



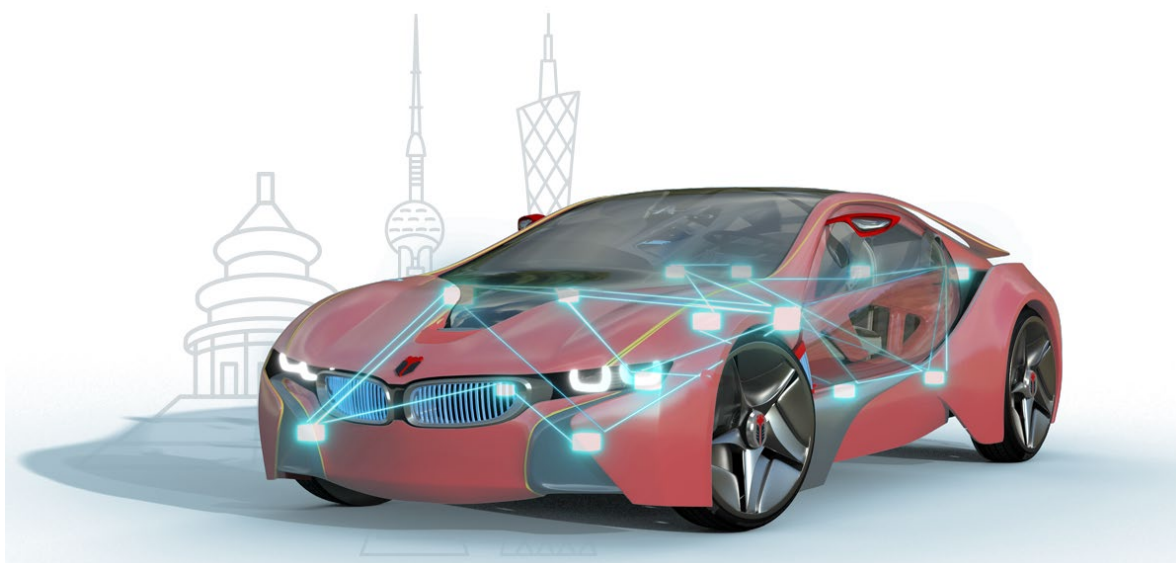
知从木牛 BCC 恩智浦 MC33771 产品手册

ZC.MUNIU BCC PRODUCT MANUAL

BASED ON NXP MC33771

知从木牛基础软件平台功能安全库

ZC.MuNiu Basic Software Platform Safety Library



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1 功能概述 FUNCTIONAL OVERVIEW

知从木牛功能安全 BCC 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 Battery cell controller (BCC) 平台化软件产品。本手册说明了基于恩智浦 MC3377x 系列 BCC 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将应用到客户产品中，满足功能安全需求。

ZC.MuNiu Functional Safety BCC Series Software is designed to create a platform software product for Battery Cell Controllers (BCC) that meets customers' functional safety requirements, independently developed by ZC. This manual describes the functional safety application scheme and software architecture based on the NXP MC3377x series BCC. This software product can help system engineers and software engineers quickly apply it to customer products to meet functional safety requirements.

本产品实现了的 MC33771 芯片软件驱动功能包含：

This product implements the software driver functions for the MC33771 chip, which include:

- 基于 SPI 或 TPL 通信协议功能；
Based on the SPI or TPL communication protocol functionality;
- 单体电压的采样功能；
Single cell voltage sampling function;
- Pack 温度采样功能；
Pack temperature sampling function;
- Pack 电流采样功能；
Pack current sampling function;
- Pack 电压采样功能；
Pack voltage sampling function;
- 单体电压均衡管理功能；

Single cell voltage balancing management function;

➤ 模式管理功能;

Mode management function;

➤ 硬件诊断功能;

Hardware diagnostics function.

2 应用领域 APPLICATION FIELD

知从木牛功能安全 BCC 恩智浦 MC33771 驱动软件产品可应用于有各功能安全等级需求的电池管理系统中。例如：

ZC.MuNiu Functional Safety BCC NXP MC33771 driver software product can be applied in battery management systems that require various functional safety levels. For example:

- Hybrid electric (HEV)
- Electric vehicles (EV)
- Energy storage systems (ESS)
- Uninterruptible power supply(UPS)
- E-bikes
- E-scooters

此 BCC 恩智浦 MC33771 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，可以将 MC33771 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 MC33771 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，协助实现达到最高 ISO26262 ASIL-C 的等级要求。

This BCC NXP MC33771 driver software product manual is written for experienced hardware, software, and functional safety engineers, designed according to ISO 26262, and can integrate the MC33771 driver software product into the (sub)systems of customer application products. ZC software integration engineers can support and ensure that the MC33771 driver software product is suitable for the application integration services selected by the customer, and complies with the corresponding software development process, assisting in achieving the highest ISO 26262 ASIL-C level requirements.

3 配置环境 CONFIGURATION ENVIRONMENT

知从木牛功能安全 BCC 恩智浦 MC33771 驱动软件产品目前可适配多家芯片厂商的 MCU, MCU 包括:

ZC.MuNiu Functional Safety BCC NXP MC33771 driver software product is currently compatible with MCUs from multiple chip manufacturers, including:

- 知从木牛 BCC 驱动软件产品支持的英飞凌 AURIX 系列芯片软件配置:
ZC.Muniu BCC driver software product supports the software configuration for the Infineon AURIX series chips:

配置环境 Configuration Environment	
Hardware (Chip)	INFINEON SAK-TC2XXT-64F200W CA
Compilers Supported	HighTec GNU v4.6.5.0/ Tasking v4.2r2
Evaluation Hardware	TriBoard TC264 + MC33771
Debugger	Lauterbach(Trace32 R.2020.02.000121039) or Isystem (IC5700)
Configuration Tools	Muniu_v5.1.3
Configuration Environment	Win7 64bit

Hightec 4.6.5.0 编译器选项 Hightec 4.6.5.0 Compiler Options	
编译选项 Compiler Options	-fno-common -fno-short-enums -Os -g2 -W -Wall -Wextra -Wdiv-by-zero -Warray-bounds -Wcast-align -Wignored-qualifiers -Wformat -Wformat-security -save-temps=obj -DBRS_DERIVATIVE_TC27X -fno-builtin -iquote -Wl,-gc-sections -Wl,-mem-holes -Wl,-no-warn-flags -Wl,-c-ref -fshort-double -mcpu=tc27xx -mversion-info -std=c99 -maligned-data-sections
链接选项 Linker Options	-nostartfiles -T"..\\MC33771.ld" @iROM.objectlist -mcpu=tc27xx -Wl,-mem-holes -Wl,-warn-orphan

Taskingv4.2r2 编译器选项 Taskingv4.2r2 Compiler Options	
编译选项 Compiler Options	-Ctc27x --lsl-core=vtc --iso=99 --language=-gcc,-volatile,+strings --switch=auto --align=4 --no-clear --default-near-size=0 --default-a0-size=0 --default-a1-size=0 -O2 --tradeoff=4 --compact-max-size=200 -g --source
链接选项 Linker Options	-Ctc27x --lsl-core=vtc -I"D:\Git\xxx" -Wl-o"\${PROJ}.hex":IHEX:4 -Wl-o"\${PROJ}.sre":SREC:4 --hex-format=s -Wl-DMCU_SMALL_ENDIAN=1 "-./xxx_SW.lsl" -Wl-OtxyCL -Wl--map-file="\${PROJ}.mapxml":XML -Wl-mcrfiklsnmoduq -Wl--error-limit=42 -g

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；恩智浦 MC33771 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。

Currently, the electronic and electrical architecture of automobiles is becoming increasingly complex, and the safety requirements for automotive electronics are also becoming higher. To meet the safety needs of automobiles, functional safety in automobiles is being taken more and more seriously. In recent years, the industry has referred to the ISO 26262 standard for functional safety; NXP MC33771 series chip is suitable for the selected applications and complies with such application standards, and in the electronic and electrical systems, it is designed and developed using the SEooC (safety element out of context) approach.

由于 BCC 为特定 ASIL-x 等级电池管理系统提供单体电压、Pack 电流、温度检测，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。

Since the BCC provides single cell voltage, pack current, and temperature detection for battery management systems of a specific ASIL-x level, according to ISO 26262-5(2011) Clause 8, it introduces two metrics: Single-point fault metric (single point fault measure) and Latent-fault metric (latent fault measure). Different ASIL level requirements and fault failure analysis methods all require it to meet the corresponding ASIL-x level for single-point fault measure and latent fault measure.

	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 %

根据 MC33771 的安全手册中描述，MC33771 的不同安全目标满足最高 ASIL C 等级要求以及对应的 SPFM 和 LFM 要求。如下：

According to the safety manual of the MC33771, the different safety objectives of the MC33771 meet the highest ASIL C level requirements and the corresponding SPFM and LFM requirements. These are as follows:

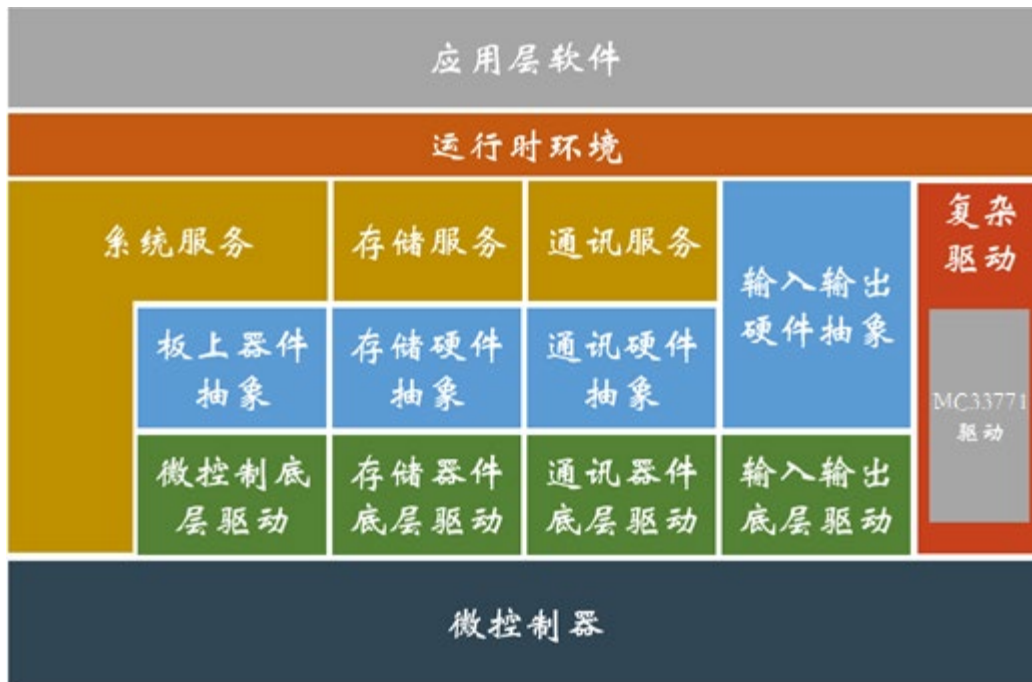
	Rank	Single-point fault metric	Latent fault metric	Portion of system PMHF
Safety goal		%	%	FIT
SA1	ASIL C	≥ 97	≥ 80	≤ 0.9
SA2	ASIL C	≥ 97	≥ 80	≤ 0.8
SA3	ASIL C	≥ 97	≥ 80	≤ 0.8
SA4	ASIL C	≥ 97	≥ 80	≤ 0.3
SA5	ASIL C	≥ 97	≥ 80	≤ 0.3
SA6	ASIL C	≥ 97	≥ 80	≤ 0.8
SA7	ASIL C	≥ 97	≥ 80	≤ 0.8

因此，在客户应用项目中若需符合 ASIL-C 安全等级，知从 BCC 恩智浦 MC33771 驱动软件产品提供软件方案，满足功能安全需求，实现 MC33771 安全手册中相关的安全机制。

Therefore, in customer application projects that require compliance with the ASIL-C safety level, ZC.MuNiu BCC NXP MC33771 driver software product offers a software solution that meets functional safety requirements and implements the safety mechanisms described in the MC33771 safety manual.

5 功能描述 FUNCTIONAL DESCRIPTION

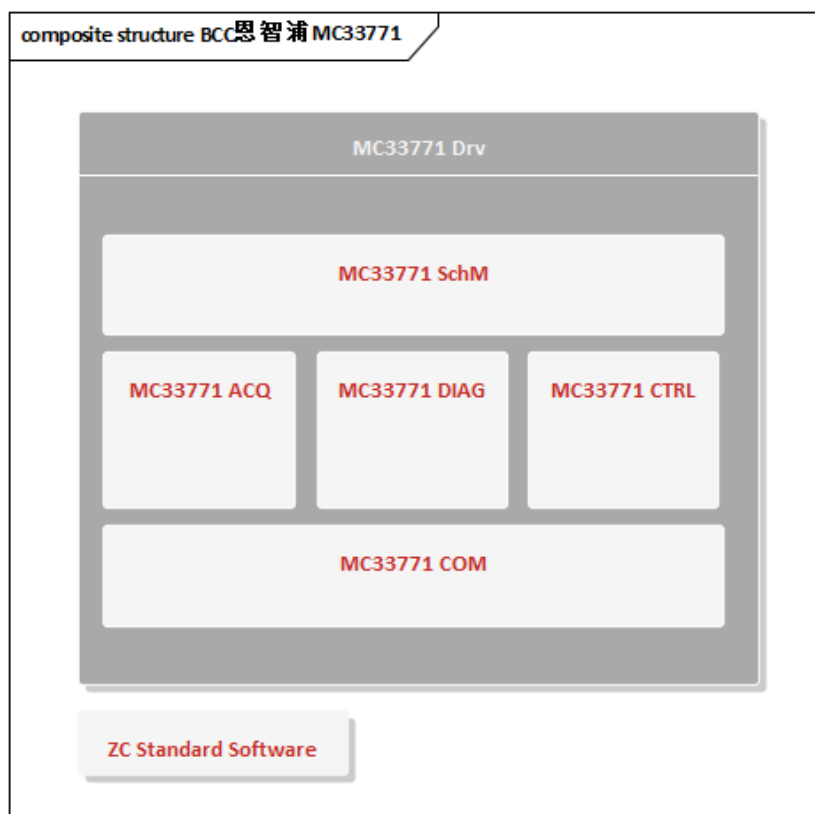
5.1 产品特点 Product Feature



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, with flexible adaptation.
- 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 needs of different customers.
- 高安全性：支持 MC33771 大部分的安全机制，满足 ASIL-C 需求
High safety: Supports most of the safety mechanisms of the MC33771, meeting ASIL-C requirements.

5.2 软件架构 Software Architecture



软件架构

Software Architecture

软件模块包括:

The software modules include:

模块 Module	子模块 Submodule	描述 Description
MC3377x Drv	MC3377x COM	实现MC33771的通信管理功能，包括SPI通信与TPL通信处理 Implement the communication management functions of the MC33771, including SPI communication and TPL communication processing.
	MC3377x SchM	实现MC33771的调度管理功能，用于对MC33771功能的调度以及与应用层接口

		Implement the scheduling management functions for the MC33771, used for scheduling of MC33771 functions and interfacing with the application layer.
	MC3377x ACQ	实现MC33771的采样功能，包括单体电压、Pack电流、Pack电压、温度等采样 Implement the sampling functions of the MC33771, including sampling of individual cell voltage, pack current, pack voltage, temperature, and other measurements.
	MC3377x CTRL	实现MC33771的单体均衡管理功能，主要对单体电芯的均衡处理 Implement the single cell balancing management function of the MC33771, primarily for the balancing treatment of individual cells.
	MC3377x DIAG	实现MC33771的诊断功能，主要实现安全手册中的安全机制 Implement the diagnostic functions of the MC33771, mainly to realize the safety mechanisms described in the safety manual.

5.3 诊断功能 Diagnostic Function

为了满足功能安全需求，恩智浦 MC33771 实现了通用的安全机制设计。基于此安全机制的实现，MC33771 可实现对芯片硬件内部电路的诊断以及对外的通信等诊断功能。

To meet functional safety requirements, NXP MC33771 series chip has implemented a general safety mechanism design. Based on the implementation of this safety mechanism, it can perform diagnostics on the chip's internal hardware circuits as well as diagnostics for external communications.

基于此安全机制的设计，知从 BCC 恩智浦 MC33771 驱动软件产品提供软件方案，可根据客户实际需求进行配置，实现的相关安全机制包括：

Based on the design of this safety mechanism, ZC.MuNiu BCC NXP MC33771 driver software product offers a software solution that can be configured according to the actual needs of customers, and the implemented safety mechanisms include:

NO.	SM ID	Safety Mechanisms
1	SM01	OV and UV Functional verification
2	SM02	CTx Open Detect and Open Detect Functional Verification
3	SM03	Cell Voltage Channel Functional Verification
4	SM04	CTx Cell Terminal Leakage Monitor
5	SM05	GPIOx OT/UT Functional Verification
6	SM06	GPIOx Open Terminal Diagnostics
7	SM07	ADC1-a and ADC1-b Functional Verification
8	SM08	Oscillator Frequency Monitor
9	SM09	VCOM Short/UV Protection Detection
10	SM10	VANA Short/UV Protection Detection
11	SM11	Onboard Temperature Protection Mode
12	SM12	Loss of Ground Detection
13	SM13	Fuses ECC
15	SM15	VANA OV Detection
17	SM17	Register address identification frame
18	SM18	Echo of register content
19	SM19	Eight bit CRC with non zero seed
22	SM22	TAG ID for Conversion Data
23	SM23	VCOM OV Detection
24	SM24	VPWR OV Detection
25	SM25	VPWR UV Detection
29	SM29	OV/UV internal detection

NO.	SM ID	Safety Mechanisms
30	SM30	Read data ready bit
31	SM31	Fuses bit error flag
32	SM32	Use interleaved cyclic and on demand conversion
33	SM33	Plausibility check of redundant ANx in the pack controller
34	SM34	OV/UV detection in the pack controller
35	SM35	Rolling counter
36	SM36	Diagnostic of open between shunt and PGA
37	SM37	Diagnostic of measurement chain offset with shorted PGA inputs
38	SM38	Diagnostic of measurement chain with minimum PGA gain
39	SM39	Use of AN5 and AN6 as current measurement input
40	SM40	Cell balance open load detection
44	SM44	Cell Voltage plausibility test at system level
45	SM45	VPWR comparison to sum of cell voltages

5.4 软件测试 Software Testing

测试环境 Test Environment	
静态代码 QAC Static code QAC	Helix QAC 2019.1 MISRA-C: 2012
动态 Tessy Dynamic Tessy	4.3.12
Evaluation Hardware	TriBoard TC264 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 Documentation Description
需求收集 Requirement Collection	客户需求文档 Customer Requirement Document
软件需求分析 Software Requirement Analysis	需求分析文档 Requirement Analysis Document
	软件需求追踪表 Software Requirement Traceability Matrix
	问题沟通表 Issue Communication 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	软件详细设计说明书 Software Detailed Design Specification
	配置工具设计文档 Configuration Tool Design Document
	软件详细设计追踪表 Software Detailed Design Traceability Matrix
	软件详细设计评审表 Software Detailed Design Review Form
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	集成策略 Integration Strategy
	集成手册 Integration Manual

开发流程 Development Process	文档描述 Documentation Description
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	系统测试报告 System Test Report
	系统测试报告评审 System Test Report Review
发布 Release	发布文档 Release Documentation

7 功能安全 FUNCTIONAL SAFETY

7.1 功能安全评估报告 Functional Safety Assessment Report

7.2 功能安全证书 Functional Safety Certificate

To be continued.



公众号



业务联系

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

