MSPM0 MCU Advantages in Automotive Application

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The global automotive industry is undergoing a once-in-a-century technological revolution. According to Strategy Analytics, automotive electronics now account for over 35% of total vehicle costs in 2024, a figure projected to exceed 50% by 2024. This transformation is driven by two core forces:

- **Electrification**: Global sales of new energy vehicles (NEVs) surpassed 14 million units in 2024, with China's market penetration reaching 35% (data from CAAM). This surge has dramatically increased demand for high-reliability MCUs in powertrain systems (battery, motor, and control).
- **Intelligence**: Over 30% of vehicles now feature L2+ autonomous driving capabilities, while smart cockpits and vehicle connectivity have become mainstream, pushing annual computing power demand for chips to grow by more than 20%.

MCUs: The "Invisible Battleground": The number of MCUs per vehicle has risen from 70 in traditional ICE vehicles to 300+ in smart vehicles, with the automotive-grade MCU market expected to reach $12 billion by 2025 (Yole Développement).

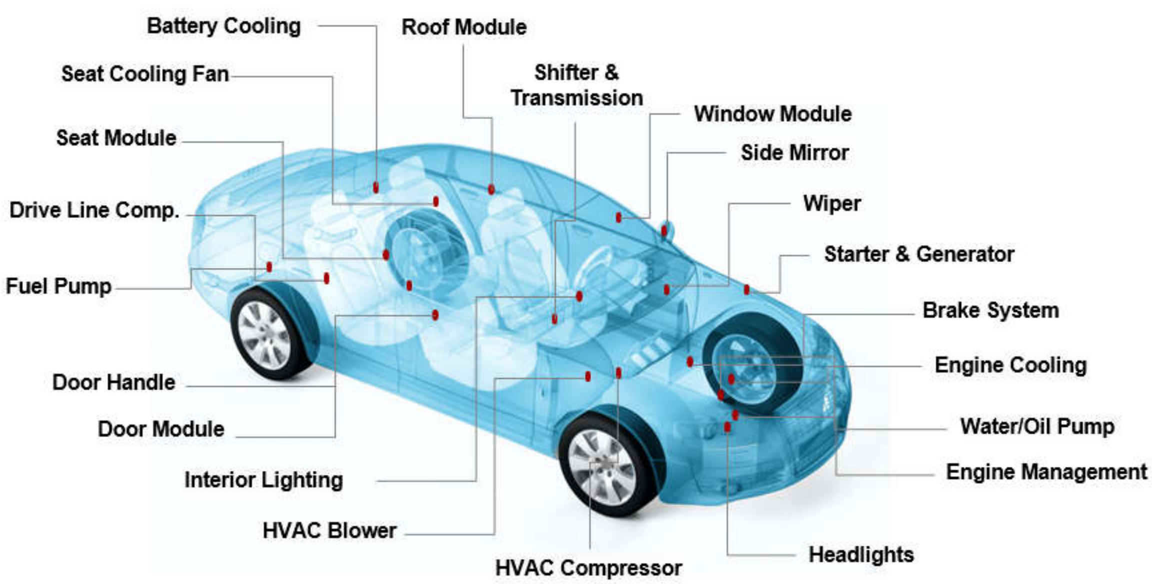

Figure 1-1. Expanding Use of MCUs in Automotive

The "Three Barriers" of Automotive-Grade Chips

Automotive electronics fundamentally differ from consumer electronics in their extreme demands for functional safety, reliability, and supply chain resilience:

1. **Functional Safety: ISO 26262 and ASIL Levels**
    a. Safety Baseline: ASIL B has become the entry threshold for body control and comfort systems. For example, power window anti-pinch failures can cause physical harm, requiring ≥90% single-point fault coverage.

2. **Reliability: AEC-Q100 Certification**
    a. Rigorous Testing: Includes 2,000-hour high-temperature aging (125°C), 1,000 thermal cycles (-55°C to approximately 150°C), and mechanical vibration (50G acceleration).
    b. Lifetime Requirements: Automotive chips must maintain 10+ years of service with a failure rate below 1 FIT (1 failure per billion hours).
3. **Supply Chain Resilience: Independent Production Line**
    a. Long-Term Commitment: Vehicle development cycles span 3-5 years, requiring chips to maintain 15+ years of stable supply.

MSPM0's Advantages in Automotive Applications

Tailored for medium-to-low-risk scenarios (ASIL A/B), MSPM0 redefines the body electronics market with safety, affordability, and ease of development:

- **Balancing Safety and Cost**:
  - Meet **ISO 26262** standards. The TI new-product development process features many elements necessary to manage systematic faults. Additionally, the documentation and reports for these components can be used to assist with compliance to a wide range of standards for customer's end applications including automotive and industrial systems.
  - Achieves **ASIL B** via single-core self-test architecture, reducing hardware costs by 40% compared to competitor products.
  - Provide **MCAL** which is a core component of the Basic Software Layer defined in the **AUTOSAR** standard. And the **AUTOSAR** is provided by third party like EB Tresos. AUTOSAR's modular and layered architecture natively aligns with ISO 26262 safety requirements, and their combined use empowers the creation of secure, reusable automotive electronic systems with high efficiency.
  - **AEC-Q100 Grade 1**(–40°C to 125°C) qualified. Customer can submit request to get the report from TI Production Part Approval Process (PPAP) site.
  - Meet **ISO 9001 / IATF 16949** standards. The MSPM0 MCU was developed using TI's new product development process which has been certified as compliant to ISO 9001 / IATF 16949 as assessed by Bureau Veritas (BV).
- **Strong Open Ecosystem For Easy Development**:
  - Compatibility for CCS/Keil/IAR development environments. Green Hills MULTI IDE also supports INTEGRITY, AUTOSAR Classic and u-velOSity.
  - Support multiple programmers like XDS-110, Segger J-link, PEMicro Cyclone, C-GANG and etc..
  - Abundant drivers and librarys support by the 3rd party to meet different application requirements like Secure boot library, CAN/LIN stack library, AUTOSAR software and etc..
- **TI's Own Supply Chain Resilience**:
  - Manufactured using Lehi's 300-millimeter wafer fab, maintain stable production capacity.
  - Dedicated automotive chip warehouses in Shanghai cut delivery lead times to several weeks.
  - Long term commitment over 15 years of stable supply.

Figure 1-2. TI Lehi Wafer Fab

ISO 26262 Standards Compliance Flow

Table 1-1. ISO 26262 Standards Compliance Flow

	ISO 26262
Standards Compliance Flow	1. ASIL Level: Define safety integrity level.
	2. Functional Safety Manual: Guides development processes, defines safety goals and mechanisms.
	3. FMEDA: Quantitatively verifies ASIL Level compliance.
	4. FIT: Validates ASIL Level random hardware failure probability targets.

ISO 26262 is the international functional safety standard for automotive electronics, designed to systematically reduce safety risks caused by failures in electrical/electronic (E/E) systems. Key aspects include:

- Scope: Covers the entire life cycle of E/E systems in passenger vehicles, from concept design to production, operation, and decommissioning.
- Objective: Ensure systems maintain a safe state even in the presence of random hardware failures or systematic errors.
- Structure: Divided into 10 parts (Part 1–Part 10), addressing safety management, system-level development, hardware/software development, and more.

ASIL A-D is a risk classification system defined in ISO 26262 to quantify the rigor of safety requirements for systems or functions.

Table 1-2. ASIL Levels

Level	Risk Requirement	Typical Applications
ASIL A	Lowest	Sunroof control, ambient lighting
ASIL B	Medium	Instrument cluster, anti-pinch windows
ASIL C	High	Brake assist, battery management
ASIL D	Highest	Autonomous driving, electric power steering

Functional Safety Manual is a compliance guide for product development teams, typically provided by chip manufacturers. Below are the key contents in a Functional Safety Manual.

1. **Safety Goals**:
   a. Define target ASIL levels and requirements (SPFM ≥90% for ASIL B).
2. **Safety Mechanisms**:
   a. Hardware: ECC memory, dual-core lockstep.
   b. Software: Watchdog timers, periodic self-tests.
3. **Development Process**:
   a. Safety analysis (FMEA/FTA), traceability matrices.
   b. Tool chain certification (TÜV-certified compilers).

FMEDA is a quantitative analysis method mandated by ISO 26262 to evaluate hardware safety performance. This analysis method usually includes the following steps:

1. **Failure Mode Identification**: List potential hardware faults open/short circuits).
2. **Impact Analysis**: Assess safety consequences (brake signal loss).
3. **Diagnostic Coverage Calculation**: Measure fault detection rates (ECC covers 90% of memory faults).
4. **Metrics**:
   a. **Single-Point Fault Metric (SPFM)**: ≥90% (ASIL B), ≥99% (ASIL D).
   b. **Latent Fault Metric (LFM)**: ≥60% (ASIL B), ≥80% (ASIL D).

Table 1-3. FMEDA Report Example

Component	Failure Mode	Diagnostic Coverage	ASIL Compliance
CPU Core	Instruction error	99%	ASIL D
SRAM	Bit-flip	95%	ASIL B
ADC Module	Sampling drift	80%	ASIL A

FIT is a critical metric for measuring the reliability of electronic components or systems. It is widely used in high-safety industries such as automotive and aerospace, particularly in ISO 26262 functional safety to quantify random hardware failure rates.

1 FIT represents the probability of a component failing once per billion hours of operation. ISO 26262 mandates limits on the Probabilistic Metric for Hardware Failures (PMHF) based on ASIL levels:

- ASIL D: PMHF ≤ 10 FIT (≤10 failures per billion hours).
- ASIL B: PMHF ≤ 100 FIT.

As a summary, **ISO 26262** provides the framework, while **ASIL** defines its implementation rigor. The **Functional Safety Manual** guides theory into practice, with **FMEDA** and **FIT** offering quantitative validation. For ASIL B MCUs (MSPM0), focus on balancing safety (SPFM ≥90%) and cost efficiency.

ISO 26262 Technical Implementation Path

Table 1-4. ISO 26262 Technical Implementation Path

	ISO 26262
Technical Implementation Path	1. AUTOSAR: an automotive software architecture standard aimed at software component reusability and cross-platform compatibility.
	1.1 MCAL: Provides hardware access for the Safety Library, directly impacting FMEDA results.
	2. Safety Library: Delivers software-level safety mechanisms, usually integrated into AUTOSAR.

AUTOSAR (Automotive Open System Architecture) is an open standard for automotive E/E software architecture developed collaboratively by leading automakers, suppliers, and tool developers. Its core goal is to decouple software from hardware in traditional automotive development, enabling modular software design, cross-platform reusability, and efficient collaborative development.

Traditional automotive software development faced challenges such as: Incompatible ECU software from different suppliers led to high integration costs. Advanced features (autonomous driving, OTA) demanded more flexible architectures. Systematic compliance with standards like ISO 26262 was difficult. AUTOSAR's solution solves these challenges by standardized interfaces and a layered architecture decouple software from hardware, allowing software components to be combined like building blocks.

A common core architecture of AUTOSAR shows the following:

- **Application Layer**:
  - Implements vehicle-specific functions (engine control, lighting).
  - Developers focus on business logic without hardware dependencies.
- **Runtime Environment (RTE)**:
  - Provides communication interfaces (signal passing, service calls), isolating applications from hardware.
- **Basic Software Layer (BSW)**:
  - Standardized service modules, including:
    - Services Layer: diagnostics, memory management.
    - ECU Abstraction Layer: unified access to sensors/actuators.
    - MCAL: low-level hardware drivers for ADC, CAN, and so forth.

Microcontroller Abstraction Layer (MCAL) is a core component of the BSW (Basic Software Layer) defined in the AUTOSAR standard. Its primary purpose is to abstract hardware operations, providing a unified interface for upper software layers (application layer, ECU abstraction layer) to access hardware, thereby shielding differences between microcontrollers (MCUs).

Core functions of MCAL shows below:

- **Hardware Driver Encapsulation**:
- Standardized drivers (ADC, PWM, CAN, SPI, GPIO) directly interact with MCU registers but expose uniform APIs to upper layers.
- **Hardware Independence**:
- Switching MCUs requires only modifying the MCAL layer, leaving upper application logic unchanged.
- **Real-Time Performance and Safety**:

- Ensures timing reliability for hardware operations and supports ISO 26262 functional safety requirements (fault detection, redundancy checks).

Safety Library comprises pre-integrated software modules for real-time hardware fault detection and safety responses. The safety library usually integrated in AUTOSAR project. At the same time, customers can use the safety library independently in their project to meet custom function safety requirements.

Table 1-5. Safety Library Functions and Implementation

Diagnostic Type	Target	ASIL Requirement
CPU Self-Test	Register/instruction anomalies	ASIL B/D
Memory Diagnostics	SRAM/Flash bit-flips (ECC)	ASIL B
Peripheral Monitoring	ADC/PWM failures	ASIL A/B
Communication Checks	CAN/LIN CRC errors	ASIL B

AEC-Q100 Standard

The AEC-Q100 standard, established by the Automotive Electronics Council, defines reliability certifications for integrated circuits (ICs) to make sure their long-term stability in harsh automotive environments. Grade 0 and Grade 1 are two critical temperature grades under AEC-Q100, differing primarily in operating temperature range, application scenarios, and test rigor. Below is a detailed comparison:

Table 1-6. Differences between AEC-Q100 Grade 0 and Grade 1

Criteria	Grade 0	Grade 1
Operating Temperature Range	-40℃ to approximately +150℃	-40℃ to approximately +125℃
Typical Applications	Engine compartments, transmissions, turbochargers	Body control, infotainment systems, dashboards
Test Rigor	Higher (longer high-temperature aging)	Moderate
Cost	Higher (specialized materials/processes)	Lower
Market Share	~15% (high-end/high-power)	~70% (mainstream automotive ICs)

Below is the common application scenarios for Grade 0 and Grade 1 due to the different requirement.

- **Grade 0 Applications**
  - Powertrain Systems: Fuel injection control, motor drivers (electric power steering).
  - High-Temperature Sensors: Exhaust gas temperature sensors, turbocharger pressure sensors.
  - High-Power Chips: Power MOSFETs, IGBT drivers.
- **Grade 1 Applications**
  - Body Electronics: Window lifters, seat adjusters, lighting control.
  - Infotainment Systems: Navigation, voice recognition, display drivers.
  - Low-Power Modules: Tire pressure monitoring systems (TPMS), passive entry/passive start (PEPS).

Resources

Please reach out to the sales team and ask for the above documents if you require any of them to develop your project.

- Texas Instruments, Functional Safety Manual for MSPM0G, functional safety manual.
- Texas Instruments, Functional Safety, function safety resources website.
- Texas Instruments, MCAL Access Link, MCAL.
- Texas Instruments, EB Tools Access Link, EB Tools.

Trademarks

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