TI mmWave Sensors update for automotive

June 2023

TEXAS INSTRUMENTS

Why TI for automotive

Our technology, design resources, manufacturing and purchasing process empower you to create innovative automotive solutions and bring them to market faster.

Broad portfolio designed for auto

7,000+ auto-qualified analog and embedded processing products

Source a wide range of automotive products from a single supplier

The right parts for your design needs

Continuously innovating

40+ years designing products for automotive

Consistently introduced 500+ new automotive ICs annually since 2014

Driving innovation at every step of the product cycle

System expertise

Our engineers work with you to understand your unique vision, meet your deadlines and get you to production

Tools, software and local support help accelerate time to market

Support for 150 automotive applications and 350+ fully tested reference designs on TI.com

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# Enhancing ADAS with innovative technology

mmWave radar sensors
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TI mmWave radar solutions enable safer and easier driving experiences by sensing and reacting to exterior and interior environments.

Reduce system size and cost while optimizing high-speed data transfer in camera designs for advanced driver assistance systems.

SERDES FPDLink
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SENSE

COMMUNICATE

PROCESS
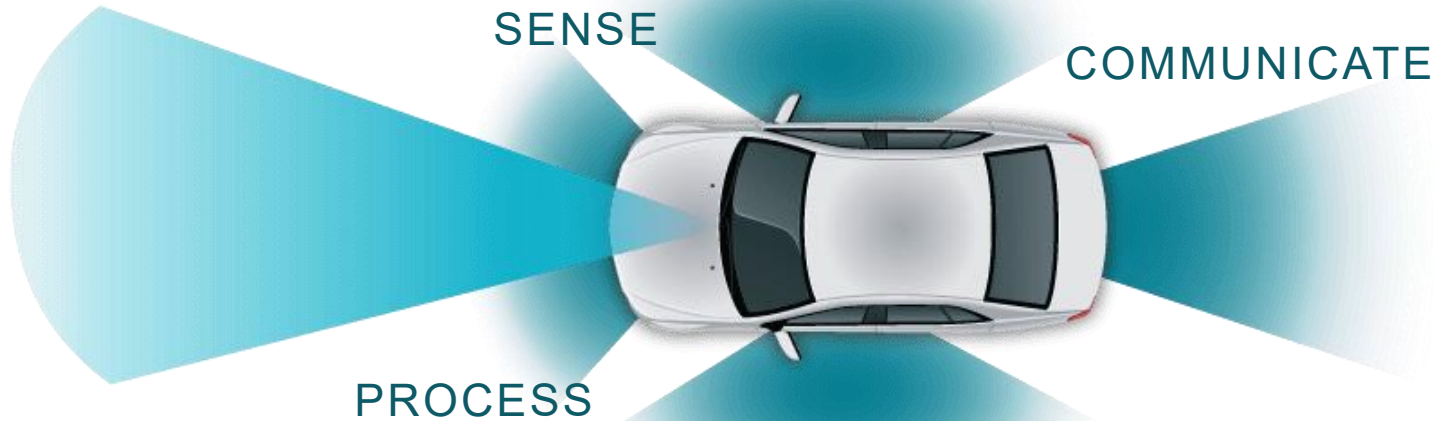
Arm® based processors
TEXAS INSTRUMENTS

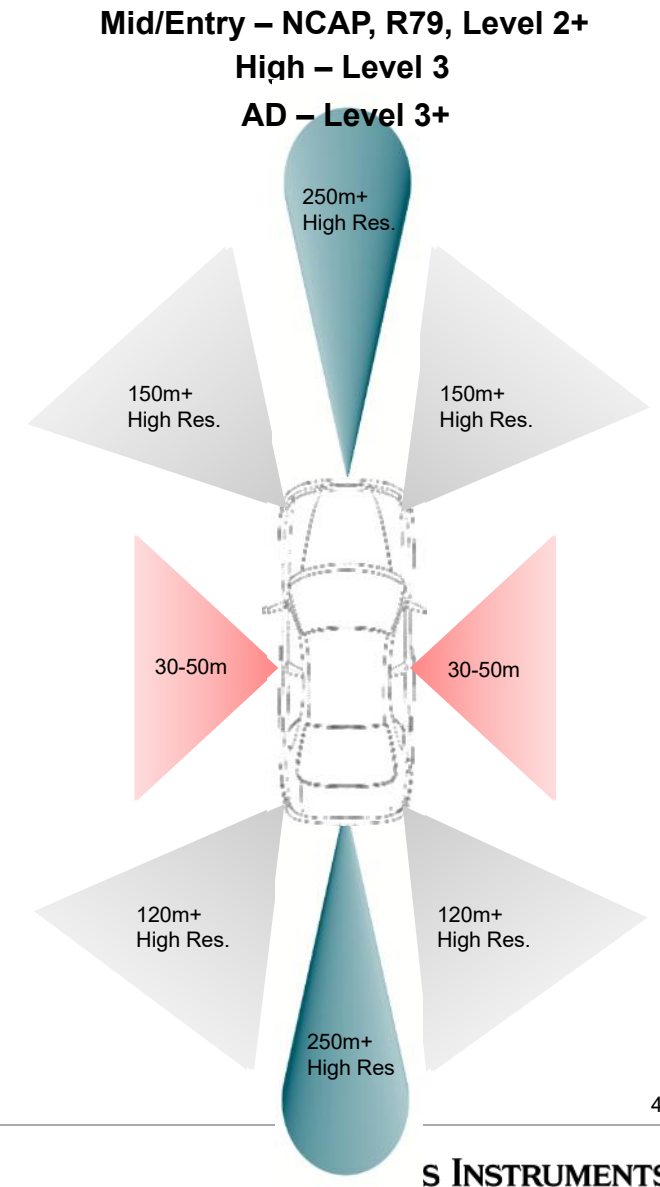Enhance automated driving with AEC Q100-qualified Arm-based processors.

PMIC solutions for automotive camera and radar applications, most with robust fault protection and monitoring.

Power Management ICs
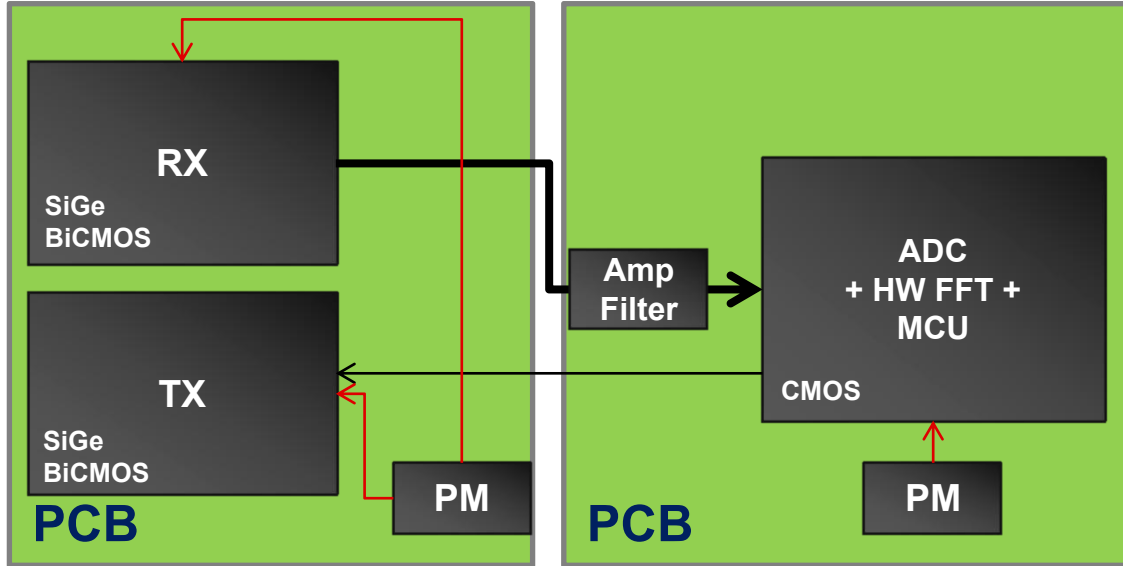TEXAS INSTRUMENTS

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Auto Radar Market Trend

- NCAP, R79 and Level 2+ driving
  - Number of sensors per car (3 → 5 → 8)
  - Multiple functions per sensor
  - Performance vs. cost
  - Standardization of cyber security (UNECE)

- Vehicle architecture evolving for Level 3+
  - Smart sensors vs. Satellite sensors
  - Communication interface
    - CAN-FD, Ethernet (100Mbps, 1Gbps)
    - FPD-link, MIPI A-PHY
  - Redundancy for Safety

- Emerging applications for radar
  - Park-assist/automated parking
 - Door sensors, Kick-to-open / Hands-free-access
  - Incabin Sensing

250m+
High Res.

150m+
High Res.

150m+
High Res.

30-50m

30-50m

120m+
High Res.

120m+
High Res.

250m+
High Res

4

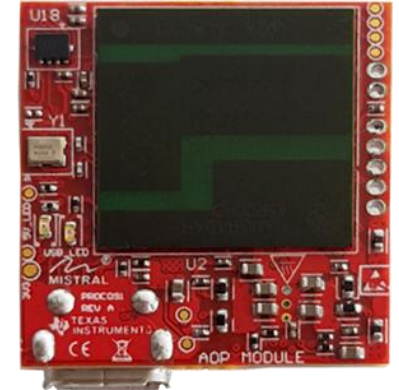S INSTRUMENTS

TI Innovation – Single-Chip CMOS

Discrete Multi-Chip mmWave Sensor

- Discrete solution – expensive
- Complex and critical signal routes
- Unconventional packaging
- Prone to noise
- Lack of system level observability
- Crude implementation of RF and Baseband safety

Antenna on Package AOP solution
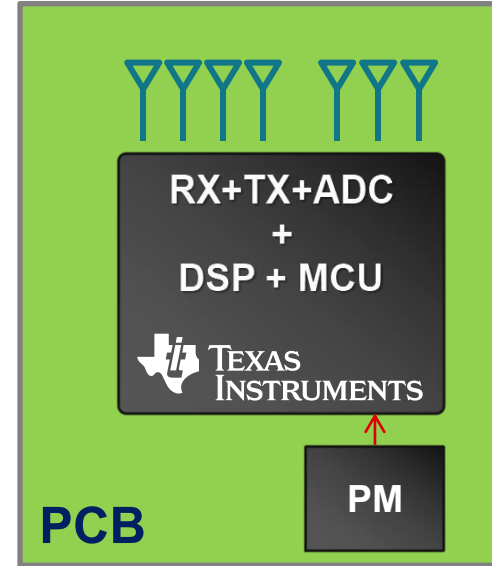
TI Single-Chip mmWave Sensor

- Smaller in size
- Simpler design
- Built in monitoring and calibration (SIL)
- High Resolution, less false positives
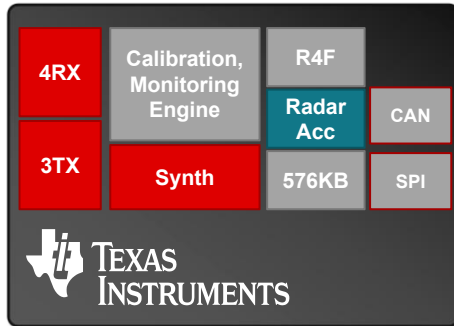- Programmable core
- Lower Power

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TI mmWave Sensing Solutions for Automotive
Advanced Driver Assistance Systems(ADAS)

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76 – 81 GHz mmWave Sensors

1st Gen	2nd Gen

AWR1443

4RX | Calibration, Monitoring Engine | R4F
3TX | Synth | Radar Acc | CAN
 | | 576KB | SPI

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mmWave Application Sensor
HWA

AWR1642

4RX | Calibration, Monitoring Engine | R4F | CANFD
2TX | Synth | C674x | CAN
 | | 1.5MB | SPI
 | Crypto | HIL

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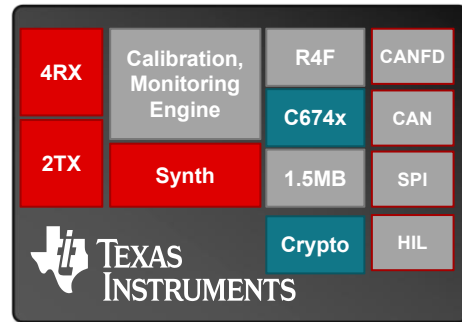
mmWave Application Sensor
MCU

AWR1843 (AOP)

4RX | Calibration, Monitoring Engine | R4F | CANFD
3TX | Synth | C674x | CAN
 | | 2 MB | SPI
 | Crypto | HIL
 | Radar Acc |

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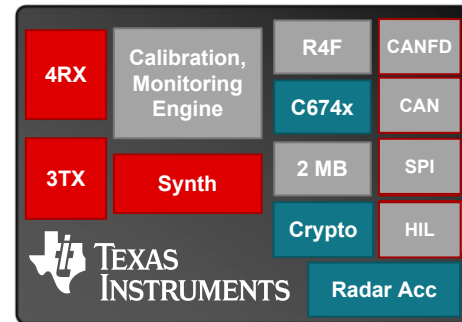
mmWave Application Sensor
HWA + MCU + Antenna

AWR2944/3

4RX | Calibration Monitoring Engine | R5F | 2xCAN FD
4/3 TX | Synth | C66x | ETH
 | | 4/3.5 MB + Comp. | SPI
 | HSM | HIL/ MDO

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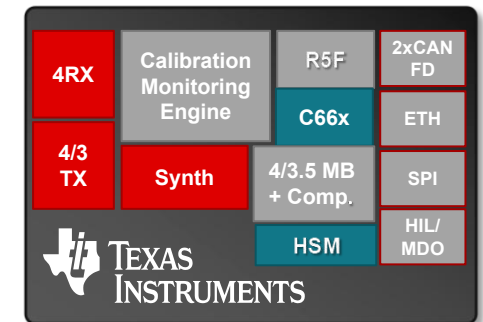
mmWave Application Sensor
HWA + MCU + HSM

Common Component / Reusable Software (SDK)

AWR1243

4RX | Calibration, Monitoring Engine |
3TX | Synth | CSI2
 | | SPI

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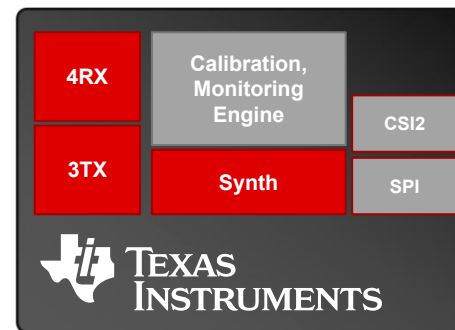
mmWave Front-End Sensor

AWR2243

4RX | Calibration, Monitoring Engine |
3TX | Synth | CSI2
 | | SPI

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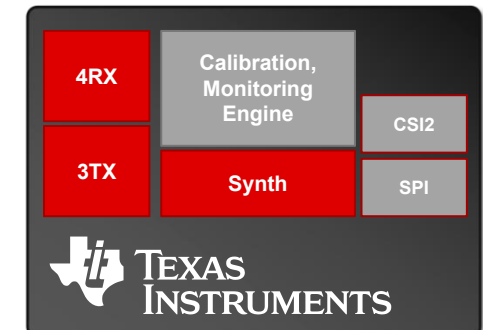
mmWave Front-End Sensor
Cascade Capable

https://www.ti.com/sensors/mmwave-radar/automotive/overview.html

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AWR2944 & AWR2943

- Integrated transceiver with 4 Rx and 3/4 Tx

- More than 50% increase in RF performance compared to Gen1, I-only front-end

- 37.5 Msps sampling rate and 15MHz IF bandwidth

- C66x Core @ 360 MHz, R5F LS @ 300 MHz

- HWA 2.0 @ 300 MHz (FFT, log magnitude, memory compression)

- 3.5/4 MB SRAM

- Interfaces: SPI, Ethernet, CAN-FD, UART, PWM, GPIOs, Aurora

- ASIL-B capable

- Temperature range Tj = –40° to 140° C
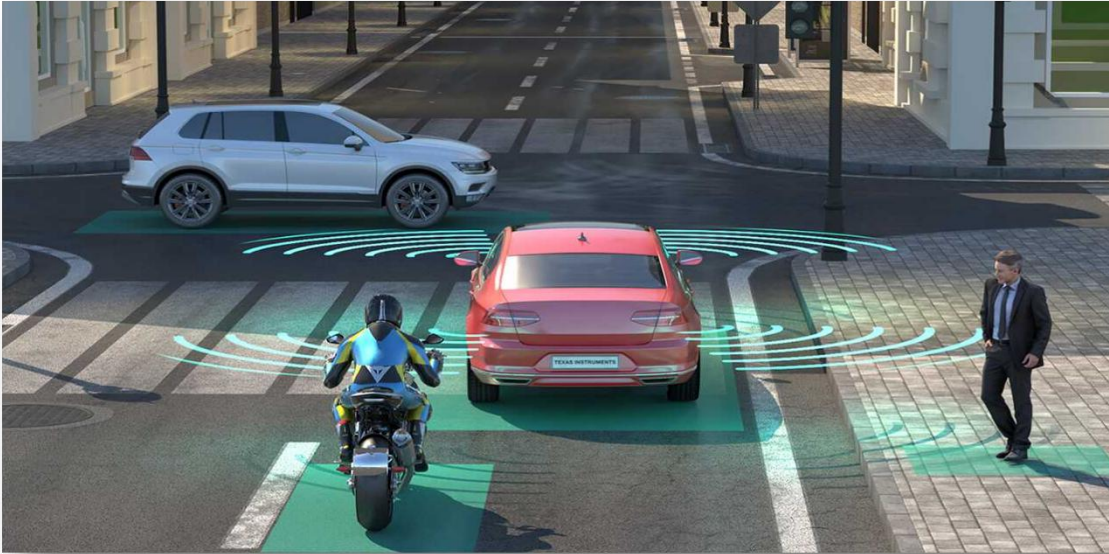
- In Production

Texas Instruments
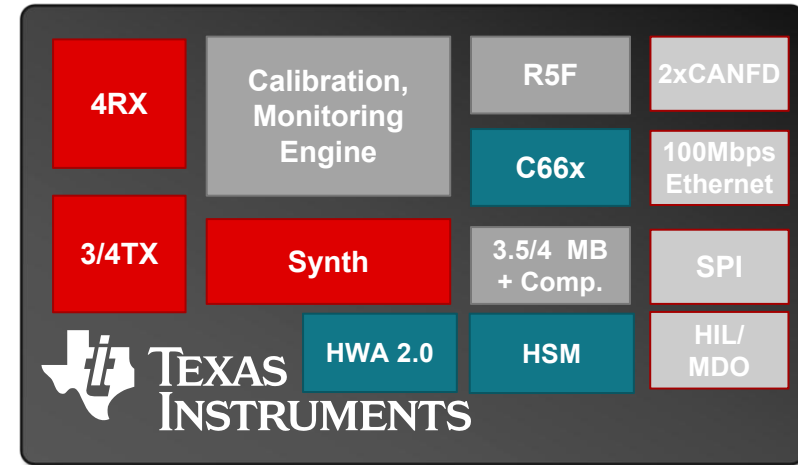
Corner Radar Using Single Chip Radar Sensor

200m+ Detection Range for Cars	30% Smaller Sensor Size	HSM, Ethernet Cybersecurity, Vehicle Arch.

Applications
- Automatic Lane Change (ALC)
- Blind Spot Detection (BSD)
- Adaptive Cruise Control (ACC)
- Automated Emergency Braking (AEB)
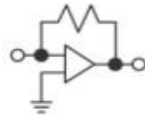- Cross Traffic Alert (CTA)

Key Features
- 1st SoC sensor meeting R79 NCAP
- 4th TX for 33% higher angular resolution
- Superior behind the bumper performance with low amplitude noise & uncorrelated phase noise
- 4cm separation of objects
- Support up to 2048 unique chirp in GEN2

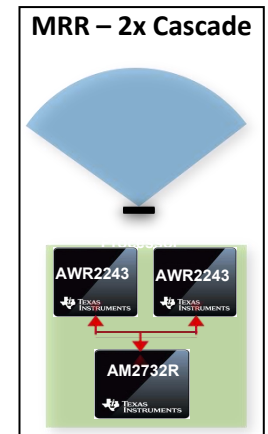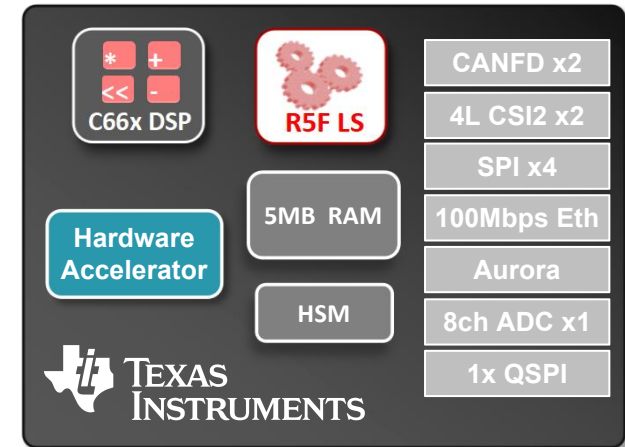| Products	Reference Designs	Videos	Article
• AWR2944 • AWR1843 • AWR1642	• High-end corner radar • Short range radar	• Meeting NCAP regulations with AWR2944 • MRR demonstration video using AWR1843	• What ADAS engineers need to know about the new NCAP requirements for radar

AM2732R– High Performance MCU

- 1x C66x DSP @ 450 MHz, 64KB cache, 384KB L2

- 1x R5F LS @ 400 MHz, 32KB cache, 64KB L1, 960KB L2

- 3.625 MB L3 RAM (Total of 5MB SRAM)

- HWA 2.0 @ 350 MHz
  - FFT, complex windowing, histogram, log magnitude
  - DC estimation/correction, interference estimation

- 100Mbps Ethernet, 2x 4 lanes 600 Mbps CSI-2, 2x CAN-FD, 4x SPI, 1x QSPI, 1x 8-ch ADC, Aurora

- Hardware Security Module (HSM)

- ASIL-B capable

- Temperature range Tj = –40° to 140° C

- In Production

C66x DSP — R5F LS — CANFD x2 — 4L CSI2 x2 — SPI x4 — 100Mbps Eth — Aurora — 8ch ADC x1 — 1x QSPI — Hardware Accelerator — 5MB RAM — HSM

Texas Instruments

MRR/LRR — AWR2243 — AM2732R

MRR – 2x Cascade — AWR2243 — AWR2243 — AM2732R
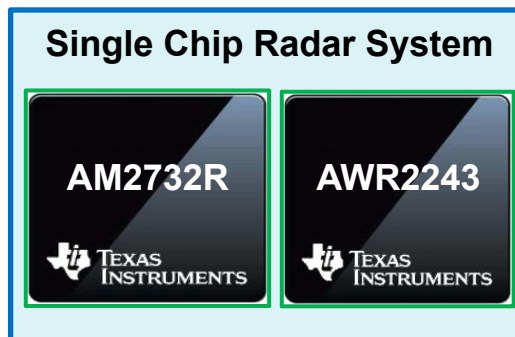
TI Solutions for Front Radar Applications

Enabling Front Radar Applications like:
- Autonomous Emergency Braking (AEB)
- Adaptive cruise Control (ACC)
- Forward Collison Warning (FCW)
- 4D Imaging Radar
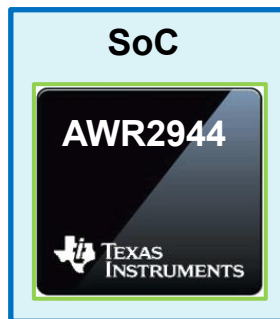
Performance

Max range : 300m+;
<4 deg angular resolution

Cost Effective Two Chip Cascade

AM2732R

AWR2243

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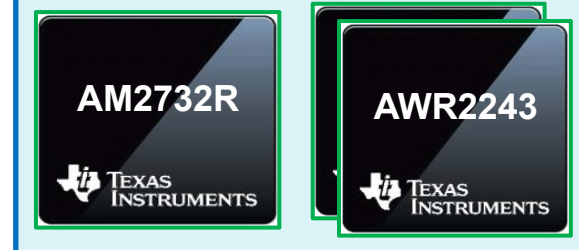
Cascade solution enabling higher
angular resolution with higher max range

Max range : 250m+

Single Chip Radar System

AM2732R

AWR2243

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Max range : 200m+

SoC

AWR2944

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Imaging Radar Using Cascade High Performance Front End

| 350m+ Detection Range for Cars | <1° Angular Resolution | Beam Steering |

Applications
- Automated Driving (AD) / Highway Pilot
- Adaptive Cruise Control (ACC)
- Automated Emergency Braking (AEB)
- Autonomous Emergency Steering (AES)
- Forward Collision Warning (FCW)

Key Features
- Best in-class RF performance
- In-built phase coherent cascade capability
- Multi-channel antenna calibration for MIMO and beamforming
- Beam steering for longer range object tracking
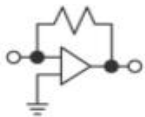
Products	**Reference Design**	**Video**	**Article**
• AWR2243	• Imaging radar using cascade	• Imaging radar demonstration video • SRS 2-chip and 4-chip cascade imaging radar	• Imaging radar: one sensor to rule them all

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TI mmWave Sensing Solutions for Automotive
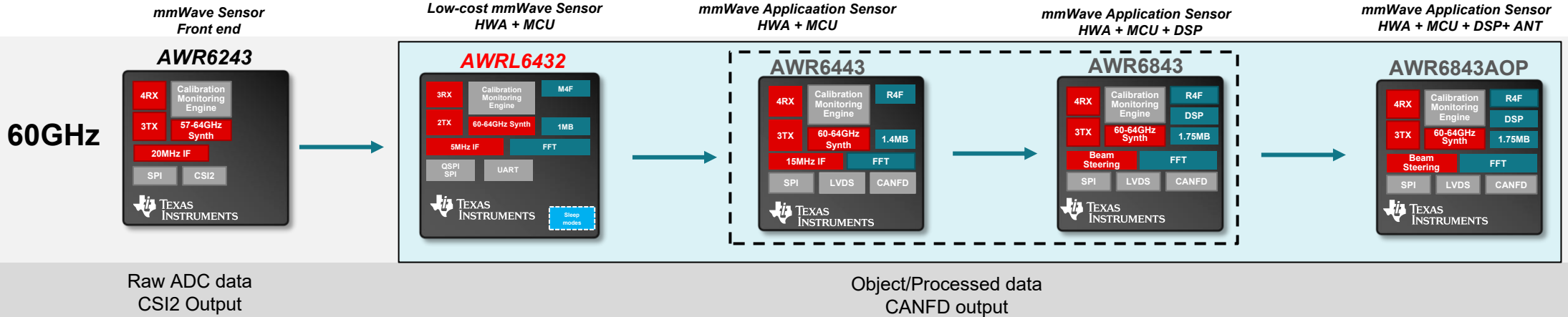## In-Cabin and Near-Field Applications

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60GHz Incabin Radar – Portfolio Overview

mmWave Sensor Front end	Low-cost mmWave Sensor HWA + MCU	mmWave Applicaation Sensor HWA + MCU	mmWave Application Sensor HWA + MCU + DSP	mmWave Application Sensor HWA + MCU + DSP+ ANT
AWR6243	**AWRL6432**	AWR6443	AWR6843	AWR6843AOP

60GHz

Raw ADC data
CSI2 Output

Object/Processed data
CANFD output

Common Component / Reusable Software (SDK)

- o **Frequency regulation agnostic design :** Pin 2 Pin compatibility with 60GHz and 77GHz sensors.
- o **One Software Investment:** Common software API and framework across 60GHz devices (as well as 77Ghz devices) make software re usable and portable across devices.
- o **Safety story:** ASIL B safety level for automotive applications

Region	North America	Europe	Korea	Japan	China
Frequency band	57- 64 GHz	57- 64 GHz	57- 64 GHz	57 – 64GHz	TBD

Key problems for in-cabin radar sensing

Child Presence Detection / Intrusion Sensing

Function
- Detection of children left behind in car-seat or in vehicle footwells (Euro – NCAP)

Products
- AWR6843 / AWR6443
- AWRL6432

Seat Belt Reminder

Function
- Localization of adults and children within vehicle to replace in-seat weight sensors

Products
- AWR6843 / AWR6843AOP
- AWR6243

Seat Belt Reminder +

Function
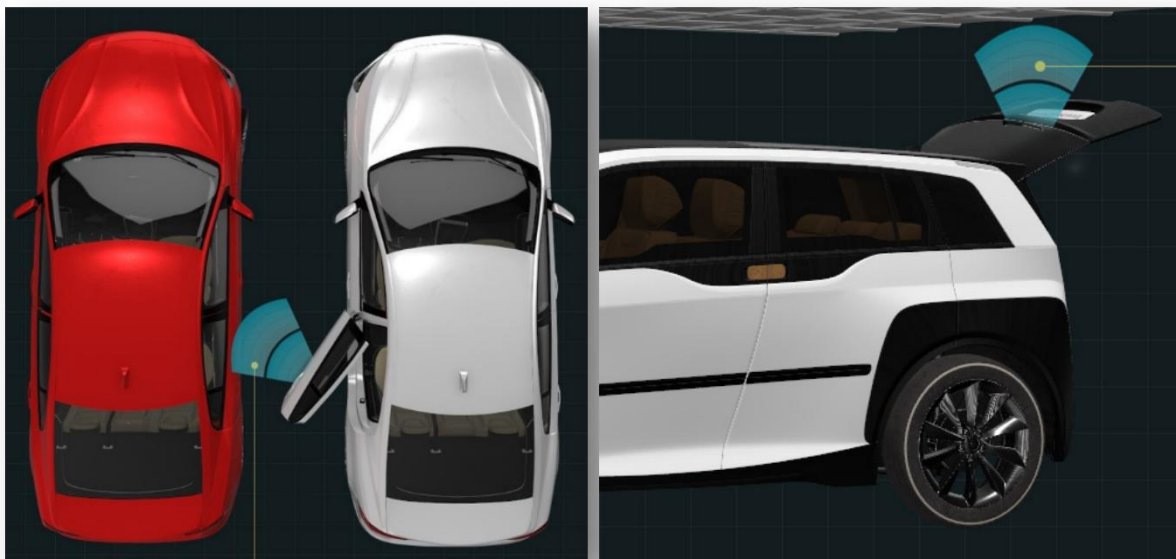- Classification of occupants age and posture for use in airbag deployment

Products
- AWR6843 / AWR6843AOP
- AWR6243 (cascade)

Body Applications Using Single Chip Radar Sensor

140° FOV in Elevation & Azimuth	<1in x 1in in size w/ Antenna on Package	Highly Accurate with <4cm range resolution

Applications
- Door obstacle detection
- Door and trunk open/close
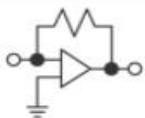- Kick to open / hands free access

Key Features
- Smallest form factor with ~80% reduction in size with Antenna on Package (AoP)
- Touchless interactions
- Multimodal sensor capability
- Wide band capable enables separation of objects as close as 4cm

Products	Reference Design	Video	Article
AWR1843AOP	Door Obstacle Detection	Obstacle detection demonstration video	How AoP technology expands radar sensor placement
AWR1642	Gesture Detection	Kick to open demonstration video	

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Parking Radar Using Single Chip Radar Sensor

140° FOV in Elevation & Azimuth	360° Surround View Capable	4cm – 50m+ Detection Range
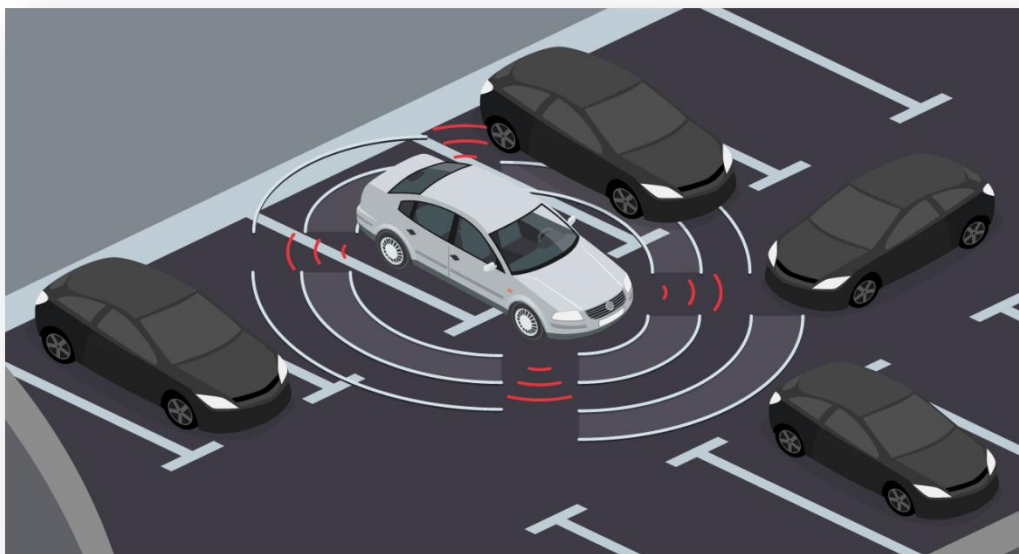
Applications

- Park Assist (PA)
- Automated Parking
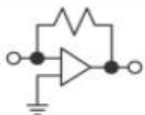- Automated Valet Parking (AVP**)**

Key Features

- Weather enduring advantage over existing technologies
- Eliminates bumper holes
- Multimodal sensor capability
- Wide-band capability enables separation of objects as close as 4cm
- Detection of 200+ objects with multimode

Products	Reference Design	Video	Article
• AWR1843 • AWR1843AOP	• Automated Parking	• Parking demonstration video using AWR1843AOP	• How radar outmaneuvers ultrasonic in automated parking

 TEXAS INSTRUMENTS

Key features across applications

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Safety Measures

Product Development _Process Certification_	Product Architecture _Product Certification ASIL – A/B/C/D_

Product Development
Process Certification

- TÜV-SÜD certified SafeTI **Hardware** functional safety **development process** AP210 in 2013 for:
    - ISO 26262 ASIL-D

- TÜV-SÜD certified SafeTI **Software** functional safety **development process** AP213 in 2019 for:
    - ISO 26262 ASIL-D

Hardware Development Process

Software Development Process

Product Architecture
Product Certification ASIL – A/B/C/D

- Improved robustness with **built in autonomous safety mechanisms** to reduce loading and improving system efficiency.

- ASIL-B Functional Safety Compliance (TUV-SUD Assessment) for **AWR1642, AWR1843 & AWR2243** (includes BootROM & BIST Firmware)

- **Software** safety part of customer driven System Certification Enabled via:
    - Compliance Support Package documentation for **MCAL Drivers** for Autosar OS, **Safety Diagnostics Library**

- TÜV-Nord Assessed SafeTI Compiler **Tools** for ISO 26262, enabling customer System Certification:
    - TI ARM C/C++ & C6xxx DSP Compiler Qualification Kit

Security Measures

| Protection Against Running Unauthorized Software	Protection Against Theft of IP

- Secure Boot
  - Take over protection using Asymmetric Key based authentication & Encryption (Usage of HW Features of **Crypto**, **Secure RAM** etc.)
- Run-time Security
  - Secure Zone Operation, Key Derivation (Usage of **HSM subsystem** & **Secure RAM)**
  - **Secure communication** using Asymmetric Key based authentication & Encryption
  - Side Channel Attack Resistance (Usage of HW based **Voltage monitoring and Clock monitoring**)
  - Security through authenticated of debug, test and trace capabilities during development (Usage of HW Features of **Firewalling**, **JTAG Sec-AP Read** etc.)
	- Cypto Accelerators
	  - **AES, PKA, HASH/HMAC** and **TRNG** to protect and encrypt image
	
	- Secure Image Update using Chain of trust
	
	- Secure Diagnostics
	  - Ability to diagnose the secure device in case of field return without compromising the customer software

- Available Collaterals
  - "*mmWave SECDEV*" having **Key Burning Tool**, **Secure Image Creator**
  - **Security addendum** for Technical Reference manual
  - **MMWAVE Security Features** application note

Interference Detection & Mitigation

- Issues with Interference
  - Missed detection (Blind spots) & Ghost objects

- Detection with TI Devices
  - Built in monitoring for interference glitches

- Mitigation with TI Devices
  - Built in hardware for all seven mitigation methods highlighted MOSARIM (also known as More safety for all by Radar Interference Mitigation) report

- Interference Lab/Example Application
  - Source code & User's guide: Interference Detection & Mitigation Lab
  - Interference Detection & Mitigation Video

Noise Floor Rise with Interference

Noise Floor Reduction after Mitigation
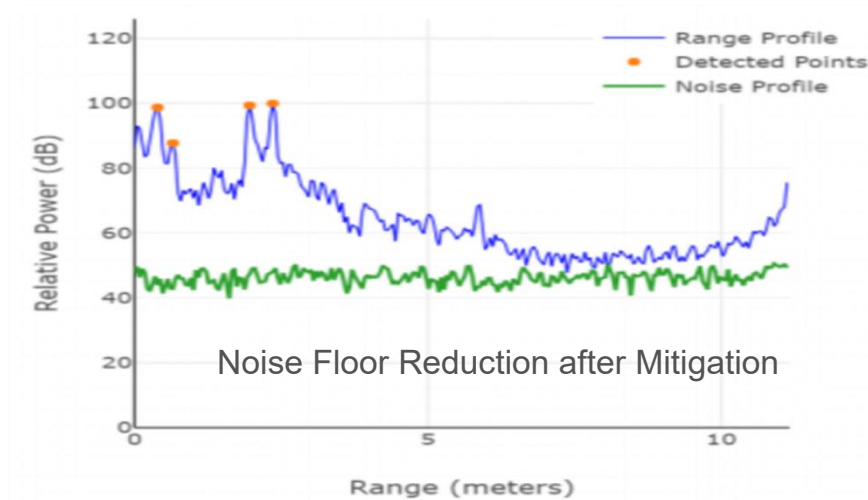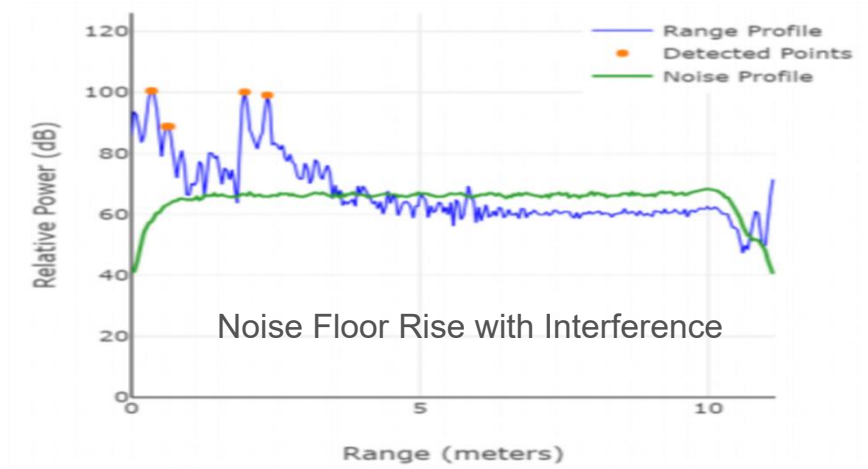
Start NOW

System Performance - Range, Max Velocity, Angle Accuracy, Angular Resolution etc. with Evaluation Boards (*AWR2944EVM*, *AWR1843BOOST*, *AWR1843AOPEVM*, *AWR2243BOOST*, *Imaging Radar Reference Design*, *AWR1642BOOST*) and mmWave SDK, mmWave DFP & mmWave Studio

EVALUATE

Design schematic, layout, thermal design with Evaluation Board Design Files (*AWR2944EVM*, *AWR1843BOOST*, *AWR1843AOPEVM*, *AWR2243BOOST*, *Imaging Radar Reference Design*, *AWR1642BOOST*), Hardware Collaterals (AWR2944 AWR1843 AWR1843AOP AWR2243 AWR1642 AWR1243)

HW DESIGN

Develop Application software, Port Autosar, Drivers (CAN-FD, CAN, SPI etc.), Safety & Security Functionality with mmWave SDK, MCAL for Autosar, Safety Diagnostics Lib, SECDEV

DRIVERS & SW

Capture Raw Data over Ethernet using *DCA1000* Board, Existing algorithm libraries for Peak Grouping, Static Clutter Removal, Angle Of Arrival Estimation, FFT, CFAR-CA and CFAR-OS, DBScan Clustering, Tracking & Windowing with mmWave SDK

ALGORITHMS

E2E Forum for prompt customer support with less than 1 day first response time on-line, on-demand video training

SUPPORT

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Thank You!

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