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ABSTRACT

The [TCA9539A-Q1](#) is a next-generation 16-bit I²C general purpose parallel input and output (GPIO) expander that builds on the proven functionality of [TCA9539-Q1](#) and [TCA9539QPWRQ1](#).

The TCA9539A-Q1 supports wider supply-voltage range and features dual address variants, as orderable part numbers [TCA9539AQPWRQ1](#) and [TCA9539BQPWRQ1](#), that allow up to eight devices on a single I²C bus, simplifying scalable GPIO expansion in zonal and high-density architectures. The TCA9539AQPWRQ1 is designed to be pin-to-pin and software compatible with TCA9539-Q1 and TCA9539QPWRQ1, enabling straightforward replacement in existing automotive designs while offering enhanced robustness.

Table of Contents

1 Introduction to TCA9539A-Q1 I²C GPIO expander	2
2 Key Specification Comparison: TCA9539A-Q1 vs TCA9539-Q1	3
2.1 I ² C Addressing Scheme and Compatibility.....	4
2.2 Multidevice and Zonal Architectures.....	5
3 Why Use Interrupts with I²C GPIO Expanders?	6
4 Application Examples Using TCA9539A-Q1	6
4.1 Zonal Controller.....	6
4.2 Infotainment and ADAS Peripheral Control.....	7
4.3 Automotive Body Control Module (BCM).....	8
4.4 Audio and Peripheral Monitoring.....	9
5 Summary	10
6 References	11

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1 Introduction to TCA9539A-Q1 I²C GPIO expander

GPIO expanders are commonly used in automotive systems to increase input and output (I/O) availability while minimizing microcontroller pin count and routing complexity. The [TCA9539-Q1](#) device is widely adopted in body electronics and control modules. The orderable part number [TCA9539AQPWRQ1](#) extends this portfolio as a drop-in upgrade for automotive applications such as:

- Body control modules
- Door, mirror, and seat control modules
- Automotive lighting and LED control
- Switch and sensor input monitoring
- Zonal controllers

The [TCA9539A-Q1](#) provides 16-bits of GPIO expansion for I²C bus designed for 1.65V to 5.5V. Key specifications and features include:

- AEC-Q100 qualification
- 400kHz I²C Fast mode
- Interrupt ($\overline{\text{INT}}$ pin) asserted when an input port changes state
- Polarity Inversion
- Hardware $\overline{\text{RESET}}$ pin
- Two I²C address schemes: [TCA9539AQPWRQ1](#) and [TCA9539BQPWRQ1](#) each enabling four addresses or a total of eight unique addresses on the I²C bus.

2 Key Specification Comparison: TCA9539A-Q1 vs TCA9539-Q1

The TCA9539AQPWRQ1 is designed to be pin-to-pin compatible with TCA9539-Q1 and TCA9539QPWRQ1, supporting direct replacement in existing designs without requiring schematic, layout, or firmware changes in applications detailed in [Application Examples Using TCA9539A-Q1](#).

Table 2-1 lists key specifications relevant for migration from TCA9539-Q1 to TCA9539A-Q1.

Table 2-1. Comparison Table: TCA9539-Q1 and TCA9539A-Q1

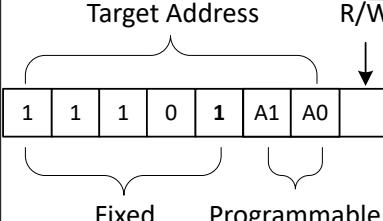
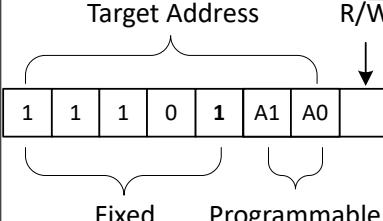
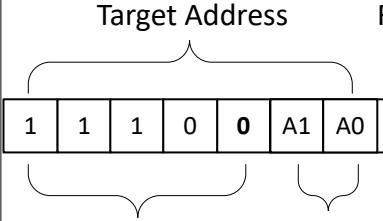
Parameter	TCA9539-Q1	TCA9539A-Q1
Supply Voltage Range	1.65V to 3.6V	1.65V to 5.5V
GPIO Count	16	16
I ² C Data Rate	Up to 400kHz (Fast-mode)	Up to 400kHz (Fast-mode)
Operating Temperature	-40°C to 125°C	-40°C to 125°C
Maximum Junction Temp (TJ)	135°C	140°C
5V Tolerant I/Os	Yes	Yes
V _{OL} / I _{OL} V _{OH} / I _{OH}	0.5 V at 8mA, 0.7V at 10mA 3.3V at -8mA, 3.2V at -10mA	0.5V at 8mA, 0.7 V at 10mA 4.7V at -8mA, 4.5 V at -10mA
Reset Pin	Yes	Yes
Interrupt Output	Yes	Yes
Number of I ² C Addresses	Four (TCA9539QPWRQ1)	<ul style="list-style-type: none"> • Eight • Four (TCA9539AQPWRQ1) and • Four (TCA9539BQPWRQ1)
ESD (HBM)	±2kV	±2kV
ESD (CDM)	±1kV	±1kV
Package	TSSOP-24	TSSOP-24

2.1 I²C Addressing Scheme and Compatibility

The TCA9539AQPWRQ1 uses the same I²C addressing scheme as the TCA9539-Q1 (orderable part number TCA9539QPWRQ1), verifying full compatibility at the bus level when replacing an existing device. Both devices support programmable I²C target addresses through external address pins. The TCA9539AQPWRQ1 allows selection of up to four unique addresses on the I²C bus using A0 and A1 hardware selectable address pins similar to TCA9539QPWRQ1.

Because the address pin definition and encoding are unchanged, existing pull-up or pull-down configurations on the address pins can be reused without modification when migrating from TCA9539-Q1 to TCA9539A-Q1.

Table 2-2. I²C Address Scheme: TCA9539-Q1 (TCA9539QPWRQ1) vs TCA9539A-Q1 (TCA9539AQPWRQ1 and TCA9539BQPWRQ1)

Parameter	TCA9539-Q1			TCA9539A-Q1			TCA9539A-Q1		
	Orderable part number TCA9539QPWRQ1			Orderable part number TCA9539AQPWRQ1			Orderable part number TCA9539BQPWRQ1		
I ² C target address scheme	Target Address R/W 			Target Address R/W 			Target Address R/W 		
I ² C target addresses	A1	A0	ADDRESS	A1	A0	ADDRESS	A1	A0	ADDRESS
	L	L	116 (decimal) 74 (hex)	L	L	116 (decimal) 74 (hex)	L	L	112 (decimal) 70 (hex)
	L	H	117 (decimal) 75 (hex)	L	H	117 (decimal) 75 (hex)	L	H	113 (decimal) 71 (hex)
	H	L	118 (decimal) 76 (hex)	H	L	118 (decimal) 76 (hex)	H	L	114 (decimal) 72 (hex)
	H	H	119 (decimal) 77 (hex)	H	H	119 (decimal) 77 (hex)	H	H	115 (decimal) 73 (hex)
Number of I ² C Addresses	Four addresses			Four addresses			Four addresses		
							Eight addresses		

2.2 Multidevice and Zonal Architectures

Maintaining an identical I²C addressing scheme is especially important in automotive systems that employ multiple TCA9539-Q1 GPIO expanders on a shared bus, such as body electronics and zonal controller architectures. The TCA9539AQPWRQ1 can be introduced into these systems without requiring changes to I²C address maps or software configuration.

For applications requiring a larger number of unique I²C addresses, device also offers related device variant with orderable part number TCA9539BQPWRQ1 with expanded address capability allowing another four unique I²C addresses as shown in [Table 2-2](#). This allows up to eight unique devices on the same I²C bus if using both TCA9539AQPWRQ1 and TCA9539BQPWRQ1 as shown in [Figure 2-1](#)

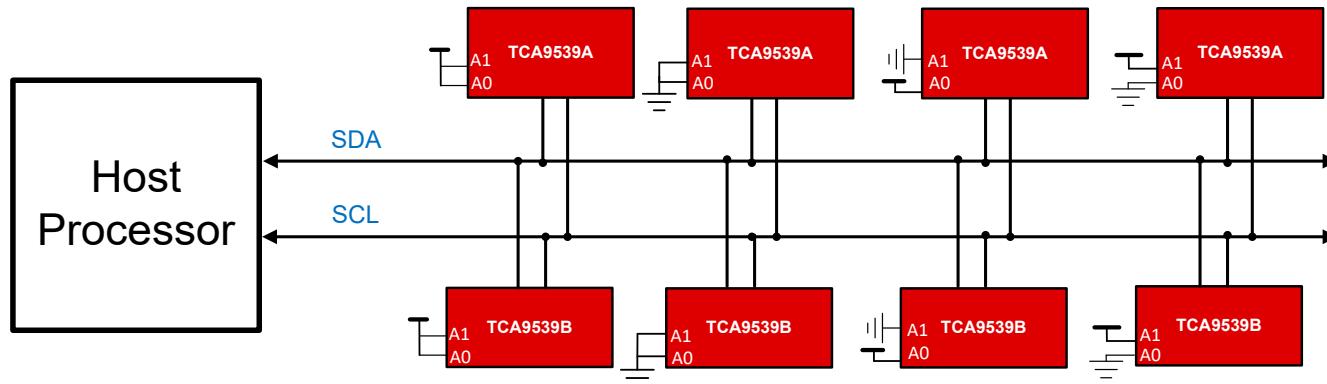


Figure 2-1. Using 4x TCA9539A and 4x TCA9539B for Multi-Device and Zonal Architectures

Although the TCA9539AQPWRQ1 is designed as a drop-in replacement, TI recommends validating system-level requirements such as supply voltage, GPIO loading, power-up behavior, and thermal margin when migrating any device.

3 Why Use Interrupts with I²C GPIO Expanders?

The TCA9539A-Q1 open-drain interrupt output is asserted when any input state differs from the corresponding input port register state. This interrupt is used to indicate to the host MCU or SoC that an input state has changed, prompting the controller to initiate a read operation. This allows the host MCU or SoC to operate in an event-driven manner rather than continuously polling GPIO status registers.

This interrupt driven operation reduces I²C bus traffic, lowers software overhead, and can improve system response time in automotive designs.

4 Application Examples Using TCA9539A-Q1

4.1 Zonal Controller

Zonal architectures consolidate multiple vehicle functions into centralized controllers, increasing the demand for flexible and scalable GPIO resources. The TCA9539A-Q1 enables GPIO expansion close to the zone controller while minimizing wiring complexity.

As shown in [Figure 4-1](#), up to eight TCA9539A-Q1 devices can share the same I²C bus using configurable addressing, allowing designers to scale GPIO count as system requirements evolve. Interrupt signaling supports event-driven architectures that reduce software overhead.

The device integrates simply with SoCs from TI ([TIDA-00296: Automotive Body Control Module Driver Reference Design, Zonal Architecture and MCU I/O expansion](#)) as well as other popular vendor (reference designs) for Zonal Control Module.

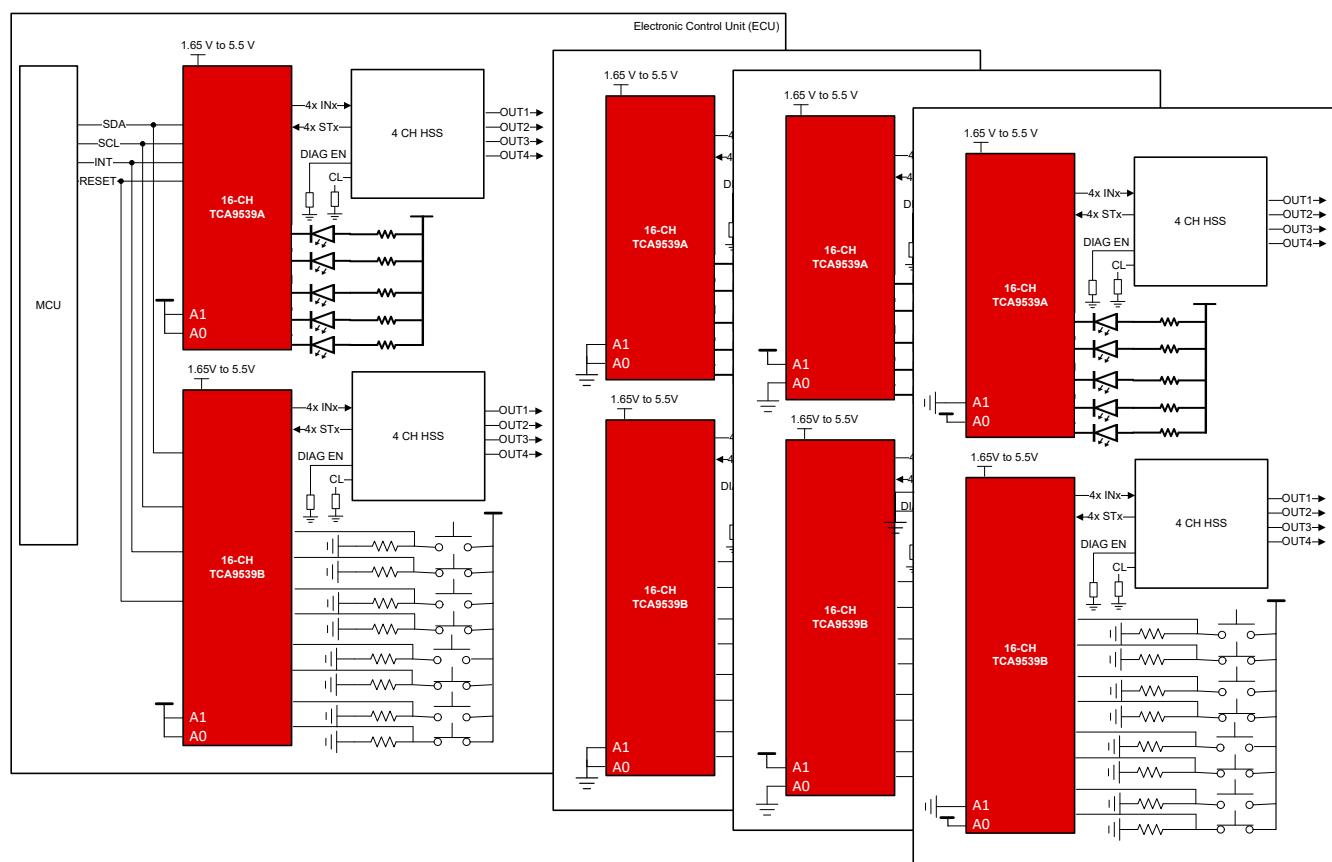


Figure 4-1. Block Diagram of GPIO Expansion Using TCA9539A and TCA9539B for Zonal Controller

4.2 Infotainment and ADAS Peripheral Control

Modern infotainment head units, digital cockpit platforms, and ADAS systems integrate displays, serializers and deserializers, image sensors, and other peripherals that require low-speed control and status monitoring. GPIO expanders simplify this integration by offloading enable, reset, and mode-select signals from the main SoC.

The TCA9539A-Q1 is typically connected to the infotainment or ADAS SoC via I²C and used to control peripheral enable pins and monitor fault or status signals as shown in [Figure 4-2](#). Wide supply-voltage range (1.65V to 5.5V) supports mixed-voltage architectures commonly found in automotive platforms. The interrupt feature allows prompt detection of peripheral state changes, while the reset pin enables deterministic system startup.

The device integrates easily with SoCs from TI ([TIDEP-01008 reference design, Efficiently Driving Automotive Dashboard Loads With TPS1HC100-Q1](#)), as well as other popular vendor (and reference designs) for Infotainment and ADAS, and can be paired with I²C level translators or buffers as needed for multi-voltage systems.

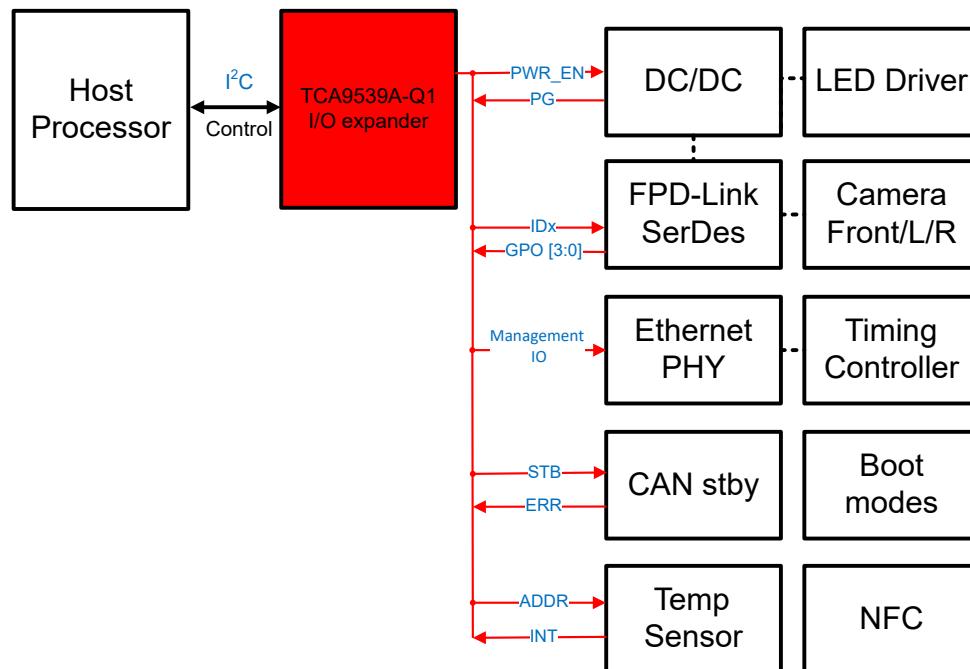


Figure 4-2. Block Diagram of I²C GPIO Expander for Infotainment and Driver Assistance

4.3 Automotive Body Control Module (BCM)

In automotive body control modules, GPIO availability is often constrained due to increasing feature content such as lighting control, switch monitoring, and actuator enable signals. The TCA9539A-Q1 provides scalable GPIO expansion over the I²C bus, allowing designers to reduce MCU pin count while maintaining flexibility.

In this application, as shown in [Figure 4-3](#), the TCA9539A-Q1 is connected to the main body MCU through an I²C interface. Input pins are used to monitor switch states, while output pins control LEDs and relays. The device port configured as output pins support up to 10mA source current and 8mA sink current. The interrupt output signals the MCU when an input state changes, reducing the need for continuous polling.

The device integrates simply with SoCs from TI ([TIDA-00296: Automotive Body Control Module Driver Reference Design](#)) as well as other popular vendor for Body Control Module.

Key design considerations include proper interrupt configuration, reset behavior during power-up, and verification of GPIO loading. The pin-to-pin compatibility of TCA9539AQPWRQ1 allows direct replacement in existing BCM designs using TCA9539-Q1, while the wider supply-voltage range supports mixed-voltage architectures.

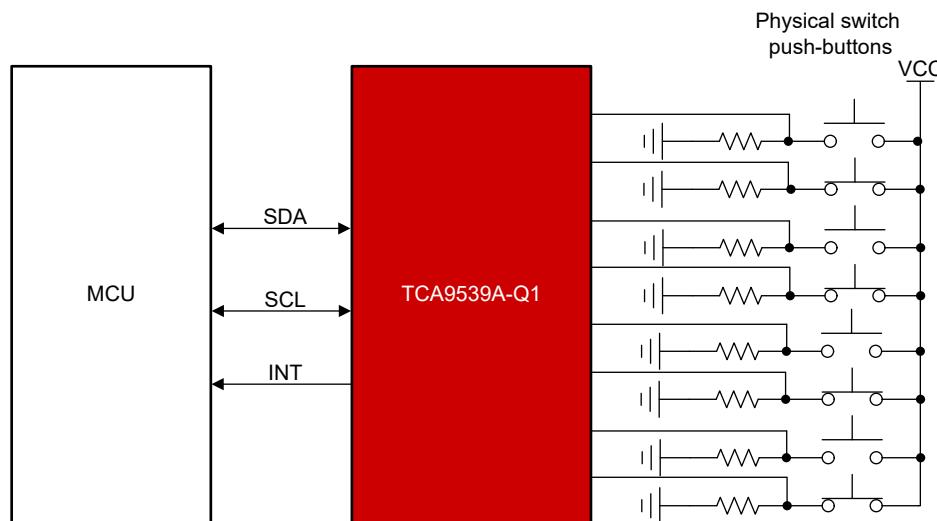


Figure 4-3. Block Diagram of I²C GPIO Expander for Automotive Body Control Module

4.4 Audio and Peripheral Monitoring

In automotive audio systems, GPIOs are required for device enable, fault monitoring, and mode control of codecs, amplifiers, and DSPs. The TCA9539A-Q1 complements high-speed audio data interfaces such as I²S or TDM by handling low-speed control and monitoring signals as shown in [Figure 4-4](#). Using an I²C-based GPIO expander helps isolate control functions from time-critical audio data paths while simplifying system integration.

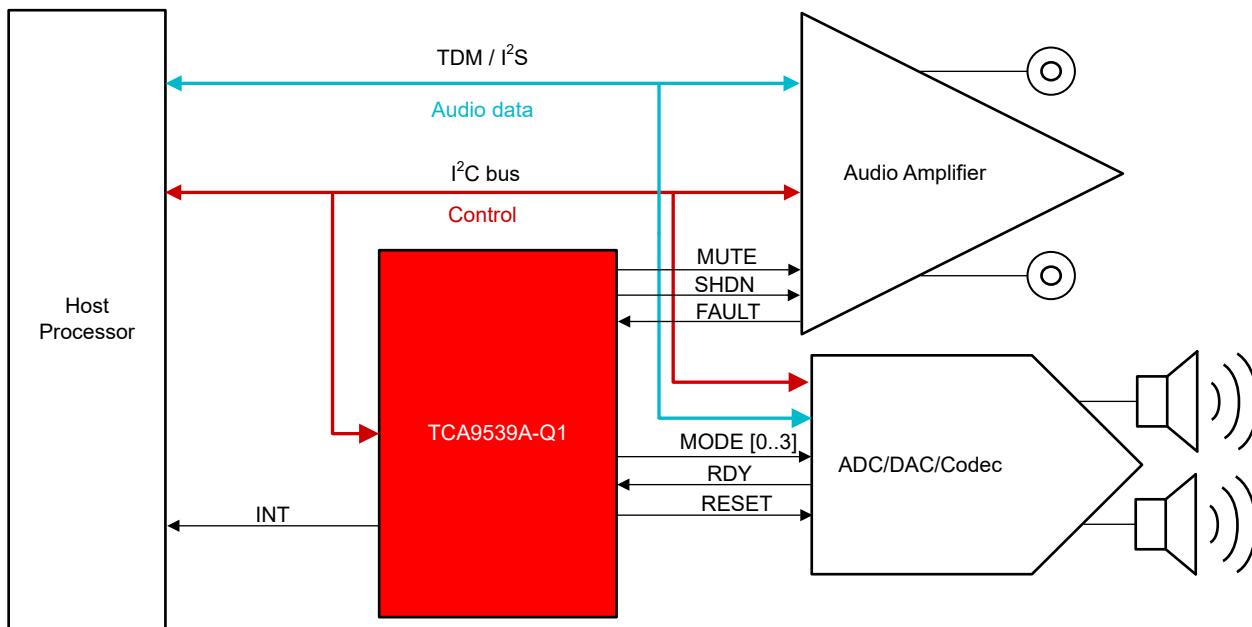


Figure 4-4. Block Diagram of I²C GPIO Expander for Automotive Audio and Peripheral Monitoring

5 Summary

The [TCA9539AQPWRQ1](#) delivers a seamless, drop-in upgrade for [TCA9539-Q1](#)/[TCA9539QPWRQ1](#) automotive designs, combining full pin-to-pin and software compatibility with improved system flexibility and robustness. Designers can migrate without schematic, layout, or firmware changes while immediately benefiting from a wider 1.65V to 5.5V supply range, more I²C addresses, and higher thermal margin.

With Fast-mode I²C support, integrated interrupt signaling, and hardware reset, the device enables efficient event-driven operation that reduces MCU overhead and bus traffic. Dual address variants ([TCA9539AQPWRQ1](#) and [TCA9539BQPWRQ1](#)) allow up to eight devices on a single bus, simplifying scalable GPIO expansion in zonal and high-density architectures.

Preferred for zonal and body domain controller, infotainment, ADAS, and peripheral monitoring, the [TCA9539A-Q1](#) reduces MCU pin count and minimizes routing complexity.

For smaller pin-count needs, the [TCA9536-Q1](#) offers a compact (1.08mm²), 4-bit, cost-optimized alternative, while [TCAL9539-Q1](#) extends the same 16-bit I/O architecture with advanced diagnostics and functional-safety features in the QFN package.

6 References

1. Texas Instruments, [Automotive Low-Voltage 16-Bit I²C-Bus, SMBus I/O Expander](#), datasheet.
2. Texas Instruments, [TCA9539-Q1 Low Voltage 16-Bit I²C and SMBus Low-Power I/O Expander](#), datasheet.
3. Texas Instruments, [Automotive Body Control Module Driver Reference Design](#), reference design.
4. Texas Instruments, [Zonal Architecture and MCU I/O expansion](#), application brief
5. Texas Instruments, [Multi-sensor platform reference design on Jacinto™ ADAS processors](#), reference design.
6. Texas Instruments, [Efficiently Driving Automotive Dashboard Loads](#), application note.
7. Texas Instruments, [Understanding I²C bus](#), application note.

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