TI mmWave Sensors
AWR1x Family Device Overview
Agenda

• Device Overview
  – TI mmWave sensor portfolio
  – AWR1x Signal processing chain
  – Example System topologies

• Functional Blocks
  – Device Block Diagram
  – RF and Analog Subsystem
  – Radar Subsystem (aka BSS or BIST Subsystem)
  – Master Subsystem (MSS)
  – DSP Subsystem (DSS: AWR16xx only)
  – Radar Hardware accelerator

• Boot modes

• Software Platform
Device Overview
Automotive mmWave Sensors 76 – 81 GHz

**Radar Sensor**

- **Use Cases**
  - Imaging Radar Sensor
    - 2x AWR12 (cascade) + External DSP
    - 4x AWR12 (cascade) + External DSP

**Radar Sensor + HW Accelerator**

- **Use Cases**
  - Entry-level Single-chip Radar
    - Proximity warning, Blind spot

**Radar Sensor + DSP**

- **Use Cases**
  - USRR Single Chip Radar
    - 160 Degree, 40m
  - SRR Single chip Radar
    - 120m Cross traffic Alert
Key Features

- FMCW Radar transceiver with 76-81 GHz operating frequency and 4 GHz chirp bandwidth
- Scaling from Front-end only to complete Single Chip Radar solution
- MIMO: Up to three transmitter and four receiver chains
- Programmable, flexible chirp profiles for both long and short range sensing in the same radar frame
- 200MHz ARM Cortex R4F MCU for user application processing
- Radar Hardware accelerator for FFT and CFAR processing (AWR14xx only)
- C674x DSP for advanced tracking, clustering and object classification (AWR16xx only)
- Continuous monitoring and calibration of Analog/RF through a second dedicated Cortex R4F MCU
- CAN and CAN-FD (AR1W6xx only) support for ECU Interface
- QSPI Serial Flash support for autonomous boot
- MIBSPI, SPI, I2C, and UART Serial Interfaces Support
- CSI2 (AWR12xx only) interface for high speed raw data transfer
- LVDS/Debug interface for measurements.
- ASIL-B Capable
AWR1x mmWave Signal Processing

RF Front-End → ADC → ADC Data

AWR1243

Pre-Processing (Interference Mitigation) → 1st Dim FFT (Range) → 2nd Dim FFT (Velocity) → Detection → 3rd Dim FFT (Angle Arrival) → Point Cloud [Range, Velocity, Angle]

Point Cloud [Range, Velocity, Angle] → Objects

AWR1443

Clustering → Tracking → Object Classification

Objects

AWR1642
Example System Topologies

High resolution Imaging (Cascaded)

- AWR1243
- AWR1243
- AWR1243
- AWR1243
- CSI2
- Processor

Corner / MRR (Cascaded)

- AWR1243
- AWR1243
- CSI2
- Processor
Example System Topologies

Long Range Radar (LRR)

- AWR1243
- CSI2
- Processor

Satellite Configuration

- AWR1642
- AWR1642
- AWR1642
- AWR1642
- CAN-FD
- Processor
Functional Blocks
RF and Analog Subsystem
RF and Analog: Clock Subsystem

- Supports 40MHz crystal.
- Clean-up PLL provides high-frequency reference for modulated synthesizer and clocks to digital, ADCs.
- FMCW waveforms synthesized in a 19-20.25GHz closed loop frequency synthesizer.
RF and Analog: Transmit Subsystem

• Single-ended antenna interface matched to a 50 ohm GCPW on the PCB at the edge of the package.
• Power/impedance monitors at the edge of the die.
• Binary (0/180) phase modulation for MIMO radar and interference mitigation.

12dBM
RF and Analog: Receive Subsystem

- Complex (I/Q) baseband.
- Programmable high pass filters to compensate for channel loss.
- CTSDM ADC supports IF bandwidths up to 15MHz.
Radar Subsystem (aka BSS)
Radar Subsystem (BSS)

- Also known as the BSS, includes the DFE (digital front-end) and Ramp Generator
- Includes a dedicated Cortex R4F MCU for configuration, monitoring, and calibration of the low-level RF/Analog components
- Access to the Radar subsystem provided through hardware mailboxes and a well defined API
Master Subsystem (MSS)
Master (Control) Subsystem

- The MSS includes an ARM Cortex R4F processor clocked at 200 MHz for running application code.
- User application running on MSS controls overall operation of the device, including Radar subsystem (BSS) control via well-defined API messages and perform radar signal processing.
- This subsystem also includes the various external interfaces available on the 14 or 16xx devices.
DSP Subsystem (DSS)
DSP Subsystem (DSS): AWR16xx only

- C674x DSP clocked at 600 MHz for advanced Radar signal processing
- High bandwidth interconnect for high performance (128-bit, 200MHz)
- 256 KB L2 and 1 MB of L3 memory
- Four DMAs for data transfer, LVDS interface for Measurement data output, ADC buffers, CRC engine and data handshake memory
Radar Hardware Accelerator
Radar Hardware Accelerator

- Accelerates FFT and CFAR detection operations
- Simple pre-FFT processing and Magnitude and Log-Magnitude computation capability
- Flexible data flow and data sample arrangement to support efficient multi-dimensional FFT operations and transpose accesses
- Chaining and Looping mechanism to sequence accelerator operations with minimal intervention from the main processor
- CFAR-CA detector support (linear and logarithmic)
Boot Modes
Boot Modes

**Functional Mode:**
- Bootloader looks for a valid image in the serial flash memory, interfaced over the QSPI port.
- Bootloader transfers the same to Master System’s memory sub-system

**Flashing Mode:**
- Bootloader enables the UART driver
- Expects a data stream comprising of User Application (Binary Image)
- Loads data to appropriate sections of the serial FLASH
Software Platform
**mmWave Software**
Simplified evaluation and development

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**mmWave SDK**

Includes:
- TI RTOS
- Drivers
  - SPI
  - CAN/CANFD
  - LVDS / CSI-2
  - EDMA
  - UART
  - I2C
  - GPIO
  - Timers
  - FFT HW
- Signal Processing Library
  - On DSP
  - On HW Accelerator
- mmWaveAPI
- mmWaveLink
- mmWaveLib

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**mmWave Examples**

- TI Designs:
  - AWR14xx Proximity Sensor
  - AWR16xx Short-Range Radar
- Examples:
  - mmWaveDemo (OOB)

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**mmWave Studio**

Includes:
- Visualizer – visualize output (point-cloud and proximity grid) from the sensor on the PC
- System Estimator – define chirp configuration through abstracted parameters like max range, minimum range, etc
- Capture – capture raw ADC data from capture HW onto the PC
mmWave Sensing Estimator

- Sensing Estimator enables prototyping chirp configuration through scene parameters
- Error checking and tips provide a convenient check on any out of bound or impossible values
- Helps customers jump start evaluation of their usecase for the mmWave sensors
mmWave SDK – The TI components

**mmWave SDK**
- Modular design
- Well defined APIs
- Documentation – doxygen, release notes, user guide
- MISRA-C compatibility for all foundational components

**RTOS Drivers**
- Encapsulate the functionality of the hardware IPs in the SOC
- Provide a well defined API to the higher layers.
- OS-agnostic via the OSAL layer

**OSAL**
- An abstraction layer for some of the common OS services (Semaphore, Interrupts, Clock)
- Sample TI RTOS based port in mmWaveSDK
- Customers can port the OSAL for their custom OS, as per their requirements

**BSS Firmware**
- ROM Firmware for mmWave Front End
- Provides well defined APIs to configure, start and monitor mmWave Front End
- Communicates with MSS via Mailbox and proprietary protocol

**mmWaveLink**
- Low level control for mmWave Front End
- Communicates over Mailbox to BSS (front end)
- Implements the communication protocol between the BIST subsystem and Master subsystem

**mmWave API**
- Simple APIs for application to perform the task of radar sensing
- High level control for mmWave Front End and DSS
- Runs on top of mmWaveLink/IPC and Drivers.

**mmWaveLib**
- Provides functions for elements or sub functions of typical radar processing chain
- Optimized for C674x
- Speed customer development and reduce the SW effort to achieve a working radar processing chain
mmWave SDK - Packaging

- Uses TI compiler tools (Cortex-R4F, C674X) provided as part of CCS
- Demo built over TI RTOS
- Simple makefile based build system
Learn more about TI Automotive mmWave Sensors

- Learn more about AWR1x devices, please visit the product pages

- Get started evaluating the platform with AWR1x EVMs, purchase EVM at

- Download mmWave SDK @ [http://www.ti.com/tool/MMWAVE-SDK](http://www.ti.com/tool/MMWAVE-SDK)

- Ask question on TI’s E2E forum @ [http://e2e.ti.com](http://e2e.ti.com)