



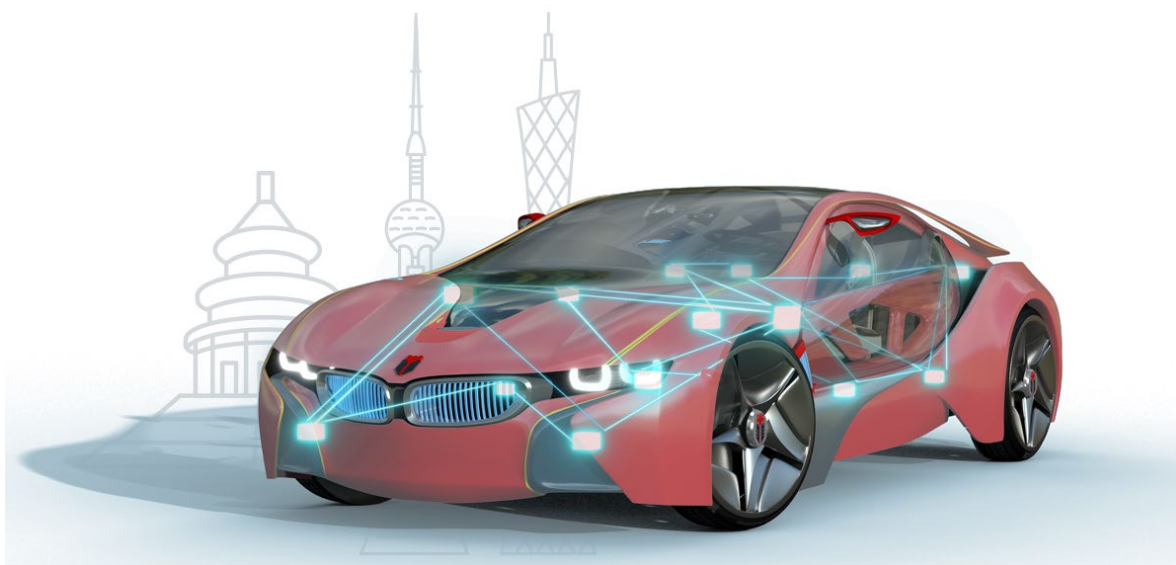
知从木牛 SBC 恩智浦 FS6500-FS4500

产品手册

**ZC.MuNiu SBC Product Manual Based On
NXP FS6500-FS4500**

知从木牛基础软件平台功能安全库

**ZC Basic Software Platform Functional Safety
Library**



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1 功能概述 FUNCTION OVERVIEW

知从木牛功能安全 SBC 系列软件旨在打造知从科技自主研发的满足客户功能安全要求的 System Basis Chip (SBC) 平台化软件产品。本手册说明了基于恩智浦 FS6500-FS4500 系列 SBC 实现的功能安全应用方案、软件架构等内容。本软件产品可帮助系统工程师和软件工程师能够快速地应用到客户产品中，满足功能安全需求。

The ZC.MuNiu functional safety SBC series software is designed to create a platform software product for the System Basis Chip (SBC) that meets customer functional safety requirements, independently developed by ZC Technology. This manual describes the functional safety application scheme and software architecture based on the NXP FS6500-FS4500 series SBC. This software product can help system engineers and software engineers to quickly apply it to customer products to meet functional safety requirements.

本产品实现了的 FS6500-FS4500 芯片软件驱动功能包含：

The software driver functions of the FS6500-FS4500 chip realized by this product include:

- 多路电源输出管理；

Multi-channel power output management;

- CAN/LIN 收发器管理；

CAN/LIN transceiver management;

- LDT 定时器管理；

LDT (Low-Dropout Timer) management;

- SBC 状态机控制、低功耗控制与唤醒管理；

SBC state machine control, low power control, and wake-up management;

- 输出电压诊断管理；

Output voltage diagnostic management;

- MCU 与 SBC 的 SPI 通信处理;

SPI communication processing between MCU and SBC;

- SBC 片内 ABIST/LBIST 自检管理;

Internal ABIST (Array Built-In Self-Test) / LBIST (Logic Built-In Self-Test) management for the SBC;

- 看门狗管理;

Watchdog management;

- MCU 错误监控管理;

MCU error monitoring management;

- SBC 片外安全关断路径处理。

External safe shutdown path processing for the SBC.

知从科技已适配开发的 FS6500-FS4500 系列大部分型号（不限于以下型号）：

ZC Technology has adapted and developed for most models in the FS6500-FS4500 series (not limited to the following models):

Type	Package	Note
MC33FS4500CAE	48-pin LQFP exposed pad	N/A
MC33FS4503CAE	48-pin LQFP exposed pad	N/A
MC33FS6500CAE	48-pin LQFP exposed pad	N/A

2 应用领域 APPLICATION FIELD

知从木牛功能安全 SBC 恩智浦 FS6500-FS4500 驱动软件产品可应用于有各功能安全等级需求的汽车控制器。

ZC.MuNiu functional safety SBC, the NXP FS6500-FS4500 series driver software product, can be applied to automotive controllers that require various functional safety levels.

例如:

For example:

- 电池管理系统(BMS)

Battery Management System (BMS)

- 逆变器(Inverter)

- DC-DC 转换器(DCDC)

DC-DC Converter (DCDC)

- 电动助力转向(EPS)

Electric Power Steering (EPS)

- 电子驻车系统(EPB)

Electronic Parking Brake System (EPB)

- 车身控制器(BCM)

Body Control Module (BCM)

- 发动机管理系统(EMS)

Engine Management System (EMS)

- 底盘域线控系统相关应用

Chassis Domain Control System Related Applications

- 智能驾驶控制器(ADAS)

Advanced Driver Assistance System Controller (ADAS)

此 SBC 恩智浦 FS6500-FS4500 驱动软件产品手册是为有经验的硬件、软件和功能安全工程师编写的，根据 ISO 26262 设计，并参考安全相关系统的 E-GAS 三层架构理论，可以将 FS6500-FS4500 驱动软件产品集成到客户应用产品的(子)系统中。知从软件集成工程师可支持和确保 FS6500-FS4500 驱动软件产品适合客户选择的应用程序集成服务，并符合相应的软件开发流程，协助实现达到 ISO26262 ASIL-D 的等级要求。

This SBC NXP FS6500-FS4500 driver software product manual is written for experienced hardware, software, and functional safety engineers, designed according to ISO 26262, and refers to the E-GAS three-layer architecture theory for safety-related systems, allowing the FS6500-FS4500 driver software product to be integrated into the customer's application product

(sub)system. ZC software integration engineers can provide support and ensure that the FS6500-FS4500 driver software product is suitable for the customer's chosen application integration services, complies with the corresponding software development processes, and assists in achieving the ISO26262 ASIL-D level requirements.

3 配置环境 CONFIGURATION ENVIRONMENT

知从木牛功能安全 SBC 恩智浦 FS6500-FS4500 驱动软件产品目前可适配多家芯片厂商的 MCU，MCU 包括：

The ZC.MuNiu functional safety SBC, the NXP FS6500-FS4500 series driver software product, can currently be adapted to work with MCUs from multiple chip manufacturers. The MCUs include:

- 知从木牛 SBC 驱动软件产品支持的 NXP S32K 系列芯片软件配置：

The ZC.MuNiu SBC driver software product supports software configuration for the NXP S32K series chips:

配置环境 Configuration Environment	
Hardware (Chip)	S32K144/S32K146/S32K148
Compilers Supported	S32 Design Studio for ARM(2018.R1)
Evaluation Hardware	S32K144 EVB
Debugger	Lauterbach (Trace32 R.2018.02) Isystem (IC5700)
Configuration Tools	Muniu_v5.0.5
Configuration Environment	Win7 64bit

- 知从木牛 SBC 驱动软件产品支持的 NXP PowerPC 系列芯片软件配置：

The ZC.MuNiu SBC driver software product supports software configuration for the NXP PowerPC series chips:

配置环境 Configuration Environment	
Hardware (Chip)	MPC 5748G / MPC5744P/ MPC5746C
Compilers Supported	WindRiver Diab V5.9.4.0
Evaluation Hardware	SPC5748GSMKU6 1N81M
Debugger	Lauterbach (Trace32 R.2018.02) Isystem (IC5700)
Configuration Tools	Muniu_v5.2.2
Configuration Environment	Win7 64bit

- 知从木牛 SBC 驱动软件产品支持的英飞凌 AURIX 系列芯片软件配置：

The ZC.MuNiu SBC driver software product supports software configuration for the Infineon AURIX series chips:

配置环境 Configuration Environment	
Hardware (Chip)	INFINEON SAK-TC275TP_64F200W CA

Compilers Supported	Tasking 4.2r2 or HighTec 4.6.6.1
Evaluation Hardware	TriBoard TC275+MC33FS6500
Debugger	Lauterbach (Trace32 R.2018.02) or Isystem (IC5700)
Configuration Tools	Muniu_v5.1.3
Configuration Environment	Win7 64bit

4 开发背景 DEVELOPMENT BACKGROUND

目前，汽车上的电子电气架构越来越复杂，对汽车电子的安全性要求也越来越高，为了满足汽车的安全性需求，汽车功能安全越来越受到重视。业界近年来，在功能安全标准上参考 ISO 26262；在软件安全架构上参考 E-GAS 分层。恩智浦 FS6500-FS4500 适合所选应用，并符合此类应用标准，并在电子电气系统中，应用 SEooC(safety element out of context)进行设计开发。

The electronic and electrical architecture of vehicles is becoming increasingly complex, and the safety requirements for automotive electronics are also rising. To meet the safety demands of vehicles, functional safety is gaining more and more attention. In recent years, the industry has referred to the ISO 26262 standard for functional safety; and for the safety architecture of software frameworks, it has referred to the E-GAS layered approach. The NXP FS6500-FS4500 is suitable for the selected applications and complies with these application standards, and in the electronic and electrical systems, it is designed and developed as a SEooC (Safety Element out of Context).

由于 SBC 为特定 ASIL-x 等级 MCU 的供电系统、时序监控系统，按照 ISO 26262-5(2011) Clause 8 中介绍了 2 个度量：Single-point fault metric(单点故障度量)和 Latent-fault metric(潜伏故障度量)，不同的 ASIL 等级要求和故障失效分析方法均要求其达到单点故障度量和潜伏故障度量需要达到相应同等 ASIL-x 等级。

As an SBC (System Basis Chip) for an MCU (Microcontroller Unit) of a specific ASIL-x level, it serves as a power supply and timing monitoring system. According to ISO 26262-5(2011) Clause 8, two metrics are introduced: Single-point fault metric (measuring the occurrence of single faults) and Latent-fault metric (measuring the occurrence of faults that are not immediately apparent). The requirements for different ASIL levels and fault failure analysis methods all demand that the single-point fault metric and latent fault metric meet the corresponding ASIL-x level standards.

	ASIL B	ASIL C	ASIL D
Single-point fault metric	≥90 %	≥97 %	≥99 %

	ASIL B	ASIL C	ASIL D
Latent-fault metric	≥60 %	≥80 %	≥90 %

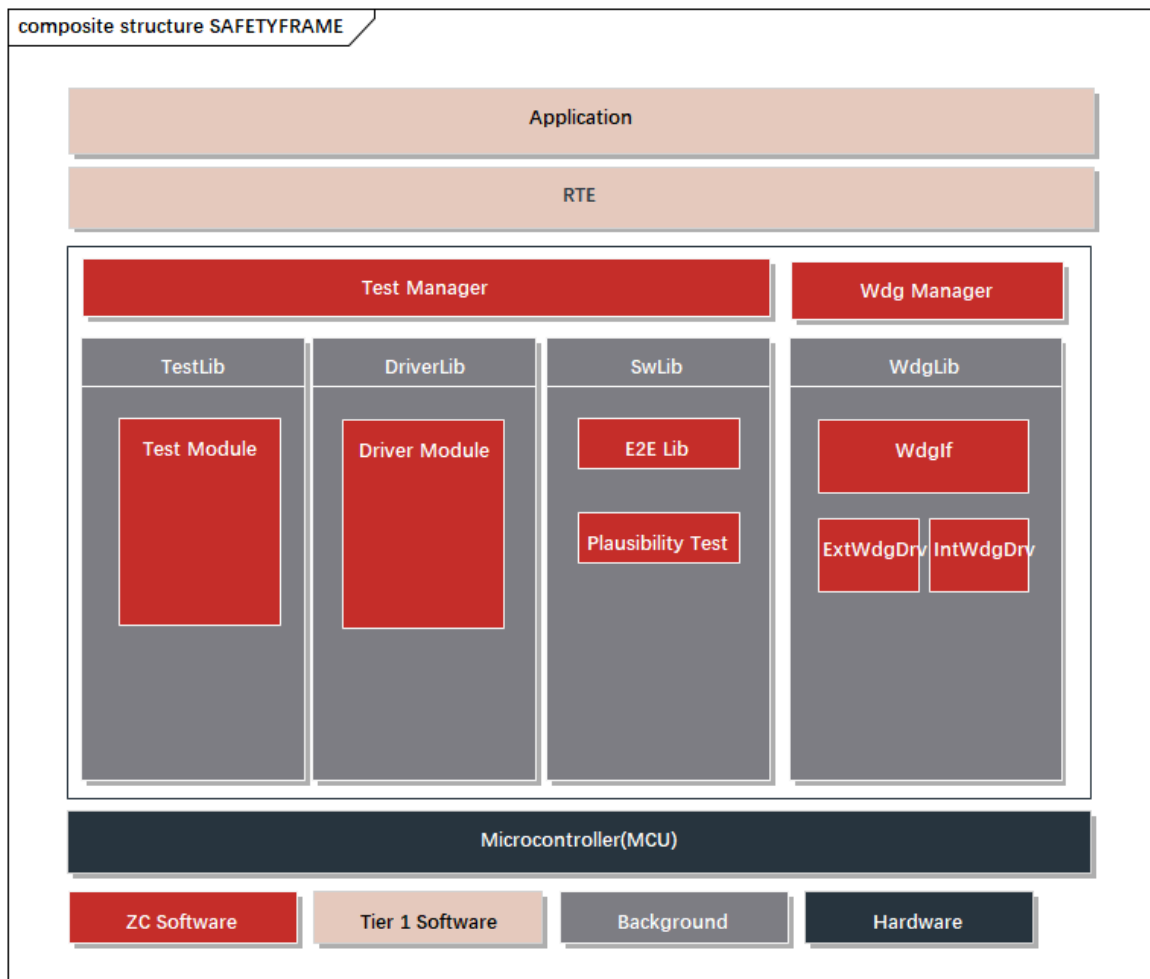
因此，在客户应用项目中若需符合 ASIL-D 安全等级，知从 SBC 恩智浦 FS6500-FS4500 驱动软件产品提供软件方案，满足功能安全需求，相关功能包括：

Therefore, in customer application projects where compliance with the ASIL-D safety level is required, the ZC SBC NXP FS6500-FS4500 driver software product provides a software solution to meet functional safety requirements, including:

- 看门狗管理功能，实现 MCU 的程序流监控
Watchdog management function to implement program flow monitoring for the MCU.
- 电压诊断功能
Voltage diagnostic function.
- SPI 通信诊断功能
SPI communication diagnostic function.
- FS0B/FS1B 处理和诊断功能
FS0B/FS1B processing and diagnostic function.
- ABIST/LBIST 诊断功能
ABIST/LBIST diagnostic function.

5 功能描述 FUNCTIONAL DESCRIPTION

5.1 产品特点 Product Feature



AUTOSAR 架构 AUTOSAR Architecture

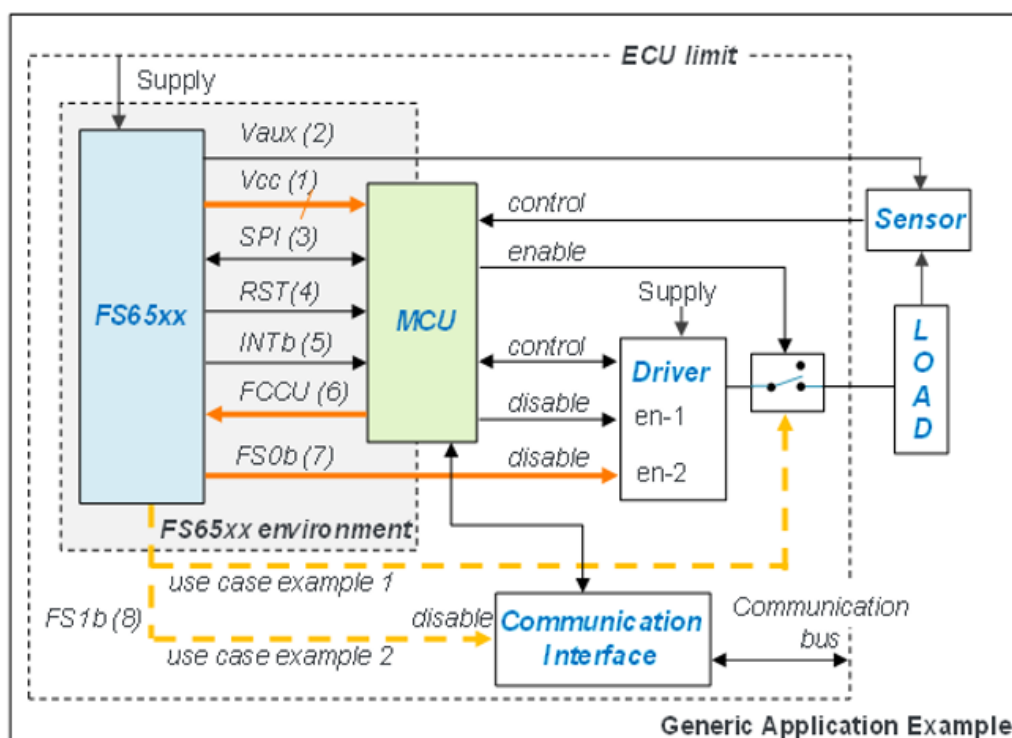
- 可作为复杂驱动集成到 AUTOSAR 中
Can be integrated as a complex driver into AUTOSAR .
- 可集成到非 AUTOSAR 软件架构中，灵活适配
Can be integrated into non-AUTOSAR software architectures.
- 支持多核测试及应用
Support multi-core testing and applications.
- Safety Library 具有内部程序流监控
Safety Frame has internal program flow monitoring.
- 高安全性：支持多核自检测测试，搭配知从科技 TLF35584Lib 可实现高达 ASIL-D 需求

High security: Supports multi-core self-testing, and can achieve up to ASIL-D requirements when paired with ZC 's TLF35584Lib.

➤ 高扩展性：各模块可配置满足不同客户的应用需求

High scalability: Each module can be configured to meet the application requirements of different customers.

5.2 功能安全架构 Functional Safety Architecture



系统安全架构 System Safety Architecture

为了满足功能安全需求，恩智浦 FS6500-FS4500 实现了通用的安全系统架构设计。基于此系统安全架构，FS6500-FS4500 可实现 MCU(VCORE and VCCA)和传感器(VAUX)的供电监控，同时，实现看门狗监控 MCU 和 MCU 故障监控，通过 FS0B/FS1B 实现系统的安全状态转换等。

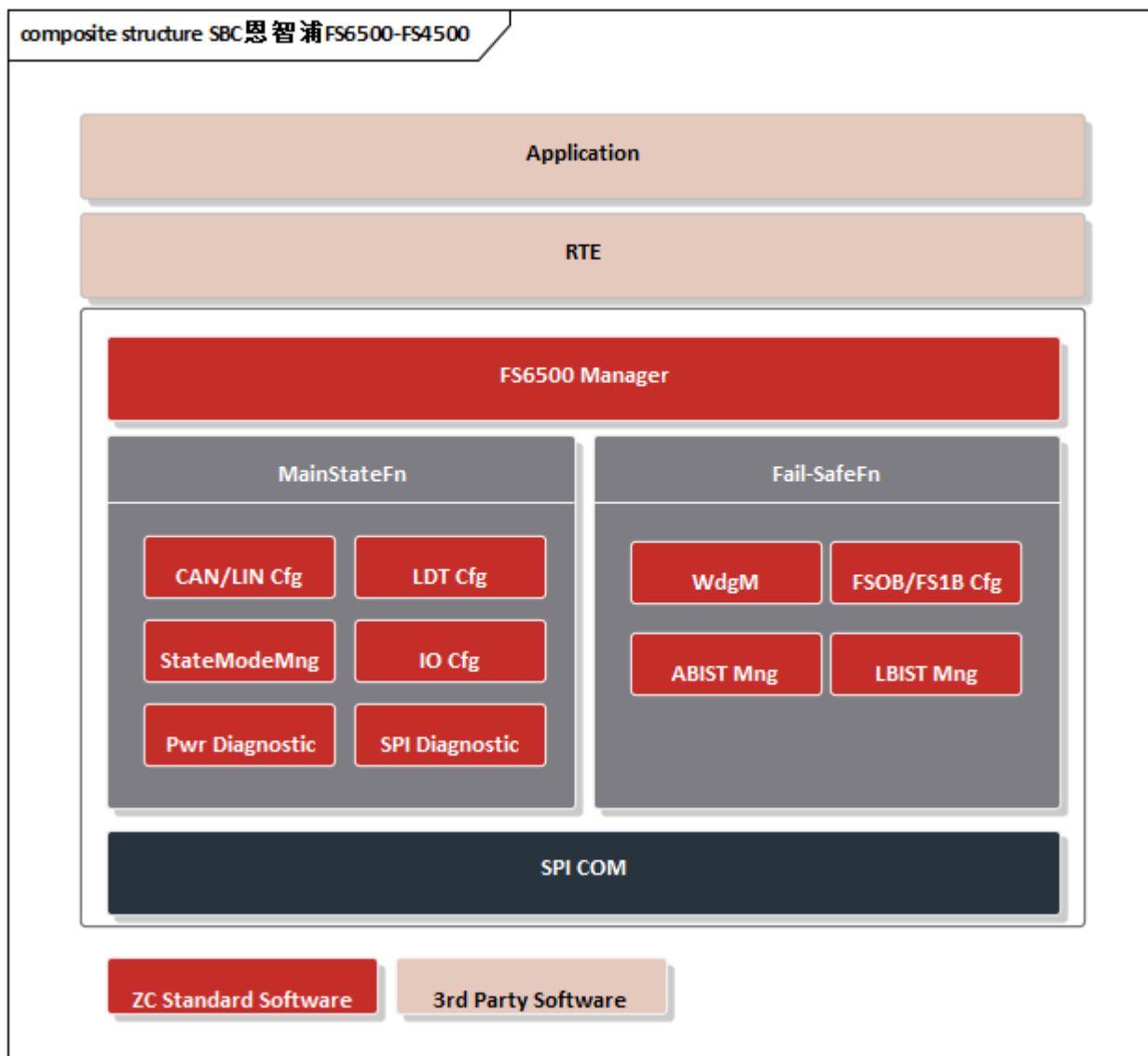
To meet functional safety requirements, the NXP FS6500-FS4500 has implemented a generic safety system architecture design. Based on this system safety architecture, the FS6500-FS4500 can achieve power supply monitoring for the MCU (VCORE and VCCA) and sensors (VAUX). At the same time, it implements watchdog monitoring for the MCU and fault monitoring of the MCU, and achieves safe state transitions of the system through FS0B/FS1B.

基于此系统安全架构，知从 SBC 恩智浦 FS6500-FS4500 驱动软件产品提供软件方案，可根据客户实际架构设计进行配置，实现的相关功能包括：

Based on this system safety architecture, the ZhiCong SBC NXP FS6500-FS4500 driver software product provides a software solution that can be configured according to the customer's actual architectural design to implement the following functions:

- 看门狗管理功能，实现 MCU 的程序流监控
Watchdog management function to implement program flow monitoring for the MCU.
- MCU 故障管理，通过 IO_2:3 引脚监控 MCU 内部故障
MCU fault management, monitoring internal MCU faults through the IO_2:3 pins.
- 电压诊断功能
Voltage diagnostic function.
- SPI 通信诊断功能
SPI communication diagnostic function.
- FS0B/FS1B 处理和诊断功能
Processing and diagnostic functions for FS0B/FS1B.
- ABIST/LBIST 诊断功能
ABIST/LBIST diagnostic function.

5.3 软件架构 Software Architecture



FS4500 软件架构 FS4500 Software Architecture

模块 Module	子模块 Submodule	描述 Description
MainStateFn	CAN/LIN Cfg	实现CAN/LIN收发器配置功能 Implement CAN/LIN transceiver configuration functionality.
	LDT Cfg	实现LDT工作模式配置 Implement LDT (Low-Dropout Timer) working mode configuration.
	StateModeMng	实现FS6500状态机管理 Implement FS6500 state machine management.
	IO Cfg	实现IO引脚配置，包括 Multiplexer输出控制 Implement IO pin configuration, including Multiplexer output control.
	Pwr Diagnostic	实现VPRE/VCORE/VCCA/VAUX供电诊断功能

		Implement power supply diagnostic functions for VPRE, VCORE, VCCA, and VAUX.
	SPI Diagnostic	实现SPI通信诊断功能 Implement SPI communication diagnostic functionality.
Fail-SafeFn	WdgM	实现基于问答机制的看门狗功能 Implement watchdog functionality based on a question-and-answer mechanism.
	FS0B/FS1B Cfg	实现FS0B/FS1B功能配置 Implement FS0B/FS1B feature configuration.
	ABIST Mng	实现ABIST1/ABIST2的诊断功能 Implement diagnostic functions for ABIST1/ABIST2.
	LBIST Mng	实现LBIST诊断管理功能 Implement LBIST (Logic Built-In Self-Test) diagnostic management functionality.
SPI COM	SPI COM	实现SPI通信驱动功能 Implement SPI communication driver functions.
FS6500 Manager	SBC Manager	实现SBC管理功能，包括调度以及与应用层接口管理等 Implement SBC (System Basis Chip) management functions, including scheduling and management of interfaces with the application layer.

5.4 软件测试 Software Testing

测试环境 Test Environment	
静态代码 QAC Static Code QAC	7.2 R MISRA-C: 2004
动态 Tessy Dynamic Tessy	4.2.8
Evaluation Hardware	TriBoard TC275 V2.0 with Evaluation Board
Configuration Environment	Win7 64bit

6 过程文档 PROCESS DOCUMENTATION

开发流程 Development Process	文档描述 Document Description
需求收集 Requirements Gathering	客户需求文档 Requirements Document from the Customer
软件需求分析 Software Requirements Analysis	需求分析 Requirements Analysis
	需求分析规格书 Requirements Analysis Specification
	软件需求追踪表 Software Requirements Traceability Matrix
	客户问题沟通表 Customer Inquiry Tracking Form
软件架构设计 Software Architectural Design	软件架构说明书 Software Architecture Specification
	软件架构的追踪表 Software Architecture Traceability Matrix
软件详细设计和单元设计 Software Detailed Design and Unit Design	详细设计说明书 Detailed Design Specification
	MuNui 配置工具设计 Muniu Configuration Tool Design
	软件详细设计追踪表 Software Detailed Design Traceability Matrix
	详细设计评审 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 Software Integration and Integration Testing	集成策略 Integration Strategy
	集成手册 Integration Manual PDF
	集成测试策略 Integration Testing Strategy
	集成测试报告

开发流程 Development Process	文档描述 Document Description
	Integration Test Report
	资源分析报告 Resource Analysis Report
软件认可测试 Software Acceptance Testing	软件测试报告 Software Test Report
	软件测试报告评审 Software Test Report Review
发布 Release	发布文档 Release Documentation



成为全球领先的**汽车基础软件**公司

To Be the Global Leading **Automotive Basic Software** Company

