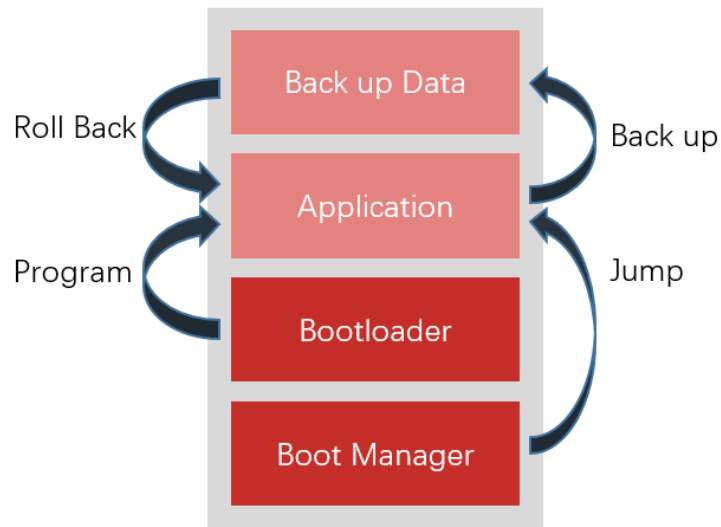


图 5-5 软件备份分区方案
 FIGURE 5-5 SOFTWARE BACKUP PARTITION SCHEME

如图 5-5 所示，将 Application 区域分为运行区和备份区，运行区用于存放运行的 Application，备份区用于存储更新前运行的 Application。当 App 软件需要回滚时，Bootloader 通过将 Back up Data 区域的数据下载回 Application 完成回滚。

As shown in Figure 5-5, the Application area is divided into a running area and a backup area. The running area is used to store the running Application, and the backup area is used to store the Application that was running before the update. When the App software needs to be rolled back, the Bootloader completes the rollback by downloading the data from the Back up Data area back into the Application.

方案优点：

Advantages of the scheme:

- Application 运行地址固定
The Application running address is fixed.
- Back up Data 区域大小可以通过压缩算法进行压缩
The size of the Back up Data area can be reduced through compression algorithms.

方案缺点：

Disadvantages of the scheme:

- 回滚需要一定时间

Rolling back requires a certain amount of time.

- 仅能将 Application 回滚为旧版本，无法将旧版本切换回新版本

Only the Application can be rolled back to an older version; it is not possible to switch an old version back to a new version.

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 Testing | Integration Integration | 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 | System | 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 |



公众号



业务联系

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To Be the Global Leading Automotive Basic Software Company

