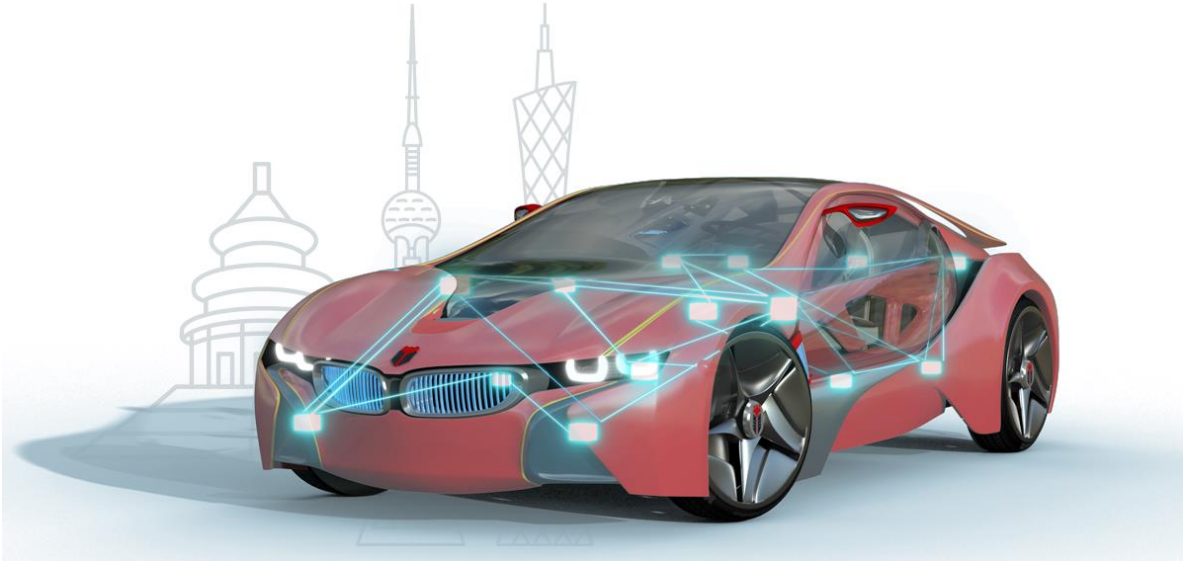
知从青龙 UART BOOTLOADER TMS570 产品手册
ZC.QINGLONG UART BOOTLOADER PRODUCT MANUAL BASED ON TMS570

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 已支持 NXP、Infineon、Renesas、ST、TI 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 program flashing software (BootLoader) independently developed by ZC Technology. For controllers using the ZC.QingLong BootLoader, the update function of application programs can be achieved through communication methods such as CAN, LIN, SPI, UART, and Uart. The ZC.QingLong BootLoader already supports chips from multiple manufacturers including NXP, Infineon, Renesas, ST and TI. Moreover, it is compatible with the program flashing specifications of multiple vehicle manufacturers and can provide customized development services.

在知从青龙 BootLoader 的基础上，知从青龙 Uart BootLoader 基于 TMS570 平台，结合 Uart 串口通信协议实现了 Uart 刷写功能，控制器可以通过 Uart 通信方式执行数据刷写，并在此基础上支持强制刷写功能，提高程序刷新的效率和安全性。

Building upon the ZC.QingLong BootLoader, the QingLong UART BootLoader is based on the TMS570 platform. It implements UART flashing functionality by integrating the UART serial communication protocol. The controller can execute data flashing via UART communication and supports forced flashing capabilities, thereby enhancing the efficiency and security of program updates.

2 应用领域 APPLICATION FIELD

知从青龙 Uart BootLoader 可应用于使用 TMS570 系列芯片的控制器程序刷新功能。支持的控制器包括:

The ZC.Qinglong Uart BootLoader can be applied to the program flashing function of controllers using the TMS570 series of 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 Domain controllers, zone controllers, gateways, etc.
- 动力系统 Power Systems
  电池管理系统等 Battery management systems, 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

3 配置环境 CONFIGURATION ENVIRONMENT

配置环境 Configuration Environment	
Hardware (Chip)	TMS570
Compilers Supported	CCS12.8.0.00012
Debugger	Lauterbach TRACE32

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。

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.

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。

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.

UART 作为一种基础的串行通信方式，在汽车电子领域始终占有一席之地。其核心价值在于硬件连接极其简洁，仅需发送（Tx）、接收（Rx）和地线（GND）三根线缆即可实现全双工异步通信，无需复杂的时钟同步信号。这种简化的物理结构带来了高可靠性和低成本的显著优势，使其特别适合汽车内部对成本敏感且空间受限的电子控制单元（ECU）之间，或者 ECU 与简单传感器、执行器之间进行低速率、点对点的数据交换。尽管当今车载网络技术正向 CAN FD、FlexRay 乃至 Automotive Ethernet 等高速总线演进，但 UART 因其协议简单、软硬件实现成本极低的特点，在特定的车载应用场景中仍是理想选择。

UART, as a fundamental serial communication method, continues to hold a significant place in the automotive electronics field. Its core value lies in its extremely simple hardware connection, requiring only three cables for transmission (Tx), reception (Rx), and ground (GND) to achieve full-duplex asynchronous communication, without the need for complex clock synchronization signals. This simplified physical structure offers significant advantages of high reliability and low cost, making it particularly suitable for low-speed, point-to-point data exchange between cost-sensitive and space-constrained Electronic Control Units (ECUs) within the automotive interior, or between ECUs and simple sensors/actuators. Although modern in-vehicle network technologies are evolving towards high-speed buses like CAN FD, FlexRay, and even Automotive Ethernet, UART remains an ideal choice for specific automotive application scenarios due to its simple protocol and very low hardware/software implementation costs .

在汽车电子系统的开发、生产乃至整车网络架构中，UART 发挥着多种关键作用。在开发和生产阶段，UART 接口常被预留为诊断与固件烧录（ISP）的通道，工程师可以通过它输出底层调试日志，实现与 ECU 最直接的“对话”。在车载信息娱乐系统（IVI）中，诸如 T-Box（远程信息处理器）或自动驾驶域控制器等外设模块，也常通过 UART 与主机交换简单的控制指令和状态数据。此外，面对汽车电子电气架构向域控制和区域控制演进的趋势，UART 技术也在持续进化。例如，为了降低系统复杂度和成本，业界出现了“MCU-Less”等新架构，在此类架构下，衍生出了像“UART over CAN”这样的创新技术，使得域控制器能够利用 CAN 总线的物理层来传输基于 UART 指令的数据包，从而实现对远端简单器件的直接控制，省去了这些节点上独立的微控制器，实现了降本增效。

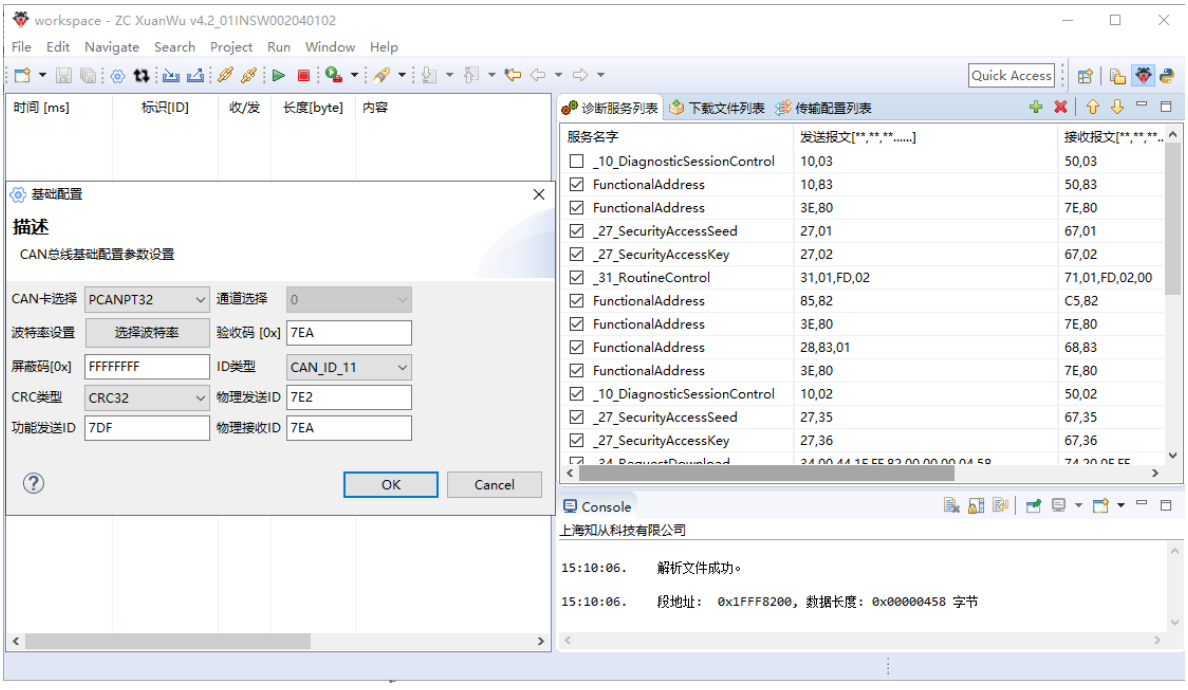
Within the development, production, and even the overall vehicle network architecture of automotive electronic systems, UART plays several key roles. During the development and production stages, UART interfaces are often reserved as channels for diagnostics and firmware programming (ISP). Engineers can use them to output low-level debug logs, enabling the most direct "dialogue" with the ECU . In In-Vehicle Infotainment (IVI) systems, peripheral modules such as T-Boxes (Telematics Boxes) or autonomous driving domain controllers often exchange simple control commands and status data with the host system via UART . Furthermore, facing the trend

towards domain control and zonal architectures in automotive E/E architecture, UART technology continues to evolve. For instance, to reduce system complexity and cost, new architectures like "MCU-Less" have emerged in the industry. Under such architectures, innovative technologies like "UART over CAN" have been derived. This allows domain controllers to utilize the CAN bus physical layer to transmit UART-based instruction packets, enabling direct control of remote simple devices and eliminating the need for separate microcontrollers at those nodes, achieving cost reduction and efficiency improvement .

5 功能描述 FUNCTIONAL DESCRIPTION

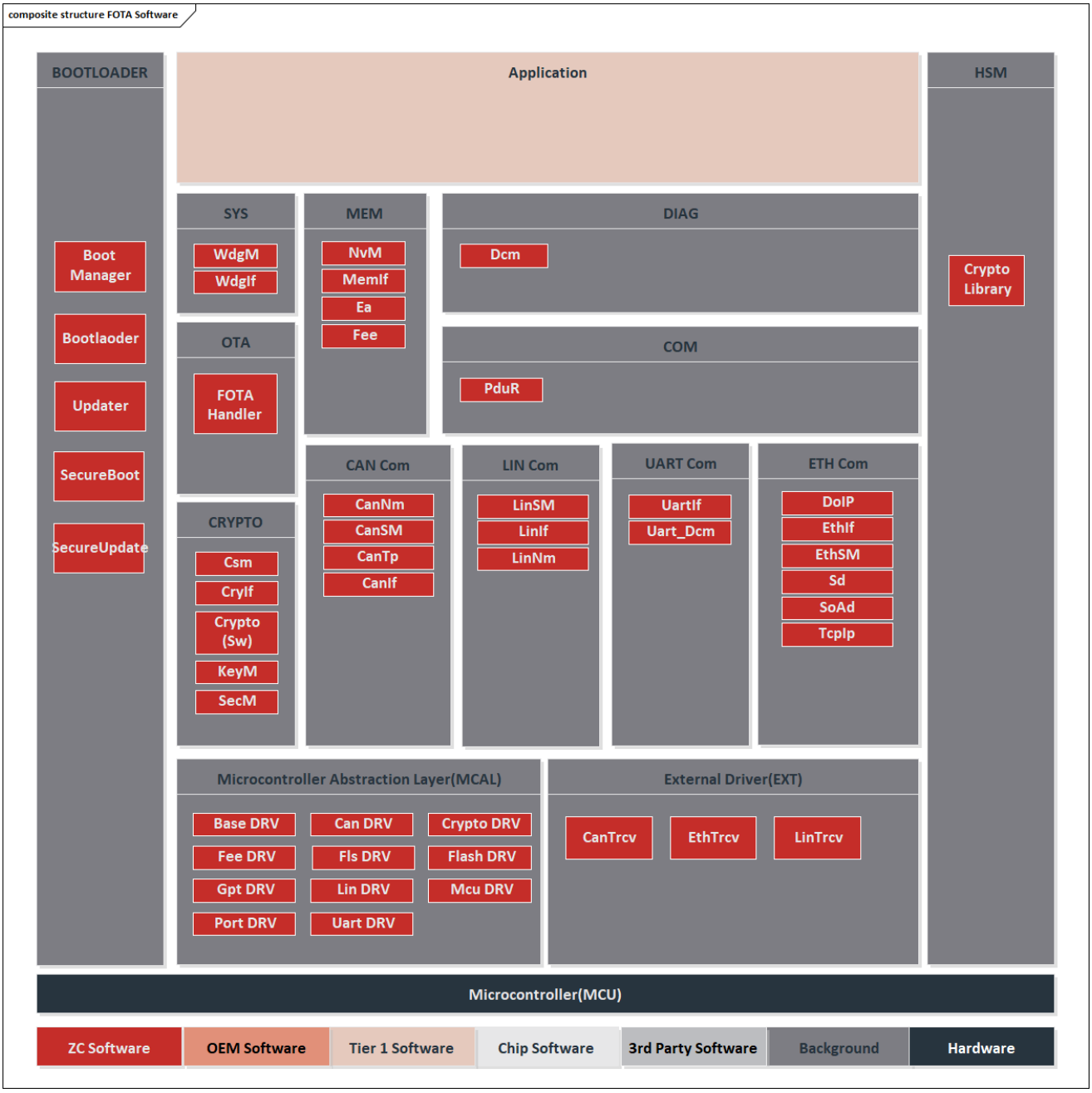
5.1 产品特点 Product Features

- 使用 Uart 串口通信协议传输数据
  Uses UART Serial Communication Protocol for data transmission
- 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.



知从玄武—程序更新工具
ZC.XuanWu—Program Update Tool

5.2 软件架构 Software Architecture



FOTA 系统架构
FOTA SYSTEM ARCHITECTURE

知从青龙 Uart BootLoader 系统架构支持 Uart 通信场景下的 FOTA 功能，通过 UartIf, Uart_Dcm 模块实现 Uart 串口通信刷写，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：

The Qinglong Uart BootLoader system architecture supports the FOTA function in Uart communication scenarios. It realizes the UART Serial Communication Flashing through the UartIf, Uart_Dcm modules, and meets the Cybersecurity requirements of various OEM specifications by adapting to the Crypto Library. The following are the function descriptions of each module:

- 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。

- 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.

- Uart Com

  使用 Uart 串口通信协议传输数据。通过特定引脚电平、自定义指令实现刷写流程，实现 Uart OTA 功能。

- Uart Com

  Use Uart serial communication protocol to transfer data. Brush-write process through specific pin levels, custom commands to implement Uart OTA function.

5.3 通信流程 Communication Sequence

外部设备 Master 端与车内 Slave 端,通过特定引脚电平、自定义指令实现刷写流程，实现 Uart OTA 功能。

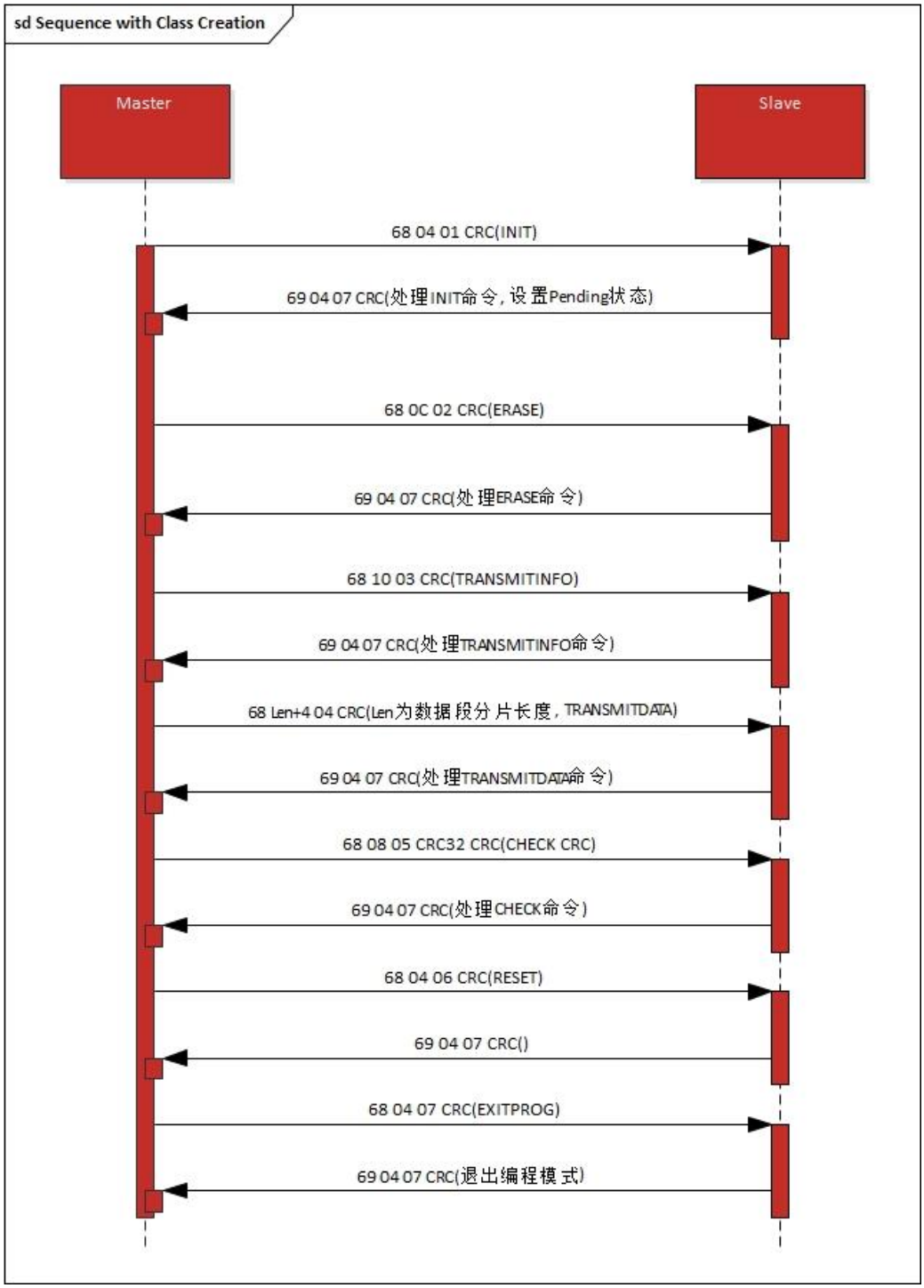
The Master side of the external device and the Slave side of the car, through the specific pin level, custom commands to achieve the process of brushing and writing, to achieve the Uart OTA function.

UART 通信采用 CRC8 校验。每帧报文的 CRC（FCS）位于帧尾，校验范围包括起始字节、数据长度、功能 ID 和所有数据字段（不含 FCS）。发送端计算 CRC 并填入 FCS；接收端重新计算并与 FCS 比对，不一致则判定为校验失败，丢弃该帧。CRC 用于检测传输错误，提升通信可靠性。

UART communication employs CRC8 checksum verification. The CRC (FCS) for each frame is located at the end of the frame. The verification scope includes the start byte, data length, function ID, and all data fields (excluding the FCS). The sender calculates the CRC and fills it into the FCS field. The receiver recalculates the CRC and compares it with the FCS. If they do not match, the verification is deemed failed, and the frame is discarded. CRC is used to detect transmission errors and enhance communication reliability.

外部设备 Master 端与车内 Slave 端建立通信的流程如下图所示。

The process of establishing communication between the Master side of the external device and the Slave side of the car is shown in the following figure.



UART 刷写流程

UART FLASHING PROCESS

5.4 知从玄武刷写工具刷写流程 ZC.Xuanwu Programming Sequence

知从玄武刷写工具已支持 Uart 串口通信协议的 Uart 刷写功能。使用知从玄武刷写工具进行刷写前，需要适配通信接口类型、通信 IP 地址、端口号、源地址 SA、目的地址 TA 等。

The ZC.Xuanwu Flashing Tool already supports the Uart serial communication protocol Uart brushing function. Before using the ZC.Xuanwu Flashing Tool for flashing, it is necessary to configure the communication interface type, communication IP address, port number, source address (SA), destination address (TA), etc.

刷写执行刷写前需要导入预设的 xml 文件，载入对应 OEM 刷写规范的刷写流程，或自行配置刷写流程服务。

Before performing the flashing operation, you need to import a preset XML file to load the flashing process corresponding to the OEM's flashing specifications, or configure the flashing process services by yourself.

诊断服务列表 | 下载文件列表 | 传输配置列表

服务名称	服务子功能或数据	发送报文[**,**,**.....]	接收报文[**,**,**.....]	物理寻址	响应抑制
_22_ReadDataByIdentifier	-	22,F1,93	62,F1,93	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,95	62,F1,95	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,87	62,F1,87	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,75	62,F1,75	TRUE	FALSE
_10_DiagnosticSessionCont...	03_ExtendedSession	10,03	50,03	FALSE	FALSE
_27_SecurityAccessSeed	-	27,01	67,01	TRUE	FALSE
_27_SecurityAccessKey	-	27,02	67,02	TRUE	FALSE
_31_RoutineControl	-	31,01,F0,02	71,01	TRUE	FALSE
_85_ControlDTCSetting	-	85,02	C5,02	FALSE	FALSE
_28_CommunicationControl	-	28,03,03	68,03	FALSE	FALSE
_10_DiagnosticSessionCont...	02_ProgrammingSession	10,02	50,02	TRUE	FALSE
DelayTimer	01_DefaultSession	70,00	50,02	TRUE	FALSE
_27_SecurityAccessSeed	-	27,03	67,03	TRUE	FALSE
_27_SecurityAccessKey	-	27,04	67,04	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,84	62,F1,84	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,80	62,F1,80	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,86	62,F1,86	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,70	62,F1,70	TRUE	FALSE
_2E_WriteDataByIdentifier	01_DefaultSession	2E,F1,84,20,25,01,20,39,2E,31,2E,30,20,20	6E,F1,84	TRUE	FALSE
_34_RequestDownload	-	34,00,44,FD,C0,10,00,00,00,0E,F6	74	TRUE	FALSE
_36_TransferData	path	36,01	76	TRUE	FALSE
_37_TransferExit	-	37	77	TRUE	FALSE
31_RoutineControl	-	31,01,F1,A0,BA,00,07,46	71,01,F1,A0	TRUE	FALSE

玄武刷写工具刷写流程配置界面

FLASHING PROCESS CONFIGURATION INTERFACE OF THE XUANWU FLASHING TOOL

刷写流程开始后，用户可以通过流程报文监控界面观察刷写进度以及刷写过程中出现的错误。

After the flashing process starts, users can observe the flashing progress and any errors that occur during the flashing process through the process message monitoring interface.

时间 [ms]	标识[ID]	收/发	长度[byte]	内容
09:33:49:841	00, 00, 07, 5A,	R	4	74, 20, 00, C8,
09:33:49:892	00, 00, 07, 52,	T	200	36, 01, 02, F4, 91, 10, 00,
09:33:49:921	00, 00, 07, 5A,	R	2	76, 01,
09:33:49:944	00, 00, 07, 52,	T	68	36, 02, D9, FF, A6, C1, DC,
09:33:49:971	00, 00, 07, 5A,	R	2	76, 02,
09:33:49:972	00, 00, 07, 52,	T	1	37,
09:33:49:990	00, 00, 07, 5A,	R	1	77,
09:33:50:003	00, 00, 07, 52,	T	8	31, 01, 02, 02, BB, 77, C2,
09:33:50:012	00, 00, 07, 5A,	R	3	7F, 31, 78,
09:33:50:160	00, 00, 07, 5A,	R	3	7F, 31, 78,
09:33:50:180	00, 00, 07, 5A,	R	5	71, 01, 02, 02, 04,
09:33:50:181	00, 00, 07, 52,	T	4	31, 01, FF, 01,
09:33:50:189	00, 00, 07, 5A,	R	3	7F, 31, 78,
09:33:50:315	00, 00, 07, 5A,	R	5	71, 01, FF, 01, 04,
09:33:50:315	00, 00, 07, 52,	T	2	11, 01,
09:33:50:335	00, 00, 07, 5A,	R	2	51, 01,
09:33:50:335	00, 00, 07, 52,	T	2	10, 03,
09:33:52:338	00, 00, 07, 52,	T	2	10, 03,
09:33:54:337	00, 00, 07, 5A,	R	6	50, 03, 00, 32, 00, C8,
09:33:54:337	00, 00, 07, 52,	T	2	10, 01,
09:33:54:338	00, 00, 07, 5A,	R	6	50, 01, 00, 32, 00, C8,

玄武刷写工具流程报文监控界面

XUANWU FLASHING TOOL PROCESS MESSAGE MONITORING INTERFACE

6 过程文档 PROCESS DOCUMENTATION

开发流程 Development Process	文档描述 Document Description
需求收集 Requirement Gathering	顾客的需求文档 Document Description
软件需求分析 Software Requirements Analysis	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	BootLoader 详细设计说明书 BootLoader 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
	BootLoader 详细设计评审 BootLoader 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**	BootLoader 软件测试报告 BootLoader Software Test Report
	BootLoader 软件测试报告评审 BootLoader Software Test Report Review
发布 **Release**	发布文档 Release

7 证书 CERTIFICATE

中华人民共和国国家版权局
计算机软件著作权登记证书

证书号：软著登字第14035707号

软件名称：知从青龙BootLoader软件
[简称：知从青龙]
V9.1.0

著作权人：上海知从科技有限公司

权利取得方式：原始取得

权利范围：全部权利

登记号：2024SR1631834

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2024年10月29日

知从青龙 BOOTLOADER 软件证书

ZC.QINGLONG BOOTLOADER SOFTWARE CERTIFICATE