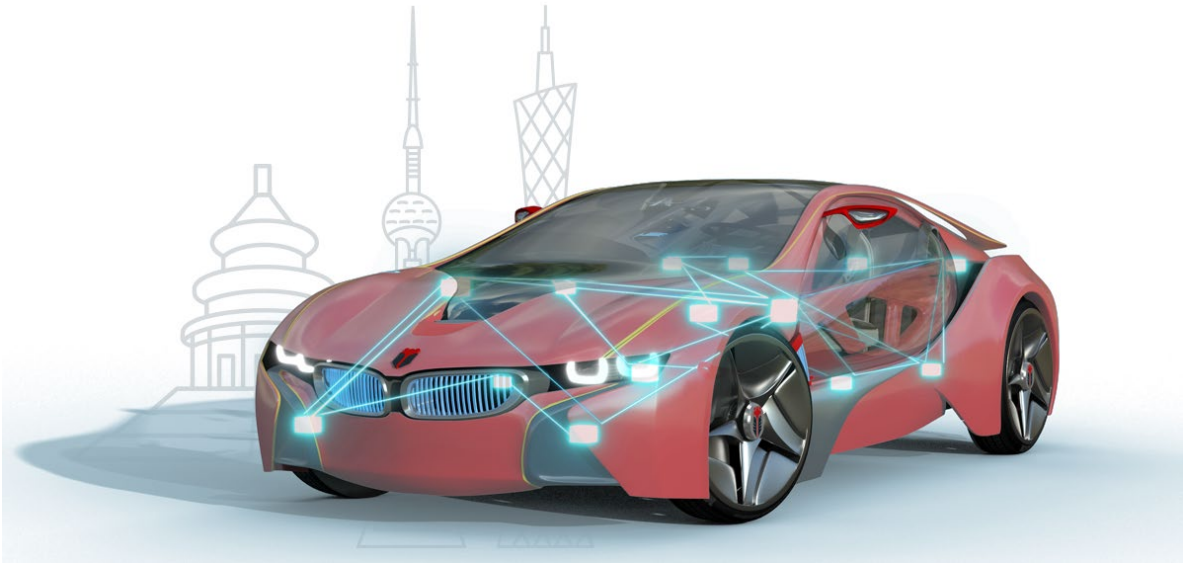
知从青龙 SECUREBOOT 恩智浦 S32K3 产品手册

ZC.QINGLONG SECUREBOOT PRODUCT MANUAL BASED ON NXP S32K3

知从青龙 BootLoader

ZC.QINGLONG BootLoader



知从青龙 SECUREBOOT 恩智浦 S32K3 产品手册

ZC.QINGLONG SECUREBOOT PRODUCT MANUAL BASED ON NXP S32K3

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。目前，知从青龙 BootLoader 已支持 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。

The ZC.QingLong BootLoader is an independently developed program update software (BootLoader) by ZC. Controllers using the ZC.QingLong BootLoader can update application programs through communication methods such as CAN, LIN, SPI, and UART. Currently, the ZC.QingLong BootLoader supports chips from various manufacturers including NXP, Infineon, Renesas, and ST, and it also supports the program update standards of multiple vehicle manufacturers, providing customized development services.

知从青龙 SecureBoot 是基于 NXP S32K3 平台，实现 BootLoader 的 Security 功能。通过实现 SecureBoot，控制器可以识别 BootLoader 程序和应用程序是否被篡改，特别是在 FOTA 过程中，可以保证程序刷新的安全性。

ZC.QingLong SecureBoot is based on the NXP S32K3 platform and implements the Security features of the BootLoader. With the implementation of SecureBoot, the controller can detect whether the BootLoader program and application program have been tampered with, especially during the FOTA process, ensuring the security of the program update.

2 应用领域 APPLICATION FIELD

知从青龙 SecureBoot 可应用于使用 S32K3 系列芯片的控制器程序刷新功能。支持的控制器包括:

ZC.QingLong SecureBoot can be applied to the controller program update function using the S32K3 series chips. The supported controllers include:

- 车身控制器

  Body Controller

- 网关控制器

  Gateway Controller

- 车载娱乐系统控制器

  In-Vehicle Infotainment System Controller

- 电子驻车制动系统

  Electronic Parking Brake System

- 胎压监测系统

  Tire Pressure Monitoring System

- 电池管理系统

  Battery Management System

- 空调控制系统

  Air Conditioning Control System

- 车窗控制系统

  Window Control System

- 门控系统

  Door Control System

3 配置环境 CONFIGURATION ENVIRONMENT

配置环境 Configuration Environment	
Hardware (Chip)	S32K312
Compilers Supported	GreenHills v2021.1 S32DS_ARM_v3.4
Debugger	Lauterbach (Trace32 R.2021.02) Isystem (IC5700)

GreenHills 编译器 GreenHills Compiler	
编译选项 Compilation options	-cpu=cortexm7 -DS32K312 -thumb -fsingle -DGHS -DAUTOSAR_OS_NOT_USED -DS32K312 -DUSE_SW_VECTOR_MODE -C99 -Osize -Wall-G -c --unsigned_fields --unsigned_chars -keeptempfiles -preprocess_assembly_files --no_exceptions -dual_debug --prototype_errors -Wundef -noslashcomment -Wimplicit-int -Wshadow -Wtrigraphs -nostartfile --no_commons --incorrect_pragma_warnings -list --short_enum --ghstd=last --gnu_asm
链接选项 Linking options	-e Reset_Handler -map -keepmap -Mn -delete -ignore_debug_references -L thumb2 -lmath_sd -larch -lstartup -lind_sd -keep=C40_Ip_AccessCode

S32DS 编译器 S32DS Compiler	
编译选项 Compilation Options	-O0 -g3 -Wall -c -fno-short-enums -ffunction-sections -fdata-sections -Wstrict-prototypes -Wsign-compare -Werror=implicit-function-declaration -Wundef -Wdouble-promotion -mcpu=cortex-m7 -mthumb -mlittle-endian -mfloat-abi=hard -mfpu=fpv5-sp-d16 -specs=nano.specs -specs=nosys.specs
链接选项 Linking Options	-nostartfiles --entry=Reset_Handler -ggdb3 -T "linker_flash_s32k312.ld" -Wl,-Map,"S32K312_Bootloader.map" -mcpu=cortex-m7 -mthumb -mlittle-endian -mfloat-abi=hard -mfpu=fpv5-sp-d16 -specs=nano.specs -specs=nosys.specs

4 开发背景 DEVELOPMENT BACKGROUND

目前，汽车上的电子电气架构越来越复杂，并伴随着汽车的电动化、智能化、网联化、共享化，软件的研发在汽车上占比越来越大。软件更新的频率越来越高。而且，在汽车的整个生命周期中，包括研发阶段、生产阶段、售后阶段，各个阶段都需要实现软件的更新功能。因此，客户对软件程序更新的需求越来越迫切。

Currently, the electronic and electrical architecture of automobiles is becoming increasingly complex. With the electrification, intelligence, connectivity, and sharing of vehicles, the proportion of software R&D in automobiles is growing larger. The frequency of software updates is also increasing. Moreover, throughout the entire lifecycle of a car, including the R&D phase, production phase, and after-sales phase, software update functionality is required in each stage. Therefore, customer demand for software program updates is becoming more urgent.

并且，随着车联网的落地，信息安全越来越受重视，芯片作为信息的载体，因此，对芯片中的数据保护尤其重要。知从青龙 SecureBoot 是基于 NXP S32K1xx 平台，实现 BootLoader 的 Security 功能。通过实现 SecureBoot，控制器可以识别 BootLoader 程序和应用程序是否被篡改，特别是在 FOTA 过程中，可以保证程序刷新的安全性。

Furthermore, with the implementation of the Internet of Vehicles, information security is gaining more attention. As chips serve as carriers of information, data protection within the chips is particularly important. ZC.QingLong SecureBoot, based on the NXP S32K1xx platform, implements the security features of the BootLoader. By implementing SecureBoot, the controller can detect if the BootLoader program and application programs have been tampered with, ensuring the security of program updates, especially during the FOTA process.

5 功能描述 FUNCTIONAL DESCRIPTION

5.1 产品特点 Product Features

- 适用于多达十几家整车厂的程序更新规范

Suitable for the program update specifications of up to a dozen car manufacturers

- 支持应用程序和数据的更新功能

Supports update functions for applications and data

- 支持 BootLoader 自更新功能

Supports self-update functionality for BootLoader

- 支持 HIS 规范

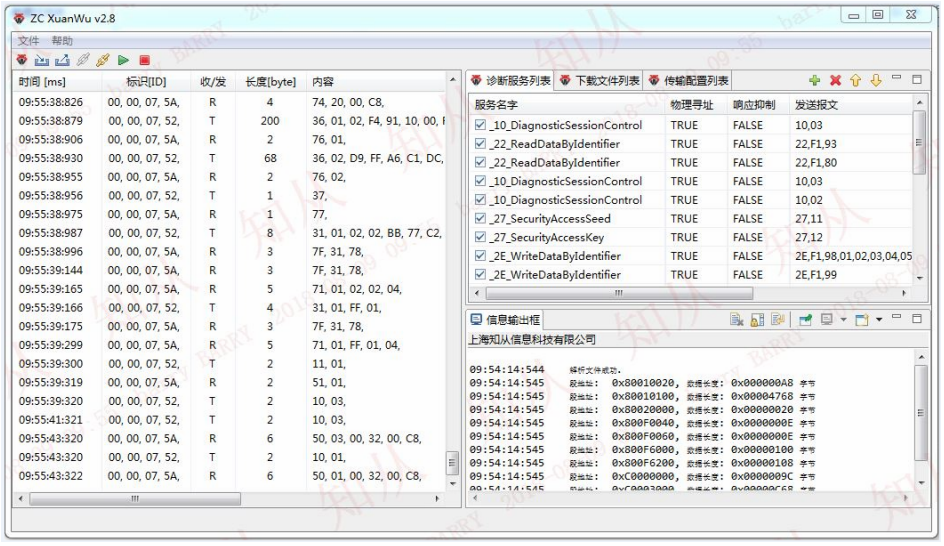
Supports HIS specifications

- 支持 CAN/LIN/SPI/UART 等通信

Supports communication via CAN/LIN/SPI/UART, etc.

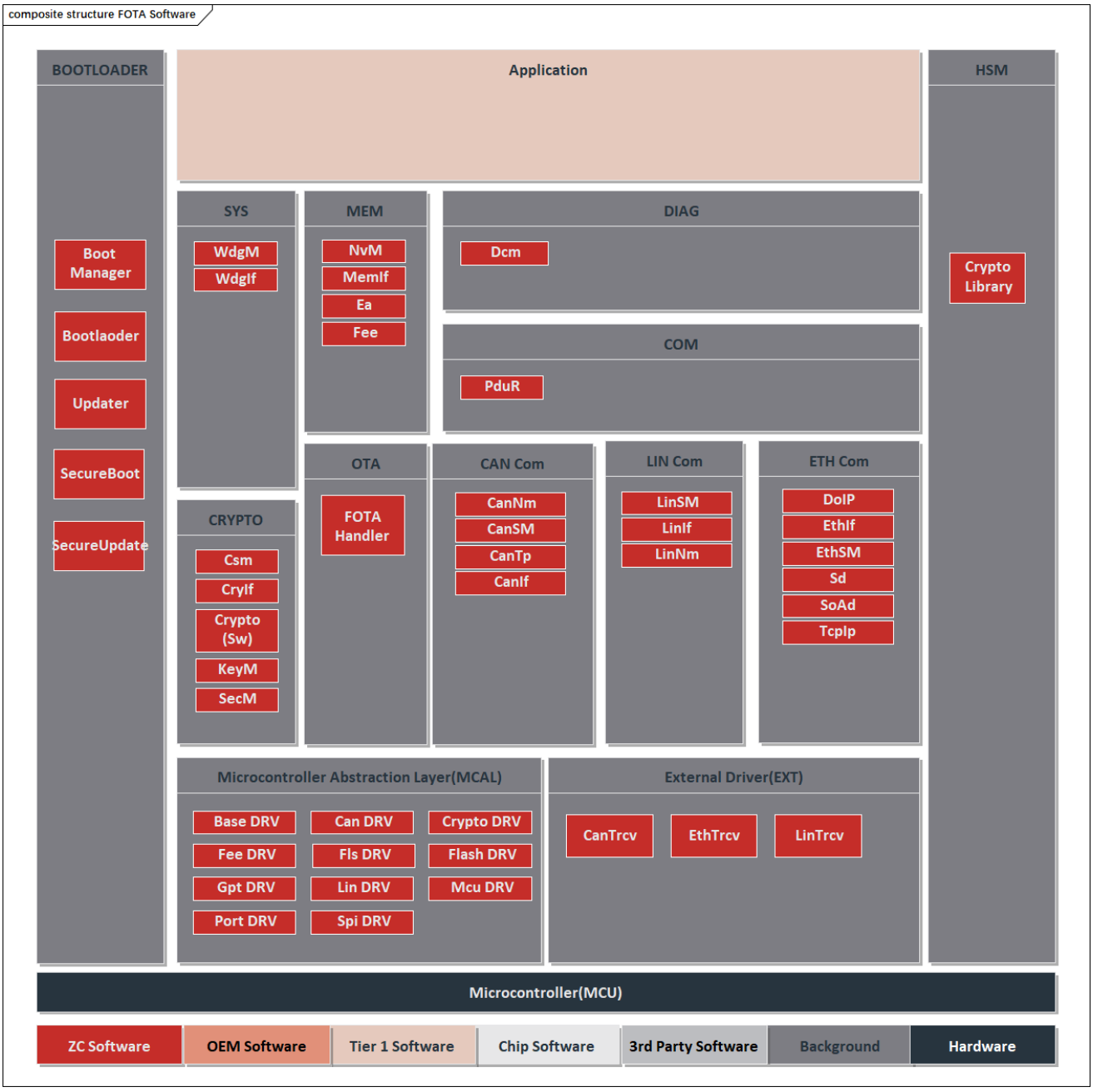
- 适配知从玄武程序更新工具，提供完整的程序更新解决方案

Adapts to ZC.XuanWu program update tools, offering a complete solution for program updates



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

5.2 软件架构 Software 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.

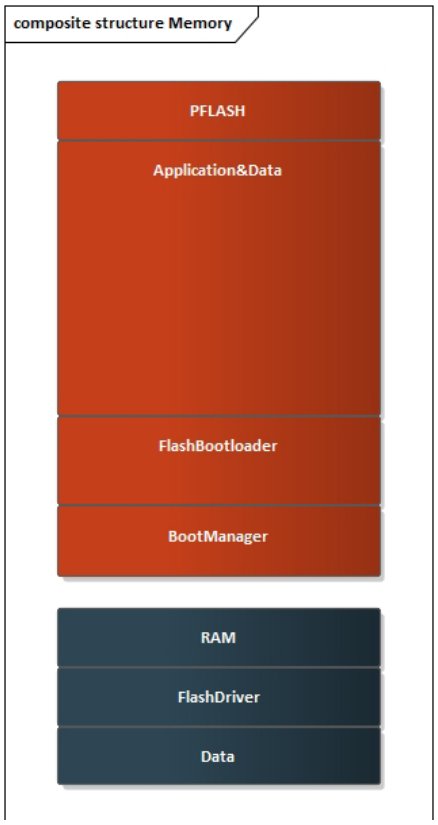
- Dcm

  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 内存结构 Memory Structure



ECU 的内存分为 PFLASH 和 RAM，PFLASH 区分为 Application&Data 和 BootLoader 区，RAM 区分为 FLASH Driver 和 Data。

The ECU's memory is divided into PFLASH and RAM. PFLASH is further divided into Application & Data and BootLoader areas, while RAM is divided into FLASH Driver and Data areas.

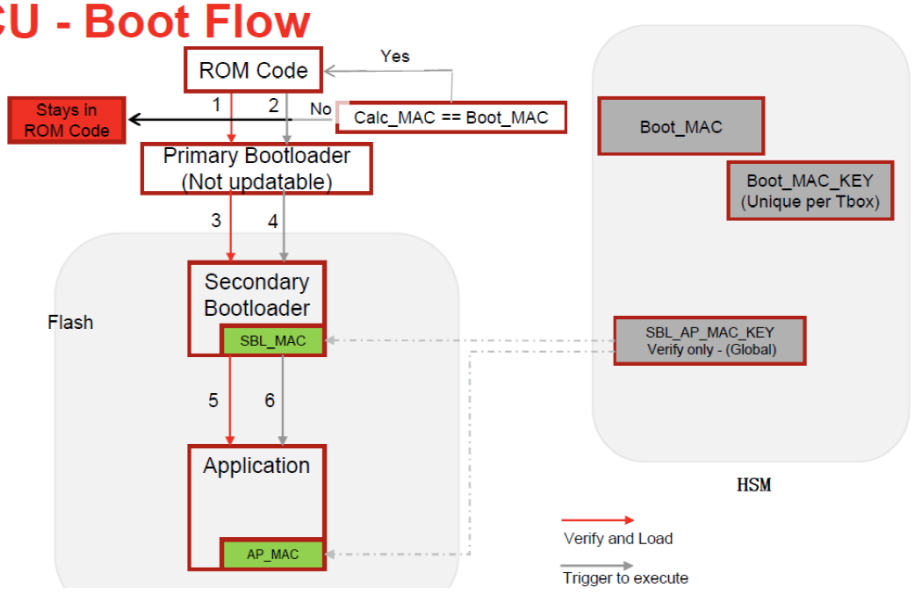
5.4 安全启动 SecureBoot

知从青龙 SecureBoot 支持安全启动和安全刷写，满足不同的客户算法需求。

ZC QingLong SecureBoot supports secure booting and secure flashing, meeting the diverse cryptographic algorithm needs of various customers.

Secure Boot MCU - Boot Flow

- BOOT_MAC is stored in a non-rewritable memory and is used to verify the Primaryloader (PBL) by reading the BOOT_MAC and BOOT_MAC_KEY pre-loaded in SHE
- If BOOT_MAC is verified, PBL verifies Secondary Bootloader (SBL) with SBL_AP_MAC_Key in SHE and SBL_MAC stored in the SBL
- If SBL is passed, SBL verifies Application (AP) with SBL_AP_MAC_KEY in SHE and AP_MAC stored in AP
- If any of the above check is failed, the Tbox stays in the most booted status: e.g. If AP check failed, system stays in SBL status



6 过程文档 PROCESS DOCUMENTATION

开发流程 Development Process	文档描述 Document Description
需求收集 Requirement Collection	顾客的需求文档 Customer Requirement Document
软件需求分析 Software Requirement 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 BootLoaderBootLoader 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 QACAnalysis 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
软件系统测试 **Software System Testing**	BootLoader 软件测试报告 BootLoader BootLoader Software Test Report
	BootLoader 软件测试报告评审 BootLoader BootLoader Software Test Report Review
发布	发布文档 Release Documentation

7 功能安全 FUNCTIONAL SAFETY

1. 功能安全评估报告 Functional Safety Assessment Report

2. 功能安全证书 Functional Safety Certificate

SGS

SGS TÜV SAAR

CERTIFICATE NO FS/71/220/23/1031
ZERTIFIKAT NR.:

PAGE 1/1
SEITE(N)

LICENCE HOLDER & MANUFACTURER
GENEHMIGUNGSINHABER & HERSTELLER

Shanghai ZC Technology Co., Ltd.
Building C, 888 Huanhu West 2nd Road,
Pudong New Area,
Shanghai,
P.R. China

PROJECT NO/-ID *PROJEKT-NR/-ID*	LICENSED TEST MARK *GENEHMIGTES PRÜFZEICHEN*	CERT. REPORT NO. *ZERTIFIKATSBERICHT NR.*
T4A8-AU01	SGS TÜV SAAR ASIL D COMPLIANT Functional Safety ISO 26262 www.sgs-tuv-saar.com	T4A80002 is an integral part of this certificate. *ist ein integraler Bestandteil dieses Zertifikats.*

Certified product(s)
Zertifizierte(s) Produkt(e)
SafetyFrame
Version 2.1.0

Tested according to
Geprüft nach
ISO 26262-2:2018
ISO 26262-6:2018
ISO 26262-8:2018
ISO 26262-9:2018

Technical Data and Parameter
Technische Daten und Parameter
The judgement of the achieved functional safety for the above-mentioned SafetyFrame Software is "accepted" according to above mentioned standards ASIL D requirements.

The SafetyFrame Software is suitable for integration into systems up to ASIL D.

The certificate is based on voluntary tests. The compliance of the certified product against the requirements of above listed functional safety standards was evaluated. Any changes to the design, components or processing may require repetition of some parts of the certification to retain the certification. All applicable requirements of the testing and certification regulations of SGS-TÜV Saar GmbH have to be complied, see www.sgs-tuv-saar.com/tcr-muc and www.sgs-tuv-saar.com/gtc-muc

Certification Body for Functional Safety & Cyber Security SGS-TÜV Saar GmbH
Zertifizierungsstelle für Funktionale Sicherheit & Cyber Sicherheit

Reference to SGS Certification Database

Munich, Feb 22, 2023
Gudrun Neumann

SGS-TÜV Saar GmbH, Hofmannstr. 50, 81379 München, *Deutschland* / Germany
Website: www.sgs-tuv-saar.com
E-Mail: fs@sgs.com

CERTIFICATE

8 证书 CERTIFICATES

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3073051号

软件名称：知从青龙bootloader软件
[简称：青龙]
V1.0

著作权人：上海知从科技有限公司

开发完成日期：2018年01月04日

首次发表日期：2018年01月10日

权利取得方式：原始取得

权利范围：全部权利

登记号：2018SR743956

根据《计算机软件保护条例》和《计算机软件著作权登记办法》的规定，经中国版权保护中心审核，对以上事项予以登记。

中华人民共和国国家版权局
计算机软件著作权登记专用章
2018年09月13日

No. 02965607

青龙软件著作权登记证书

QINGLONG SOFTWARE COPYRIGHT REGISTRATION CERTIFICATE

软件产品证书

经评估，知从青龙bootloader软件V1.0 符合《进一步鼓励软件产业和集成电路产业发展的若干政策》和《软件产品评估标准》（T/SIA003 2017）的有关规定，评估为软件产品，特发此证。

申请企业：上海知从科技有限公司
软件类别：沪RC-2019-3315
证书编号：嵌入式应用软件
有 效 期：五年

评估机构：上海市软件行业协会
日期：二〇一九 年 九 月 廿五 日

青龙软件产品登记证书

QINGLONG SOFTWARE PRODUCT REGISTRATION CERTIFICATE