Advanced Driver Assistance (ADAS) Solutions Guide

Texas Instruments

www.ti.com/adas

2015

Advanced driver assistance (ADAS)
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Texas Instruments commitment to automotive safety

Advanced driver assistance systems (ADAS) are one of the fastest-growing application areas in vehicles today as ADAS features are incorporated into even the middle and lower ends of the car market. A multitude of features can now warn drivers, allow better visibility into what is going on outside the car and support features like park assist and adaptive cruise control — these are achieved with radar-, camera-, light detection and range (LIDAR)- and ultrasound-based systems. Advanced ADAS functions and autonomous driving do require the use of multiple systems together. TI provides both analog and digital solutions and has a strong road map to support the evolution and growth of this exciting application space.

During the past 10 years, safety has become as much of a selling point in the automotive market as fuel economy and performance. Today's safety systems are designed to help vehicle passengers not only escape injury during an accident, but actually help prevent the accident in the first place. Texas Instruments (TI) is committed to providing industry-leading technologies for ADAS solutions, complete with excellent product documentation, which meets increasingly demanding OEM specifications and makes the road a safer place. From lane-departure warnings to drowsiness monitoring, ultrasonic park assist, advanced braking systems and other ADAS applications, TI's power-management and control solutions, robust processors, communication interfaces, display components and microcontrollers help you deliver world-class ADAS features.

Automotive-qualified products (Q1)

TI's automotive-qualified products are indicated by the Q1 suffix. The Q1 indicates that a product has met TI's stringent automotive standards and includes:

- 180-day product-change notification from final notice
- Extended temperature qualification
- Automotive documentation service
- Target zero defects

Advanced driver assistance (ADAS)
Overview

Today most advanced driver assistance system (ADAS) functions are basically their own independent system, with radar, camera and ultrasound the most common sensor types. Going forward, TI sees an increasing trend to use multiple, different sensor inputs and combine them to make more accurate decisions and identify critical situations.

Vision

- Strong trends in the various ADAS systems lead to a need for new and advanced semiconductor components
- Digital signal communication replaces analog to allow higherbandwidth and image processing
- Reduced solution size and reduced power dissipation are critical for reducing camera module size
- Reduced weight and complexity of the wiring harness saves cost and fuel
- DSP performance increases to run multiple and higher-performance vision algorithms

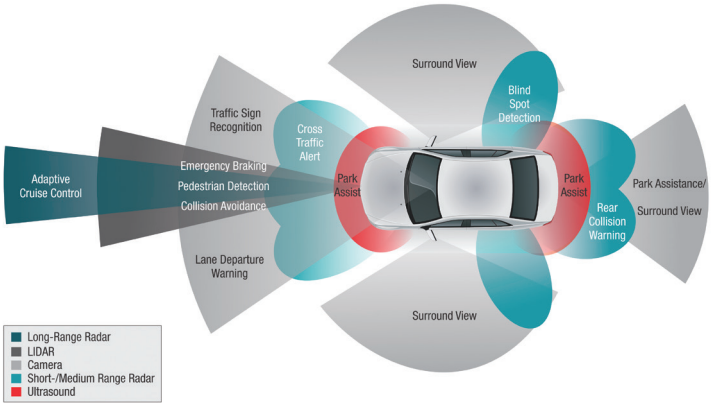
Radar

- Integration of the analog front end, phase-locked loop (PLL) and synthesizers — as well as RF components — reduce system cost and lower total power consumption and board space
- Clocks with low jitter and phase noise, voltage-controlled oscillators with up to 38 GHz, PLLs with 10 GHz+, and synthesizers with waveform generation are needed to achieve the required radar system performance
- Low-noise RF supplies increase and enable performance of the radar and analog signal chain

General ADAS requirements

- Safety-critical systems (e.g., autonomous braking and steering) need to have ISO26262 certification
- Sensor fusion (camera, radar, ultrasound) achieves higher system performance than independent systems
- Lower power consumption
- Car safety ratings (NCAP, NHTSA), government mandates and consumer safety awareness drive the rapid growth of the ADAS market

Application/sensor type	Video	Infrared	Long range radar 76 to 81 MHz	Short/mid range radar 24 to 26 GHz/ 76 to 81 GHz	Ultrasound 48 kHz
Adaptive front light (AFL)	X				
Night vision (NV)	X	X			
Adaptive cruise control (ACC)	X	X	X		
Lane-departure warning (LDW)	X				
Low-speed ACC, emergency brake assist (EBA), lane-keep support (LKS)	X	X		X	
Pedestrian detection	X	X		X	
Blind-spot detection (BSD), rear collision warning (RCW), lane-change Assist (LCA)	X			X	
Park assist (PA)	X			X	X
Traffic-sign-recognition (TSR)	X				



ADAS embedded main processors

DSP, ADAS accelerator and ARM-based processors

Sensor fusion

Scalable performance for sensor data fusion and safety related decision making

Front camera	Park assist/fusion	Radar
Scalable performance low power safety processors	**Integrated performance scalable from rear to 3D surround view**	**Scalable performance for SRR, MRR, LRR safety**
• Optimal mix of performance and power to run >5 ADAS apps at <3 W • Scalable single to multicore architecture with C6x DSPs, ADAS accelerators and ARM cores • SafeTI support from QM to ASIL B • Small footprint for miniaturization	• Optimal mix of integration, performance and power for single to complex multicamera apps • Scalable single to multicore architecture with C6x DSPs, ADAS Accelerators, ARM, video and graphics cores • POP memory and MCU integration for rear camera miniaturization	• Optimal mix of performance and power to run entry radar at ~1 W and high-end radar at <3 W • Scalable single to multicore architecture with C6x DSPs, FFT accelerators and ARM cores • SafeTI support from QM to ASIL B • Seamless AFE radar interfaces

Camera-based systems
Overview

The use of camera-based systems ranges from advanced driver assistance systems (ADAS) features like backup-camera and surround-view systems, to driver-drowsiness warning, lane-departure warning and collision avoidance. The image from a CMOS camera sensor is processed and either displayed to the driver or used for machine vision. Depending on the application, the complexity and number of cameras varies.

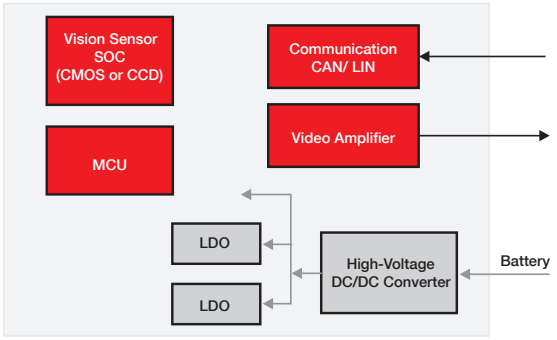
Design considerations

LVDS interfaces are used to transfer large amounts of data via a high-speed serial connection to an external location like a video screen or from the video source (digital camera chip).

General-purpose microcontrollers handle system-control functions as well as communication with other modules in the car. The core digital function comes from the DSP, processing the data from the digital input source (e.g., a CMOS camera). Depending on the required performance, from simply driving a screen to performing complex digital algorithms, pattern recognition may be necessary.

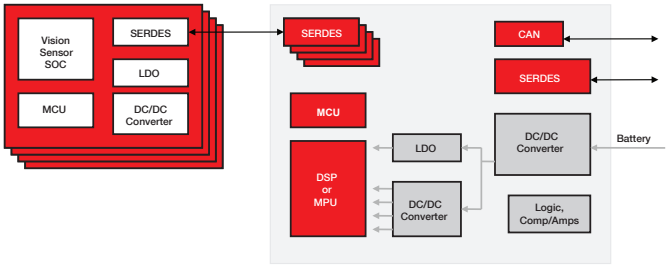
Basic analog camera module

Basic analog camera modules are used in backup camera and surround-view systems.



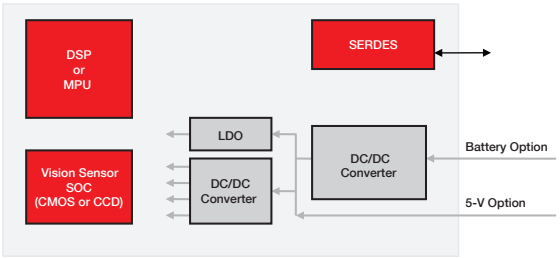
Multi camera module

Camera systems with multiple cameras can provide surround view and process video data for warnings and additional driver information.



Smart camera module

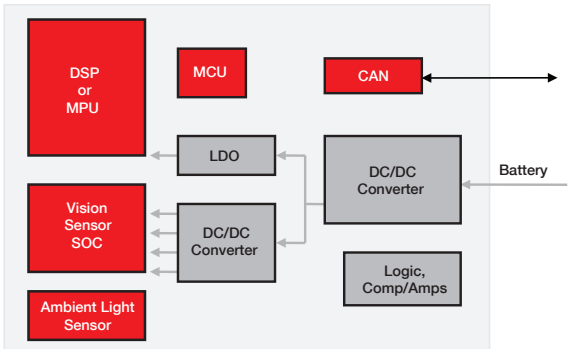
Smart camera modules are used in more advanced backup camera and park-assist systems.



Safety MCUs offer an ARM Cortex-R4F-based solution and are certified for use in systems that need to achieve ISO26262 ASIL-D safety levels. These MCUs also offer integrated floating-point, 12-bit ADCs, CAN and FlexRay interfaces. Hercules™ safety MCUs can also be used to implement scalar and vector-control techniques and support a broad range of performance requirements.

Front camera module

For applications that need high data processing for machine vision, camera modules include a powerful DSP to process the video data. Examples are lane-departure warning, adaptive front lights, traffic-sign recognition and pedestrian/object detection. Other uses would be blind-spot detection and driver-drowsiness warning.



Camera-based systems
TDAx ADAS SoC

TDA2x system-on-chip (SoCs) family

Overview

TI's TDA2x system-on-chips(SoCs) is a highly optimized and scalable device family designed to meet the requirements of leading advanced driver assistance systems (ADAS). The TDA2x family empowers broad ADAS applications in today's automobiles by integrating an optimal mix of performance, low power and ADAS vision-analytics processing that aims to facilitate a more autonomous and collision-free driving experience.

The TDA2x SoC makes possible sophisticated embedded vision technology, providing the industry's broadest range of ADAS applications such as front camera, park assist, surround view and sensor fusion on a single architecture. Front-camera applications include high-beam assist, lane-keep assist, adaptive cruise control, traffic-sign recognition, pedestrian/object detection and collision avoidance. Park-assist applications include intelligent 2-D and 3-D surround view and rear-collision warning and detection. The TDA2x SoC is also capable of handling the fusion of radar and camera sensor data, allowing for a more robust ADAS decision-making process.

TDA2x architecture

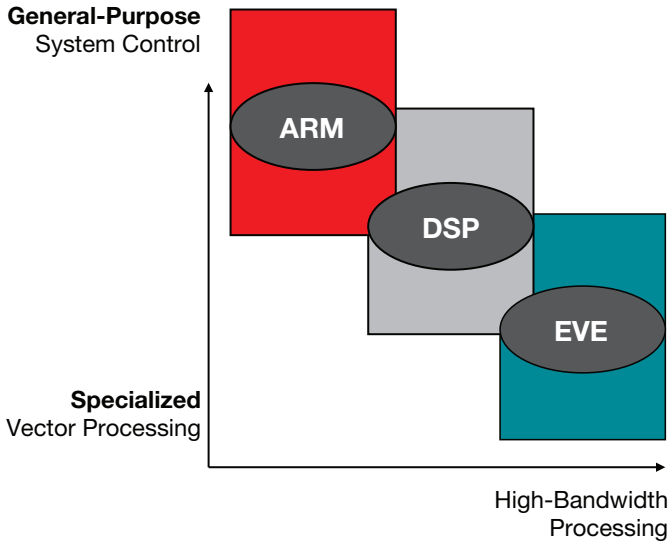
The TDA2x SoC incorporates a heterogeneous, scalable architecture that includes a mix of TI's fixed- and floating-point TMS320C66x digital signal processor (DSP) generation cores, Vision AccelerationPac, ARM Cortex-A15 MPCore and dual Cortex-M4 processors. The integration of video for decoding multiple video streams over Ethernet audio-video bridging (AVB) networks, along with graphics accelerators for rendering virtual views, allows for a 3-D viewing experience. And the TDA2x SoC integrates a host of peripherals, including multicamera interfaces (both parallel and serial) for LVDS-based surround-view systems, displays, CAN and Gigabit Ethernet AVB.

Specifically, vision-oriented applications are partitioned into low-, middle- and high-level processing. With the TDA2x, TI has efficiently mapped out the ARM general-purpose processing cores to manage core control processing.

Mid- to high-level processing is performed by one or more DSP cores optimized for real-time functions such as object detection, and low- to mid-level processing is handled by the Vision AccelerationPac. The Vision AccelerationPac was specifically designed to offload the processing of vision algorithms from the TDA2x DSP and ARM cores, yielding the best performance for low- to mid-level vision processing at the lowest-power footprint.

Heterogenous SoC concept for the highest processing performance and power efficiency

- Vision accelerationPac (EVE)
  - Vector processing
  - Highest data bandwidth
- DSP
  - Pipelined processing
  - General purpose
- ARM
  - System control
  - High-level postprocessing



Camera-based systems
TDAx ADAS SoC

The TDA2x SoC includes TI's Vision AccelerationPac, which delivers up to a 10× improvement in performance for advanced vision analytics over existing ADAS systems at similar power levels. The Vision AccelerationPac for this family of products includes multiple embedded vision engines (EVEs) offloading the vision-analytics functionality from the application processor. The Vision AccelerationPac is optimized for vision processing with a 32-bit RISC core for efficient program execution and a vector coprocessor for specialized vision processing. With each core operating a 16 MAC-per-cycle computing engine up to 650 MHz (8 bit or 16 bit), the Vision AccelerationPac is able to deliver more than 10.4 GMACs per core, for a total of > 40 GMACs for quad EVEs devices. This provides the most efficient vision analytics for real-time vision-based automotive applications and allows the most 16 × 16-bit multiplies compared to other processor architectures.

The TDA2x SoC includes a broad range of cores. It includes dual next-generation C66x fixed-/floating-point DSP cores that operate at up to 750 MHz to support high-level signal processing and a 750 MHz Cortex-A15 core for control and general-purpose processing. With 200 MHz of processing performance, the Cortex-M4 cores deliver efficient control and processing camera streams. TI's IVA-HD core is an imaging and video codec accelerator running at up to 532 MHz to facilitate full HD video encoding and decoding.

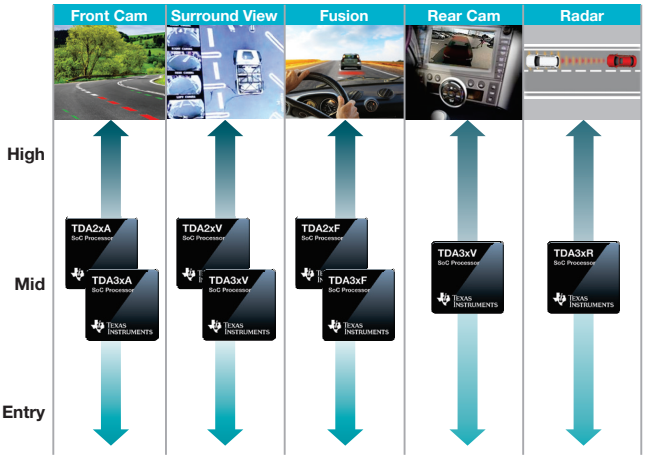
The TDA2x SoC has up to 2.5 MB of on-chip L3 RAM with single error correct and double error detect (SECDED) support to minimize the impact of soft error rate (SER). Each of the DSP cores has 32 KB of both L1 data and programming memory as well as a unified 256 KB L2 cache. The ARM cores have 32 KB of L1 data and programming memory as well as a combined 2 MB L2 cache.

The integrated peripherals are another key component of the TDA2x SoC. Three video input ports, each with two 16-bit supports, provide four to six camera inputs needed for surround-vision applications. The integrated high-performance Gigabit Ethernet with AVB enables systems using Ethernet for the surround view. TI's versatile display subsystem offers three video overlays and one graphic overlay. Two high-end CAN controllers allow communications within the vehicle without the need for a host computer, reducing system cost and footprint. Four SPIs deliver fast booting times for instantaneous video display when the vehicle is started.

TDA3x ADAS system-on-chip (SoC) Family

Overview

TI's new TDA3x device family extends TI's System-on-Chip (SoC) offerings in the Advanced Driver Assistance Systems (ADAS) space. TI announced the TDA2x device last year, to target front, surround and fusion ADAS solutions. The TDA3x SoC device family builds on that offering to scale sophisticated innovation into ADAS solutions for entry- to mid-segment automobiles for front, rear, surround, radar and fusion applications.

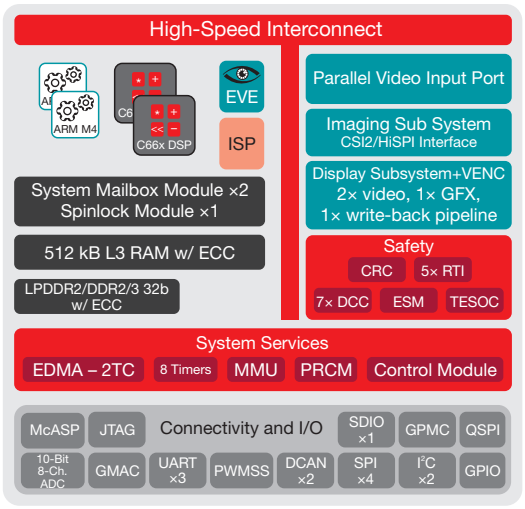


Scalability between TDA2 and TDA3x SoCs for various ADAS applications

With the TDA3x SoC, car manufacturers can develop sophisticated ADAS applications that meet or exceed NCAP requirements, reduce collisions on the road and enable a more autonomous driving experience in entry- to mid-level automobiles.

TDA3x architecture

The TDA3x SoC is based on a heterogeneous, scalable architecture that includes TI's fixed- and floating-point dual-TMS320C66x generation of DSP cores, a fully programmable Vision AccelerationPac (EVE) and dual ARM® Cortex®-M4 cores along with an image signal processor (ISP). The TDA3x SoC also integrates a host of peripherals including displays, CAN and multi-camera interfaces (both parallel and serial) for LVDS-based surround view systems.



TDA3x SoC block diagram

Camera-based systems
TDA2x/3x ADAS SoCs

The TDA3x SoC broad range of cores is aimed at supporting and delivering the fastest and most efficient processing. It includes two, next-generation TMS320C66x fixed-/floating-point DSP cores that operate at up to 500 MHz to support high-level signal processing. With 200 MHz of processing performance, the M4 cores deliver efficient control and processing camera stream.

Additionally, the TDA3x SoC has 512KB of on-chip L3 RAM with single error correct and double error detect (SECDED) support to minimize impact of soft error rate (SER). Each of the DSP cores has 32 KB of L1D data and 32 KB L1P programming memory as well as 288 KB of L2 memory (L1 and L2 memory can be configured as either flat memory or cache). The TDA3x SoC offers a rich set of integrated peripherals:

- Video input port providing 4×8-bit or 2×16-bit camera inputs
- TI's versatile display subsystem offering video and graphic overlay
- Two high-end CAN controllers allowing communications within the vehicle without the need for a host computer, thus reducing system cost and footprint
- QSPI delivers fast booting times for instantaneous video display when the vehicle is started

The TDA3x SoC introduces the automotive industry to the first package-on package (POP) including DDR memory, enabling miniaturization of the ADAS camera or radar systems. Having the capability to mount memory on top of the TDA3x SoC package reduces both the footprint and board complexity. This adds processing capability without increasing the size of the module. Multiple memory vendors including Micron, ISSI and Winbond will provide custom POP memory for the TDA3xSoC. Unlike anything else available on the automotive market today, the TDA3x 12 mm ×12 mm POP solution can be leveraged to create the smallest ADAS system.

ISP integration reducing system cost, complexity and size

By integrating an ISP that enables raw/Bayer sensors, the TDA3x processor delivers improved image quality without increasing the size, cost or complexity of the solution. Variants of the TDA3x SoC have full featured ISP including noise filters, color filter array (CFA), video noise temporal filtering (VNTF), exposure and white balance controls, as well as optional support for wide dynamic range (WDR) and lens distortion correction (LDC). The ISP can support a range of combinations for mono, stereo and up to four camera inputs providing an industry leading integrated solution.

Enhanced design for functional safety to help customers develop safer vehicles

TI's TDA3x processor is being developed to meet the relevant requirements of the ISO 26262 functional safety standard. The TDA3x SoC leverages a wide range of diagnostics from TI's award-winning Hercules™ TMS570 safety MCU family to enhance the existing TDA2x platform safety concept. The combination of hardware, software, tools and support helps TDA3x processor customers develop systems to meet challenging functional safety requirements and achieve system level functional safety certification more efficiently.

Scalability with the TDA3x device family

The TDA3x SoC scalable architecture allows for significant reuse. Variations of TDA3x are available for front camera, surround view, rear view, radar and CMS (camera mirror replacement systems). As shown below, front camera application uses 1–2 camera inputs and both DSP and EVE to enable 3–5 algorithms. Surround view systems can use CSI-2 or parallel camera inputs with ISP and DSP processing for low to- mid-segment surround view.

	Front Camera	Surround view CSI	Surround view parallel	Rear view
DSP1	✔	✔	✔	✔
DSP2	✔			
EVE	✔	✔	✔	✔
CSI input	✔	✔		✔
ISP		✔	✔	✔
VOUT		✔ (24b)	✔ (8b)	✔
VIN1a	✔		✔	✔
VIN1b			✔	
VIN2a			✔	
VIN2b			✔	

TDA3x SoC processor and video input/output usage for different applications

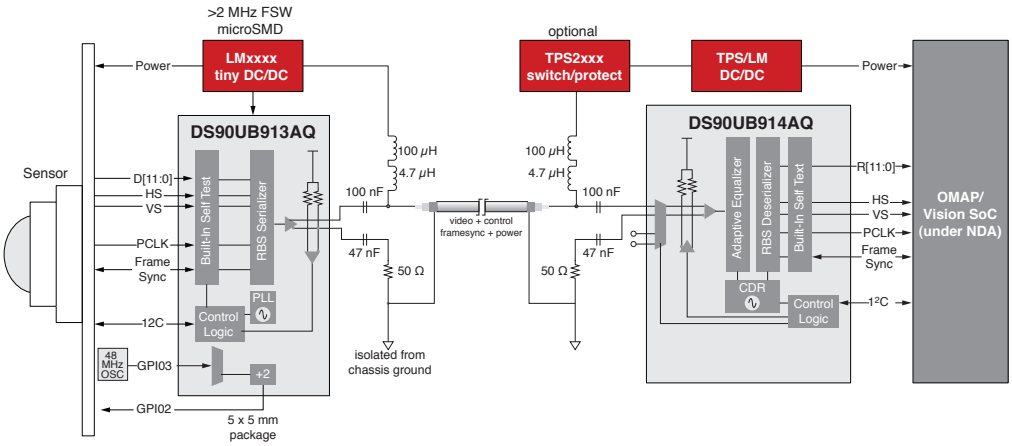
Tools and software for quickly getting started

TI's ADAS-related Vision Software Design Kit (SDK) enables customers to quickly and easily integrate the Vision AccelerationPac (EVE) and DSP algorithms and then benchmark and partition them across multiple processing elements. The TI Vision SDK is a set of software development APIs, framework, tools and documentation allowing the creation of vision and analytics applications for the TI TDA3x SoC hardware platform. In addition to the SDK, TI also has a number of libraries available for vision kernels on Vision AccelerationPac (EVE) and DSP. The SDK and libraries reduce development efforts and time to market while enabling customers to innovate and differentiate on their solution.

Camera-based systems
FPD-link/LMH6551Q-Q1

FPD-link

- DS90UB913A/914A serializer/deserializer (SERDES)
- Supports megapixel image sensors
- No compression for best video quality
- Small camera module size
  - No microcontroller needed
  - Video, control and power over one cable/connector
  - ISP companion chip can be located away from camera in ECU
- Low cost
  - Inexpensive coax cable
  - Low component count
  - Fits on one PCB
- Very low < 15-µs latency
- Supports power-over-coax data cable
- Low power consumption
  - Less heat for better low-light performance



Differential, high-performance operational amplifier
LMH6551Q-Q1

The LMH6551-Q1 is a high-performance voltage feedback differential amplifier. The LMH6551-Q1 has the high speed and low distortion necessary for driving high-performance ADCs as well as the current-handling capability to drive signals over balanced transmission lines like CAT 5 data cables. The LMH6551-Q1 can handle a wide range of video and data formats.

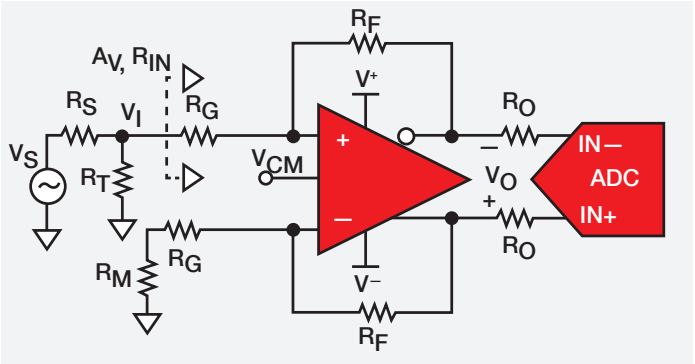
With external gain set resistors, the LMH6551-Q1 can be used at any desired gain. Gain flexibility coupled with high speed makes the LMH6551-Q1 suitable for use as an IF amplifier in high-performance communications equipment.

Key features

- 370 MHz to 3-dB bandwidth (V_{OUT} = 0.5 V_{PP})
- 50 MHz 0.1 dB bandwidth
- 2400-V/µs slew rate
- 18 ns settling time to 0.05%
- –94/–96 dB HD2/HD3 at 5 MHz
- LMH6551-Q1 is AEC-Q100 Grade 1 qualified and is manufactured on an automotive grade flow

Applications

- Fully differential video driving
- Video over twisted pair



Functional block diagram

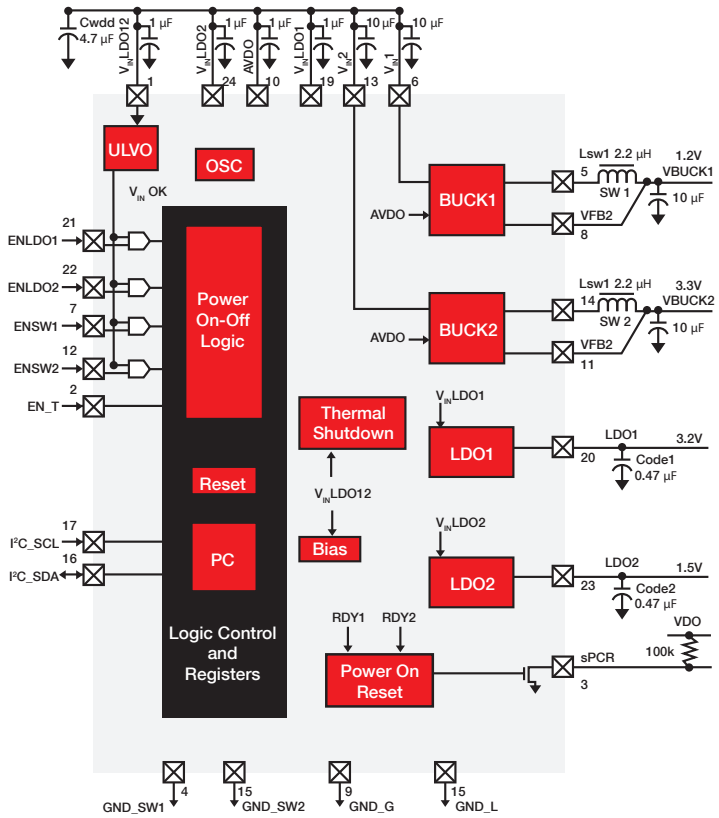
Camera-based systems
LP3907-Q1

Dual high-current step-down DC/DC and dual linear regulator with I²C-compatible interface

LP3907-Q1

The LP3907-Q1 is a multifunctional, programmable power-management unit, optimized for low-power FPGAs, microprocessors and DSPs. This device integrates two highly efficient 1 A/600 mA step-down DC/DC converters with dynamic voltage management (DVM), two 300 mA linear regulators and a 400 kHz I²C compatible interface to allow a host controller access to the internal control registers of the LP3907-Q1. The LP3907-Q1 additionally features programmable power-on sequencing.

Package options include a tiny 4 mm x 4 mm x 0.8 mm WQFN 24-pin package and an even smaller 2.5 mm x 2.5 mm DSBGA 25-bump package.



Functional block diagram

Key features

- Compatible with advanced application processors and FPGAs
- Two LDOs for powering internal processor functions and I/Os
- High-speed serial interface for independent control of device functions and settings
- Precision internal reference
- Thermal overload protection
- Current overload protection
- 24-lead 4 mm × 4 mm × 0.8 mm WQFN or 25-bump 2.5 mm x 2.5 mm DSBGA package
- Software-programmable regulators
- External power-on reset function for Buck1 and Buck2
- Under-voltage lock out detector to monitor the input supply voltage
- LP3907-Q1 is an automotive-grade product that is AECQ-100 Grade 1 qualified

Applications

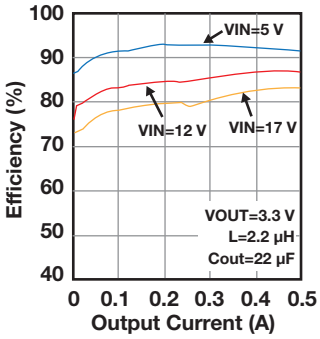
- FPGA, DSP core power
- Application processors
- Peripheral I/O power

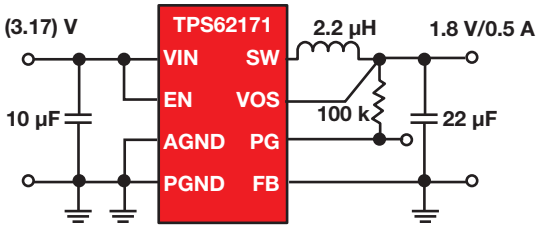
Camera-based systems
TPS62170-Q1

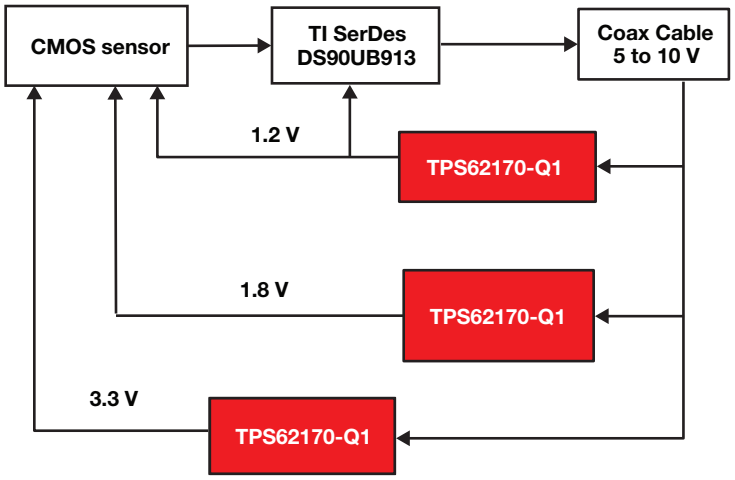
Ultra-small power supply for COAX-powered cameras 0.5 A, step-down converter in 2 x 2 SON package

TPS62170-Q1

The TPS62170-Q1 family includes easy-to-use synchronous step down DC/DC converters optimized for automotive applications with high power density. A high switching frequency of typically 2.25 MHz allows the use of small inductors and provides fast transient response as well as high output voltage accuracy by utilization of the DCS-Control™ topology. With its operating input voltage range of 3 V to 17 V, these devices are ideally suited for coax-powered camera systems.







Key features

- Smallest solution size: only 70 mm^2 including all passives
- DCS-Control™ topology: fast AC line and load transient response
- Small inductor and low ESR capacitors
- 100% duty cycle
- 17 uA typ Iq
- Power good output
- 2 x 2 SON package

Applications

- Ultra-small ADAS camera modules powered over coax
- Infotainment
- Other automotive POL

TI designs

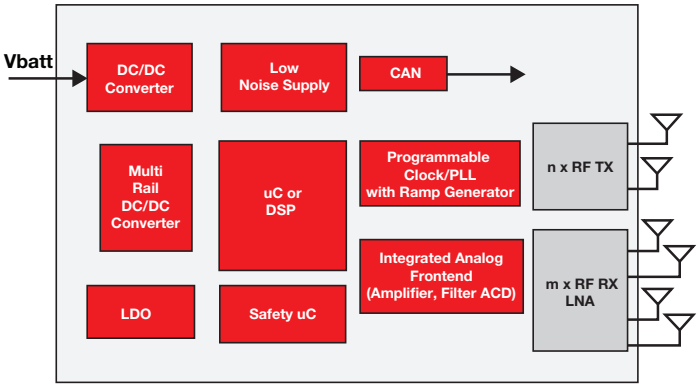
- TIDA-00262: ADAS camera with APTINA sensor
- PMP9758: generic CMOS sensor power supply

Radar-based systems
Overview

Radar systems

As cost decreases, radar systems (to use in blind-spot detection, for example), are being installed in more classes of vehicles. Automotive radar systems can be classified in two sets: long-range radar systems and medium/short-range radar systems.

Long-range radar systems are always mounted in the front of the car and look forward. These systems see distances of more than 100 m and are typically used for adaptive cruise control, brake assistance and collision warning.



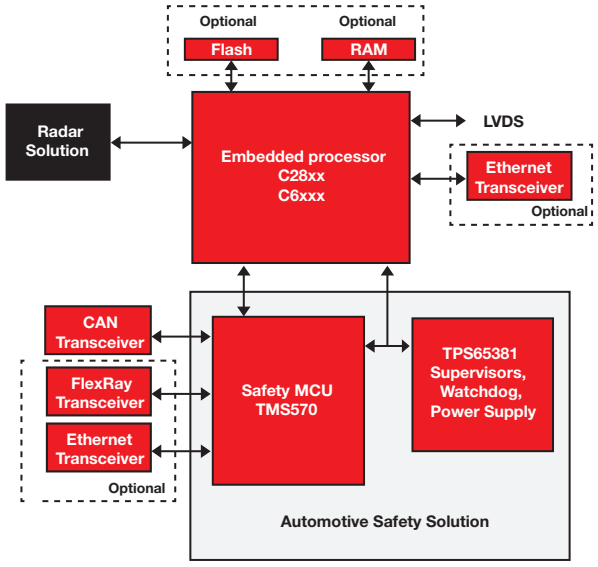
Long-range radar system diagram

Due to their longer vision range, higher resolution, and ability to identify and distinguish multiple objects, long-range radar systems need more processing power on the DSP side, precise signal conditioning and in many cases a safety microcontroller. As applications like adaptive cruise control begin to take control over some functions in the car (such as the accelerator/brakes), they require higher safety levels than pure warning functions like blind-spot detection or side-impact warning.

Driving factors in the development of long-range radar systems include:

- A reduction in system size
- Lower system power dissipation (allowing for smaller packages and less cooling effort)
- Low-noise components and design (for high signal performance)
- Antenna designs that allow more resolution and better object detection/differentiation capabilities
- DSPs to run the complex software algorithms

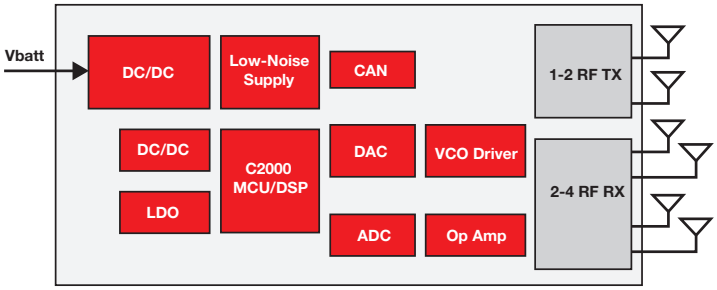
In systems where the radar can impact functions of the car, safety functionality is also important.



Automotive safety system diagram

Radar-based systems
Overview

TI supports radar trends with highly integrated baseband and analog front ends, as well as integrated synthesizers/ ramp pulse generators, high-performance DSPs and safety microcontroller and (low-noise) power-supply solutions. The other group of radar systems is medium-/ short-rangeradar.



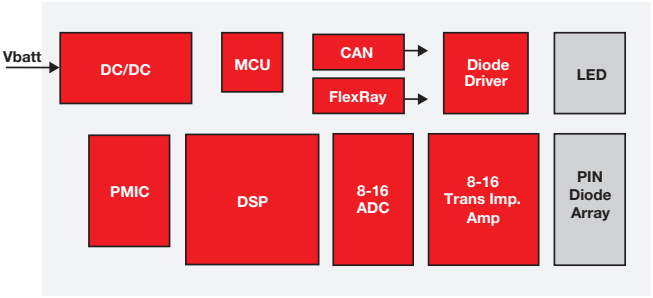
Short-and medium-range radar system diagram

These systems typically include blind-spot detection, side-collision warning, cross-traffic alert and lane-change assistance. The overall performance of these systems is lower compared to their long-range brethren; they are even available in some mid-range cars as standard equipment. Medium-/short-range radar systems are mounted in different locations of the car, depending on their function. Because of their use and functionality, system size and cost are important. The lower performance often allows the use of microcontrollers instead of DSPs.

TI's portfolio offers the right mix of catalog and differentiated ICs to help you be successful and meet your design, space and price targets.

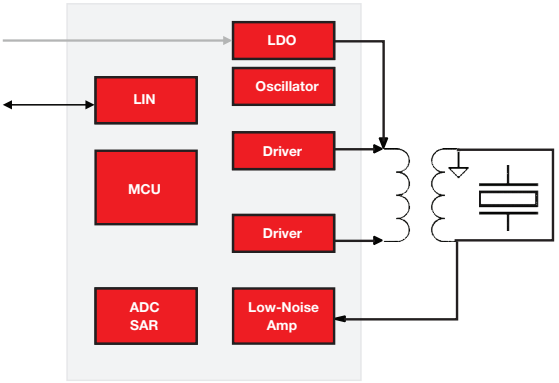
Light detection and range (LIDAR)

LIDAR is used in adaptive cruise control, accident avoidance and mitigation and object detection. It is important for autonomous driving features.



Ultrasonic park assist

Ultrasound is used in park-assist applications and has already reached high maturity and broad market acceptance. System-on-chip is the preferred solution for ultrasound sensors.



Radar-based systems
AFE5401

Baseband analog receive front-end for broadband FMCW radar

AFE5401

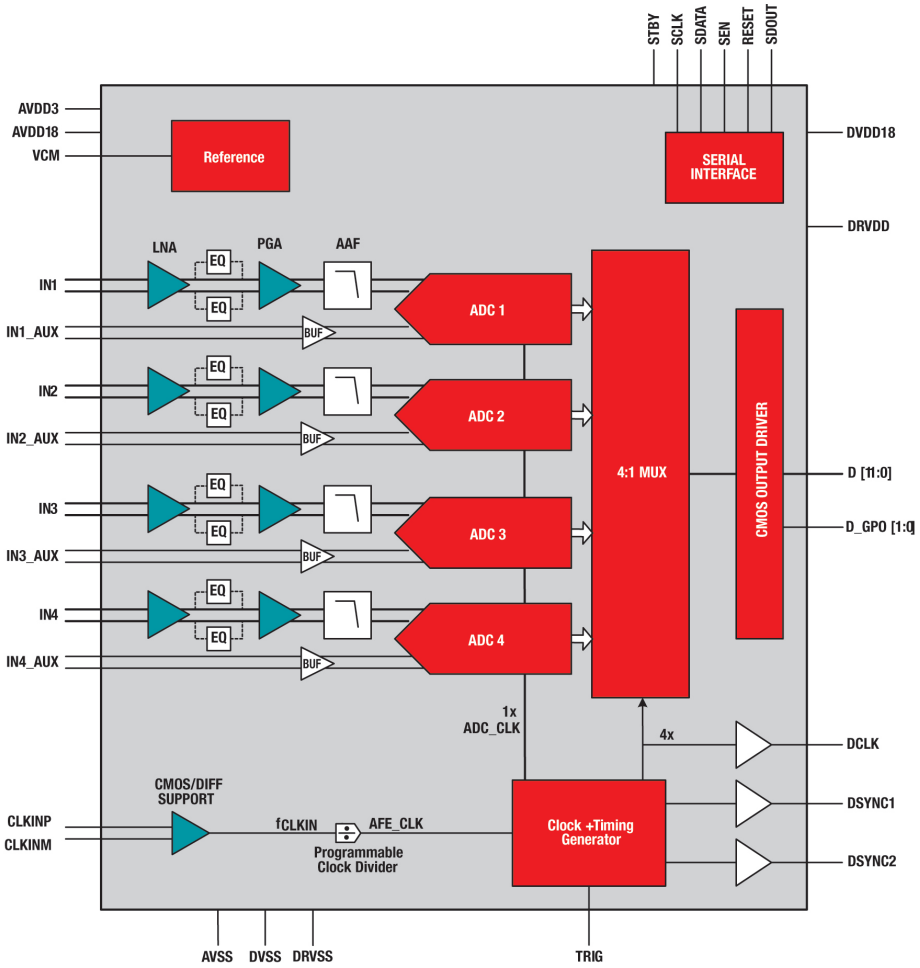
The next generation of frequency-modulated/continuous wave (FMCW) automotive radars will use faster chips that require wider broadband receivers, thus making the AFE5401, with four parallel channels at 25 MSPS, an ideal solution. The simultaneous sampling also benefits digital beamforming architectures, while its very low power enables smaller, more compact solutions.

Each of the four differential input pairs of the AFE5401 is amplified by a low-noise amplifier (LNA) and is followed by a programmable-gain amplifier (PGA) with a range from 0 dB to 30 dB. A third-order antialias low-pass filter is also integrated between the PGA and ADC, together with a bypassable equalizer. The antialias filter drives the on-chip 12-bit, 25-MSPS ADC. The four ADC outputs are multiplexed into a single 12-bit parallel CMOS output bus, which includes auxiliary signals for the seamless interface/control of the video port of a DSP like the TDA2x.

Key features

- Quad LNA, equalizer, PGA, AAF, ADC
- Four auxiliary channels
- Differential input
- 3.5 nV/rtHz input noise at max gain
- LNA: 12 dB, 15 dB, 18 dB settings
- PGA: 0 dB to 30 dB in 3 dB steps
- Integrated optional equalizer
- Third order adjustable elliptic anti alias filter
- Quad 12 bit 25 MSPS ADC
- Power dissipation: 65 mW/channel
- 100 MSPS CMOS parallel output glueless interface to DSP video port
- 64-pin QFN (9 mm^2 x 9 mm^2)
- 1.8-V analog and digital supply
- 3.3-V analog supply

Samples available – release 1Q14



Radar-based systems
TPS65310A-Q1

Power Management unit for advanced driver assistance systems

TPS65310A-Q1

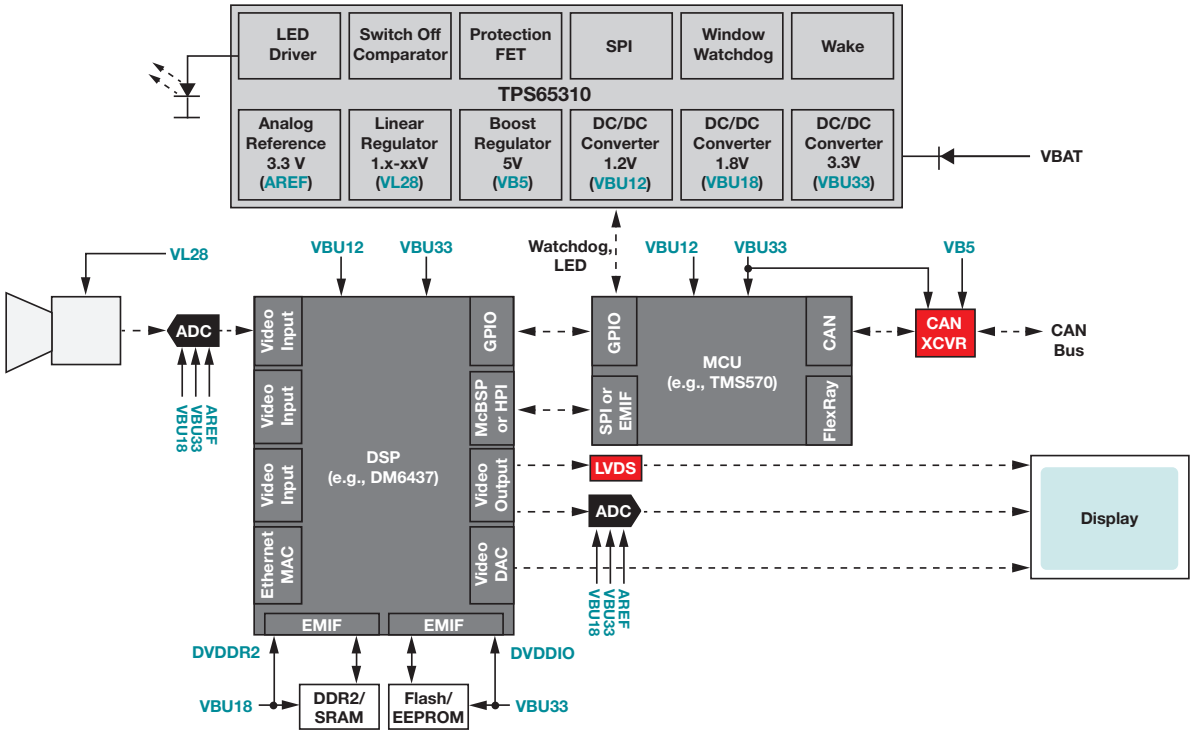
The TPS65310A-Q1 device is a power-management unit, meeting the requirements of DSP-controlled automotive systems like advanced driver assistance systems (ADAS). It is ideally suited for camera- or radar-based vision systems to support features like lane-departure warning, collision avoidance systems, blind-spot detection, park assist and traffic-sign detection.

The device includes one high-voltage buck controller for preregulation, combined with two buck controllers and one boost converter for post regulation. A further integrated low dropout (LDO) rounds up the power-supply concept and offers a flexible system design with five independent voltage rails. The device offers a low-power state (LPM0 with all rails off) to reduce current consumption in case the system is constantly connected to the battery line. All outputs are protected against overload and overtemperature.

The integrated window watchdog and SPI for control and diagnosis enables safety-related applications in ADAS systems. Safety levels up to ASIL-B can be realized using the TPS65310A-Q1.

Key features

- –40°C to 125°C ambient operating temperature
- Device HBM ESD classification level H1B
- Device CDM ESD classification level C3B
- Input voltage range: 4 V to 40 V, transients up to 60 V; 80 V
- Single-output synchronous buck controller
- Peak gate drive current 0.6 A
- 490 kHz fixed switching frequency
- Pseudo-random frequency hopping spread-spectrum or triangular mode
- Dual synchronous buck converter
- Designed for output currents up to 2 A
- Out-of-phase switching
- Switching frequency: 0.98 MHz
- Adjustable 350 mA linear regulator
- Adjustable asynchronous boost converter
- 1 A integrated switch
- Switching frequency: 0.98 MHz
- Soft-start feature for all regulator outputs
- Independent voltage monitoring
- Undervoltage (UV) detection and overvoltage (OV) protection



Functional block diagram

Radar-based systems
TPS65381-Q1

Power-management unit for safety critical advanced driver assistance systems

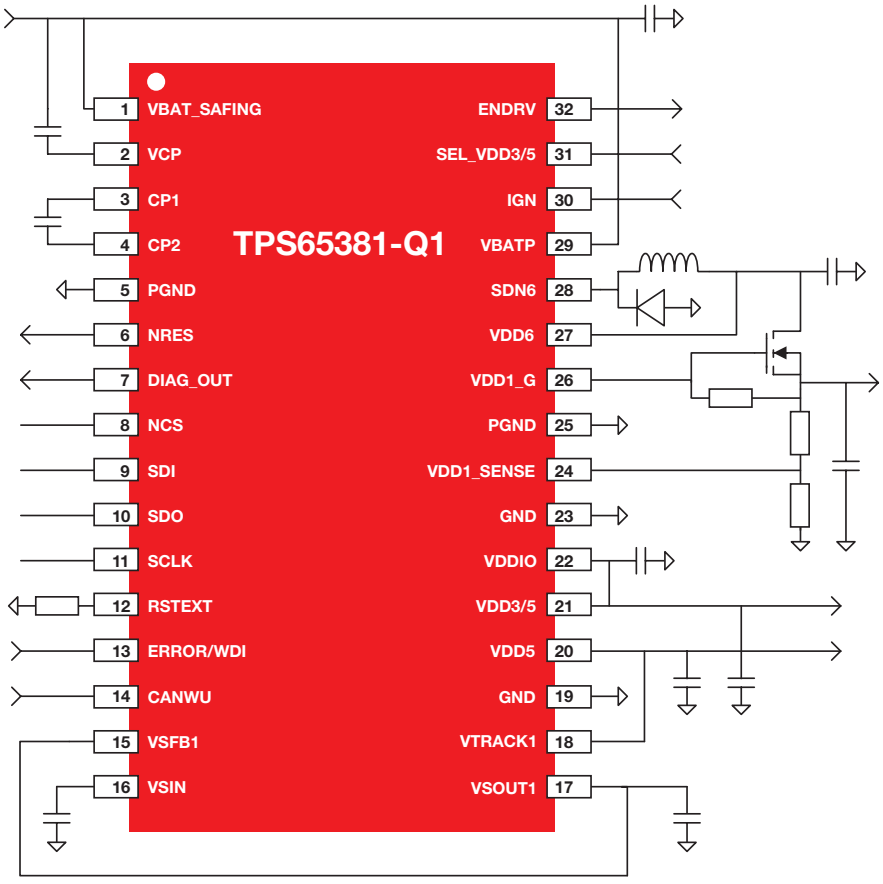
TPS65381-Q1

Today's automotive systems often require ever-higher levels of safety (such as ASIL-D), as well as increased computation power delivered by safety microcontroller units (MCUs). The TPS65381-Q1 provides a high level of integration of all main power rails required by safety MCUs in safety systems. It enables easy implementation and quick verification of functional safety in a small footprint.

The TPS65381-Q1 integrates multiple supply rails to power the MCU, CAN or FlexRay and an external sensor. An asynchronous buck switch-mode power-supply converter with an internal field-effect transistor converts the input battery voltage to a 6 V preregulator output. Furthermore, the device supports wakeup from ignition or from a CAN transceiver.

Key features

- Input voltage range:
  - 5.8 V to 36 V (CAN, I/O, MCU core and sensor supply regulators functional)
  - 4.5 V to 5.8 V (3.3 V I/O and MCU core voltage functional)
  - 6 V asynchronous switch-mode pre-regulator
  - 5 V (CAN) supply voltage
  - 3.3 V or 5 V MCU I/O voltage
  - 0.8 V to 3.3 V adjustable MCU core voltage
- Sensor supply
- Charge pump
- Power supply/system monitoring
- Microcontroller interface
- SPI interface



Radar-based systems
TMS320F2837xD

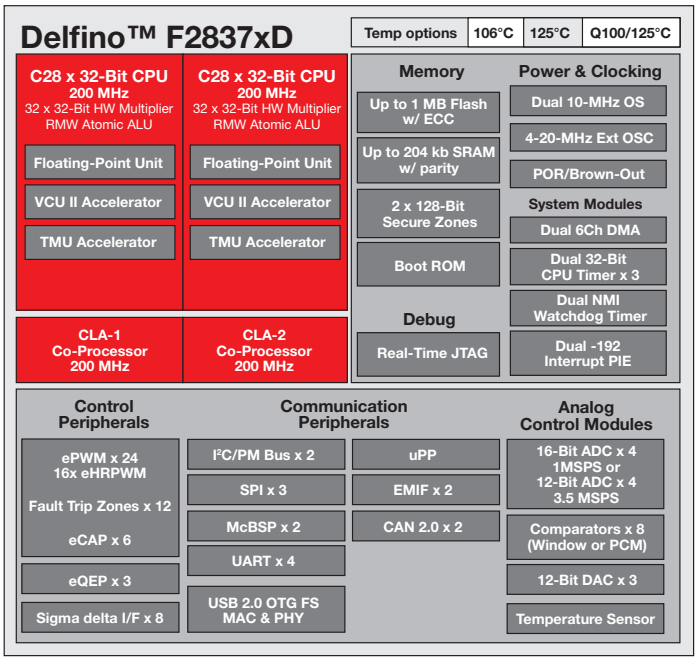
C2000™ real time 32-bit floating point MCU/DSP for advanced driver assistance systems

TMS320F2837xD

The C2000 family of high-performance microcontrollers with integrated analog and control peripherals provide a real-time engine targeted at applications requiring heavy signal processing like advanced driver assistance systems (ADAS). These MCUs provide up to 800 MIPS of DSP performance with available dual C28x CPUs and dual CLA (control law accelerator) co-processors. The integrated trigonometric math unit (TMU) and Viterbi complex unit (VCU) enhance the performance of the C28x CPU by reducing the number of instruction cycles necessary to perform calculations commonly made in ADAS applications. There is also up to 1 MB of integrated Flash memory with ECC in addition to 204 KB of integrated RAM in the device. Two external memory interface (EMIF) ports are available to connect to additional external memory. In additional a universal parallel port (uPP) is available for interfacing with other processors or FPGAs in the system.

There are also a number of integrated peripherals that are optimized for real time control tasks commonly found in ADAS applications. Up to 4 separate 16-bit and 12-bit ADCs with 12 channels each enable fast and precise data acquisition from sensors. Enhanced PWM modules offer sophisticated shadowing, synchronization, edge positioning and trip logic in addition to duty cycle edge placement down to 55 ps time unit increments. 12-bit buffered DACs are also available to provide enhanced control capabilities.

C2000 MCUs also include an array of communication peripherals necessary for communication with board level and module level nodes in the automobile. There are a total of 4 UARTs, 3 SPI , 2 I^2C and 2 CAN modules available. There are also many C28x optimized CAN protocol stacks/drivers commonly used in automotive available including CANopen, SAE J1939 and ISO 15765.



Key features

- –40°C to 125°C ambient operation temperature
- AEC Q100 qualification
- Up to 800 MIPS of performance
- Up to 200 MHz CPU frequency
- IEEE 754 single-precision floating-point unit
- Up to 1 MB of flash memory w/ECC
- Up to 204 KB of RAM w/parity
- Dual 6-channel DMA controller
- 2 CAN ports/2 I^2C ports/3 SPI ports
- 4 UARTs
- 4 16-bit ADCs w/ up to 12 ch each
- 3 12-bit buffered DAC outputs
- 24 PWM channels
- 6 enhanced capture modules
- Dual external memory interfaces
- Universal parallel port

Radar-based systems
Ultrasonic park assist

PGA450-Q1 ultrasonic sensor interface

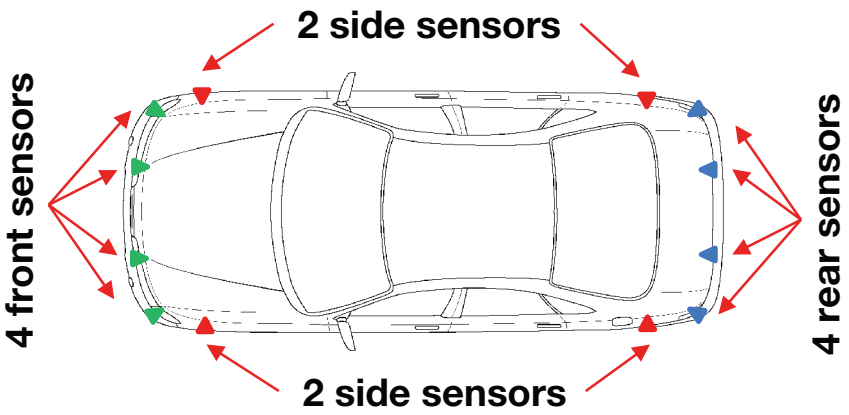
PGA450-Q1

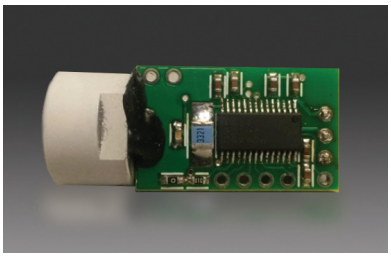
Ultrasonic sensors are mainly used in park assist applications and are now high in volume shipment with broad market acceptance. Typically a car would have eight to twelve of these sensors.

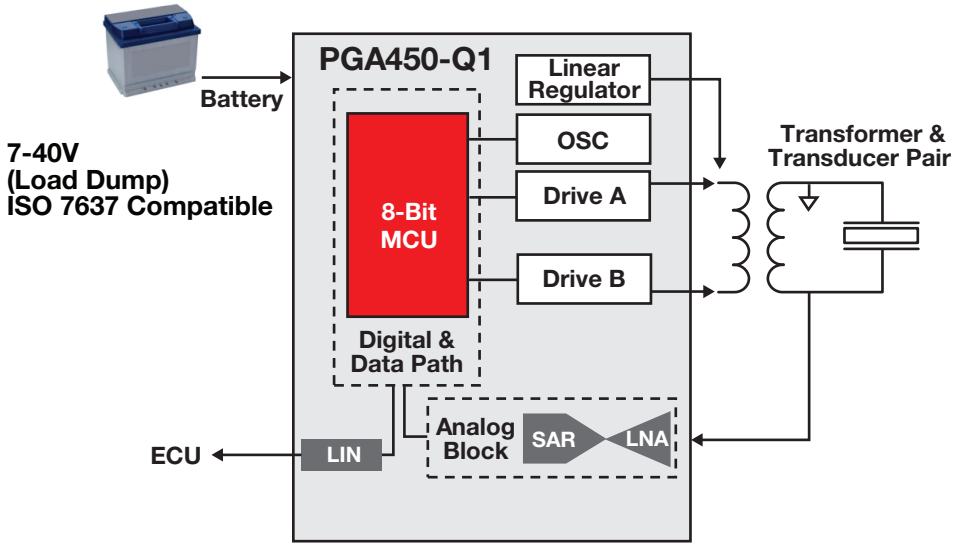
The PGA450-Q1 is a fully integrated interface device for ultrasonic transducers used in these park assist applications. It is designed to be configurable and also customizable for processing the transducer echo signals and for calculating the distance between the transducer and objects. Its MCU and program memory allow for this full configurability for the specific end application. It also has an integrated LIN 2.1 communication protocol to transmit data. The LIN 2.1 physical layer is slave-only and does not implement the LIN wake-up feature. All other LIN 2.1 features can be implemented. This device can measure distances from 10 cm to more than 6 m.

Key features

- Dual NMOS low-side drivers
- Configurable burst generator
- Low-noise amplifier
- 12-bit SAR ADC
- Configurable digital band-pass filter
- Digital signal envelope detect
- On-chip 8-bit microprocessor
- LIN 2.1 physical Interface and protocol
- Watchdog timer
- Four-Wire SPI for testability/programming
- 8 K bytes OTP
- 768 bytes of FIFO RAM
- 256 bytes scratchpad RAM
- 8 K bytes of development RAM
- 32 bytes of EEPROM





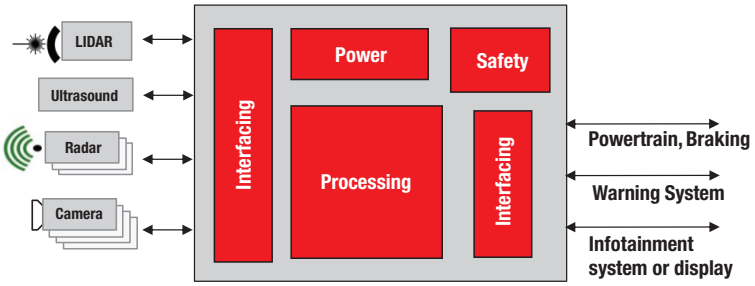


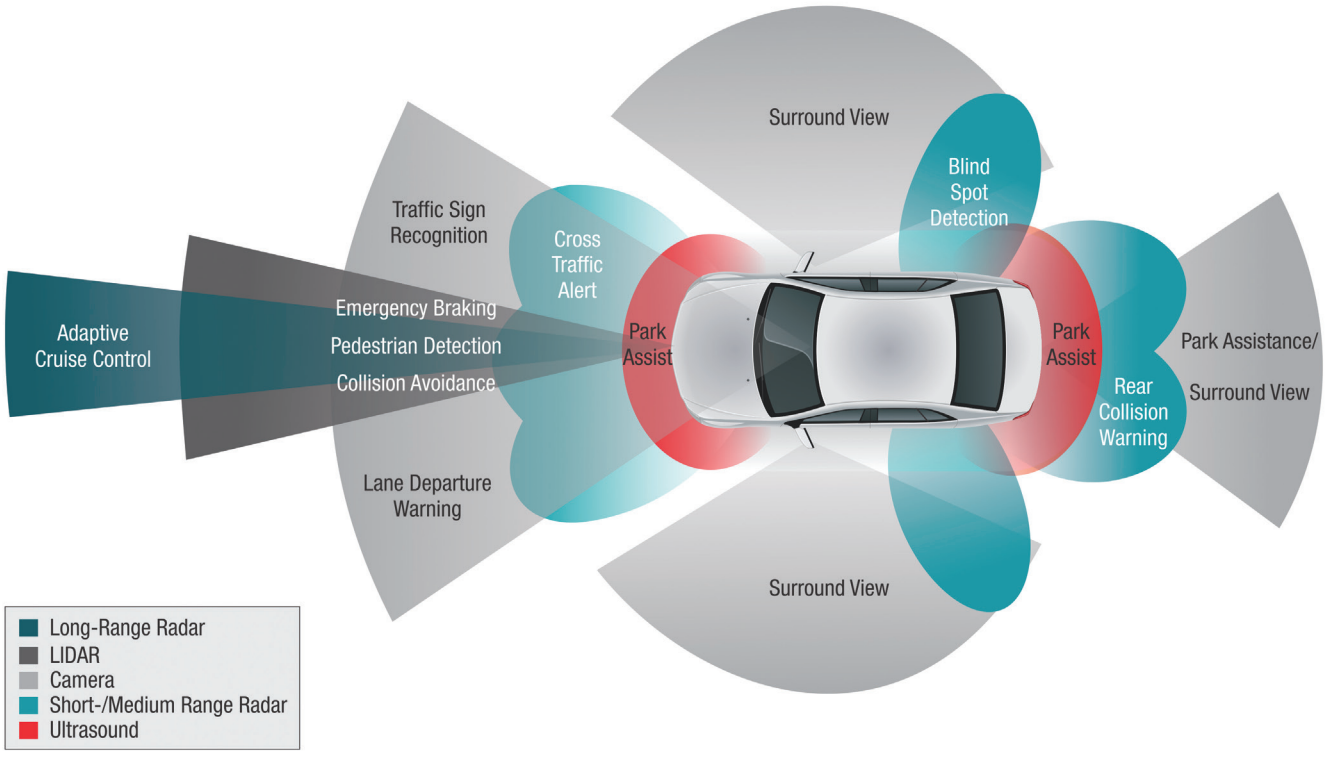
Sensor fusion
Overview

Advanced driver assistance systems (ADAS) are still treated as separate systems, independent from each other. Each system has its own purpose and either displays information or performs an activity (such as a chime) without consideration for any other ADAS systems. Depending on the type of sensor technology (radar, camera, ultrasound, light detection or range), this allows certain functionality, but does not make the best use of the systems.

To build fully autonomous cars, it will be necessary to combine the information and data from different sensors, exploiting their individual advantages and making up for the weaknesses each individual system always has. This is called sensor fusion. Instead of multiple, completely independent systems, the various ADAS systems feed their information into a central sensor fusion engine control unit (ECU) that can combine all of the information to provide better situational awareness. Depending on the system partitioning chosen, either raw data (e.g., uncompressed video) or preprocessed data (e.g., object data from the radar) is provided to the fusion ECU. This has a big impact on the processing power demands of the fusion ECU, as well as the power-supply needs and type of communication interfaces to the subsystems (the individual ADAS modules supplying the sensor data).

Most systems developed today have a mix of centralized and decentralized data processing. Due to the high impact a fusion ECU has on the safety of a car and its passengers, a fusion ECU should have ASIL certification. This has an impact not only on the ECU and system design, but also on IC selection.





Hercules™ safety MCUs
Overview

Hercules microcontrollers are based on TI's 20+ years of safety-critical system expertise, industry collaboration and proven hardware for the automotive market. The platform consists of two ARM® Cortex®-based microcontroller families (RM and TMS570) that deliver scalable performance, connectivity, memory and safety features. Unlike many microcontrollers that rely heavily on software for safety capabilities, Hercules microcontrollers implement safety in hardware to maximize performance and reduce software overhead.

The Hercules RM family provides the highest level of performance for broad safety applications, including medical and industrial, and are developed to the IEC 61508 SIL-3 safety standard. The Hercules TMS570 family provides high performance for transportation applications and is well suited for applications that need to meet IEC 61508 SIL-3 or ISO 26262 ASIL-D requirements.

The RM and TMS570 dual-CPU lockstep architectures simplify development while eliminating redundant system requirements to reduce cost. CPU hardware built-in self test (BIST) detects latent defects without complex safety software and code-size overhead. Hardware comparison of CPU outputs provides nearly instant safety response time without any additional performance impact. ECC logic is integrated in the CPU to protect both memories and busses. All RAM memories can be tested using HW BIST for high diagnostic coverage and an integrated memory protection unit (MPU) helps protect against deterministic errors in application software.

Hercules MCUs are also an integral part of many SafeTI™ functional safety design packages (**www.ti.com/safeti**). SafeTI design packages help enable compliance with safety standards by including functional safety-enabled semiconductor components, safety documents, tools and software, complementary embedded processing and analog components, quality manufacturing process and a safety development process.

Hercules safety support and certification

SafeTI and companion ICs

SafeTI design packages for functional safety provide standards specific solution bundles:

- SafeTI-61508
- SafeTI-26262
- SafeTI-60730
- SafeTI-QM

www.ti.com/safeti

Functional safety is made easy with Hercules

Safety documentation

Documents provided by TI assist in the safety certification process:

- *Component Safety Manual (SM)*
  Product safety architecture and recommended usage
- *Safety Analysis Report (SAR)*
  FIT rate and device FMEDA
- *Safety Report*
  Summary of compliance to IEC 61508 and/or ISO 26262

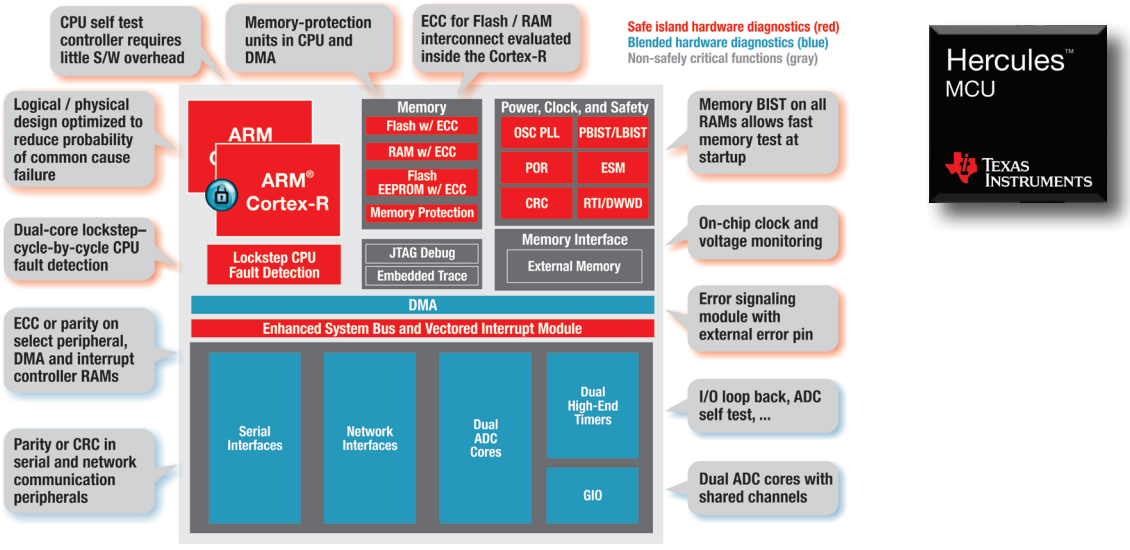
Safety certification

Hardware development process and component certification:

- TÜV-SÜD certification for functional safety development process
  - SafeTI-61508
  - SafeTI-26262
- Device safety assessment and certificates
  - Exida

Hercules safeTI tools and software

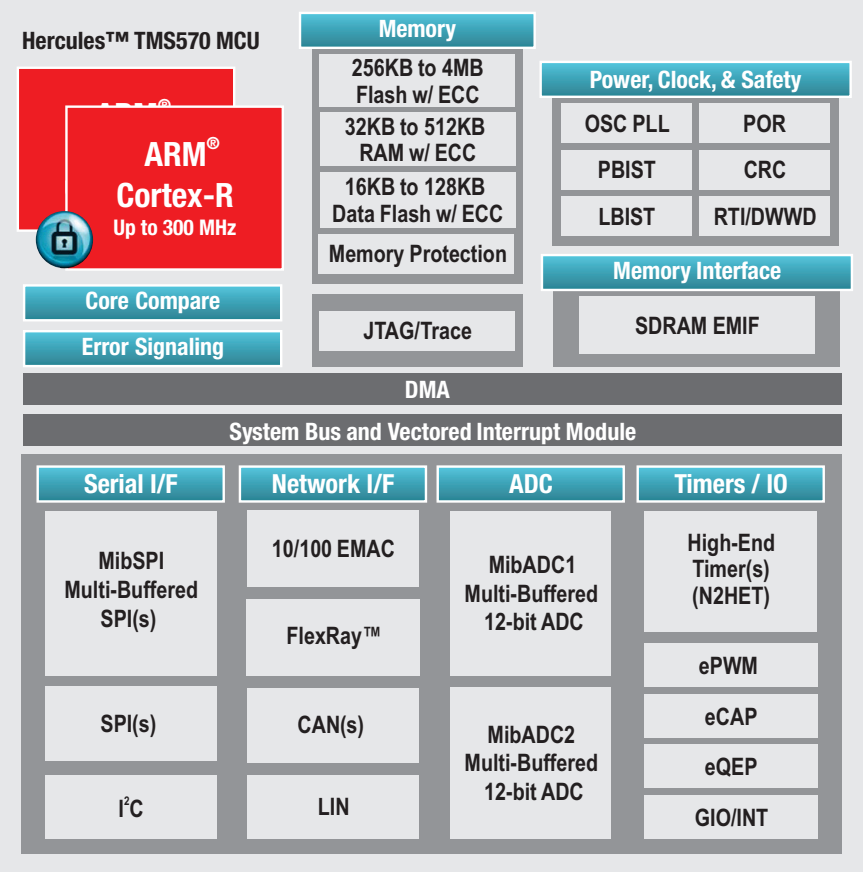
- SafeTI Compiler Qualification Kit
- SafeTI Diagnostic Library



Hercules™ safety MCUs
TMS570LS

Hercules™ TMS570LS safety MCU
TMS570LS

The Hercules TMS570 microcontroller family enables customers to easily develop safety-critical products for transportation applications. Developed to the requirements of the ISO 26262 ASIL-D and IEC 61508 SIL-3 safety standards and qualified to the AEC-Q100 automotive specification this ARM® Cortex®-R-based family offers several options of performance, memory and connectivity. This family includes options with Cortex-R4 and Cortex-R5 CPUs. Dual-core lockstep CPU architecture, hardware BIST, MPU, ECC and on-chip clock and voltage monitoring are some of the key functional safety features available to meet the needs of automotive, railway and aerospace applications.



Packages: 100 QFP (14 × 14), 144 QFP (20 × 20), 337 nfBGA (16 mm × 16 mm, 0.8 mm)

Key features

- ARM Cortex-R CPU in lockstep (fixed- and floating-point options)
- From 80 MHz up to 300 MHz
- Integrated safety features simplify SIL-3/ASIL D applications
- From 256 KB up to 4 MB flash with ECC
- From 32 KB up to 512 KB RAM with ECC
- Memory protection units in CPU and DMA
- Multiple communication peripherals:
  - Ethernet, FlexRay™, CAN, LIN, SPI
- Motor control and programmable timer interfaces
- 12-bit analog/digital converter
- External memory interface

Targeted transportation applications

- Braking systems (ABS and ESC)
- Electric power steering (EPS)
- HEV/EV inverter systems
- Battery management systems
- Active driver assistance systems
- Aerospace and avionics control systems
- Railway control, communications and signaling
- Off-road vehicles

Hercules™ safety MCUs

Hercules™ evaluation and development kits

Quick-start

Hercules LaunchPad

LAUNCHXL-RM42 – RM42 LaunchPad

Hercules LaunchPad features:

- USB powered
- On-board USB XDS100v2 JTAG debug
- On-board SCI-to-PC serial communication
- 40-pin BoosterPack XL header for add-on BoosterPacks

LAUNCHXL-TMS57004 – TMS570 LaunchPad

- Footprint for an additional expansion header (not populated)
- LEDs and light sensor
- Available CCStudio IDE, HALCoGen and code examples for download

Evaluation

Low-cost USB stick evaluation/development kits

TMDXRM48USB – RM48 USB stick kit

USB stick kit features:

- USB powered
- On-board USB XDS100v2 JTAG debug
- On-board SCI-to-PC serial communication
- Access to select signal pin test points

TMDX570LS31USB – TMS570 USB stick kit

- LEDs, temp sensor and light sensor
- CAN transceiver
- Includes code composer studio™ (CCStudio) IDE, HALCoGen and code examples

Development

Hercules development kits

TMDX570LS31HDK – TMS570LS31x/21x development kit
TMDX570LS12HDK – TMS570LS12x/11x development kit
TMDX570LS04HDK – TMS570LS04x/03x development kit
TMDX570LC43HDK – TMS570LC43x development kit

TMDXRM48HDK – RM48 development kit
TMDXRM46HDK – RM46 development kit
TMDXRM42HDK – RM42 development kit
TMDXRM57LHDK – RM57 development kit

Hercules development kit features:

- On-board USB XDS100v2 JTAG debug
- On-board SCI-to-PC serial communication
- External JTAG and 32-bit ETM trace (RM48 and TMS570LS31)
- Access to signal pin test points
- LEDs, temp sensor and light sensor

- 2 CAN transceivers
- RJ-45 10/100 Ethernet interface (RM48/RM46 and TMS570LS31/12)
- USB-A host and USB-B device interfaces (RM48)
- Includes CCStudio IDE, HALCoGen, and code examples

SafeTI evaluation eits

SafeTI™ Hitex safety kits

SAFETI-HSK-RM48 – RM48 SafeTI Hitex safety kit

SafeTI Hitex safety kit features:

- Cost-effective platform to ease evaluation of SafeTI components – Hercules MCU and TPS65381 PMIC for use in safety-critical applications requiring compliance to functional safety standards such as ISO 26262 and IEC 61508
- Accelerometer, temperature sensor, CAN transceiver and LCD module

SAFETI-HSK-570LS31 – TMS570 SafeTI Hitex safety kit

- Software and host GUI with capabilities for hardware fault injection, application and run-time profiling of fault diagnostics, and system response monitoring in real-time
- On-board USB XDS100v2 JTAG debug
- Includes CCStudio IDE, HALCoGen, SafeTI diagnostic library and evaluation version of SAFERTOS®

Hercules safety MCUs

Hercules™ tools and software

Development tools

Integrated development environment

Compilers and debuggers:

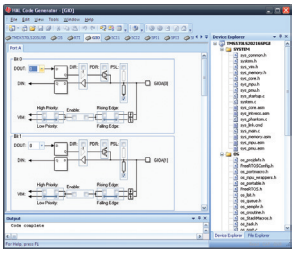
- TI Code Composer Studio™ (CCStudio) IDE
- Green Hills MULTI®
- IAR Workbench®
- ARM® DS-5
- iSystem winIDEA
- Lauterbach

IAR SYSTEMS

Green Hills SOFTWARE, INC.

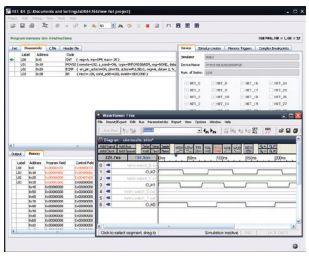
ARM DS Development Tools

GUI-based code generation tools



HALCoGen:

- GUI to configure peripherals, interrupts, clocks and other µC parameters
- Generates device init and peripheral drivers
- Import into CCStudio, IAR and ARM DS-5

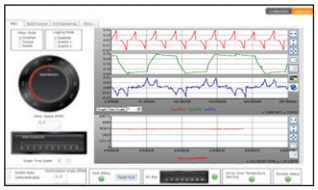


HET IDE

- Graphical programming environment
- Output simulation tool
- Generates CCStudio IDE-ready software
- Includes functional examples from TI

Development software

TI MotorWare™ software for Hercules



- Sensorless InstaSPIN™-BLDC
- Speed and torque control loops
- TI MotorWare and HALCoGen conventions
- Leverages ARM® CMSIS Math Library
- Source code CCStudio IDE projects
- Field oriented/vector control (FOC)
- Encoder sensor driver example
- Sliding mode observer (SMO) based "virtual encoder"
- Comparison of encoder and SMO derived angles
- Included in Hercules motor control kits

Safety-certifiable RTOS and AUTOSAR

Real-time operating system support:

- SAFERTOS®: High Integrity Systems
- µC/OS II/III™: Micrium
- SCIOPTA RTOS: SCIOPTA
- Mentor Graphics: Nucleus
- MicroDigital: SMXRTOS

WITTENSTEIN

Micro Digital

Micrium

Mentor Graphics

SCIOPTA

AUTOSAR RTE and MCAL support:

- Vector MICROSAR Safe
- Safe AUTOSAR from TTTech/Vector
- AUTOSAR: ElektroBit tresos
- MCAL from TI

vector

TTTech

AUTOSAR

Selection tables

Operational amplifiers/thermal management/data converters

Operational amplifiers

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
Operational amplifiers						
LMH6551Q-Q1	High-performance voltage feedback differential amplifier	370-MHz to 3-dB bandwidth (V_{OUT} = 0.5 V_{PP}), 50-MHz 0.1 dB bandwidth, 2,400 V/µs slew rate; 18-ns settling Time to 0.05%, –94/–96 dB HD2/HD3 at 5 MHz	x	—	—	—
OPA356-Q1	2.5-V, 200-MHz GBW, CMOS single	200-MHz wide bandwidth, high speed, CMOS inputs, rail-to-rail output, designed for video processing applications (i.e., ADAS camera systems)	x	—	x	—
THS4121	High-speed fully differential I/O amplifier	3.3 V, 100 MHz, 43 V/us, fully differential CMOS amplifier	—	x	x	x
THS4541	High-speed low-power, voltage-feed-back, fully differential amplifier (FDA) architecture	Negative rail input, rail-to-rail output, precision, 850-MHz fully differential amplifier	—	x	x	x
OPA2836	High-speed dual, very low power, rail to rail out, negative rail in, VFB op amp	Very low power, Iq: 1 mA/ch, power-down: < 1 uA, +2.5 V to +5 V single supply, bandwidth: 205 MHz, slew rate: 560 V/µs, HD2: –120 dBc and HD3: –130 dBc at 100 kHz	—	x	x	x
TLV274-Q1	550-µA/ch 3-MHz rail-to-rail output opertional amplifier	3-MHz bandwidth, 2.7-V to 16-V supply-voltage range, rail-to-rail output, CMOS inputs that enable use in high-impedance sensor interfaces, low power to enable battery-powered operation	x	—	—	—
TLC084-Q1	Wide-bandwidth high-output-drive single-supply operational amplifiers	10-MHz bandwidth, 4.5-V to 16-V supply-voltage range, 1.9-mA low-supply current per channel and low-input noise voltage	—	—	x	—
TLC2274A-Q1	Q1 advanced LinCMOS rail-to-rail operational amplifier	2.2-MHz bandwidth, 4.4-V to 16-V supply-voltage range, rail-to-rail output, high-input impedance and low power dissipation	—	—	x	—
OPA2354A-Q1	250-MHz, rail-to-rail I/O, CMOS Dual operational amplifier	250-MHz wide bandwidth (per channel), high speed, CMOS inputs, rail-to-rail output, designed for video processing applications (i.e., ADAS camera systems)	x	—	x	—
Amplifiers for analog video drivers						
LMH6601Q	High-speed	DG: 0.06%, DP: 0.1 deg	x	—	—	—
LMH664xQ	High-speed, low-power RRO op amp	DG: 0.16%, DP: 0.05 deg	x	—	—	—
LMH6619Q	High-speed, low-noise RRIO op amp	DG: 0.1%, DP: 0.1 deg	x	—	—	—

Thermal management

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
TMP300-Q1	1.8-V, resistor-programmable temperature switch and analog-out temperature sensor	Digital temp switch with open drain output, resistor-programmable, 1.8-V to 18-V supply-voltage range, low power	—	—	x	x

Data converters

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
DAC						
DAC5311-Q1	8-bit, low-power, single-channel DAC	8-bit, single-channel DAC, MicroPower operation, 1.8-V to 5.5-V supply range, serial SPI interface, 6-µs settling time, ±0.25 LSB INL, 80 µA at 1.8 V, –40°C to +85°C	—	—	x	—
DAC7551-Q1	12-bit, ultra-low glitch, single-channel voltage-output DAC	2.7-V to 5.5-V operation, ±0.3 5LSB INL, 0.1-nV-s glitch, 100 µA at 2.7 V, –40°C to +105°C, SPI digital interface, small form factor and low power operation, 5-µs settling time	—	—	x	—
DAC8562/63-Q1	16-bit, ultra-low glitch, dual-channel DAC with internal reference	2.7-V to 5.5-V operation, ±0.4 LSB INL, 0.1-nV-s glitch, 4 ppm/°C internal reference, –40°C to +125°C	—	—	x	—
DAC8162/63-Q1	16-/14-/12-bit, ultra-low glitch, dual-channel DAC with internal reference	16-/14-/12-bit, dual-channel DAC, 4ppm/°C internal reference, 2.7 V to 5.5 V operation, serial SPI interface, 7 µs settling time, ±4 LSB INL (16-bit), 0.1 nV-s glitch, 0.73 mA at 2.7 V, -40°C to +125°C	—	—	—	—
DAC7562/63-Q1	16-/14-/12-bit, ultra-low glitch, dual-channel DAC with internal reference	16-/14-/12-bit, dual-channel DAC, 4ppm/°C internal reference, 2.7 V to 5.5 V operation, serial SPI interface, 7 µs settling time, ±4 LSB INL (16-bit), 0.1 nV-s glitch, 0.73 mA at 2.7 V, –40°C to +125°C	—	—	—	—
ADC						
ADS5204-Q1	Dual 10-bit 40-MSPS low-power ADC with PGA	10-bit dual-channel pipeline ADC with on-chip programmable gain amp, up to 40-MSPS sampling, 3.3-V single-supply operation, low power	—	—	x	—
ADS7955-Q1	10-bit, 1-MSPS, 8-channel, single-ended, MicroPower, sr i/f, SAR ADC	10-bit, 8-channel SAR ADC, 2.7-V to 5.25-V supply range, 1-MSPS sampling with serial SPI interface, 0.5-LSB INL	—	—	x	—
ADC3422	Quad-channel, 12-bit, 25-MSPS to 125-MSPS, analog-to-digital converter	Quad-channel, 12-bit, 25-MSPS to 125-MSPS, flexible input clock buffer with divide-by 1, 2, 4; SNR = 70.2 dBFS, SFDR = 87 dBc; ultra-low power consumption: – 98 mW/ch at 125 MSPS; channel Isolation: 105 dB	—	x	x	—

*Preview Devices are listed in **bold teal.***

Selection tables

Interface/standard logic/DDR terminators/sequencers

Interface

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
TPD2E001-Q1	USB 2.0, Ethernet, LVDS ESD protection	2 ch, 8/15 kV (contact/air), 1.5 pF, SOT-533	x	x	x	x
TPD4E001-Q1	USB 2.0, Ethernet, SD card, LVDS ESD protection	4 ch, 8/15 kV (contact/air), 1.5 pF, SOT-23	x	x	x	x
TPD4E05U06-Q1	USB 3.0, HDMI 1.4, cap touch, Ethernet, LVDS, ESD protection	4 ch, 12/15 kV (contact/air), 0.5 pF, USON	x	x	x	x

Standard logic

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
IPD						
TPD2E001-Q1	USB 2.0, Ethernet, LVDS ESD protection	2 ch, 8/15 kV (contact/air), 1.5 pF, SOT-533	x	x	x	x
TPD4E001-Q1	USB 2.0, Ethernet, SD Card, LVDS ESD protection	4 ch, 8/15 kV (contact/air), 1.5 pF, SOT-23	x	x	x	x
TPD4E05U06-Q1	USB 3.0, HDMI 1.4, cap touch, Ethernet, LVDS, ESD protection	4 ch, 12/15 kV (contact/air), 0.5 pF, USON	x	x	x	x
Logic						
SN74AHC244-Q1	Octal buffers/drivers with 3-state outputs	8-bit buffer, 2-V to 5.5-V supply voltage, 40-µA max Iq	x	—	—	x
SN74LVC125A-Q1	Quadruple bus buffer gate with 3-state outputs	4-bit buffer, 1.65-V to 3.6-V supply voltage, 10-µA max Iq, 4.8-ns max Tpd	x	—	—	x
SN74LVC1G3157-Q1	Single-pole, double-throw analog switch	Single-pole, double-throw switch, 1.65-V to 5.5-V supply voltage, 50-Ω Rdson	x	—	—	—
TS5A23157-Q1	Dual single-pole, double-throw analog switch	Dual single-pole, double-throw switch, 1.65-V to 5.5-V supply voltage, 15-Ω Rdson	x	—	—	—
SN74AHC1G32-Q1	Single two-input positive-OR gate	Single two-input OR gate, 2-V to 5.5-V supply voltage, 10-µA max Iq, 7.5-ns max Tpd	x	—	—	x
SN74AHC1G86-Q1	Single exclusive-OR gate	Single two-input XOR gate, 2-V to 5.5-V supply voltage, 10-µA max Iq, 10-ns Max Tpd	x	—	x	x
SN74LVC1G66-Q1	Single-pole, single-throw analog switch	Single-pole, single-throw switch, 1.65 V to 5.5 V supply voltage, 35 Ω Rdson	x	—	x	x

DDR terminators

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
LP2998-Q1	DDR termination LDO	V_{IN} range 1.35 V to 5.5 V; I_{OUT} up to 1.5 A; DDR1, 2 and 3 memories	x	x	x	x
TPS51200-Q1	DDR termination LDO	V_{IN} range 1.1 V to 3.5 V; I_{OUT} up to 3A; DDR1, 2, 3, LV3 and LP3 memories	x	x	x	x

Sequencers

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
LM3880-Q1	Power sequencer for both power up and down	V_{IN} range 2.7 V to 5.5 V; many timing options available, 6 released; 1 enable input, 3 open drain sequence outputs	x	x	x	x

Selection tables
Power management

Power management

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
DC/DC converters and regulators						
TPS62090-Q1	3-A synchronous step-down converter with DCS control	6 V_{IN}, 97% efficiency, 3 mm x 3 mm QFN	x	—	x	x
TPS62065-Q1	2-A synchronous step-down converter	6 V_{IN}, 3 MHz, 2 x 2 SON package, smallest total solution size	x	—	x	x
LM25011AQ	42-V, 2-A constant on-time buck converter with adjustable current limit	6-V to 42-V input voltage range current-limit-adjustable to 2 A switching frequency adjustable to 2 MHz, no loop compensation required	x	x	x	x
LM26420	Dual 2-A, high-frequency synchronous step-down DC/DC regulator	2.2-MHz switching-frequency option (LM26420X)	x	—	x	x
LM2830	High-frequency 1-A step-down DC/DC regulator	3-MHz switching-frequency option (LM2830Z)	x	—	x	x
TPS54618-Q1	2.95 V to 6 V input, 3 A synchronous buck converter in 3 mm x 3 mm QFN package	0.8-V reference with 1% accuracy, 200 kHz to 2 MHz switching frequency, frequency synchronization, PG, EN	x	x	x	x
TPS54040-Q1	3.5 V to 42 V input, 0.5 A buck converter in 10 MSOP or 3 mm x 3 mm SON Packages	0.8-V reference with 1% accuracy, 100 kHz to 2.5 MHz switching frequency, frequency synchronization, PG, EN	x	—	—	—
LM34919BQ	Ultra-small 40-V, 600-mA constant on-time buck-switching regulator	Enables "off-battery" application via wide-input voltage range (6 V to 40 V), ideal for small camera modules, 2 mm x 2 mm footprint (uSMD package), up to 2.6-MHz switching frequency to minimize interference, no loop compensation required	x	—	—	—
TPS55340	Integrated 5-A MOSFET, wide-input range boost/flyback/SEPIC converter in 14 HTSSOP or 16 QFN packages	2.9 V to 32 V input voltage, frequency adjustable from 100 kHz to 1.2 MHz, frequency synchronization, 2.7 uA shutdown current, V_{OUT} adjustable to 38 V, PG, EN	x	—	—	x
LM5060-Q1	High-side protection controller with low quiescent current	Input voltage range: 5.5 V to +65 V; less than 15-µA quiescent current in disabled mode; 10-lead VSSOP	x	x	x	x
LM5117Q	65-synchronous buck controller with current monitor	Wide V_{IN} range: 5.5 V to 65 V (LM5117), 4.5 V to 42 V (LM25117), current monitoring output (I_{OUT}), low 15-µA shutdown mode quiescent current	x	x	x	
TPS62260-Q1	Step down buck converter	6 V_{IN}, 600 mA, 2.25 MHz, 2x 2 SON package	x	—	—	x
TPS62130A-Q1	Step down buck converter	17 V_{IN}, 3 A, 2.25 MHz, 3 x 3 QFN package	x	—	—	—
TPS62150A-Q1	Step down buck converter	17 V_{IN}, 1 A, 2.25 MHz, 3 x 3 QFN package	x	—	—	—
TPS62160-Q1	Step down buck converter	17 V_{IN}, 1 A, synchronous, 2 x 2 SON package	—	—	—	—
TPS62170-Q1	Step down buck converter	17 V_{IN}, 0.5 A, synchronous, 2 x 2 SON package	—	—	—	—
LP3907	Dual high-current step-down DC/DC and dual linear regulator with I^2C-compatible interface	Two 1-A/600-mA step-down DC/DC converters with dynamic voltage management (DVM), two 300-mA linear regulators, 2.1-MHz PWM switching frequency	x	x	x	x
LP8728	Quad high-current step-down synchronous DC/DC	Two 1-A synchronous step-down, two 600-mA synchronous step-down, 3.3-MHz switching frequency, spread spectrum for EMI reduction	x	x	x	x
TPS54618-Q1	2.95-V to 6-V input, 6-A synchronous buck SWIFT™ converter, integrated 12-mΩ HS and LS MOSFETs	0.8-V reference with 1% accuracy , frequency-adjustable up to 2 MHz, 3 mm x 3 mm 16-pin QFN package	—	—	x	x
TPS54061-Q1	Fully synchronous automotive AEC-Q100 grade 1-qualified, wide V_{IN} DC/DC converter, 200 mA	60 V_{IN}, 200 mA, synchronous DC/DC converter in small VSON-8 DRB 3 mm x 3 mm package, 50 MHz to 1.1 MHz switching frequency, 90 µA	x	x	x	—
TPS54240-Q1	4.5 V to 42 V, 2.5-A automotive DC/DC converter, peak current-mode control with Eco-mode™ control scheme, small SON 3 mm x 3 mm package	Integrated 200-mΩ high-side MOSFET, 100-kHz to 2.5-MHz switching frequency	x	—	x	—
TPS5434/60-Q1	4.5-V to 42-V/60, 3.5-A automotive DC/DC converter, peak CMC with Eco-mode™ control scheme in 5 mm x 6 mm thermally enhanced SOIC package	100-kHz to 2.5-MHz switching frequency, integrated boot recharge MOSFET for low V_{IN} dropout regulation	x	x	x	x
TPS5434/60-Q1	4.5-V to 42-V/60, 3.5-A automotive DC/DC converter, peak CMC with Eco-mode™ control scheme in 5 mm x 6 mm thermally enhanced SOIC package	100-kHz to 2.5-MHz switching frequency, integrated boot recharge MOSFET for low V_{IN} dropout regulation	x	x	x	x
TPS5454/60-Q1	4.5-V to 42-V/60, 5.0-A automotive DC/DC converter, peak CMC with Eco-mode™ control scheme in 5 mm x 6 mm thermally enhanced SOIC package	100-kHz to 2.5-MHz switching frequency, integrated boot recharge MOSFET for low V_{IN} dropout regulation	x	x	—	x
TPS55540-Q1	Integrated 5-A MOSFET, wide-input range boost/flyback/SEPIC converter in 14 HTSSOP or 16 QFN packages	2.9 V to 32 V input voltage, frequency adjustable from 100 kHz to 1.2 MHz, frequency synchronization, 2.7 uA shutdown current, V_{OUT} adjustable to 38 V, PG, EN	x	—	—	x

*New Devices are listed in **bold red.** Preview Devices are in **bold teal.***

Selection tables
Power management

Power management (continued)

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
Power supply						
TPS43340-Q1	Automotive catalog low Iq 30 µA, high V_{IN} quad-output power supply	Dual-buck regulator controller, single-buck regulator converter and single LDO	x	—	x	x
TPS65023-Q1	Six-channel power management IC with three DC/DCs, three LDOs, I^2C interface and DVS	Three DC/DC converters with 1.5-A, 1.2-A and 1-A current limits, 2x 200-mA LDOs, I^2C interface	x	—	—	x
TPS65320-Q1	40 V step-down converter with EcoMode™ and LDO regulator	40 V, 3.2 A, 2 MHz buck converter and 280 mA LDO	x	—	—	x
TPS4335x-Q1	Dual 150 kHz to 600 kHz buck controllers with spread-spectrum functionality on the TPS43351-Q1	Dual 150 kHz to 600 kHz buck controllers with spread-spectrum functionality on the TPS43351-Q1	x	—	—	x
TPS51220A-Q1	Fixed-frequency, 99% duty cycle peak current-mode power controller	Dual synchronous buck regulator controller, dual LDOs, 99% duty cycle, 200-kHz to 1-MHz switching frequency	x	—	—	—
TPS659039-Q1	Power management IC (PMIC) for ARM Cortex A15 processors	Power management IC with seven buck converters, six LDOs, diagnostics, and power sequencing	x	x	—	x
TPS62402-Q1	2.25-MHz 400-mA + 600-MHz Dual step-down converter	2.5-V to 6-V input dual synchronous step-down converter, up to 95% efficiency	x	—	x	x
TPS65310A-Q1	High-voltage power-management IC for automotive safety applications	Single 490-kHz DC/DC controller, dual 0.98-MHz DC/DC buck converter, single adjustable 350-mA linear regulator	x	x	x	x
TPS65311-Q1	High-voltage power-management IC for automotive safety applications	Single 490-kHz DC/DC controller, dual 2.45-MHz DC/DC buck converter, single adjustable 350-mA linear regulator	x	x	x	x
TPS65300-Q1	Automotive 3-MHz step-down regulator, triple linear regulators	3-MHz step-down regulator, single linear regulator and dual linear regulator controllers	x	x	x	x
TPS65381-Q1	Multirail power supply for microcontrollers in safety-critical applications	Wide-input voltage buck converter, LDOs including sensor supply, question-and-answer watchdog, enhanced diagnostics and BIST	x	x	x	x
TPS659119-Q1	Multirail power supply with three DC/DC converters and eight LDOs	Three DC/DC converters, control signal for external DC/DC converter, eight LDOs, I^2C interface, watchdog timer	x	—	—	x
TPS43331-Q1	Automotive catalog dual switcher and linear regulators multirail power supply	Wide-voltage supply range from 5 V to 30 V (up to 40-V transient), dual adjustable output voltage, step-down controllers and dual programmable LDOs	x	—	—	x
LDOs						
LP5907-Q1	250 mA ultra-low-noise LDO for RF/analog power	6.5 μV_{RMS}, 82 dB PSRR, 2.5 V to 5.5 V V_{IN}, stable with ≥ 0.47-µF ceramic caps, output discharge and very small soln. size (< 1 mm^2)	x	x	x	x
LP3990-Q1	150 mA linear Voltage regulator for digital applications	1% accuracy, low Iq (disabled) < 10 nA, fast turn on/off (105/175 µS), 55 dB PSRR, 2.0 V to 6.0 V V_{IN}, output discharge and tiny package (1.3 mm x 1 mm)	x	x	x	x
TPS78225/27/28/30-Q1	150 mA, ultra-low quiescent current, 1-µA Iq low-dropout linear regulator with EN function, fixed voltage options: 2.5 V, 2.7 V, 2.8 V, 3 V	Low Iq, 1 µA when I_{OUT} = 0 mA, 8 µA when I_{OUT} = 150 mA, low-dropout voltage: 130 mV at 150 mA, V_{IN} 2.2 V to 5.5 V, stable with 1-µF ceramic capacitors, thermal shutdown and overcurrent protections	x	x	x	x
TPS76201-Q1	Low-output, adjustable, ultra-low-power, 100-mA low-dropout linear regulator with EN function	Adjustable output voltage: 0.7 V to 5.5 V, input voltage 2.7 V to 10 V, 27-µA quiescent current at 100 mA,1 µA in standby mode, overcurrent protection	x	x	x	x
TPS75201-Q1	Fast transient response 2-A low dropout voltage regulator with reset	Adjustable output voltage 1.5 V to 5 V, input voltage 2.7 V to 5.5 V, typically 210-mV dropout voltage at 2 A, ultra-low 75-µA quiescent current, thermal shutdown protection	x	x	x	x
TPS74801-Q1	1.5-A low-dropout linear regulator with programmable soft start	V_{OUT} range 0.8 V to 3.6 V, 5.5-V max input voltage, 60-mV low-dropout voltage at 1.5 A, programmable soft start, stable with any output cap > = 2.2 µF, good transient response under low V_{IN}	x	x	x	x
TPS74701-Q1	500-mA low-dropout linear regulator with programmable soft start	V_{OUT} range 0.8 V to 3.6 V, 5.5-V max input voltage, 50-mV low-dropout voltage at 500 mA, programmable soft start, stable with any output cap > = 2.2 µF, good transient response under low V_{IN}	x	x	x	x
TPS73601-Q1	Cap-free, NMOS, 400-mA low-dropout regulator with reverse current protection	V_{IN} range from 1.7 V to 5.5 V, stable with no output cap, 75-mV ultra-low dropout voltage, excellent load transient, low noise: 30 μV_{RMS} (10 KHz to 100 KHz), adjustable output voltage: 1.2 V to 5.5 V, thermal shutdown protection	x	x	x	x
TPS73433-Q1	250-mA, low quiescent current, ultra-low noise, high PSRR low-dropout linear regulator	V_{IN} range from 2.7 V to 6.5 V, 125-mV dropout voltage when I_{OUT} = 150 mA, stable with a Low ESR, 2.2-µF output cap, fast startup time: 45 µS, high PSRR: 60 dB at 1 kHz, low noise: 28 μV_{RMS}, low Iq: 44 µA, adjustable output voltage: 1.25 V to 6.2 V	x	x	x	x
TPS73201/50-Q1	Cap-free, NMOS, 250-mA low-dropout regulator with reverse current protection	V_{IN} range from 1.7 V to 5.5 V, stable with no output cap, 40-mV ultra-low dropout voltage at 250 mA, excellent load transient, low noise: 30 μV_{RMS} (10 KHz to 100 KHz), adjustable output voltage: 1.2 V to 5.5 V, thermal shutdown protection	x	x	x	x
TPS71501/25/30/33/50-Q1	50-mA, 24-V, 3.2-µA supply current low-dropout linear regulators in SC70 package	V_{IN} 2.5 V to 24 V, 3.2-µA typical low Iq at 50 mA, adjustable output voltage: 1.2 V to 15 V, stable with any capacitor > 0.47 µF	x	x	x	x

Selection tables
Power management

Power management (continued)

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
LDOs (continued)						
TLV70012/18-Q1	300-mA, low-Iq, low-dropout regulator with EN	V_{IN} 2 V to 5.5 V, 35-µA typical low Iq, high PSRR: 68 dB at 1 kHz, thermal shutdown and overcurrent protection, stable with effective cap of 0.1 µF	x	x	x	x
TLV70025/30-Q1	200-mA low-Iq low-dropout regulator for portable devices with EN	V_{IN} 2 V to 5.5 V, 31-µA typical low Iq, high PSRR: 68 dB at 1 kHz, thermal shutdown and overcurrent protection, stable with effective cap of 0.1 µF	x	x	x	x
TPS79912/15/ 18/25/27/33-Q1	200-mA, low quiescent current, ultra-low noise, high PSRR, low-dropout, linear regulators with EN function, fixed-voltage options: 1.2 V, 1.5 V, 1.8 V, 2.5 V, 2.7 V, 3.3 V	40-µA low quiescent current, V_{IN} 2.7 V to 6.5 V, 100-mV dropout voltage when I_{OUT} = 200 mA, 66-dB PSRR at 1 kHz, excellent load/line transient response, fast startup time: 45 µs	—	—	x	—
TPS79633-Q1	Ultra-low-noise, high PSRR, fast, RF, 1-A linear regulator	High PSRR: 53 dB at 10 kHz, V_{IN} 2.7 V to 5.5 V, ultra-low noise, 40 μV_{RMS}, fast startup time: 50 µs, stable with 1-µF ceramic capacitor, very low dropout voltage: 250 mV at full load	—	—	x	—
TPS79501-Q1	Low-dropout linear regulator with EN function, 3.3-V fixed-output voltage	High PSRR: 50 dB at 10 kHz, V_{IN} 2.7 V to 5.5 V, ultra-low noise: 33 μV_{RMS}, fast startup time: 50 µs, stable with 1-µF ceramic capacitor, very low dropout voltage: 110 mV at full load	—	—	x	—
TPS79328-Q1	Ultra-low noise, high PSRR, fast, RF, 500-mA low-dropout linear regulator with EN function, output voltage 1.2 V to 5.5 V	High PSRR: 70 dB at 10 kHz, V_{IN} 2.7 V to 5.5 V, ultra-low noise: 32 μV_{RMS}, fast startup time: 50 µs, stable with 2.2-µF ceramic capacitor, very low dropout voltage: 112 mV at full load	—	—	x	—
TPS72301/25-Q1	200-mA low-noise, high-PSRR, negative-output, low-dropout linear regulators	V_{IN} range from –2.7 V to –10 V, 280-mV dropout voltage when I_{OUT} = 200 mA, adjustable output voltage: –1.2 V to –10 V, stable with a Low ESR, 2.2-µF output cap, high PSRR: 65 dB at 1 kHz, low noise: 60 μV_{RMS}, thermal shutdown protection	—	—	x	—
TPS71750-Q1	Low-noise, high-bandwidth PSRR low-dropout 150-mA linear regulator with EN function	V_{IN} 2.5 V to 6.5 V, 45-µA typical low Iq, adjustable output voltage: 0.9 V to 6.2 V, ultra-high PSRR: 70 dB at 1 kHz, 67 dB at 100 kHz and 45 dB at 1 MHz 4, low noise: 30 µV typical (100 Hz to 100 kHz), stable with 1-µF ceramic output cap, 170-mV dropout at 150 mA	—	—	x	—
TPS7A6601/ 33/50-Q1	150 mA 40 V high-voltage ultra-low Iq LDO	12 uA Iq and wide ouput capacitor ESR range support, full function with EN and RESET in MSOP-8 package	—	—	x	—
TPS7A6933/50-Q1	150 mA 40 V high-voltage ultra-low Iq LDO	12 uA Iq and wide ouput capacitor ESR range support, Adjustable input voltage monitoring threshold in SOIC-8 package	—	—	x	—
TPS7B6701/ 33/50-Q1	450 mA 40 V high-voltage ultra-low Iq LDO	15 uA Iq and wide ouput capacitor ESR range support, full function with EN and RESET in HTSSOP-20 package	—	—	x	—
TPS51200-Q1	3 A DDR termination LDO for DDR, DDR2, DDR3, and low power DDR3/DDR4	Input voltage supports both 2.5 V and 3.3 V, built-in soft start, UVLO and OCL	x	x	x	x
xRF PLL						
LMX2485Q	Ultra-low-power 3.1-GHz frac-N PLL	Dual PLL RF and IF 5-mA operating current at 3-V digital lock detect output	—	—	x	—
LMX2492Q	Ultra-high-performance 13.5 GHz frac-N PLL with ramping generation	Wide operating frequency range from 500 MHz to 13.5 GHz flexible ramp generation direct modulation 200-MHz maximum PDF frequency-227 dBc/Hz phase noise performance	—	—	x	—

Load switches

Device	Product description	Key specifications	Applications			
			Camera-based systems	LIDAR	Radar	Sensor fusion
TPS22965-Q1	5.5 V, 4 A, 16 mΩ automotive catalog load switch with quick output discharge and adjustable rise time	8-WSON package (2.0 mm x 2.0 mm x 0.75 mm with 0.5 mm pitch) AEC-Q100 grade 2	x	—	x	x
TPS22966-Q1	5.5 V, 4 A, 18 mΩ, 2-channel automotive catalog load switch with quick output discharge and adjustable rise time	14-WSON package (3.0 mm x 2.0 mm x 0.75 mm with 0.4 mm pitch) AEC-Q100 grade 2	x	—	x	x
TPS22968-Q1	5.5 V, 4 A, 27 mΩ, 2-channel automotive catalog load switch with quick output discharge and adjustable rise time	10-WSON wettable flanks package (3.0 mm x 2.0 mm x 0.75 mm with 0.5 mm pitch), AEC-Q100 grade 1	x	—	x	x

Selection tables

FPD-link II & III Ser/Des/TMS570 family

FPD-link II & III Ser/Des

Device	Applications	Parallel data	Pixel clock	Equalization	Spread spectrum	Other features	ESD
FPD-Link III with embedded bidirectional control bus							
DS90UB913/4	Camera	10 or 12 CMOS	10 to 100 MHz	Adaptive	Yes	2:1 Input mux	8-kV HBM, ISO 10605
DS90UB901/2	Camera	14 (16) CMOS	10 to 43 MHz	Yes	Yes	—	8-kV HBM, ISO 10605

TMS570 family

Device	Speed (MHz)	Flash	RAM (kB)	Date flash (kB)	EMAC	FlexRay	CAN	MibSP (cs)	SPI (cs)	I²C	UART (L(N)	HET (Ch)	PWM (Ch)	CAP/ QEP	Mib ADC 12 bit (Ch)	EMIF (16 Bit)	Total GIO (inter-rupt)	TRACE (EMT/ RTP/ DMM)	Package	Temp range (°C)
TMS570LS04x/03x series																				
TMS5700332 PZQQ1	80	256KB	32	16	—	—	2	1(4)	2(8)	—	1(1)	19	—	–/2	1(16)	—	45(8)	—	100 QFP	–40 to 125
TMS5700432 PZQQ1	80	384KB	32	16	—	—	2	1(4)	2(8)	—	1(1)	19	—	–/2	1(16)	—	45(8)	—	100 QFP	–40 to 125
TMS570LS0232	80	256KB	32	128	—	—	2	1(4)	2(8)	—	1(1)	19	—	–/2	1(16)	—	45(8)	—	100 QFP	–40 to 125
TMS570LS12x/11x series																				
TMS5701114 PGEQQ1 **TMS5701114 ZWTQQ1**	160 180	1MB 1MB	128 128	64 64	—	—	3 3	3(12) 3(16)	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	14 14	6/2 6/2	2(24) 2(24)	Yes	64(10) 101(16)	— —	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS5701115 PGEQQ1 **TMS5701115 ZWTQQ1**	160 180	1MB 1MB	128 128	64 64	—	2 ch 2 ch	3 3	3(12) 3(16)	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	14 14	6/2 6/2	2(24) 2(24)	Yes	58(4) 101(16)	— —	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS5701224 PGEQQ1 **TMS5701224 ZWTQQ1**	160 180	1MB 1MB	128 128	64 64	—	—	3 3	3(12) 3(16)	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	14 14	6/2 6/2	2(24) 2(24)	Yes	64(10) 101(16)	— —	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS570LS31x/21x series																				
TMS5701225 PGEQQ1 **TMS5701225 ZWTQQ1**	160 180	1MB 1MB	128 128	64 64	—	2 ch 2 ch	3 3	3(12) 3(16)	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	14 14	6/2 6/2	2(24) 2(24)	Yes	58(4) 101(16)	— —	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS5701227 PGEQQ1 **TMS5701227 ZWTQQ1**	160 180	1MB 1MB	128 128	64 64	10/100 10/100	2 ch 2 ch	3 3	3(12) 3(16)	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	14 14	6/2 6/2	2(24) 2(24)	Yes	58(4) 101(16)	— —	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS570LS31x/21x series																				
TMS5702124 APGEQQ1 **TMS5702124 AZWTQQ1**	160 180	2MB 2MB	192 192	64 64	—		3 3	3(12) 3(16)	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	— —	— —	2(24) 2(24)	Yes	64(10) 120(16)	Yes	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS5702125 APGEQQ1 **TMS5702125 AZWTQQ1**	160 180	2MB 2MB	192 192	64 64	—	2 ch 2 ch	3 3	3(12) 3(16)	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	— —	— —	2(24) 2(24)	Yes	58(4) 120(16)	Yes	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS5703134 APGEQQ1 **TMS5703134 AZWTQQ1**	160 180	3MB 3MB	256 256	64 64	—	—	3 3	3(12) 3(16	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	— —	— —	2(24) 2(24)	Yes	64(10) 120(16)	Yes	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS5703135 APGEQQ1 **TMS5703135 AZWTQQ1**	160 180	3MB 3MB	256 256	64 64	—	2 ch 2 ch	3 3	3(12) 3(16	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	— —	— —	2(24) 2(24)	Yes	58(4) 120(16)	Yes	144 QFP 337 BGA	–40 to 125 –40 to 125
TMS5703137 APGEQQ1 **TMS5703137 AZWTQQ1**	160 180	3MB 3MB	256 256	64 64	10/100 10/100	2 ch 2 ch	3 3	3(12) 3(16	1(1) 2(3)	1 1	2(1) 2(1)	2(40) 2(44)	— —	— —	2(24) 2(24)	Yes	58(4) 120(16)	Yes	144 QFP 337 BGA	–40 to 125 –40 to 125

Note: Above reflects max configuration of each module – some functions are multiplexed.

Selection tables

TDAx SoC family for camera, radar, lidar and fusion applications

TDAx system-on-chip (SoC) family

Device	Description	DSP	MPU	Accel-erator	Frequency	L1P/ L1D(3) SRAM (bytes)	L2/ SRAM (bytes)	L3/ SRAM	Video ports (hardware support)	Program /data storage	Voltage core (V)	I/O	Package
TDA2x	SoC with scalable DSP, EVE and ARM Cortex-A15 and M4, video input and output, low power, automotive qualified	C66x 1 or 2	A15	EVEs 1, 2 or 4	A15: 1 or 2 500 MHz – 1176 MHz C66x DSP: 500 MHz –750 MHz EVE: 500 MHz – 650 MHz	DSP: 32 KB L1D, 32 KB L1P ARM: 32 KB L1D, 32 KB L1P	DSP: unified 256 KB L2 cache ARM: combined 2 MB L2 cache	Up to 2.5 MiB	Up to 10	Async SRAM, SDRAM, DDR2/3, QSPI, NAND Flash, NOR	1.0	1.8/3.3 V	23 x 23 mm, BGA 17 x 17 mm BGA
TDA3x	SoC with scalable DSP, EVE and ARM Cortex-M4, video input and output, low power, automotive qualified	C66x 1 or 2	—	EVE 1	C66x DSP: 250 MHz – 650 MHz EVE: 250 MHz – 600 MHz	DSP: 32 KB L1D, 32 KB L1P ARM: 32 KB L1D, 32 KB L1P	DSP: unified 256 KB L2 cache ARM: combined 64 KB L2 cache	Up to 512 KiB	Up to 4	Async SRAM, SDRAM, DDR2/3, LPDDR2, QSPI, NAND Flash, NOR	1.0	1.8/3.3 V	15 x 15 mm BGA 12 x 12 mm PoP

Legacy ADAS SoCs

Device	Description	DSP	MPU	Accel-erator	Frequency	L1P/ L1D(3) SRAM (Bytes)	L2/ SRAM (Bytes)	L3/ SRAM	Video ports (hardware support)	Program /data storage	Voltage core (V)	I/O	Package
TMS-320DM6437	SoC with scalable DSP, single video input and output, low power, automotive qualified	C64x	—	—	300 MHz to 660 MHz	32 K/ 80 K	64 K-128 K	—	1x input 10/16 bit 1x output (digital/analog)	Async SRAM, DDR2 SDRAM, NAND Flash	1.05/ 1.2	1.8/ 3.3	BGA/ 16 x 16 mm (ZWT)BGA/ 13 x 13 mm (ZDU)
TMS-320DM648-Q7	SoC with high-performance DSP and accelerator, multiple video inputs, automotive qualified	C64x	—	VICP at 365 MHz	Q7: 730 MHz	32 K/ 32 K	1408 K	—	5x video ports	4	1.2	1.8/ 3.3	BGA/ 19 x 19 mm (ZUT)
TMS-S320C6747BZ-KBT3	SoC with entry-level DSP, low power, automotive qualified	C674x	—	—	375 MHz	32 K/ 32 K	L2: 256 K	128 K	—	4	3.3	100-QFP	BGA/ 17 x 17 mm (ZKB)
TMS-S320C6748B-Q4/Q3/Q2	SoC with scalable DSP, video input and output, low power, automotive qualified	C674x	—	—	Q4: 400 MHz Q3: 300 MHz	32 K/ 32 K	L2: 256 K	128 K	Video in: 2x 8-bit SD (BT.656), OR 1x 16 bit, OR 1x raw (8/10/12 bit) video out: 2x 8-bit SD (BT.656), OR 1x 16 bit	Async SRAM, SDRAM, DDR2, mDDR, NAND Flash, NOR	1.3	1.8/ 3.3	BGA/ 16 x 16 mm (ZWT) BGA/ 13 x 13 mm (ZCE)
OMAPL138B-Q4/Q3	SoC with scalable DSP and ARM 926, video input and output, low power, automotive qualified	C64x	ARM926 EJ-S	—	Q4: DSP at 400 MHz ARM at 400 MHz Q3: DSP at 300 MHz ARM at 300 MHz	ARM9: 16 K/ 16 K DSP: 32 K/ 32 K	L2: 256 K	128 K	Video in: 2x 8-bit SD (BT.656), OR 1x 16-bit, OR 1x raw (8-/10-/12- bit) video out: 2x 8-bit SD (BT.656) OR 1x 16-bit	Async SRAM, SDRAM, DDR2, mDDR, NAND Flash, NOR	1.3	1.8/ 3.3	BGA/ 16 x 16 mm (ZWT) BGA/ 13 x 13 mm (ZCE)
TDA1MSV-Q4/Q5	SoC with scalable DSP and ARM Cortex-A8, video input and output, low power, automotive qualified	C674x	Cortex-A8	VICP at 400 MHz	Q4: DSP at 450 MHz ARM at 600 MHz Q5: DSP at 550 MHz ARM at 600 MHz DSP at 450 MHz	—	—	—	Video in: 2x 16/24-bit, 1x 8/16 bit video out: 2x SD-DAC, 2x digital	—	—	—	BGA/ 23 x 23 mm (CYE)

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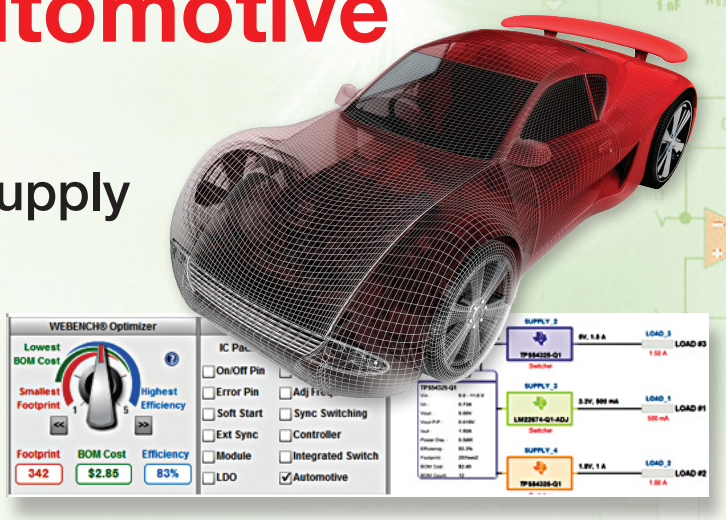

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