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Body (Zone) Domain Controller and Chip Industry Research Report,2024

July 2024

Research on body (zone) domain controller: an edge tool to reduce vehicle costs, and enable hardware integration + software SOA.

Integration is the most important means to lower vehicle costs. Function integration within the body domain has become widespread. Traditional BCM, seat, PEPS, TPMS, power distribution box, gateway and other functions tend to be controlled in a centralized way. Zoning is the inevitable result of cross-domain integration design, which can reduce wiring harnesses and help reduce vehicle costs and improve efficiency. Traditional BCM (body control module) is evolving towards BDC (body domain controller) and ZCU (zone control unit).

Zone control unit (ZCU) is a device based on BDC and connected to the vehicle according to the physical zone. At present, it mainly integrates three modules, i.e., vehicle control unit (VCU), thermal management system (TMS), and body control module (BCM), and enables three functions of electrical appliances in the zone, i.e., power distribution, communication gateway and standard I/O control. The core value of zonal architecture is to create highly integrated electronic and electrical connections and standardized and service-oriented interfaces by separating software and hardware, realize hardware platform reuse and faster and more efficient function updates and iterations, and accelerate the development of vehicle intelligence.

Seen from the central computing + zone control architecture planned by OEMs, their ZCUs now have taken shape, but their progress in mass production varies greatly. Xpeng, GAC, Xiaomi, FAW Hongqi and Chery among others have mass-produced ZCUs for their latest models, while NIO, Neta Auto, Great Wall Motor and foreign OEMs like Volkswagen, BMW and Volvo will mass-produce ZCUs and install them in vehicles during 2024-2026.

Installation of ZCUs by Some Chinese OEMs

OEM	Body Control Module	Installation Location	Integrated Functions	Cross-domain	MCU	Supplier
Xpeng	Left zone control unit	• Just above the left A-pillar lower trim	• Support traditional BCM functions: including left door lock/window, left seat, sun visor, left interior and exterior lights, interior rearview mirror and other body control functions; • Integrate air conditioning thermal management.	BCM+ air conditioning thermal management	Renesas' third-generation flagship MCU	Steelmate
	Right zone control unit	• Below copilot-seat air outlet	• Support traditional BCM functions: including right door lock/window, right seat, third-row seat, right rearview mirror/rear glass defrost, horn, right interior and exterior lights, wipers and other body control functions; • Control wireless charging, air conditioning thermal management, and EPB; • Integrate parking radar, radar, LiDAR and other sensors.	BCM + VCU + sensor		
GAC	Front zone control unit	/	• Integrate control functions for air conditioning, combination headlights, headlights, charging indicator light, wipers, horn, front radar, redundant DC/DC, etc.;	BCM + redundant DCDC + parking	/	Jingwei HiRain
	Rear zone control unit	/	• Integrate control functions for left/right rear doors, rear seats, amplifier assembly, rear combination lights, rear defrost, automatic parking, reversing radar, etc.;			
	Left zone control unit	/	• Integrate control functions for driver-side door/window, driver seat, left door lights, door monitoring, interior lights, ambient lights, left rearview mirror, etc.;			
	Right zone control unit	/	• Integrate control functions for copilot-seat door/window, copilot seat, right door light, air conditioning, ambient light, right rearview mirror, wireless charging, etc.;			
Neta Auto	Front/left/right zone control unit	• Front: front cabin • Left/right: passenger cabin	• Integrate vehicle power distribution functions (isolating switch, primary power distribution, secondary power distribution) + zonal gateway routing function (100M Ethernet, CAN-FD, LIN, etc.) + body comfort domain + new energy power domain + partial chassis domain + air conditioning thermal management;	BCM + VCU + zonal gateway + power distribution	Front: Infineon TC397 Left/right: Infineon TC377	Jingwei HiRain
Chery	Left/front zone control unit	• Lower left side of instrument panel	• Integrate driver-side door/window/lock, driver's seat adjustment/heating, PEPS, left interior and exterior lights, horn, exterior rearview mirrors, EPS, steering wheel heating, front wiper, sunlight and rain sensor, etc.;	BCM + secondary power distribution + zonal gateway	/	/
	Right/front zone control unit	• Copilot seat	• Integrate right doors/windows/locks, copilot seat adjustment/heating, right interior and exterior lights, washers, air conditioning thermal management, left/right front corner radars, ultrasonic radars, etc.;			
	Rear zone control unit	• Under the luggage compartment carpet	• Integrate left rear door/window/lock, rear seat adjustment/heating, rear wiper, taillight, rear fog light, license plate light, left/right rear corner radar, charging & discharging, power distribution, etc.			

Source: ResearchInChina

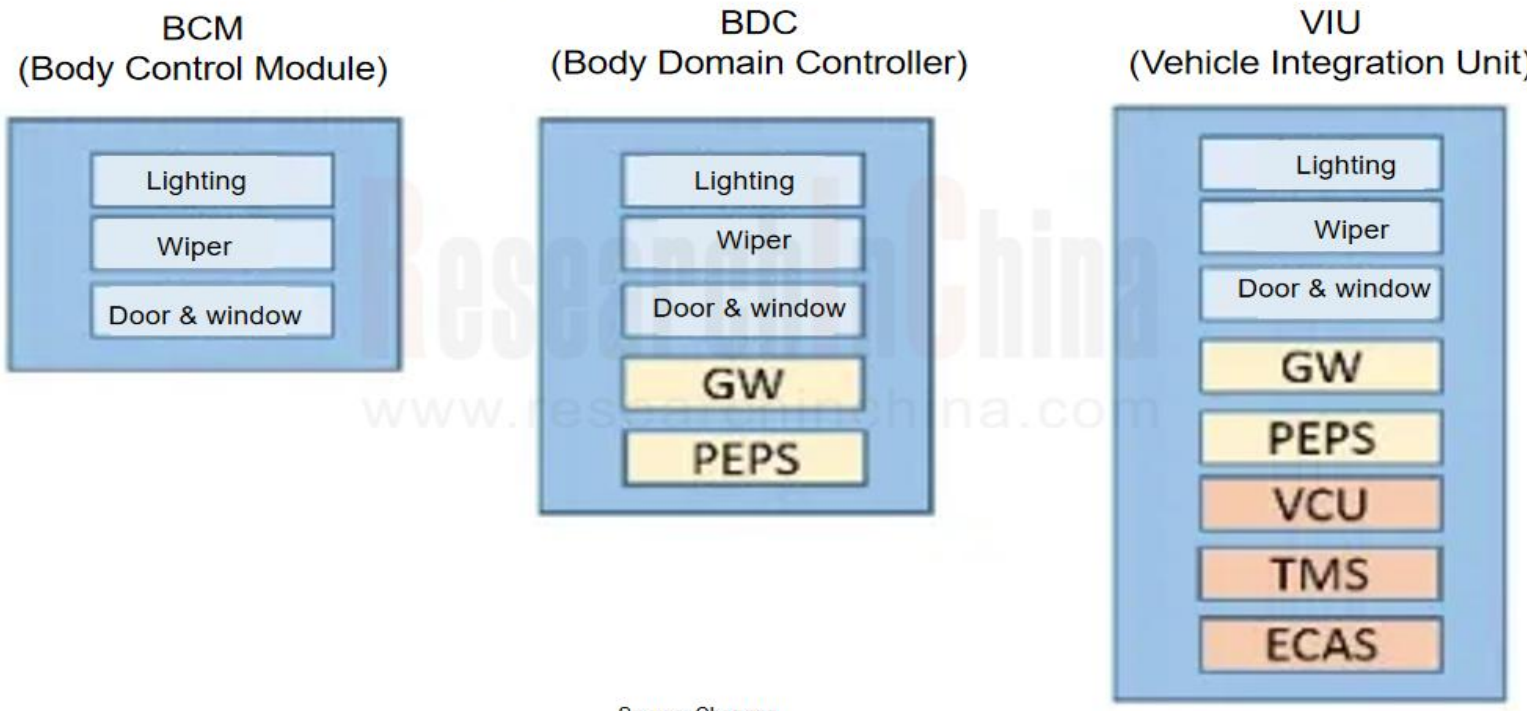
Changan's SDV architecture

Changan's SDV architecture: the architecture consists of a central computing platform composed of C2 (central computer) + EDC (experience computer), and three vehicle integration units (VIUs). Wherein, C2 delivers computing power of up to 508TOPS, and EDC offers graphics compute of 2000GFLOPS, realizing classified, centralized and reasonably arranged full-vehicle computing power.

According to Changan, as traditional BCM evolves into BDC and VIU, the integration level is gradually improved and the integration scope is also expanded from traditional body to power, chassis, thermal management and other domains. The higher integration level makes the number of I/Os increase. From BCM to VIU, the number of I/Os integrated has increased from 100+ to 800+, and the size of a single controller can be reduced by dividing it into several VIUs.

Changan's BCM-BDC-VIU Function Integration Trend

From BCM to VIU, number of I/Os integrated increases from 100+ to 800+, and the size of a single controller can be reduced by dividing it into several vehicle integration units (VIU).



Source: Changan

ZCU integrates control functions and is equipped with a high-performance MCU, eliminating scattered MCUs.

Under zonal architecture, the domain gateway will evolve into a zonal gateway, and ZCU will take on some functions of the zone information center and gateway and be responsible for communication management and information forwarding between submodules in the zone. The zonal architecture takes each controller as a zone controlled by a gateway which is placed near the components it takes charge of, and each zonal gateway is connected to the central computing platform.

Some Gateway-integrated Body (Zone) Domain Controller Products

Supplier	Product	Integrated Functions	MCU	SOP
Aptiv	Zone control unit PDC	• As a power data center, for the use of easy-to-manage zonal networks, body control can be achieved through the CAN-FD network, supporting selective wake-up;	/	2022
Continental	Zone control unit	• Responsible for all service and data management tasks in the front, left, right or rear of the vehicle;	Infineon AURIX TC4x	2024
	Cross-domain vehicle high-performance computer Body HPC2	• Integrate body control + gateway functions (such as access to interior/exterior lighting and management & diagnostic functions in software OTA updates) + vehicle control;	NXP S32G399	Aug. 2023 (GAC Hyper GT and other models)
	Body HPC1	• Body HPC integrates gateway functions (combined with intelligent vehicle communication unit or intelligent antenna module (IAM) for cloud connection) and body control functions, and is responsible for vehicle OTA update and battery management;	Renesas R-Car M3	2020 (Volkswagen ID series EV models)
UAES	Body domain controller BDU8.1	• Integrate BCM, big data collection, vehicle OTA upgrade, remote diagnosis and other system functions;	/	2021
Jingwei HiRain	Zone control unit (ZCU)	• Integrate the signal acquisition and load drive of the new energy power domain, partial chassis domain, body comfort, and air conditioning thermal management control, as well as primary power distribution, secondary power distribution and zonal gateway functions;	/	2024Q2 (GAC, Neta Auto, Xiaomi, etc.)
	Body domain control unit (BDCU)	• Simultaneously integrate vehicle control strategies for BCM, air conditioning algorithm, PEPS, door control logic, TPMS, gateway, etc.;	/	2019 (FAW Hongqi H5/HS5/HS7/ H9/ESH9, etc.)
Atech	Left / right I/O vehicle integration unit (VIU)	• Based on traditional BCM functions, integrate gateway, air conditioning thermal management and window anti-pinch functions; • One of the VIUs has relatively high computing power and acts as CAN gateway and Ethernet gateway.	Infineon TC377/397	2023 (Changan, Li Auto)

Source: ResearchInChina

ATECH’s left and right I/O core VIUs

ATECH’s left and right I/O core VIUs: VIU is based on service-oriented architecture (SOA) and integrates air conditioning thermal management, gateway and window anti-pinch functions in addition to functions of traditional BCM. The domain controllers with relatively high computing power will take on the role of CAN gateway and Ethernet gateway.

ATECH’s Left and Right I/O Core VIUs Integrating Gateway Function

VIU integrates VDC function
Platform Ethernet CAN gateway function

- Air conditioning/thermal management
- CAN/ETH gateway
- Right lights (interior and exterior lights)
- Copilot's seat
- Right rearview mirror
- Right windows (anti-pinch)
- Right hidden door handles
- ……

VIU functions

- CAN/ETH communication
- Left lights
- Driver's seat
- Left rearview mirror
- Left windows (anti-pinch)
- Left hidden door handles
- Wipers
- Door lock
- ……

Source: ATECH

In zonal architecture, a ZCU will integrate multiple ECU functions. A multi-core MCU is often required to implement multiple functions. In the multi-core MCU, each core can run a single function. In addition, the master MCU in the ZCU will require higher computing performance and storage capacity, rich CAN/LIN and high-speed vehicle Ethernet communication interfaces, and lower power consumption indicators.

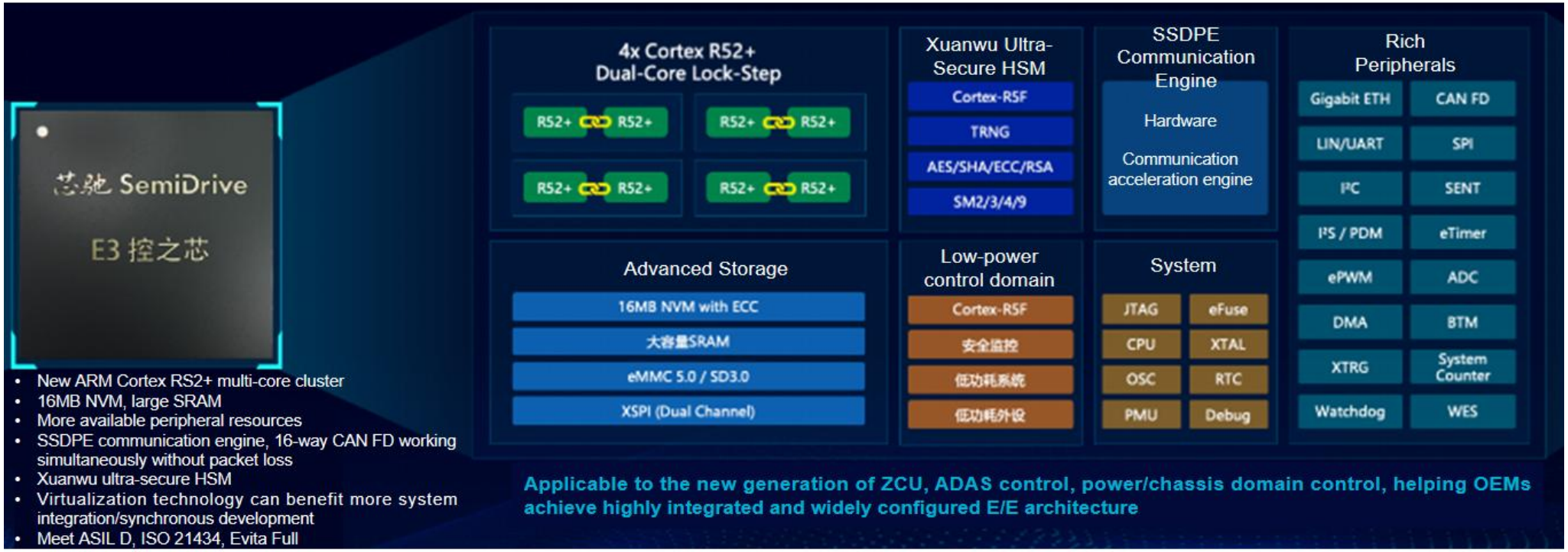
ZCU MCU product of SemiDrive

E3650, the ZCU MCU product of SemiDrive: In April 2024, SemiDrive launched a new-generation ZCU product family, coveting I/O-rich ZCU, control-integrated ZCU and compute-intensive ZCU and targeting core application scenarios such as body control, and body + chassis + power cross-domain integration. Wherein, E3650 is SemiDrive's flagship chip product designed for new-generation cross-domain integrated control ZCU applications.

Based on ASIL-D functional safety level, SemiDrive E3650 includes 4 ARM Cortex R52+ high-performance lock-step multi-core clusters. In terms of storage, it integrates 16MB embedded non-volatile memory with large-capacity SRAM. As for information security, it integrates Xuanwu Ultra Secure Hardware Security Module (HSM), and complies with the information security standards of ISO 21434, Evita Full and above, better meeting the needs of vehicle models going overseas. It uses the SSDPE (Super Speed Data Packet Engine), a hardware communication acceleration engine which achieves zero data packet loss when all CAN-FDs work simultaneously, effectively reducing CPU load and improving communication throughput. For low-power body application scenarios, E3650 can use a proprietary wake-up detection engine and a low-power CPU to reduce the overall static power consumption.

Block Diagram of E3650

Block Diagram of E3650 – SemiDrive's Flagship ZCU MCU



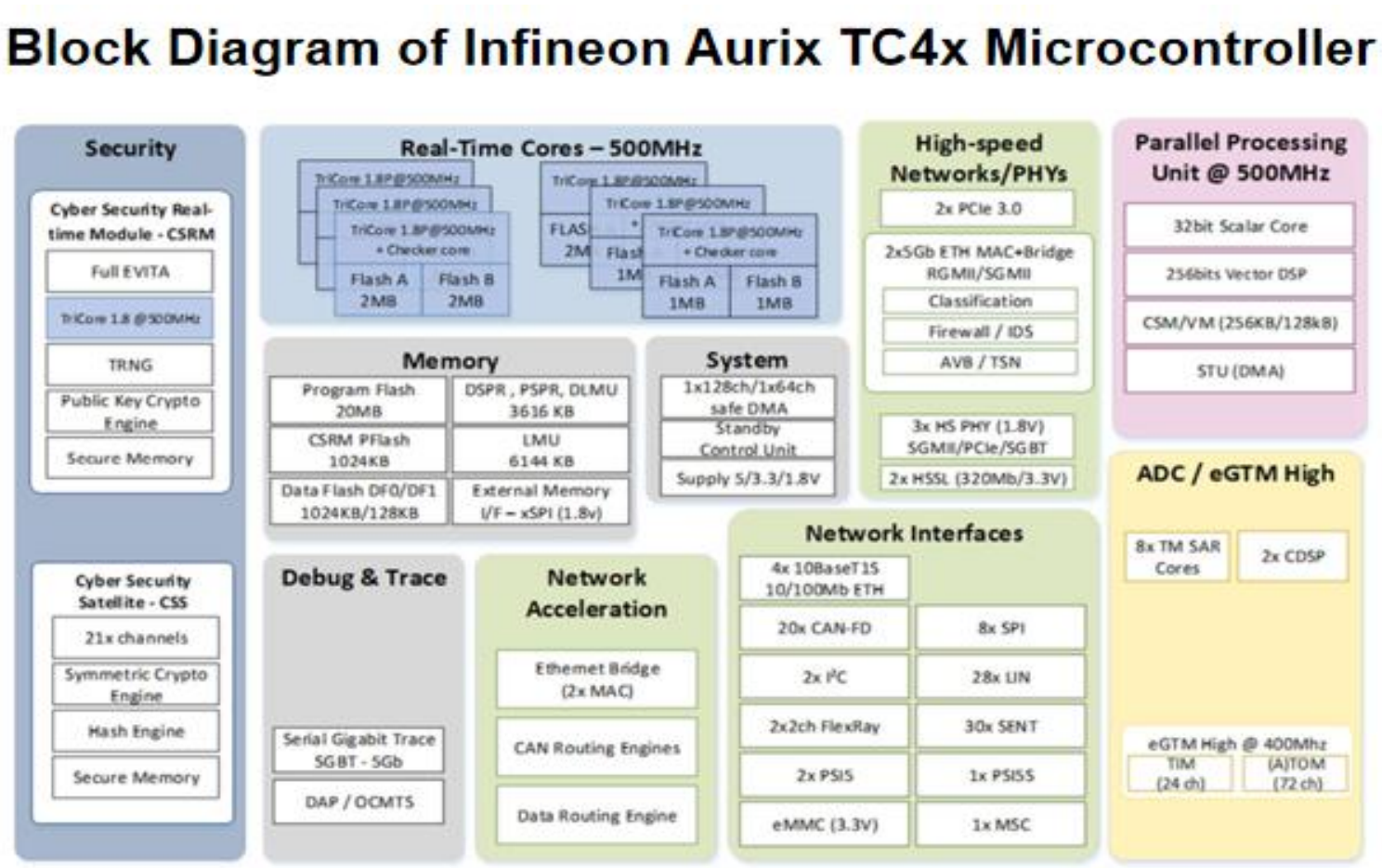
Source: SemiDrive

Infineon AURIX TC4x

Infineon AURIX TC4x: TC4x microcontroller is designed by Infineon for ZCU and HPC applications. To satisfy the requirements of ZCU architecture and realize the multi-ECU integration of ZCU, Infineon Aurix TC4x microcontroller gets upgraded in terms of functional safety, information security, high-speed internal communication routing and core. The MCU contains 6 TriCore 1.8 embedded cores, and the clock frequency of each core can reach up to 500MHz.

As intelligent driving booms, foundation models require higher computing power. To this end, Infineon integrates a PPU (Parallel Processing Unit) in TC4x products to implement models that require massive data processing or fast execution time, for example, signal filtering, algorithm processing and model predictive control. With higher computing efficiency, the PPU undertakes complex signal processing and mathematical operations such as AI, motor control, and zone control, for Tricore cores which are mainly used for control. After integrating the PPU coprocessor, TC4x boasts computing power of 8000DMIPS+72GFLOPS*1, of which the PPU contributes 72GFLOPS.

At present, Infineon's Aurix TC4x microcontroller has been used to develop multiple ZCUs, including ZCU platforms of Tier1s like Continental, G-Pulse Electronics and Marelli.



Source: Infineon

Marelli ZCU

Marelli ZCU: In April 2024, Marelli announced a zone control unit (ZCU) based on Infineon's AURIX TC4x microcontroller. Placed in specific zones of the vehicle and manage various functions, the ZCU consolidates electronic control units (ECUs) from multiple domains – including lighting, body, audio, power distribution, propulsion, thermal management, chassis control, and vehicle diagnostics. These solutions, combined with service-oriented software and cloud virtualization, enable customization of key vehicle performance through customized application software and functions.

Marelli ZCU Based on Infineon Aurix TC4x

Source: Marelli

ZCU integrates power distribution function and realizes intelligent power distribution via e-Fuse.

Under zonal architecture, the power distribution mode of vehicles will change from traditional fuse box power distribution to ZCU power distribution. ZCU integrates the surrounding electronic systems according to the physical location, with the integrated functions including BCM, power, chassis, thermal management and gateway. For the working voltages of the connected sensors and actuators are inconsistent, ZCU needs to be responsible for power supply and power management of electrical appliances in the zone to improve power efficiency and safety.

ZCU power supply adopts hierarchical distribution.

Under zonal architecture, zonal power supply generally adopts a hierarchical distribution method:

1. Primary distribution network (backbone power supply network) that requires dual power supplies (redundant backup) to transmit power from the backbone network to ZCUs;

2. Secondary distribution network where ZCU is responsible for further transmitting power downward to the underlying controller.

G-Pulse Electronics' power distribution solution based on “1+1+N” architecture

G-Pulse Electronics' power distribution solution based on “1+1+N” architecture: the architecture is composed of 1 central computing unit, 1 intelligent power distribution unit, and 4 ZCUs. Wherein, the intelligent power distribution unit includes primary power distribution, and can act as a separate power distribution controller, or integrate with the front zone control unit (FZCU) to form a primary and secondary power distribution solution, thus saving a primary power distribution unit. ZCUs are based on Infineon Aurix TC4x family, with different configurations required for customers’ vehicle models.

The front zone control unit (FZCU) in this solution integrates primary and secondary power distribution, front cabin thermal management and other functions. It is connected to two DCDC converters plus a battery for power redundancy. The primary power distribution provides a power distribution solution for the left/right/rear zone control unit through the front zone; the left/right/rear zone control unit each provide a secondary power distribution channel, and there is also a two-layer stacking board approach (1 distribution board + 1 control board) in the front zone, which allows for better centralization and better isolation and power distribution, including the thermal management and drive requirements of the front cabin.

G-Pulse Electronics' ZCU power distribution solution

G-Pulse Electronics' ZCU Power Distribution Solution

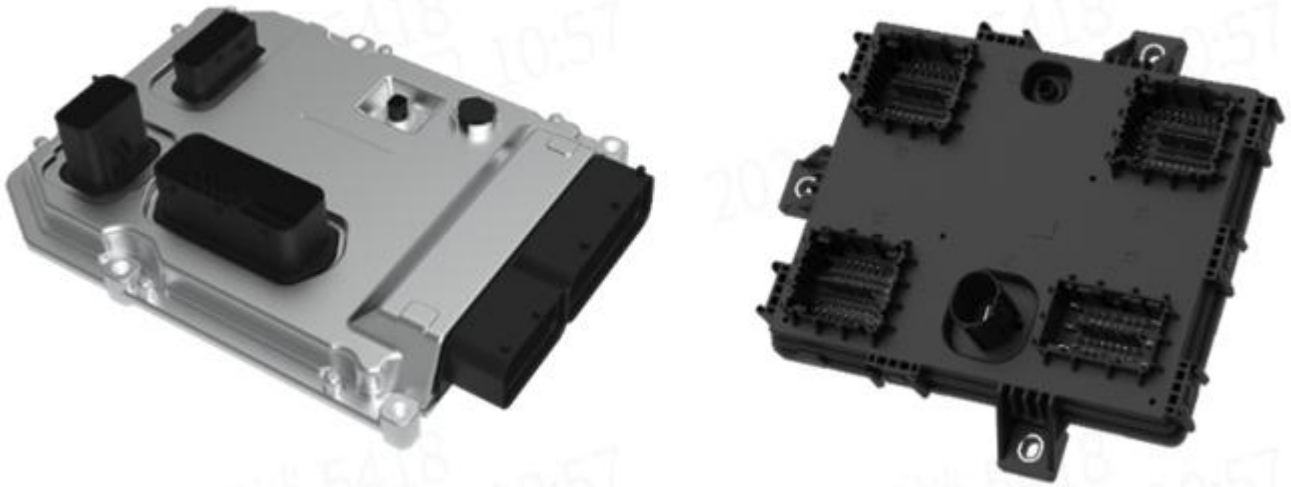
ZCU	FZCU Front Zone Control Unit Base TC4x	LZCU Left Zone Control Unit Base TC4x	RZCU Right Zone Control Unit Base TC4x	BZCU Back Zone Control Unit Base TC4x
Function	Primary power distribution, secondary power distribution, front cabin thermal management, wiper	Secondary power distribution, left body, VCU, EPB	Secondary power distribution, right body, air conditioning, EPB	Secondary power distribution, back body, suspension
Picture	 			

Source: G-Pulse Electronics

Jingwei Hirain's physical ZCU

Jingwei Hirain's physical ZCU: the ZCU meets ASIL B/D functional safety requirements, and integrates the signal acquisition and load drive of the new energy power domain, partial chassis domain, body comfort, and air conditioning thermal management control, as well as primary power distribution, secondary power distribution and zonal gateway functions. The hardware architecture is based on a multi-core MCU processor, deploys standard AUTOSAR CP software, and integrates electromechanical control algorithms such as power distribution algorithm, DC motor closed-loop control algorithm and anti-pinch algorithm, thermal protection algorithm, and authentication and localization algorithms for entry and startup.

Jingwei Hirain's ZCU Integrates Primary and Secondary Power Distribution



Source: Jingwei Hirain

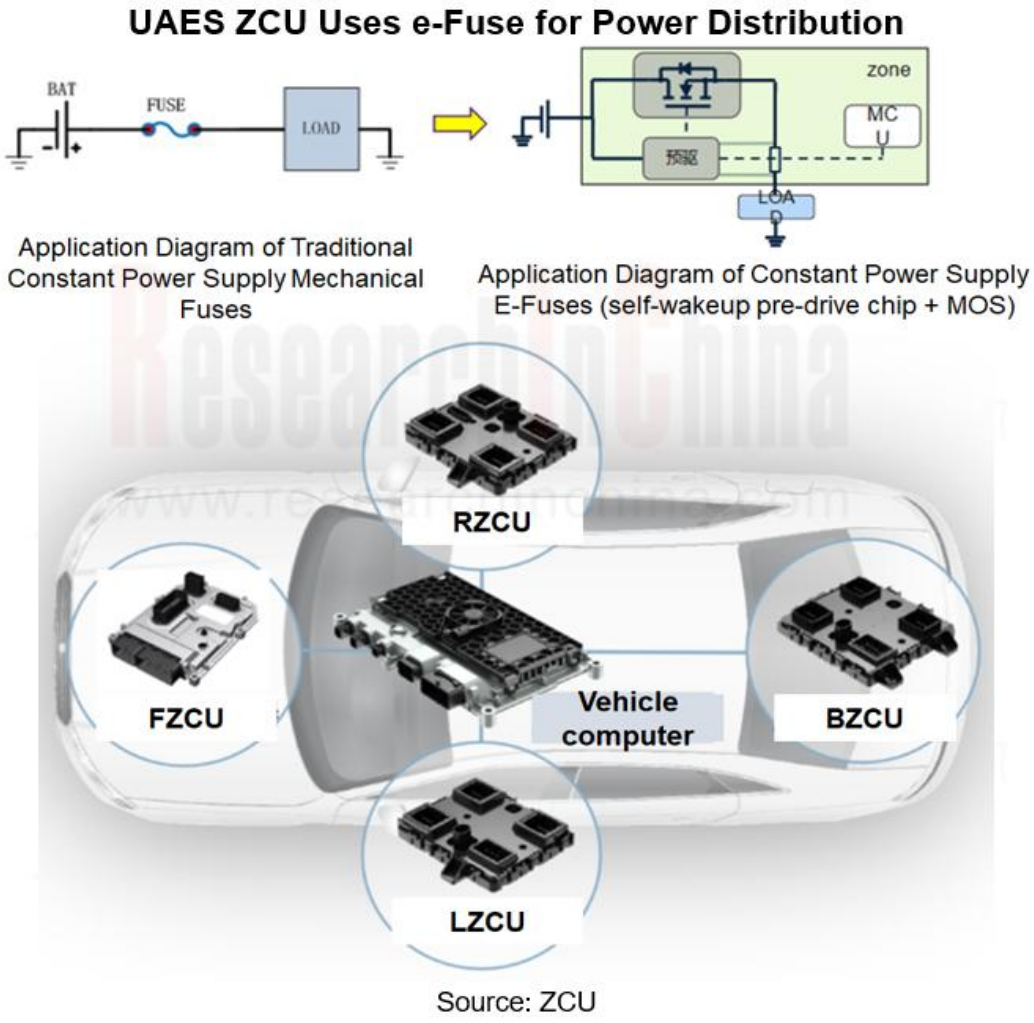
ZCU realizes intelligent power distribution via e-Fuse.

ZCU will use e-Fuse (intelligent fuse module) to replace the traditional relay + fuse solution. e-Fuse is an integrated circuit that integrates MOSFET, drive, logic circuit, diagnosis and other modules on a single chip. It adopts a software protection strategy for circuit detection, diagnosis and OTA updates to achieve intelligent power distribution and energy-efficient scheduling, thereby reducing energy consumption and increasing cruising range.

UAES: UAES's ZCU uses e-Fuse for intelligent power distribution and supports fault diagnosis and fuse self-recovery. Jointly created by UAES and TE Connectivity, this local power distribution network management solution optimizes the matching of E-fuse and wiring harness design in intelligent power distribution scenarios. Through e-Fuse intelligent power distribution, it enables separate and directional power distribution control according to working requirements of ECUs. It can cut vehicle wiring harness length by 25%, optimize wiring harness path by 28%, and reduce the number of vehicle distribution circuits by 10%.

UAES' explorations in intelligent power distribution application in ZCU:

- Case 1: When charging, cut off body-related radars to reduce power consumption and increase charging speed;
- Case 2: In sentry mode (i.e., when a vehicle is in the parking state, once it is hit or moved, the exterior camera will record surroundings and notify the owner via mobile phone APP), cut off all controllers related to intelligent driving to save power and increase cruising range;
- Case 3: When the system predicts thermal runaway risks, only retain the power consumption of safety-related components to lower the risks; in addition, upload the accessory data to allow customers to obtain power usage of most ECU controllers in different scenarios, optimizing overall power distribution of the vehicle.



Source: ZCU

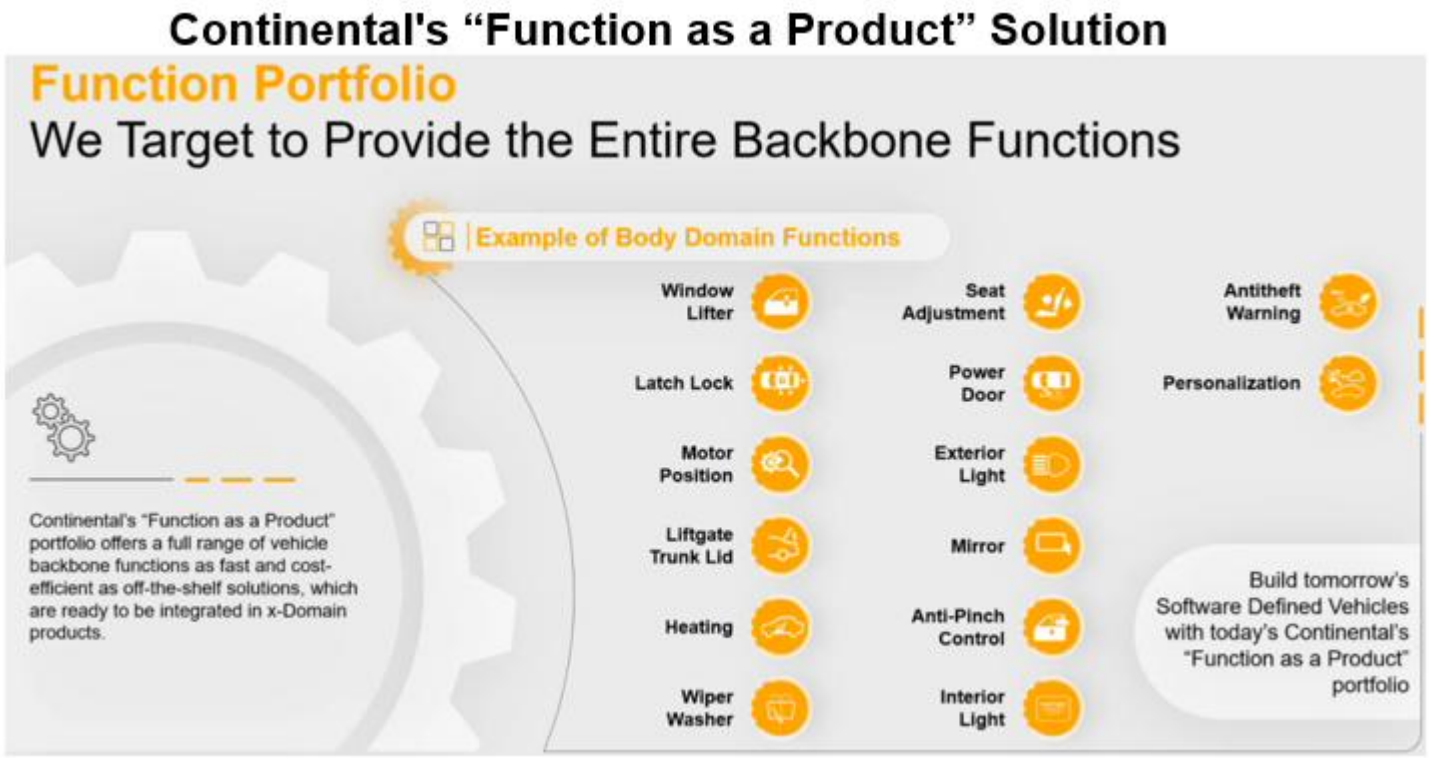
ZCU software: Implement function call and platform-based portability via SOA, helping to cut costs.

As the I/O control center in a zone, ZCU not only integrates functions of individual body domain controllers such as air conditioning control, door control, and seat control, but will also gradually integrate more cross-domain function modules such as suspension control and radar interface in the future. Wherein, most of logical calculations of software will be moved up to the central computing platform, and ZCU will only be responsible for signal acquisition and hardware driver at the bottom layer, so that I/O can be extracted from the central computing platform, realizing separation of software and hardware and making it easier for OEMs to integrate functions across domains.

To reduce costs, ZCU needs to improve scalability and versatility, and use standardized hardware platforms to adapt to different vehicle configurations of various OEMs. ZCU also makes a gradual shift from signal-based services to service-based SOA design. This process requires ZCU to standardize interfaces, transform services, and manage packaging at the function level (body comfort, AC, chassis, HCU, etc.) to facilitate the central computing platform to flexibly call functions. Therefore, ZCU requires a highly integrated, standardized, and customizable design.

Continental's Function as a Product Solution

Continental: For software solutions for the body domain and actuators, Continental has launched the "Function as a Product" service, which can be quickly integrated into vehicle cross-domain products. For example, there are corresponding software kits for various body domain functions such as window lifting, trunk control, seat adjustment, seat heating, power doors, and exterior lighting control.



Source: Continental

UAES USP 2.0 Developer Platform

UAES USP 2.0 Developer Platform: The USP 2.0 platform can integrate nearly 20 independent ECUs through zonal architecture, increasing the communication rate from 2M to up to 1000M. On the USP2.0 platform, services that can be called have penetrated into fields of body control, energy management, motion control, thermal management, etc. Currently it has 951 basic functions, 126 atomic services and 105 basic services, and can provide 1,100+ vehicle APIs, 65 OTA APIs and 55 AI operators. These APIs and operators can help developers easily realize cross-domain application scenarios for vehicles.

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