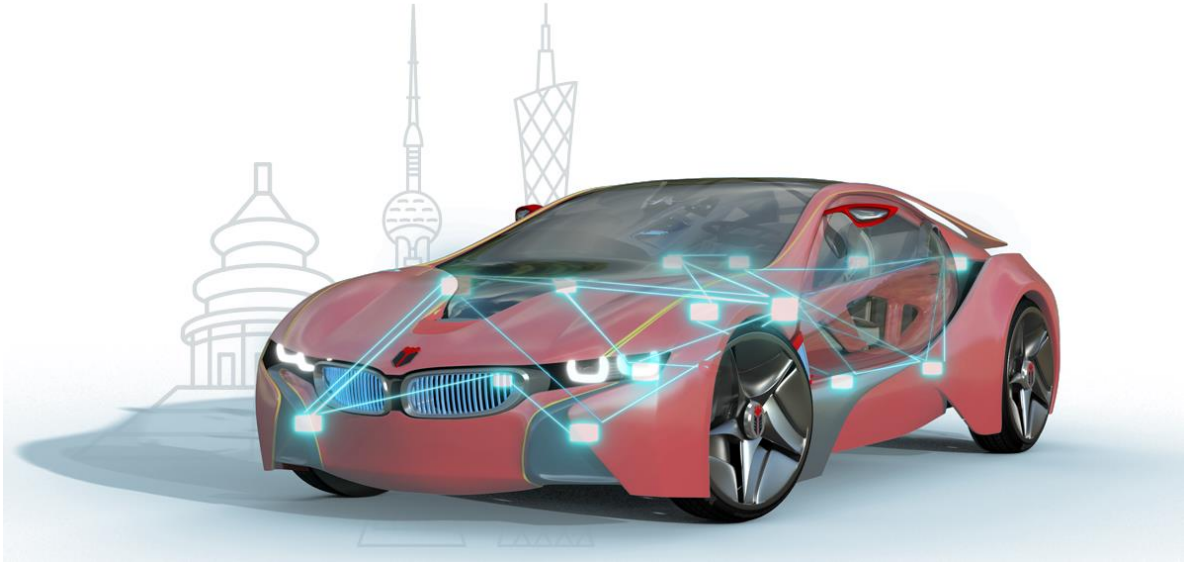
知从木牛轻量化基础软件平台产品手册

ZC.MUNIU LIGHTWEIGHT BASIC SOFTWARE PRODUCT MANUAL

知从木牛基础软件平台

ZC.MuNiu Basic Software Platform



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1 产品概述 PRODUCT OVERVIEW

知从.木牛（ZC.MuNiu）轻量化基础软件为资源受限型汽车电子控制器提供有效解决方案。该产品参考 AUTOSAR 等国际规范，有基于 AUTOSAR ARTOP 架构的上位机配置工具，支持上汽、一汽、吉利、广汽、长安、长城、北汽等整车厂的通讯、诊断、网络管理规范。该平台主要包括：通讯协议栈（CAN）、诊断协议栈(UDS)、网络管理（AUTOSAR）、标定协栈（XCP\CCP）、存储协议栈、复杂驱动模块等，配套知从的 Bootloader 刷新程序和上位机工具，可以根据不同的客户项目要求进行配置和再开发。知从科技提供基础软件产品的同时，也提供控制器基础软件功能实现的开发服务。

ZC.MuNiu lightweight basic software product provides an effective solution for resource-constrained automotive electronic controllers. This product complies with international standards such as AUTOSAR and features an upper-level configuration tool based on the AUTOSAR ARTOP architecture. It supports communication, diagnostic, and network management specifications for vehicle manufacturers including SAIC, FAW, Geely, GAC, Changan, GreatWall, and BAIC. The platform primarily includes: communication protocol stacks (CAN), diagnostic protocol stacks (UDS), network management (AUTOSAR), calibration protocol stacks (XCP/CCP), storage protocol stacks, and complex driver modules. It is complemented by ZC Bootloader update program and upper-level tools, enabling customization and further development according to specific customer project requirements. In addition to providing basic software products, ZC Technology also offers development services for the implementation of controller basic software functions.

2 开发背景 DEVELOPMENT BACKGROUND

资源受限型SoC在汽车电子、工业控制等领域的应用正不断深入。以英飞凌推出的MOTIX TLE988x 和 TLE989x 系列为例，该系列芯片凭借更高性能及在更小面积内集成更多资源的显著优势，在同类产品中表现突出。然而，传统 AUTOSAR 架构因包含大量模块和冗余特性，难以适配此类资源受限的硬件平台。为在保证 AUTOSAR 基础功能完整的前提下，充分发挥此类小型芯片的性能，知从推出了轻量化 AUTOSAR CP 基础软件产品。该产品基于对原有全量知从木牛 AUTOSAR CP 产品进行深度裁剪，同时融合知从木牛配置工具的便捷性，成功打造了适配 TLE989x 系列（如 TLE9891）的轻量化解决方案。目前，该方案已实现量产，为行业提供了满足小型化需求的成熟可靠选择。

Resource-constrained SoCs are being used in automotive electronics, industrial control and other fields. Taking the MOTIX TLE988x and TLE989x series launched by Infineon as an example, this series of chips have outstanding performance among similar products due to the significant advantages of higher performance and integration of more resources in a smaller area. However, the traditional AUTOSAR architecture contains a large number of modules and redundant features that make it difficult to adapt to such resource-constrained hardware platforms. In order to fully utilize the performance of these small chips while maintaining the integrity of AUTOSAR's basic functionality, ZC has launched the lightweight AUTOSAR CP base software product. Based on the in-depth trimming of the original full-volume AUTOSAR CP and the convenience of the ZC.MuNiu configuration tool, the product has successfully created a lightweight solution for the TLE989x series (e.g., TLE9891). At present, the solution has achieved mass production, providing the industry with a mature and reliable option to meet the demand for miniaturization.

3 应用场景 APPLICATION SCENARIOS

知从木牛轻量化 AUTOSAR CP 产品主要应用场景是对集成度、可靠性、功耗和成本要求很高的油泵、水泵等控制器中，该类控制器通常采用小型、高集成度、车规级芯片，属于低内存芯片平台，通常 Flash 资源小于 512KB，RAM 资源小于 32KB。因此知从木牛轻量化基础软件产品在保障功能严格覆盖 OEM 规范的同时，剔除了传统 AUTOSAR 架构中大量冗余组件（详见图 1），仅保留 AUTOSAR 核心功能运转的必要模块（详见图 2），有效降低系统复杂度与资源消耗。依托知从木牛配置工具强大的配置能力，实现各模块功能参数的快速配置与调整，极大提升了在资源受限型平台上的开发效率与系统运行的灵活性。

ZC.MuNiu lightweight AUTOSAR CP product is primarily designed for controllers such as fuel pumps and water pumps that demand high levels of integration, reliability, power efficiency, and cost-effectiveness. These controllers typically utilize small, highly integrated, automotive-grade chips, which are part of a low-memory chip platform, with Flash resources typically less than 512KB and RAM resources less than 32KB. Therefore, the lightweight basic software product ensures strict compliance with OEM specifications while eliminating a large number of redundant components from the traditional AUTOSAR architecture (see Figure 1), retaining only the necessary modules for the core functions of AUTOSAR (see Figure 2), thereby effectively reducing system complexity and resource consumption. Leveraging the powerful configuration capabilities of the ZC.MuNiu configuration tool, rapid configuration and adjustment of functional parameters for each module are achieved, significantly enhancing development efficiency and system operational flexibility on resource-constrained platforms.

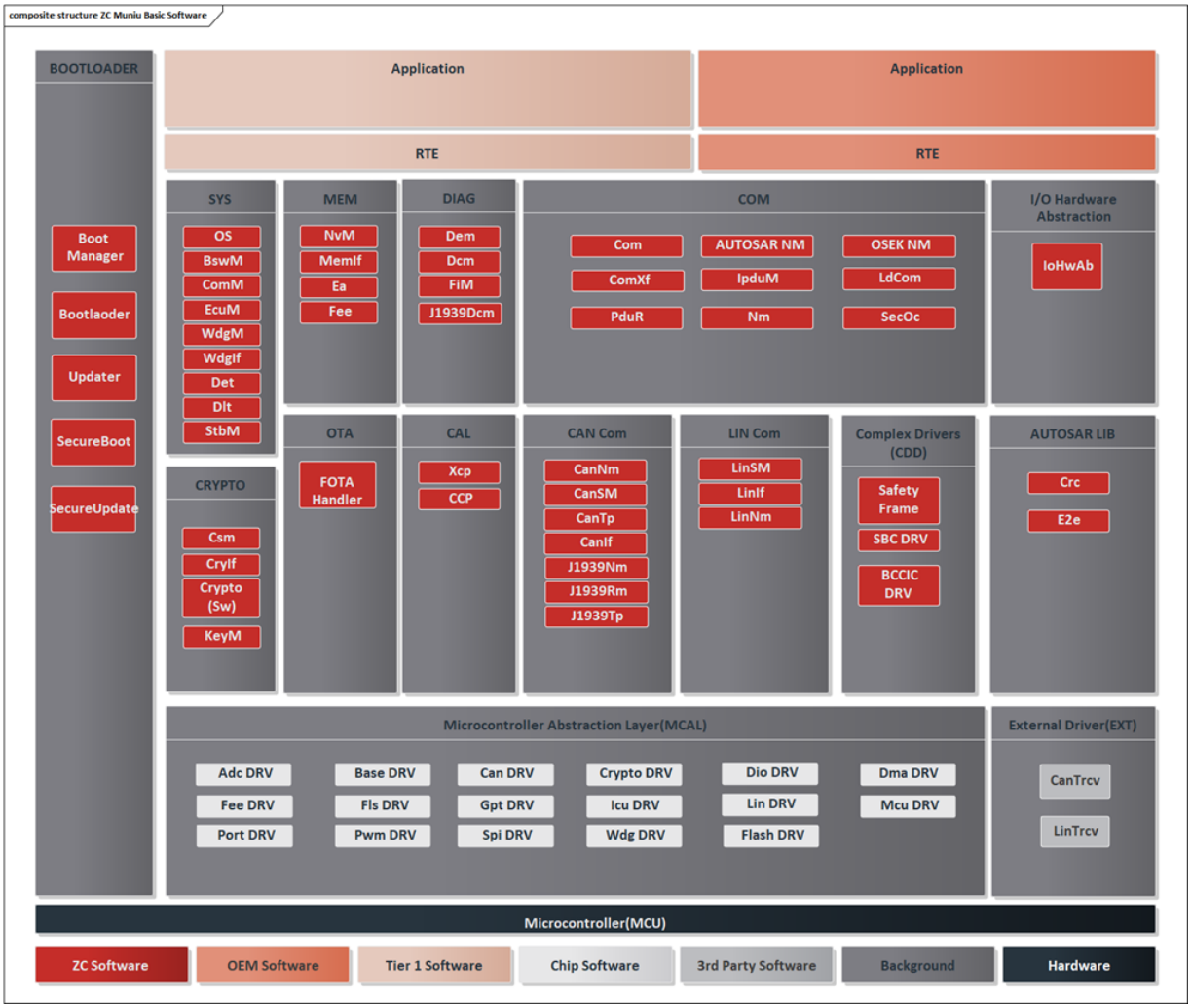

图 1 知从.木牛全量基础软件产品架构图

FIGURE 1 ZC.MUNIU FULLWEIGHT BSW PRODUCT'S ARCHITECTURE

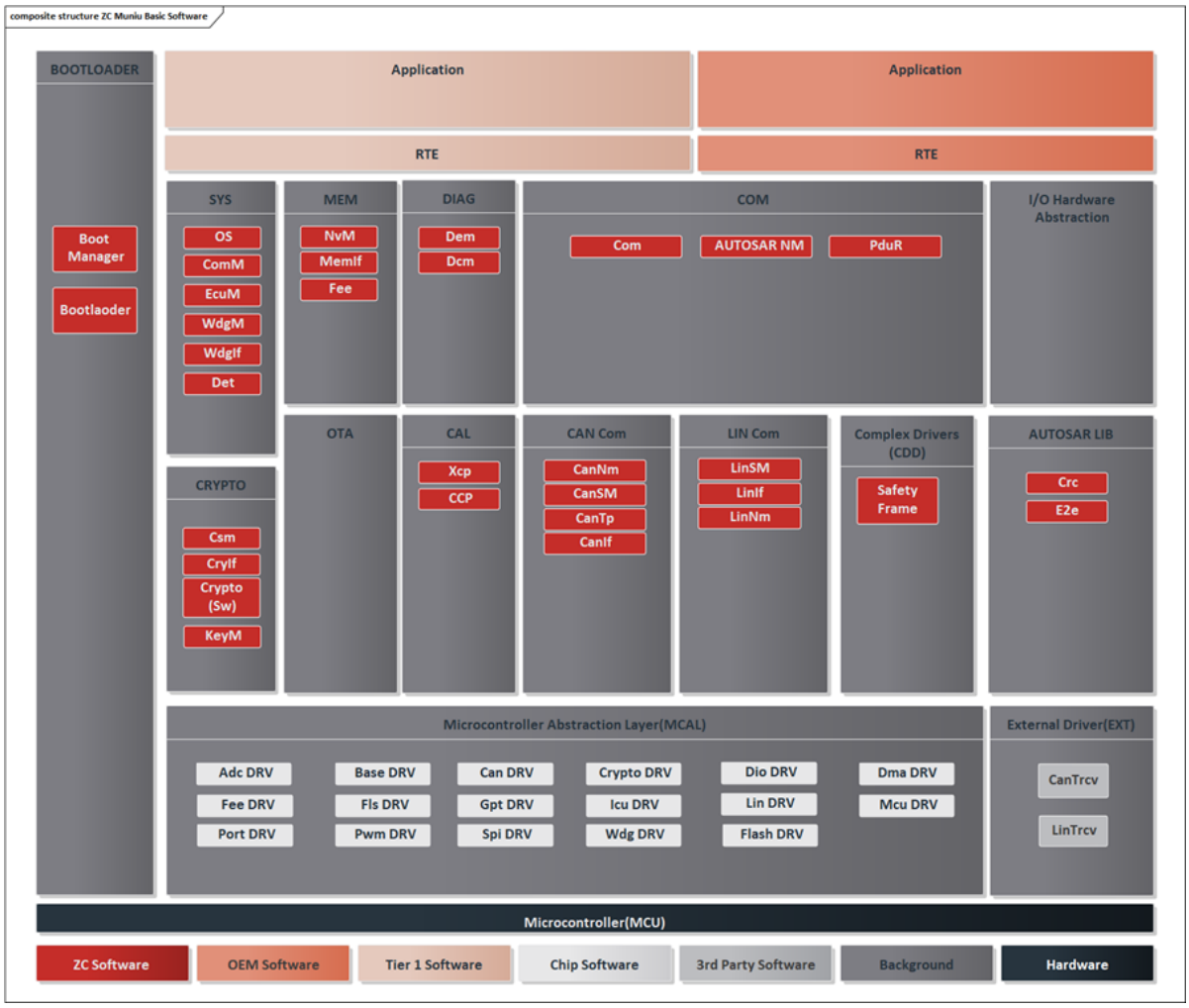

图 2 知从.木牛轻量基础软件产品架构图

FIGURE 2 ZC.MUNIU LIGHTWEIGHT BSW PRODUCT'S ARCHITECTURE

轻量化通信协议栈，支持对基础数据类型信号的拆解与组包，字节序，发送/接收回调，周期/触发型报文的发送等特性。

For lightweight communication stack, it supports features such as disassembling and grouping of packets for basic data type signals, byte order, send/receive callbacks, and sending of cycle/trigger type messages.

轻量化诊断协议栈，符合 ISO14229 规范，涵盖 10、11、14、19、22、27、28、2E、31、3E、85 等 UDS 诊断服务，完全覆盖 App 或 Bootloader 的功能需求，为系统诊断与程序升级提供坚实保障。诊断支持 CAN 和 CANFD 自适应的通信协议，确保数据在复杂环境下的高效、稳定传输。搭配可靠的轻量化存储模块功能，能够实现诊断数据的快速读取与安全存储。

For lightweight diagnostic stack compliant with the ISO 14229 standard, covering UDS diagnostic services such as 10, 11, 14, 19, 22, 27, 28, 2E, 31, 3E, and 85, it fully meets the functional requirements of apps or bootloaders, providing a solid foundation for system diagnostics and software updates. Diagnostic support for CAN and CANFD adaptive communication protocols ensures efficient and stable data transmission in complex environments. Combined with reliable

lightweight storage module functionality, it enables rapid retrieval and secure storage of diagnostic data.

轻量化网络管理协议栈，将以较小的资源消耗保障控制器配合整车网络进行有效地通信和能耗管理。

For lightweight network management stack, controller communication and energy consumption management will be effectively ensured with minimal resource consumption in conjunction with the vehicle network.

4 环境配置 ENVIRONMENTAL CONFIGURATION

配置环境 ENVIRONMENTAL ONFIGURATION	
Hardware (Chip)	MOTIX TLE989x
Compilers Supported	ArmClang.exe V6.15
Debugger	JLink-V9
Configuration Tools	Muniu_v5.1.0
Configuration Environment	Win7/Win10 64bit

ARMClang 编译器选项 ARMClang Compiler Options	
编译选项 Compiler Options	-xc -std=gnu11 --target=arm-arm-none-eabi -mcpu=cortex-m3 -c -mexecute-only -fno-rtti -flto -funsigned-char -gdwarf-3 -Ofast -ffunction-sections -Wno-packed -Wno-missing-variable-declarations -Wno-missing-prototypes -Wno-missing-noreturn -Wno-sign-conversion -Wno-nonportable-include-path -Wno-reserved-id-macro -Wno-unused-macros -Wno-documentation-unknown-command -Wno-documentation -Wno-license-management -Wno-parentheses-equality -D__UVISION_VERSION="533" -D_RTE_ -DTLE9891QTA61 -D_RTE_
链接选项 Linker Options	--cpu Cortex-M3 --strict --summary_stderr --info summarysizes --map --load_addr_map_info --xref --callgraph --symbols --info sizes --info totals --info unused --info veneers

5 产品实现 FUNCTION DESCRIPTION

在 AUTOSAR 架构工程中，COM（Communication）模块不仅是实现汽车电子通信功能的核心载体，更是整个 CP 产品架构的关键模块。下面将聚焦 COM 模块，从功能设计到代码裁剪，简单介绍其在整个产品开发中的轻量化实现思路。

In AUTOSAR architecture engineering, the COM (Communication) module is not only the core carrier for implementing automotive electronic communication functions, but also a key module in the entire CP product architecture. Below, we will focus on the COM module and briefly introduce its lightweight implementation approach in the entire product development process, from functional design to code trimming.

➢ COM 模块的轻量化功能设计 Design lightweight feature list of COM module

在 AUTOSAR 架构中，COM（Communication）模块是通信协议栈的核心组件，其核心功能可概括为以下四点：

1、信号路由与映射：信号级别路由和网关功能。

2、通信协议处理：PDU 组包/解包和通信属性的管理。

3、通信调度与控制：事件或周期触发信号发送。

4、通信服务支持：为上层 RTE 提供标准接口，诊断通信，错误处理等。

In the AUTOSAR architecture, the COM (Communication) module is the core component of the communication protocol stack, and its core functions can be summarized in the following four points:

1. Signal routing and mapping: signal-level routing and gateway functions.

2、Communication protocol processing: PDU grouping/unpacking and management of communication attributes.

3、Communication scheduling and control: event or cycle triggered signaling.

4、Communication service support: providing standard interfaces for upper layer RTE, diagnostic communication, error handling, etc.

我们保留了 COM 模块的基础功能，包括维持信号收发、数据交互及 CAN 通信支持等。剥离了非必要的冗余特性，如复杂网关路由，对动态信号，无效信号，RC 信号等小场景下的支持。针对项目的 OEM 规范，在基础功能上扩展定制化特性，既以最小的代码开销（约 1KB ROM）实现对通信需求的完整覆盖。

We have retained the basic functionality of the COM module, including maintaining signal sending and receiving, data interaction and CAN communication support. Non-essential redundant features such as complex gateway routing, support for dynamic signals, invalid signals, RC signals, and other minor scenarios are stripped out. For project OEM specifications,

customised features are extended on top of the basic functionality, both with minimal code overhead (~1KB ROM) to achieve complete coverage of communication requirements.

- COM 模块的代码裁剪策略 Tailor strategy for COM module

传统 COM 模块为覆盖多元复杂场景，设计了 40 余个功能函数，包含操作协议数据单元组、信号网管、动态信号等功能。其中较多的特性服务于不常用的场景，在工程中价值有限，且占用过多资源，这与轻量化 AUTOSAR 对精简和通用高频的初衷相矛盾。因此我们通过特性筛选与接口整合，保留了 10 余个关键接口，涵盖信号拆包与组包、协议数据单元的收发等核心流程，确保支撑整个工程的 CAN 通信、UDS 诊断的基础需求 。

Traditional COM modules are designed with over 40 functional functions to accommodate diverse and complex scenarios, including operations such as protocol data unit (PDU) grouping, signal management, and dynamic signal handling. However, many of these features are tailored for less common scenarios, offering limited value in engineering applications while consuming excessive resources. This contradicts the core principles of lightweight AUTOSAR, which aims for streamlined and universally applicable high-frequency functionality. Therefore, through feature screening and interface integration, we retained over 10 key interfaces, covering core processes such as signal unpacking and repackaging, as well as the transmission and reception of protocol data units. This ensures the basic requirements for CAN communication and UDS diagnostics across the entire project.

5.1 产品特点 PRODUCT FEATURES

- 协议栈符合 AUTOSAR 4.3.1 版本
  Code compliant with AUTOSAR 4.3.1 version
- ARTOP 架构上位机配置工具，最高适配 AUTOSAR 4.4.0 版本
  Configuration tool based on ARTOP architecture, compatible with AUTOSAR 4.4.0 version
- 通讯协议栈（CAN/LIN）
  Communication stack (CAN/LIN)
- 诊断协议栈（UDS）
  Diagnostic stack (UDS)
- 网络管理协议栈（AUTOSAR）
  Network management stack (AUTOSAR)

- 标定协议栈（XCP\CCP）
  Calibration stack (XCP/CCP)
- 存储协议栈
  Memory Stack
- 功能安全、信息安全模块、复杂驱动等定制开发
  Customised development of Functional Safety modules, CyberSecurity stack, Complex Device Drivers, etc.
- 工程服务
  Engineering services
- ... ...

5.2 软件架构 SOFTWARE ARCHITECTURE

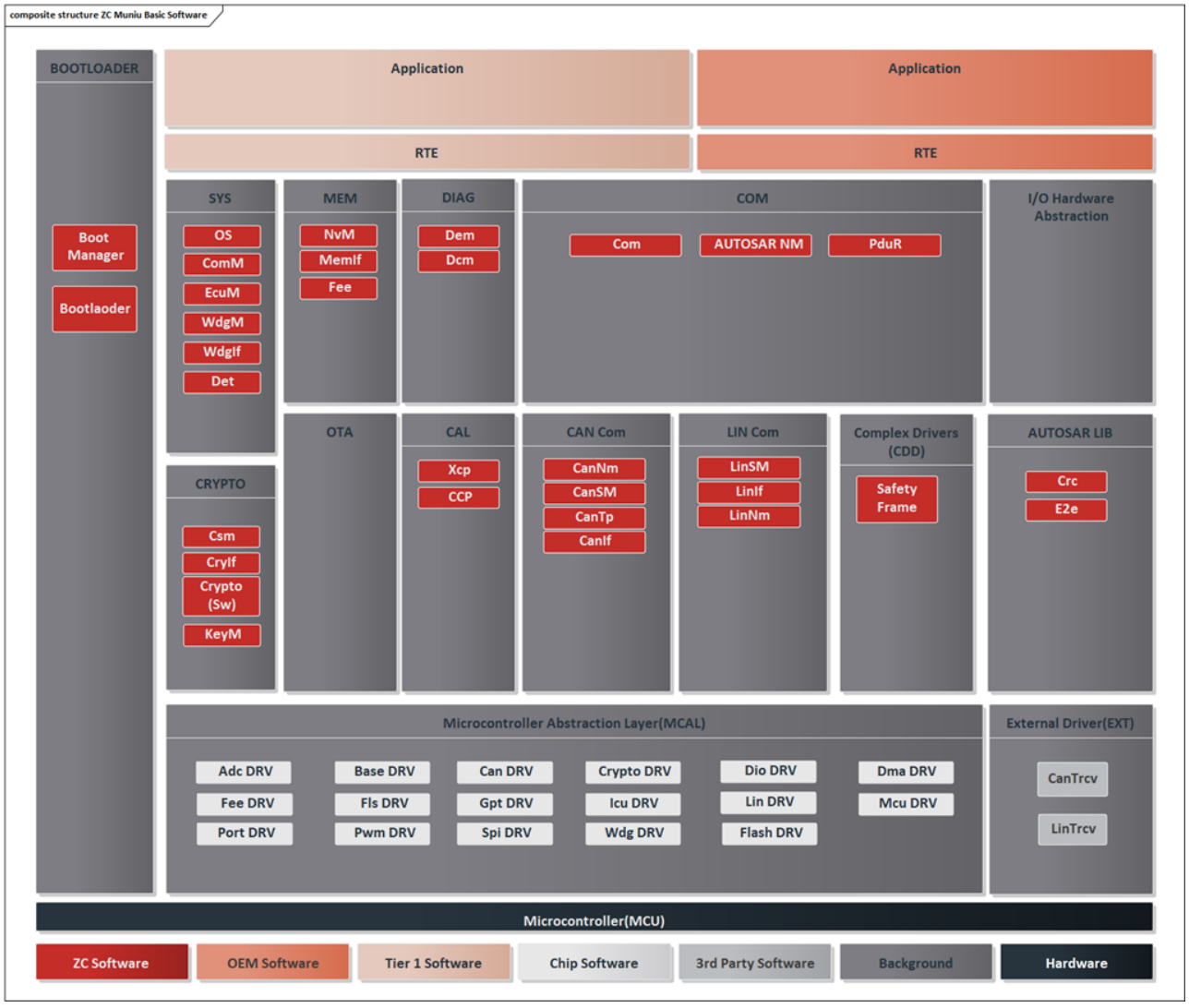

图 3 知从.木牛轻量基础软件产品架构图
FIGURE 3 ZC.MUNIU LIGHTWEIGHT BSW PRODUCT'S ARCHITECTURE

模块	子模块		描述
微控制器底层驱动集成包	MCAL 的各模块集成配置工程服务		
系统服务(SYS)	OS	操作系统	实现系统服务的AUTOSAR基础软件模块
	ComM	通信管理器	
	EcuM	ECU状态管理器	
	WdgM	看门狗管理器	
	WdgIf	看门狗接口层	
	Det	错误追踪器	
诊断服务(DIAG)	Dcm	诊断通信管理器	实现诊断管理的AUTOSAR基础软件协议栈
	Dem	诊断事件管理器	
存储服务(MEM)	NvM	NvRam管理器	实现非易失性存储管理的基础软件协议栈
	Fee	Flash的EEPROM模拟器	
	MemIf	存储器抽象层接口	
通信服务(COM)	Com	通信模块	实现通信功能和网络管理的基础软件协议栈
	AUTOSAR Nm	AUTOSAR网络管理器	
	PduR	协议数据单元路由模块	
CAN通信	CanIf	CAN接口	实现基于CAN通信和网络管理基础软件模块
	CanNm	CAN网络管理	
	CanSM	CAN状态管理器	
	CanTp	CAN传输协议	
LIN通信	LinIf	LIN接口层	实现LIN通信和网络管理的基础软件模块
	LinSM	LIN状态管理器	
	LinNM	LIN网络管理器	
AUTOSAR库(LIB)	Crc	CRC功能库	集合了相关的库函数功能的AUTOSAR基础软件模块
	E2E	E2E功能库	
复杂驱动（CDD）	Safety Frame	功能安全库	
信息安全库	CSM	加密服务管理模块	信息安全库（CyberSecurity）及加密服务协议栈
	CryIf	加密模块接口层	
	Crypto	加密模块驱动层	
	KeyM	密钥管理模块	
标定协议栈(CAL)	Xcp	XCP 通用标定协议	实现标定管理的解决方案
	Ccp	CCP CAN标定协议	

Module	Submodule		Description
Microcontroller Abstraction Layer Integration Package	MCAL module integration & configuration engineering services		
System Services(SYS)	OS	Operating System	Foundation for AUTOSAR Basic Software implementing system services
	ComM	Communication Manager	
	EcuM	ECU State Manager	
	WdgM	Watchdog Manager	
	WdgIf	Watchdog Interface Layer	
	Det	Development Error Tracer	
Diagnostic Services(DIAG)	Dcm	Diagnostic Communication Manager	Foundation for AUTOSAR Basic Software implementing diagnostic management
	Dem	Diagnostic Event Manager	
Memory Manager (MEM)	NvM	NVRAM Manager	Foundation for non-volatile memory management
	Fee	Flash EEPROM Emulator	
	MemIf	Memory Abstraction Interface	
Communication Services (COM)	Com	Communication Module	Foundation for communication functions and network management in the Basic Software Stack
	AUTOSAR Nm	AUTOSAR Network Manager	
	PduR	Protocol Data Unit Router	
CAN Communication	CanIf	CAN Interface Layer	Foundation for CAN communication and network manager basic software module
	CanNm	CAN Network Manager	
	CanSM	CAN State Manager	
	CanTp	CAN Transport Protocol	
LIN Communication	LinIf	LIN Interface Layer	Foundation for LIN communication and network manager basic software module
	LinSM	LIN State Manager	
	LinNM	LIN Network Manager	
AUTOSAR Library (LIB)	Crc	CRC Function Library	AUTOSAR Basic Software Module that aggregates related library functions
	E2E	E2E Function Library	
Complex Device Driver (CDD)	Safety Frame	Functional Safety Library	
CyberSecurity Library	CSM	Crypto Service Manager	CyberSecurity and Crypto protocol stack
	CryIf	Crypto Interface Layer	
	Crypto	Crypto Driver Layer	
	KeyM	Key Manager	
Calibration Protocol Stack (CAL)	Xcp	XCP Universal Calibration Protocol	Solution for calibration management
	Ccp	CCP/CAN Calibration Protocol	

5.3 知从木牛配置工具和界面功能展示 ZC.MUNIU Configuration Tool & Interface Demonstration

您可以使用木牛工具配置轻量化 AUTOSAR 协议栈的 Can driver、Com、PduR、CanIf、Dcm、Dem、CanTP 等模块。

You can configure Can driver, Com, PduR, CanIf, Dcm, Dem, and CanTP modules of the lightweight AUTOSAR CP product with ZC.MuNiu Configuration Tool.

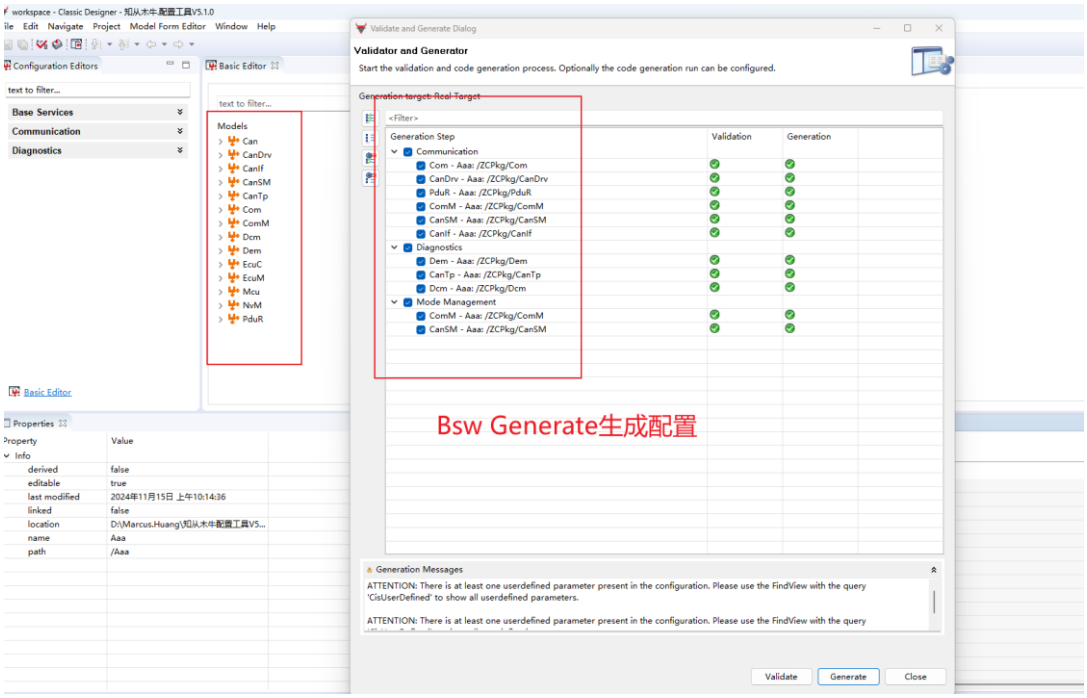

图 4-1 知从木牛工具配置界面

FIGURE 4-1 MUNIU CONFIGUE

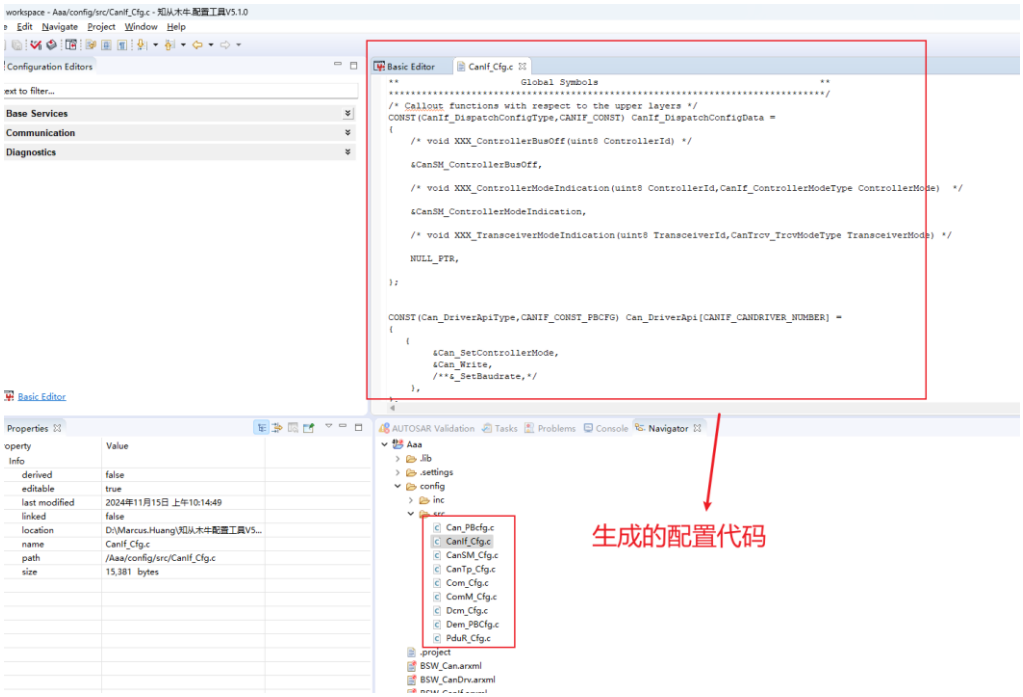

图 4-2 知从木牛工具配置界面

FIGURE 4-2 MUNIU CONFIGUE

总之，相较于传统 AUTOSAR 架构，轻量化 AUTOSAR CP 产品凭借精简的模块设计与高效的功能集成，为 TLE989x 等资源受限的应用场景提供了更具针对性的解决方案，有力推动其在市场中的广泛部署与持续创新发展。

In conclusion, compared with the traditional AUTOSAR architecture, the lightweight AUTOSAR CP products provide more targeted solutions for resource-constrained application scenarios, such as the TLE989x, by virtue of their streamlined modular design and highly efficient functional integration, which will drive their widespread deployment and continuous innovation in the market.