

Advance Your Automotive Design With the MSPM33C321A-Q1 Device



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ABSTRACT

The MSPM33C321A-Q1 microcontroller from Texas Instruments delivers a high-performance automotive MCU product for current vehicle designs and electrified automotive systems. This automotive microcontroller supports AEC-Q100 Grade-1 requirements with included features like a 160MHz Arm® Cortex®-M33 CPU with DSP, FPU, and Arm® TrustZone® security, plus 1MB dual-bank flash and 256KB SRAM. Key automotive applications include advanced motor control (up to four DC motors or two BLDC motors), body electronics, adaptive lighting systems, instrument clusters, and other vehicle systems. The device provides 30 PWM channels, dual 12-bit ADCs (9.4Mps), and dual CAN-FD interfaces for comprehensive automotive connectivity. The ASIL B functional safety compliant features and hardware security with EVITA-light cybersecurity help meet modern automotive security requirements. The integrated security features include cryptographic accelerators (AES-256, SHA-256), an immutable root-of-trust, and secure firmware update. AUTOSAR® MCAL drivers and pin-to-pin compatibility throughout the MSP family of MCUs enable scalable automotive platforms. This next-generation automotive MCU addresses vehicle software advancements, secure design, and connected car technologies while targeting cost efficiency for automotive OEMs and their suppliers.

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1 Introduction

The automotive market is fast-changing and steadily-growing. A significant shift toward implementing more technology across nearly every vehicle subsystem has occurred in recent years. New designs implement drivetrain electrification, smarter and safer vehicles, and increasingly software-focused architectures—often referred to as *software-defined vehicles*. As a result, developers need higher compute, safety, and security requirements even in traditional low-range and mid-range performance automotive ECUs.

Accordingly, microcontrollers (MCUs) are increasingly playing a critical role in modern vehicles. In some cases, vehicles now contain more than 300 MCUs, performing functions ranging from simple sensing or actuation to advanced motor control and zonal subsystem management. With so many MCUs in every vehicle, automakers are seeking higher performance at lower costs, for both next-generation platforms and in existing designs.

Texas Instruments' latest investment in the general-purpose automotive MCU segment is the MSPM33C321A-Q1 device. The [MSPM33C321A-Q1](#) device is designed to address the current needs of the automotive market. The MSPM33C321A-Q1 device provides increased compute and analog performance, automotive-grade safety and security features to address current requirements, all while maintaining a current competitive cost structure for AEC-Q100 qualified devices.



Figure 1-1. Seat Position and Comfort Switchgear



Figure 1-2. Headlight and Turn Signal Module

2 Key Considerations for an Automotive MCU

There are several device-level considerations which are of particular concern to automakers when selecting an MCU. In a previous paper, [MSP MCU Advantages in Automotive Applications](#), Texas Instruments outlined three main priorities for automotive-grade chips: functional safety, product reliability, and supply chain resilience.

The MSPM33C321A-Q1 addresses these aspects directly; the device supports ASIL B grade functional safety features, is AEC-Q100 qualified for reliability and robustness, and is backed by Texas Instruments' long-term manufacturing and supply chain strategy. This combination enables OEMs and their suppliers to deploy MSPM33 in high-safety applications with confidence over extended vehicle lifecycles.

3 The MSPM33C321A-Q1 Device Offers Performance and Value

While the need for low cost, mid-range performance devices is not new, the expectations of automakers have evolved. Modern designs necessitate MCUs to support complex software, precise control, advanced communications, and high levels of safety and security, all without significantly increasing system cost.

Texas Instruments entered the automotive general-purpose and low-power MCU market with the MSPM0 family of devices. The MSPM33 family extends the low cost, reliable, and feature-packed advantages that the MSPM0 family introduced into a higher-performance space by offering greater processing ability, more memory, and higher performance peripherals. The MSPM33C321A-Q1 device, in particular, offers a feature set that is highly capable for various applications, including advanced motor control found in many body electronics, highly-integrated system modules, such as adaptive lighting, and more.

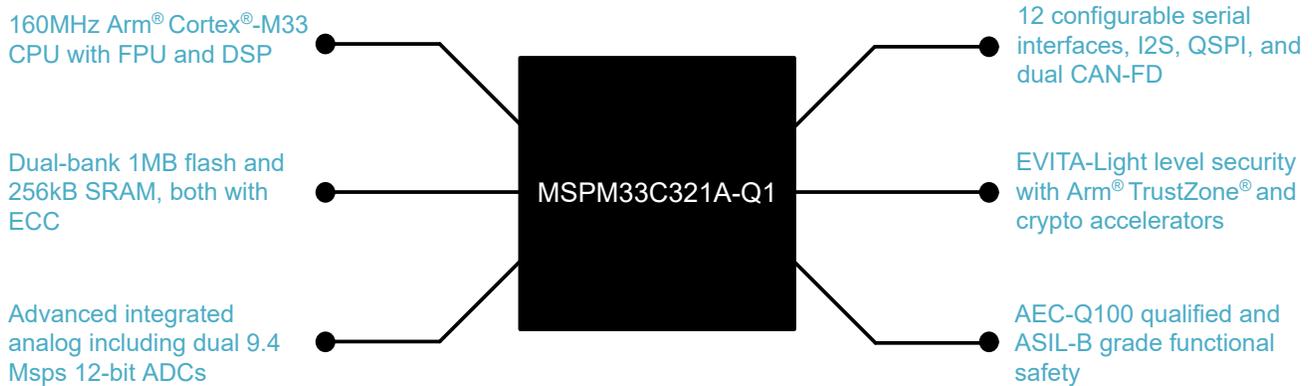


Figure 3-1. MSPM33C321A-Q1 Device Features and Advantages

Powerful Compute

The MSPM33C321A-Q1 device is built around a 160MHz Arm® Cortex®-M33 CPU, incorporating digital signal processing (DSP) instructions, a floating-point unit (FPU), and Arm® TrustZone® technology. This level of compute performance enables more sophisticated FPU-based motor control and signal-processing algorithms, faster response times, and the consolidation of multiple functions into a single MCU. Actuator control, sensing, and communications can all be handled by a single device, potentially driving down development costs from hardware and software perspectives alike.

Feature-Rich Memory Array

Dual 512kB flash banks (1MB total) and 256kB of SRAM make for a large and robust memory array, providing sufficient space for larger software stacks compared to MSPM0 alternatives. This memory configuration supports deployed-in-field firmware updates using banked flash operation and accommodates in-field expansion of diagnostics, functional safety mechanisms, and cybersecurity features over the life cycle of the vehicle.

Advanced Integrated Analog

Integrated analog sensing and control features include dual simultaneously-sampling 12-bit, 9.4Msps SAR analog-to-digital converters (ADCs) for fast and precise measurements, along with low-power comparators featuring integrated digital-to-analog converters (DACs). A total of nine timers, together supporting up to 30 PWM channels, enable advanced actuator and motor control for applications such as seats, mirrors, headlights, and more.

Highly Connected and Flexible

Robust communications are supported through dual CAN-FD interfaces and a broad set of serial peripherals, including QSPI and digital audio interfaces. Configurable UART (including LIN support), I²C, and SPI provide flexibility for inter-device communication. Together, these interfaces enable the MSPM33C321A-Q1 device to connect to a wide range of external devices and memory components—key for zone-oriented architectures, advanced housekeeping, and other applications.

Diverse Application Potential

Collectively, these features enable complex applications, such as advanced motor control (up to four DC motors or two BLDC motors), precise sensing and measurement (>12 ENOB with hardware averaging), graphical display control, and other complex body electronics. Functional safety is enhanced by the backup power domain (VBAT island), helping to mitigate power-loss scenarios and retain critical system state data.

In various body electronics use-cases, the MSPM33C321A-Q1 device serves as an effective and secure MCU for applications such as seat position and comfort modules. The combination of advanced motor control timers, high-speed ADCs, and flexible serial communication interfaces of the MSPM33C321A-Q1 device enables a single MCU to control all seat functions, including position adjustment, heating, cooling, and position memory.

The MSPM33C321A-Q1 device is also an excellent choice for lighting applications, with ASIL B support enabling control of safety-critical systems, such as headlights or brake lights. Multifaceted communication allows a single MCU to interface with multiple lighting modules, while active lighting control is achieved through integrated motor control and analog sensing. Other possible use-cases for this device include simple instrument clusters, climate control displays and switchgear, HVAC compressors, steering wheel control pads or buttons, and more.

4 Robust Cybersecurity With the MSPM33C321A-Q1 Device

Advanced security has become a baseline requirement in modern automotive systems. As a result of increased connectivity, software updates, and regulations, OEMs must standardize system-wide security requirements for MCUs. Many of these requirements are aligned with independent standards, such as the ISO 21434 and EVITA standards. As a result, automakers are increasingly redesigning products and platforms to incorporate MCUs with improved security functionality, supporting features such as secure boot, secure communication, and secure firmware updates.

The MSPM33C321A-Q1 device addresses these needs through a combination of various hardware and software features.

- **Arm® TrustZone® Technology** provides a hardware-enforced separation between secure and non-secure firmware, so that critical code is isolated from less trusted application software.
- **The Hardware Security Module (HSM)** on this device, built on TrustZone® technology, enables EVITA-light cybersecurity performance for sensitive applications.
- **Cryptographic Accelerators** supporting AES-256, SHA-256, as well as a public key accelerator (PKA) for algorithms such as ECDSA and ECDH together enable efficient and effective implementation of authentication, secure communication, and firmware integrity checks.
- **Secure Key Provisioning** from Texas Instruments means cryptographic keys are securely exchanged and managed, allowing trusted code to be programmed onto devices only after verification, further supporting secure system design.
- **Secure Boot and Firmware Update** allow automakers to maintain control, safety, and security of vehicle software from production through end-of-life.

5 Comprehensive Software Platform and Ecosystem

Software plays a principal role in automotive system design, with key factors including standardization, interoperability, and scalability. AUTOSAR® remains the most widely adopted software standard for automotive MCUs, enabling modular software development and separation of application software from underlying hardware.

At the lowest level, AUTOSAR® is built upon the microcontroller abstraction layer (MCAL) providing standardized drivers for peripherals such as CAN, SPI, PWM, and ADCs. Efficient MCAL implementations are of particular importance for mid-range MCUs, where memory and performance must be carefully balanced to maximize capability and minimize cost.

Texas Instruments offers a royalty-free MCAL package for MSP devices, compliant with AUTOSAR® Classic standards. These MCAL drivers are optimized specifically for the MSP architecture, including bespoke packages for both MSPM0 and MSPM33 devices, enabling strong performance and simple implementation in a compact memory footprint.

Across the broader MSP portfolio, Texas Instruments maintains scalability through both hardware and software by means of pin-to-pin package offerings and API-level compatibility. The MSP software platform includes a software development kit (SDK), a visual device configuration tool (Sysconfig), and a wide array of peripheral drivers and code examples. All MSP devices are highly scalable from the MSPM0 devices through the more complex, more capable MSPM33 family. Compatible software platforms support efficient development and code reuse, reducing overall software and hardware investment for automakers as these automakers build systems across the MSP portfolio.

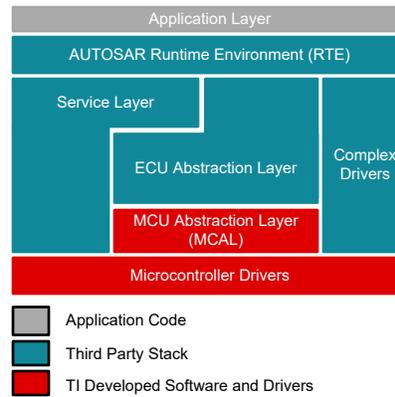


Figure 5-1. Typical Automotive Software Stack for MCUs

6 Conclusion

As automotive systems continue to grow in complexity, automakers are seeking mid-range MCUs that can deliver higher performance, stronger security, and more robust functional safety, all while maintaining cost efficiency and long-term reliability and dependability. The MSPM33C321A-Q1 device addresses these demands by extending the existing advantages of the MSP platform into higher-performance automotive applications without sacrificing scalability or simplicity.

By combining advanced device technology and a scalable software ecosystem, the MSPM33 family delivers stout processing capability, advanced integrated analog and control features, and a modern security architecture. These features equip automakers with a practical and future-ready design for a wide range of automotive ECUs, making way for the development of high-performance systems that are dependable, secure, and potentially cost effective.

Resources | Learn More and Get Started

To begin evaluating the MSPM33C321A-Q1 device for your automotive design, order an MSPM33C321A LaunchPad™ development kit! Drive your automotive design with MSPM33 code examples and user guides. You can also find other resources through the following links:

- [LP-MSPM33C321A LaunchPad™ Development Kit](#)
- [MSPM33C321A-Q1 Product Page – Datasheet, Technical Reference Manual, Ordering, and More](#)
- [MSPM0Gx5x9 to MSPM33C32xx Migration Guide](#)

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