TI mmWave Sensors
IWR14xx/16xx Device Overview

Agenda

- Device Overview
  - TI mmWave sensor portfolio
  - IWR1xx Signal processing chain
  - Example System topologies
- Functional Blocks
  - Device Block Diagram
  - RF and Analog Subsystem
  - Radar Subsystem (aka BSS or **BIS**T **S**ubsystem)
  - Master Subsystem (MSS)
  - DSP Subsystem (DSS: IWR16xx only)
  - Radar Hardware accelerator
- Boot modes
- Software Platform

Device Overview

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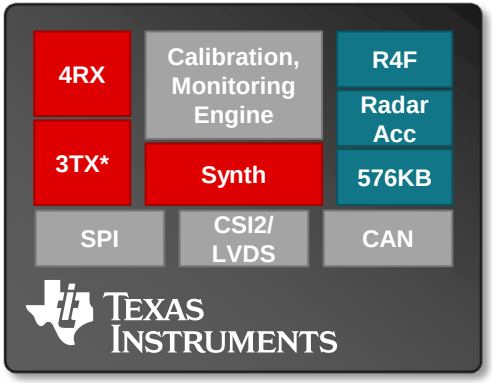
mmWave Sensors – 76-81 GHz Portfolio

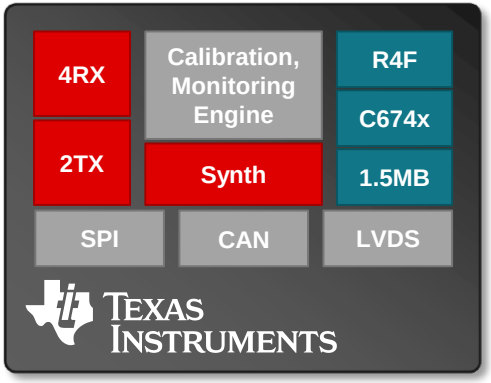
IWR1443



mmWave Sensor + HW Accelerator

- **Use Case**
  - Satellite Sensor with MCU
    - 4X IWR14 + Central Processor
    - 2X IWR14 + Central Processor
  - Entry-level Single-chip Sensor
    - Power-optimized applications
    - HW acceleration for limited processing

IWR1642

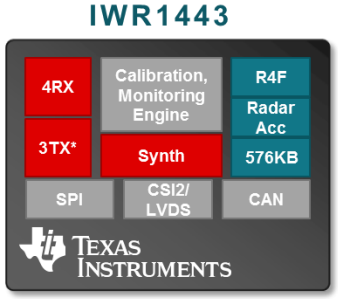


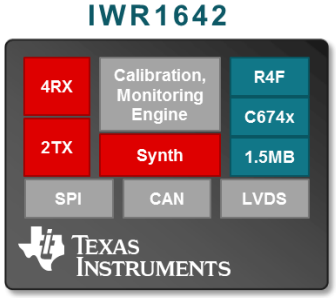
mmWave Sensor + DSP

- **Use Cases**
  - Full functionality single-chip radar
    - Increased on-board memory for higher range and resolution measurement
    - On-chip DSP for advanced algorithms

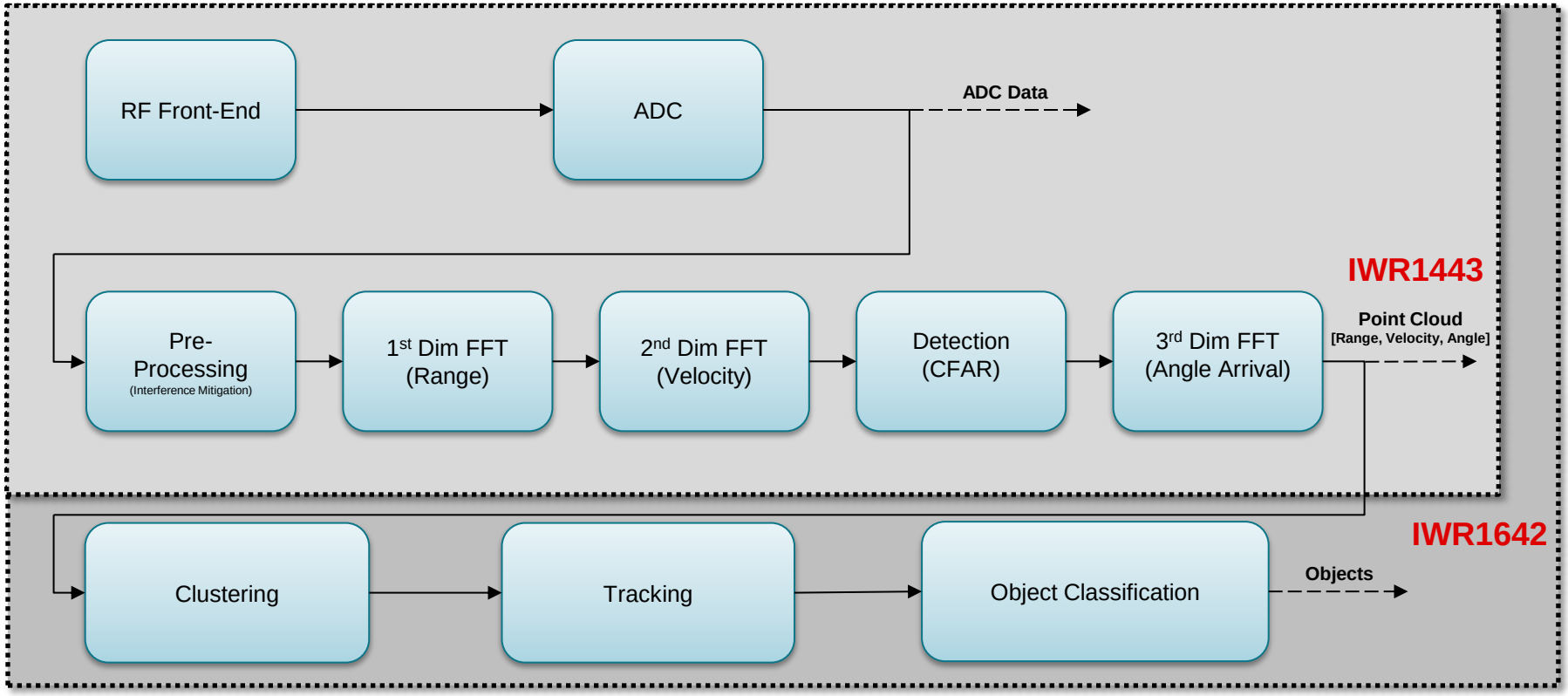
Key Features

- FMCW Radar transceiver with 76-81 GHz operating frequency with 4 GHz chirp bandwidth
- 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 (14xx only)
- C674x DSP for FMCW signal processing and advanced tracking, clustering and object classification (I16xx only)
- Continuous monitoring and calibration of Analog/RF through a second dedicated Cortex R4F MCU
- CAN support for ECU Interface
- QSPI Serial Flash support for autonomous boot
- MIBSPI, SPI, I2C, and UART Serial Interfaces Support
- CSI2 (IWR14xx only) and LVDS interfaces for high speed raw data transfer





IWR1xxx mmWave Signal Processing



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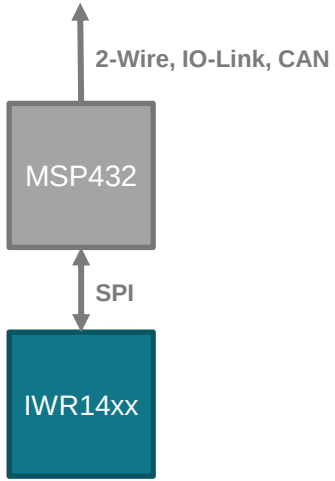
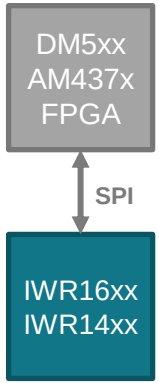
Example System Topologies

Fluid Level Sensing

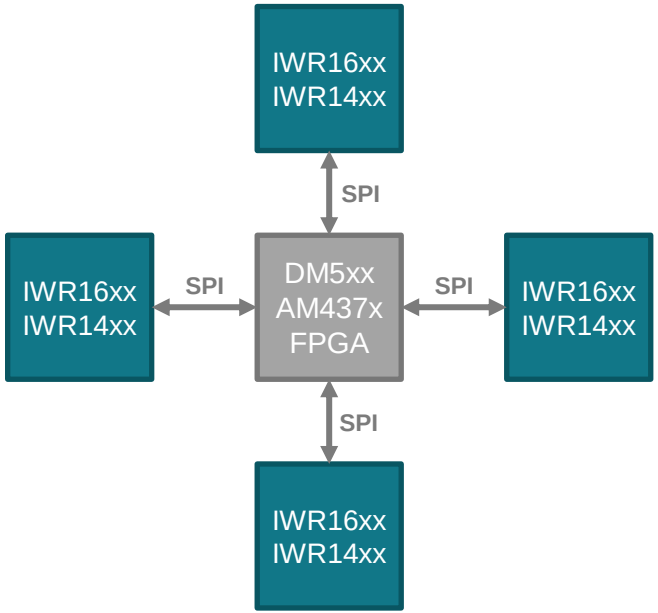


Transport and Mobile Robots: Front-View and Landing

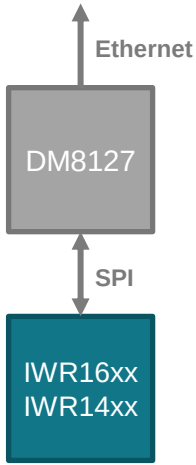


Example System Topologies

Transport and Mobile Robots: Surround Sensing



Traffic Monitoring



Functional Blocks

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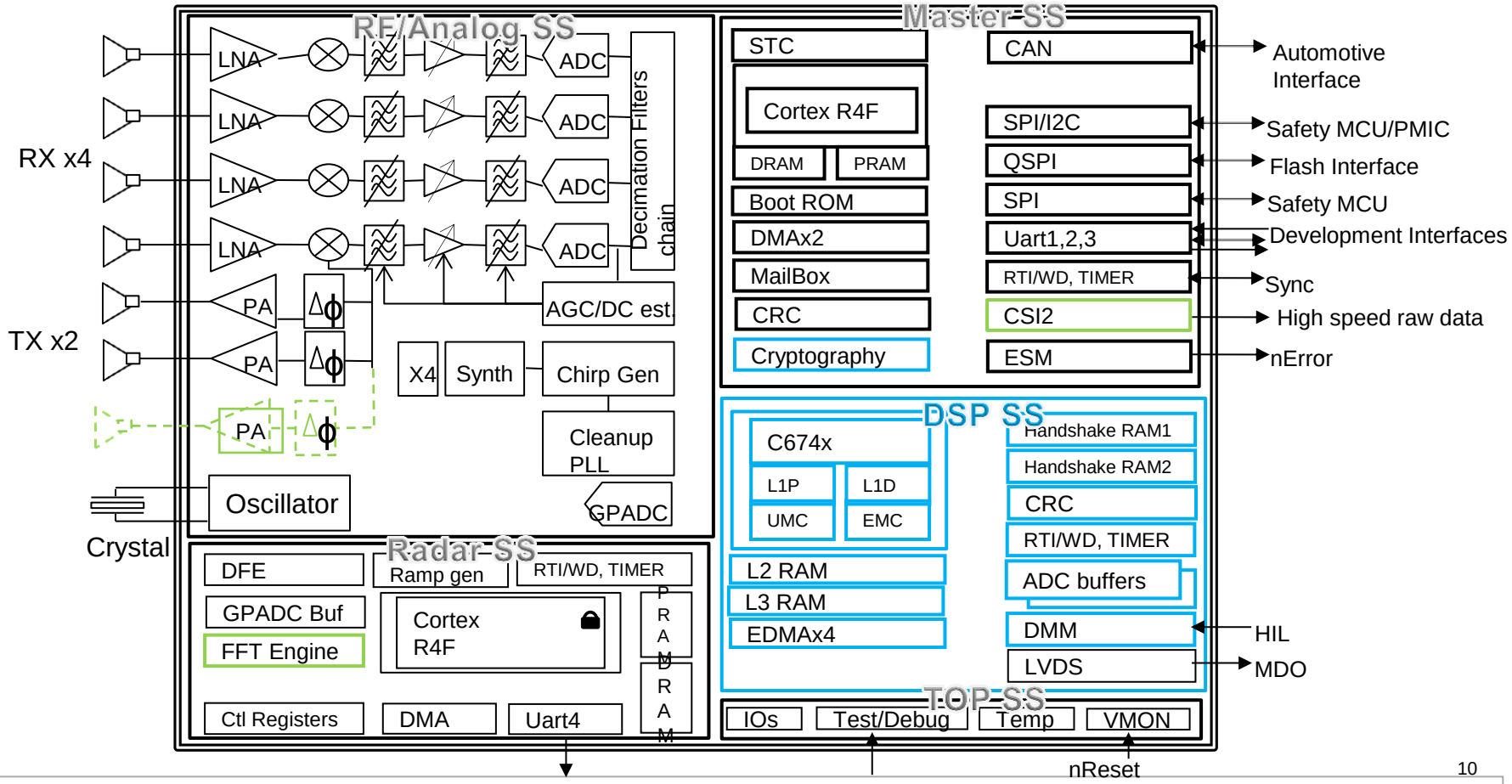
Block Diagram : IWR14xx/IWR16xx



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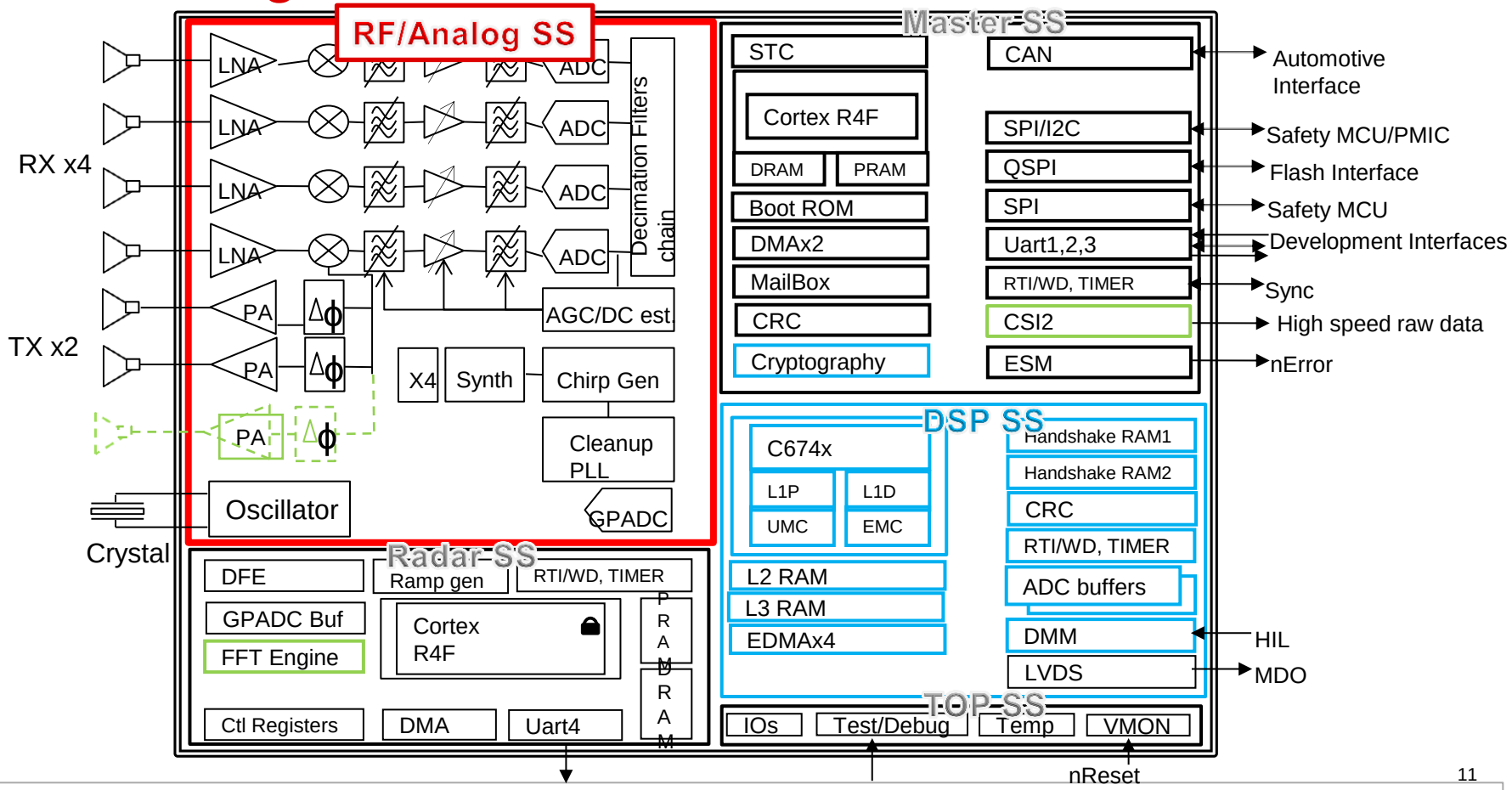

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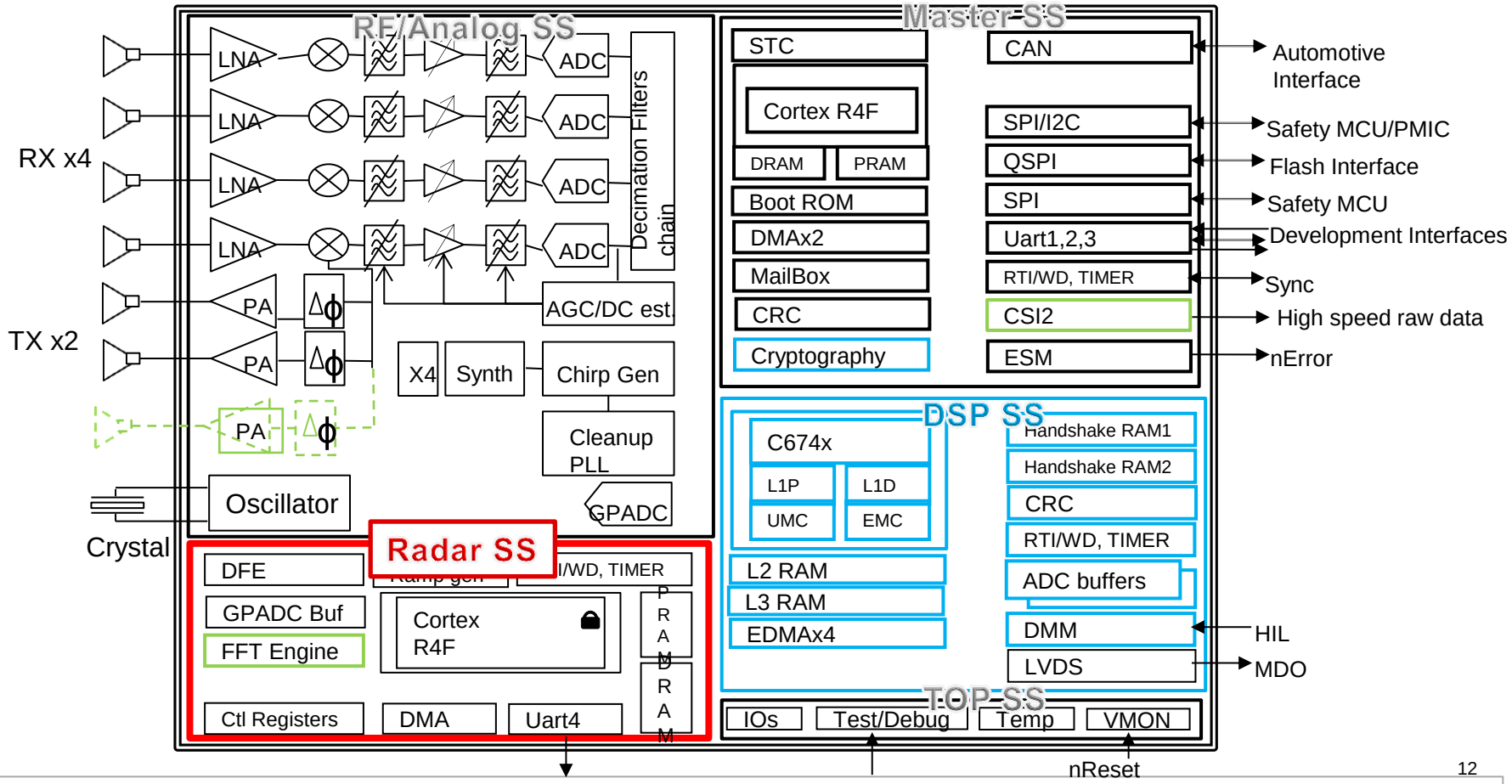

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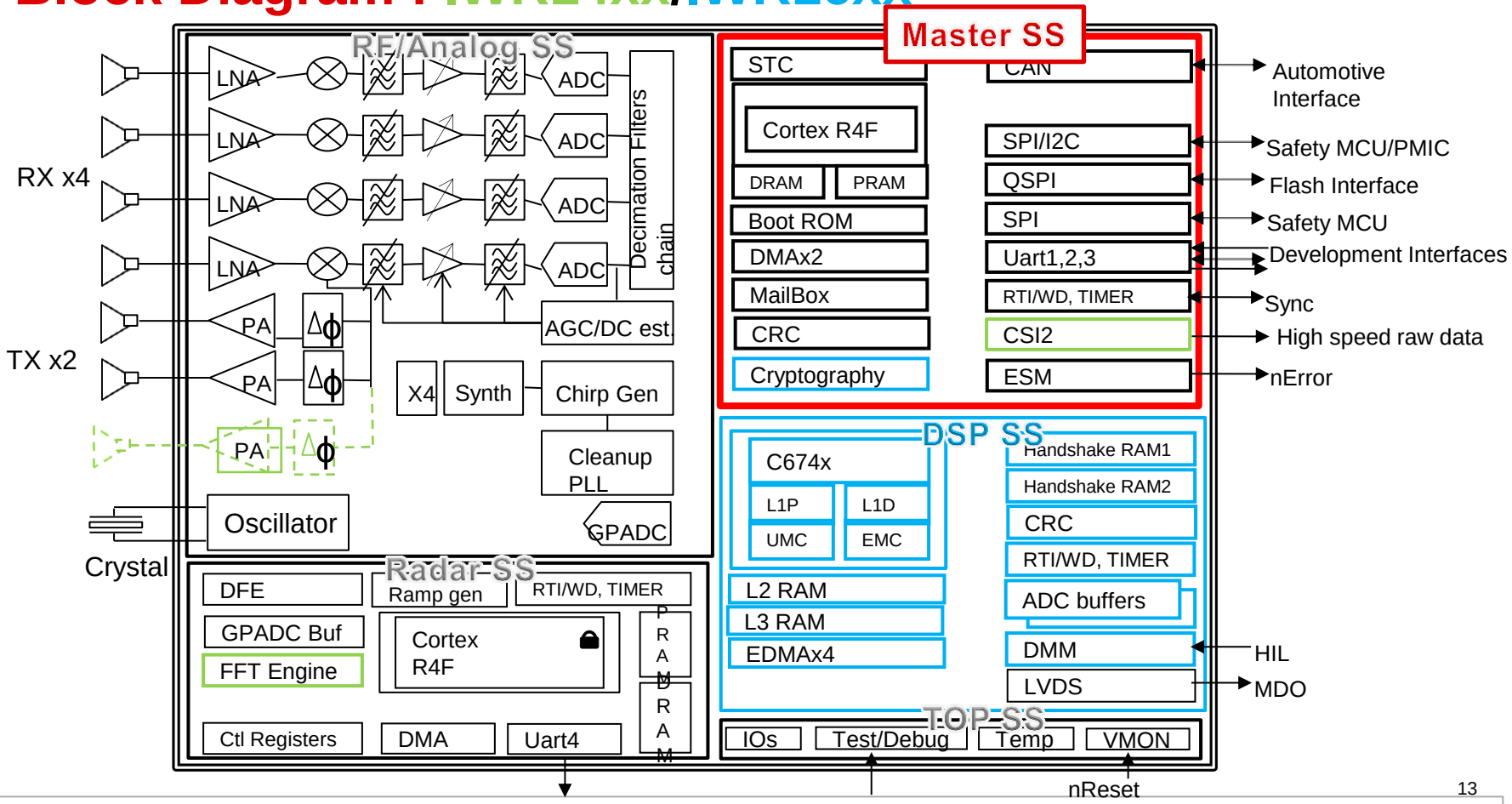

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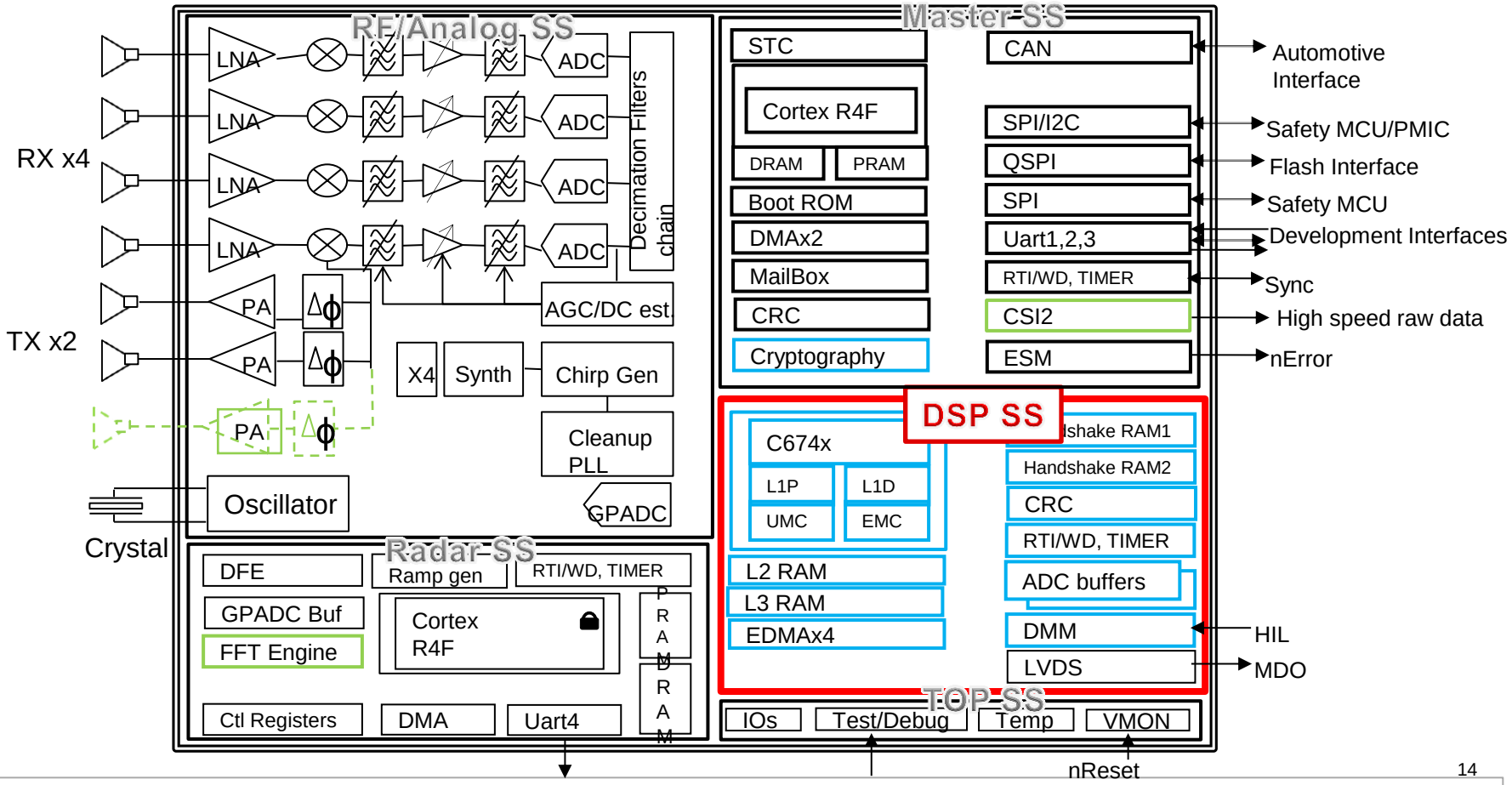
Block Diagram : IWR14xx/IWR16xx



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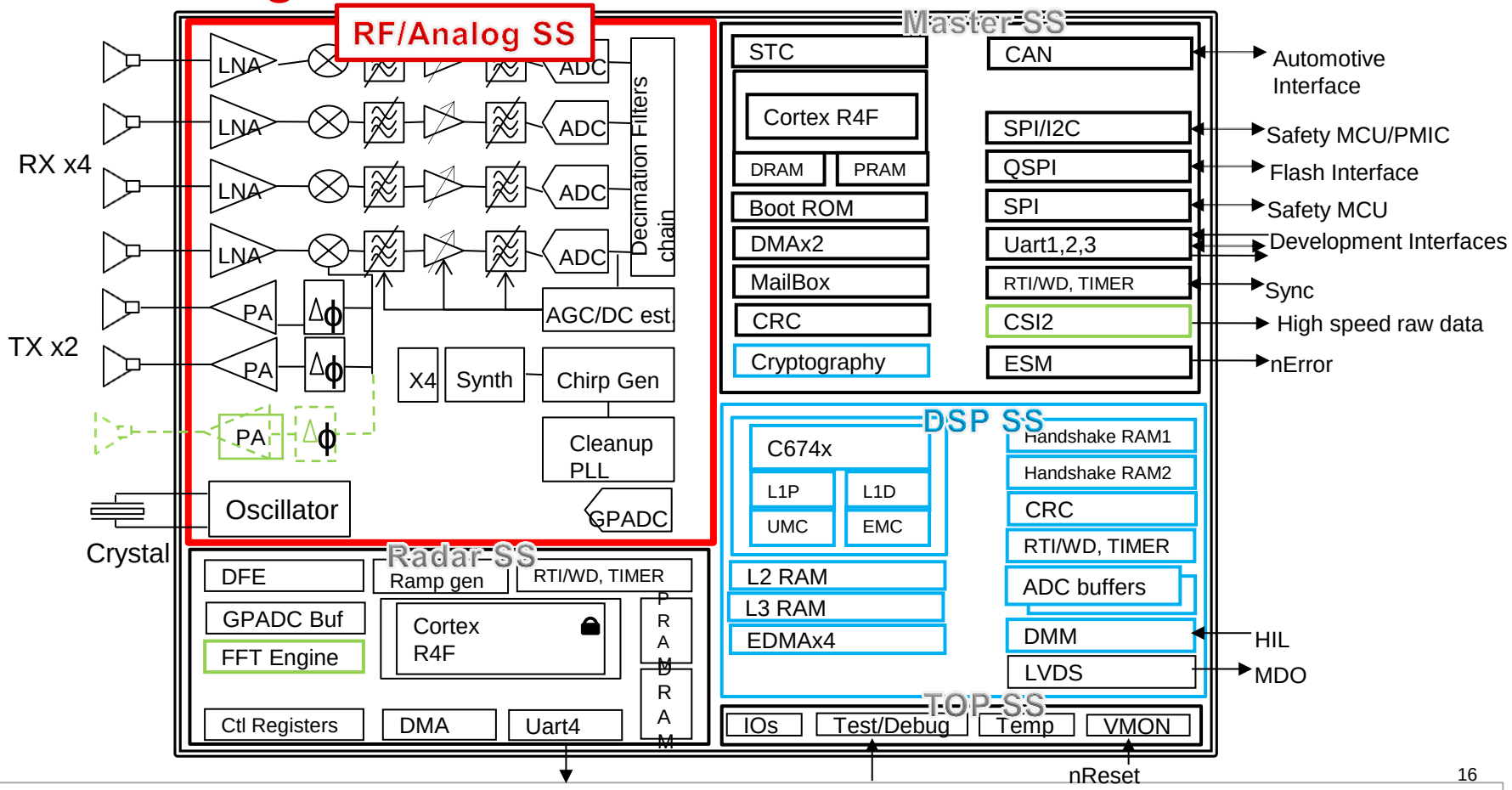
RF and Analog Subsystem

Block Diagram : IWR14xx/IWR16xx



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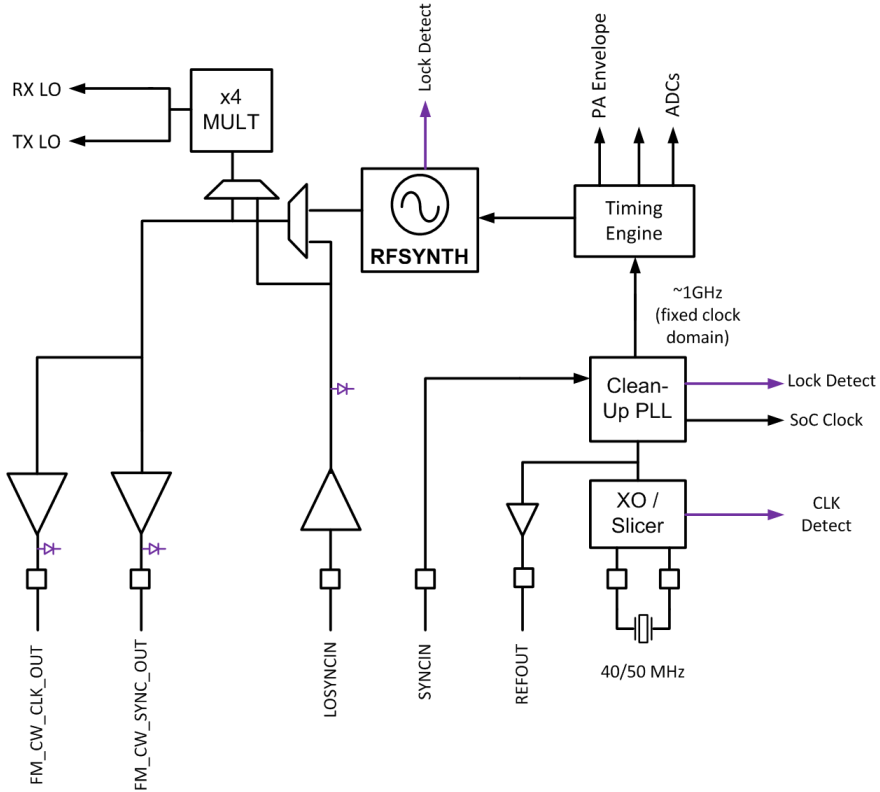
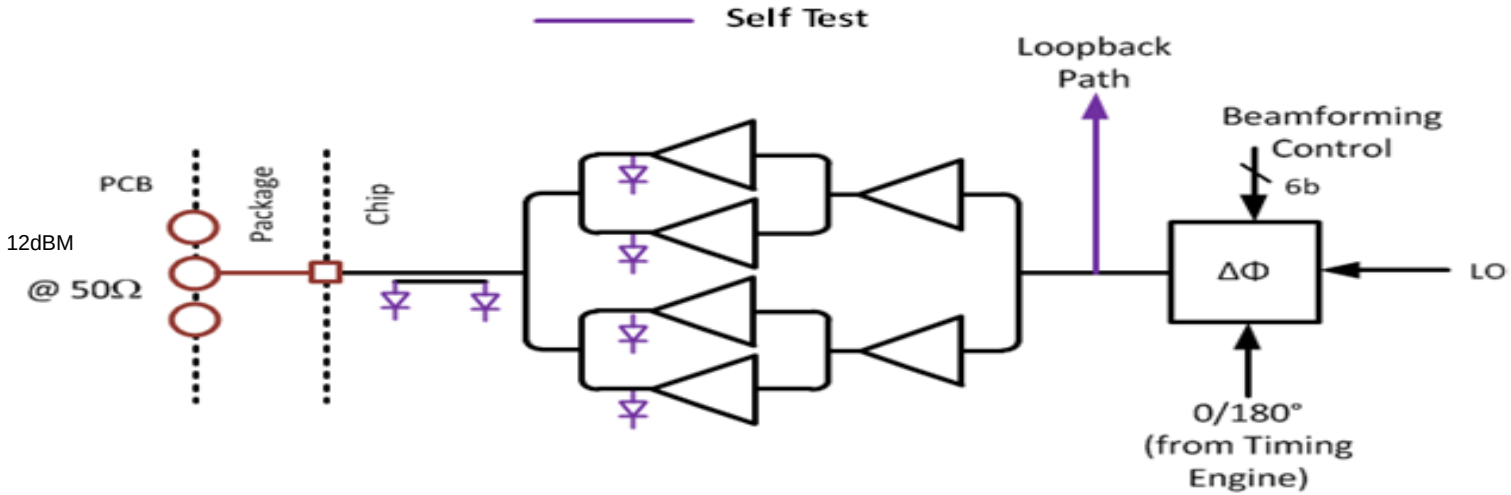
RF and Analog: Clock Subsystem

- 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.



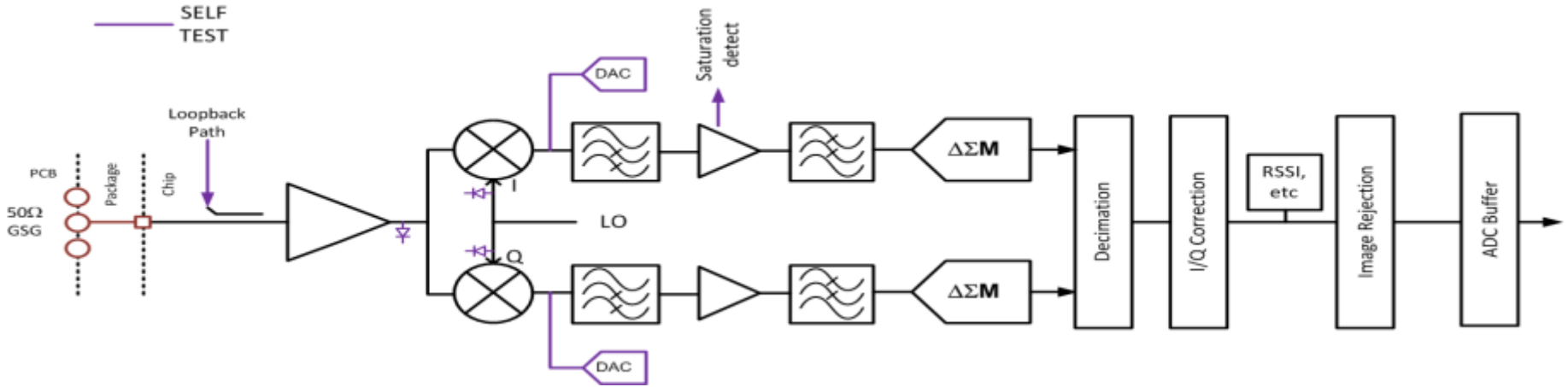
RF and Analog: Transmit Subsystem

- 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.



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)

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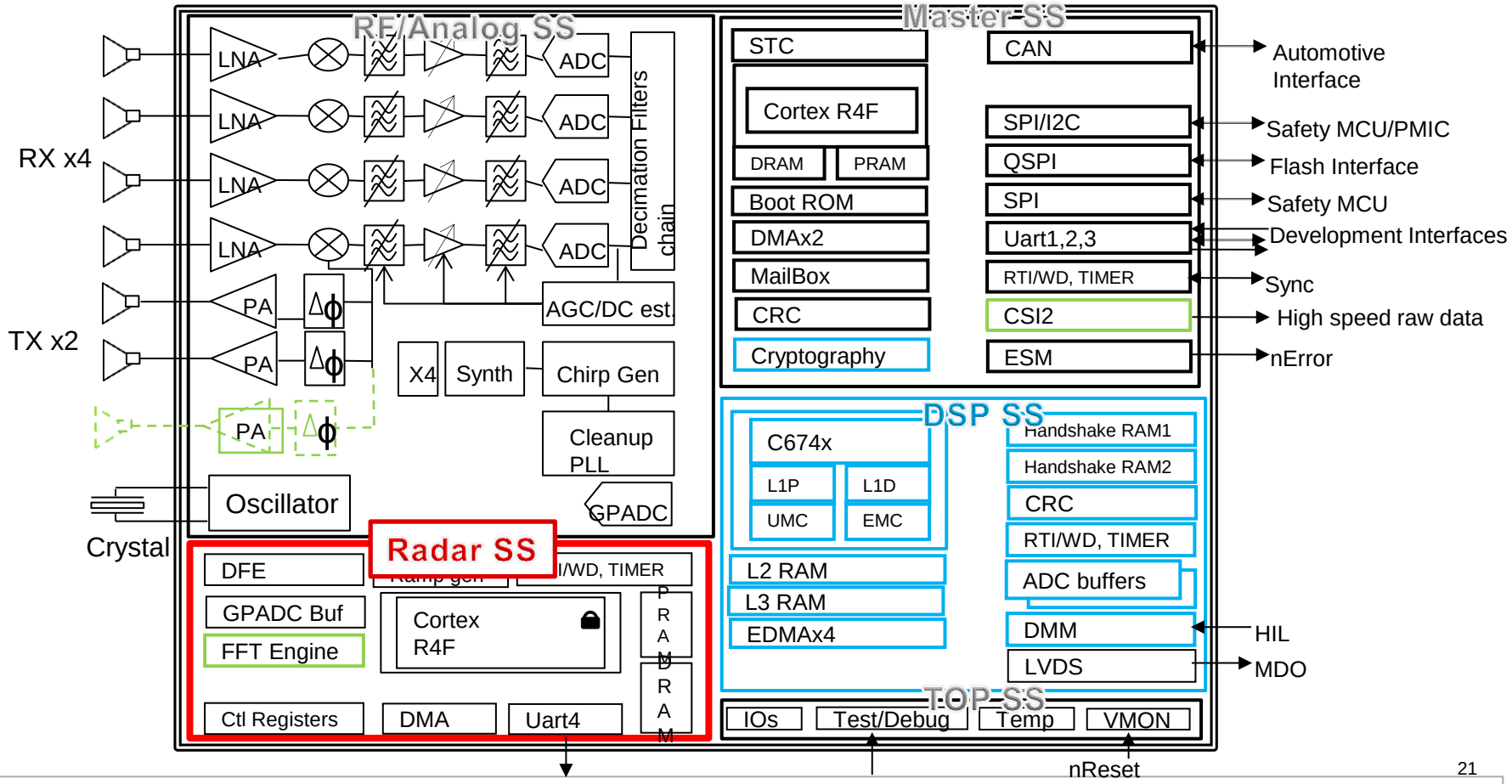
Block Diagram : IWR14xx/IWR16xx



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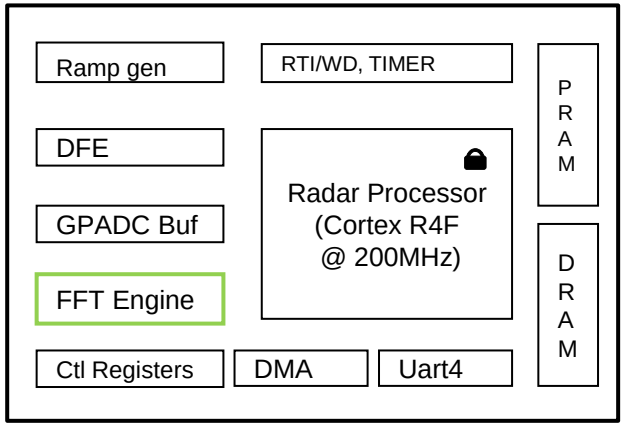
Radar Subsystem (BSS)

- Also known as the BSS, includes the DFE (digital front-end) and Ramp Generator
- Also 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



Radar Subsystem

Master Subsystem (MSS)

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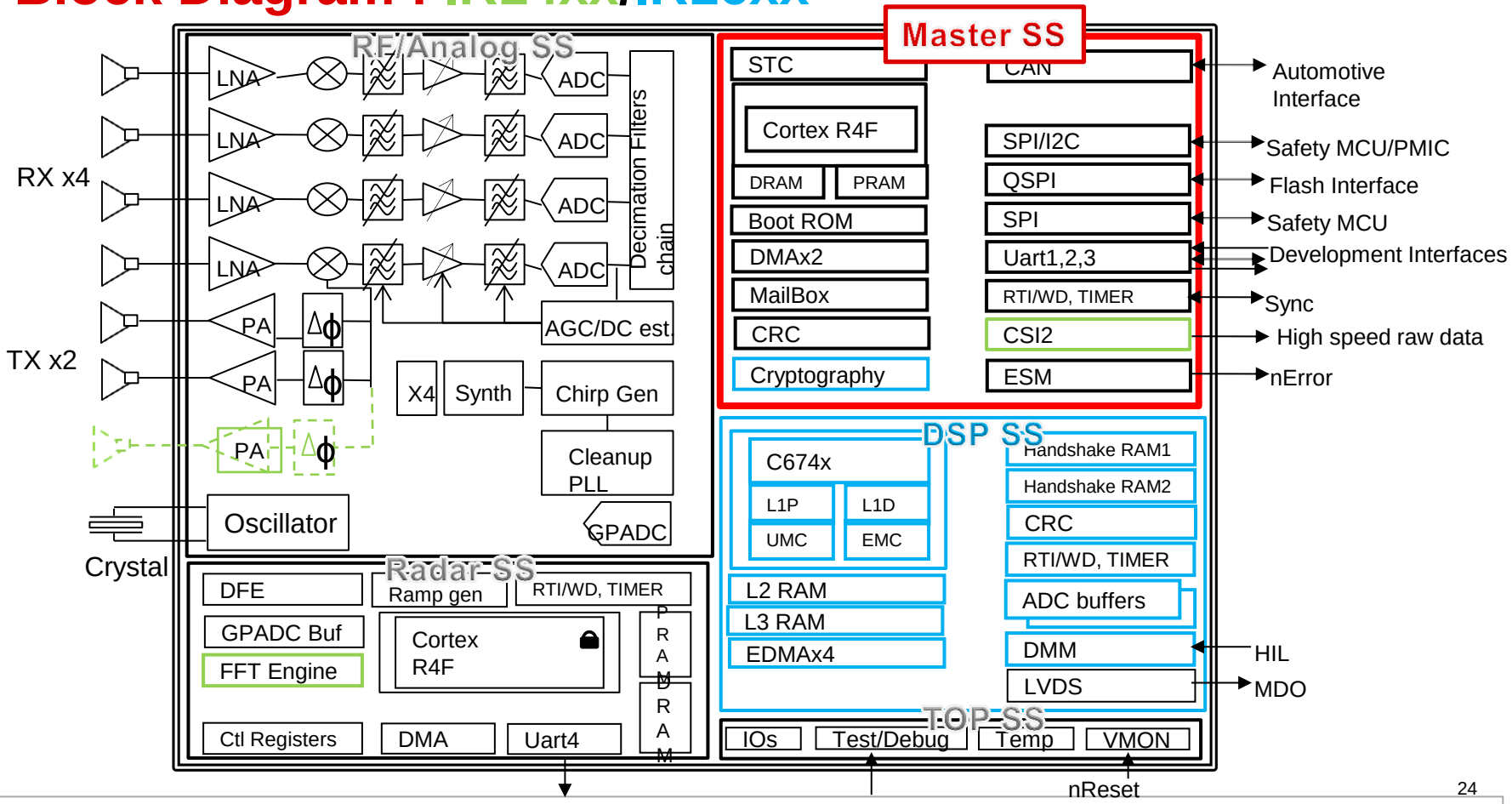
Block Diagram : IR14xx/IR16xx



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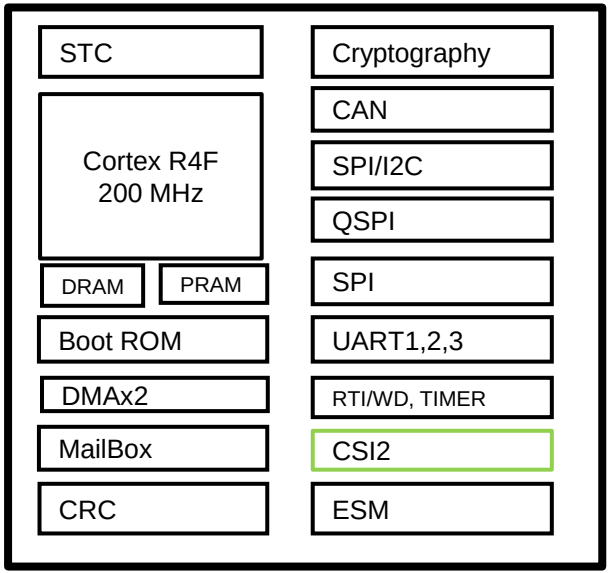
Master (Control) Subsystem

- 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.



Master Subsystem

DSP Subsystem (DSS)

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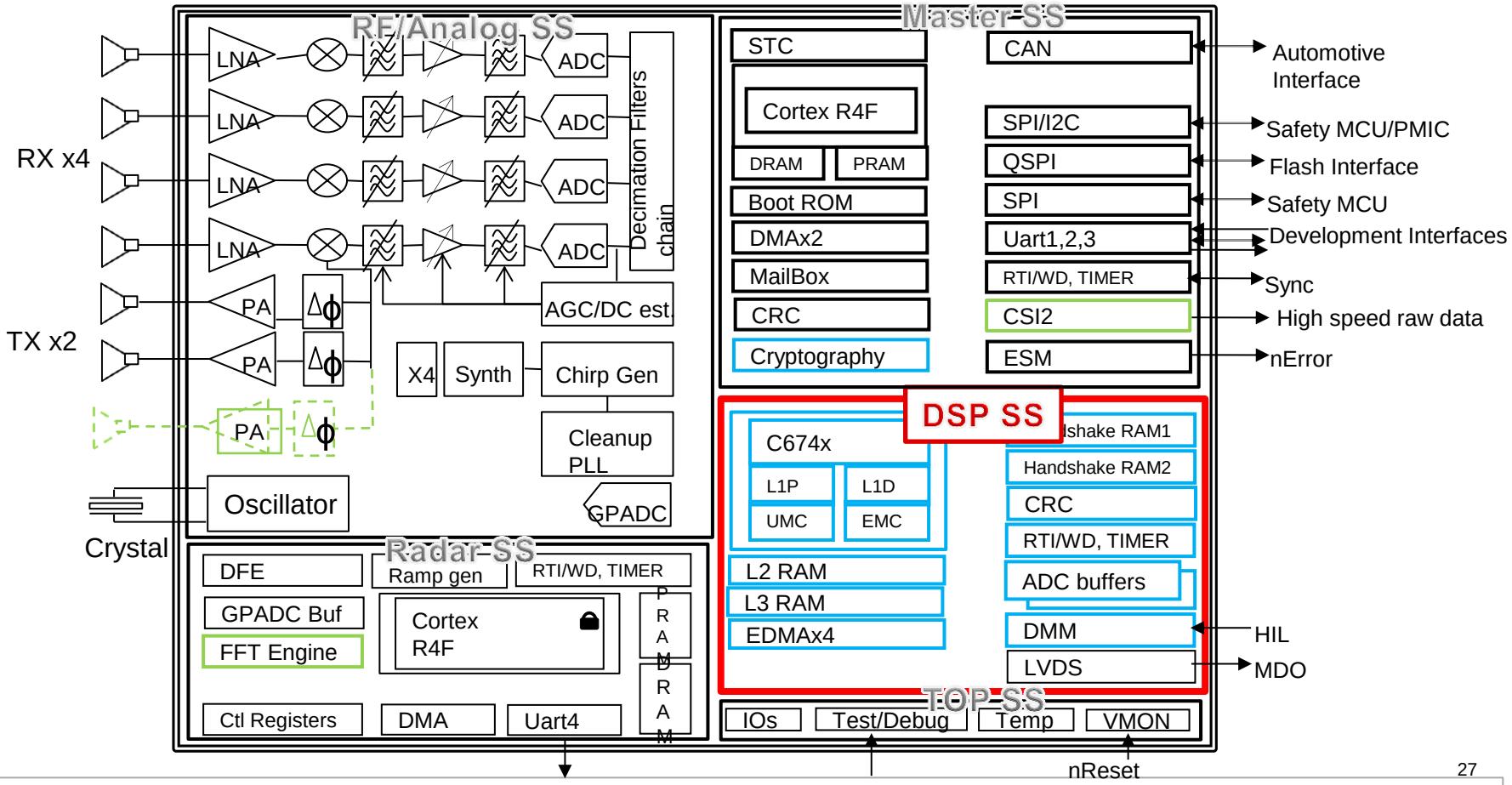
Block Diagram : IWR14xx/IWR16xx



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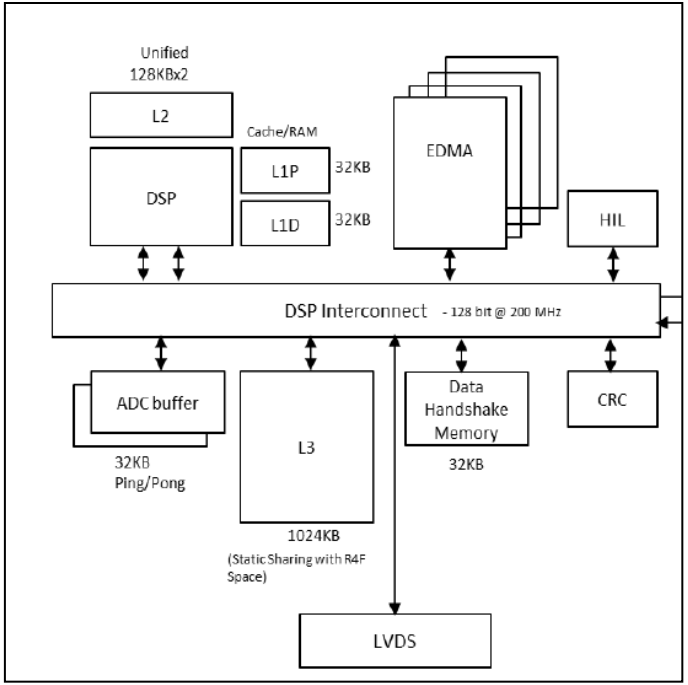
DSP Subsystem (DSS): IWR16xx only

- 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



DSP Subsystem (DSS)

Radar Hardware Accelerator

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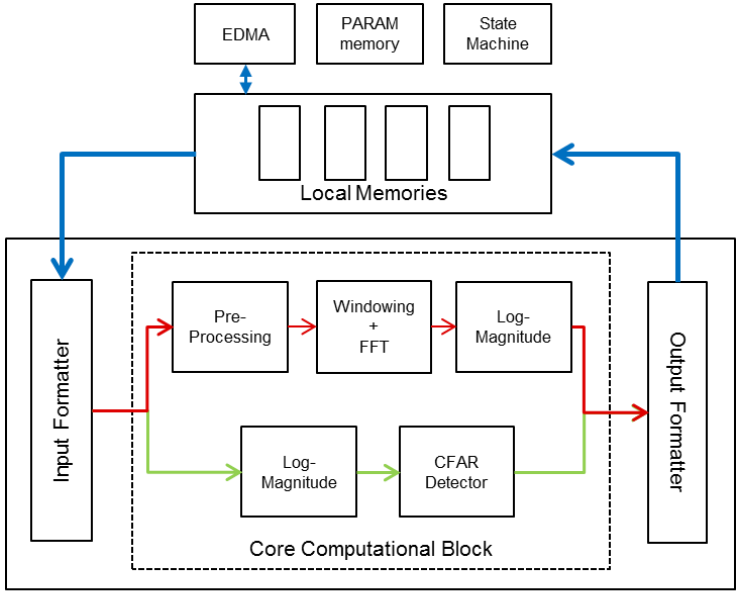
Radar Hardware Accelerator

- 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)



Radar Hardware Accelerator

Boot Modes

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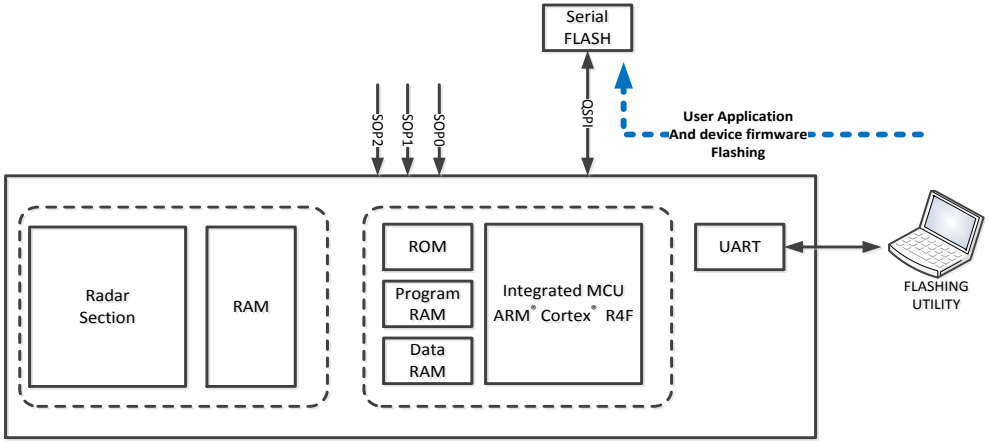
Boot Modes

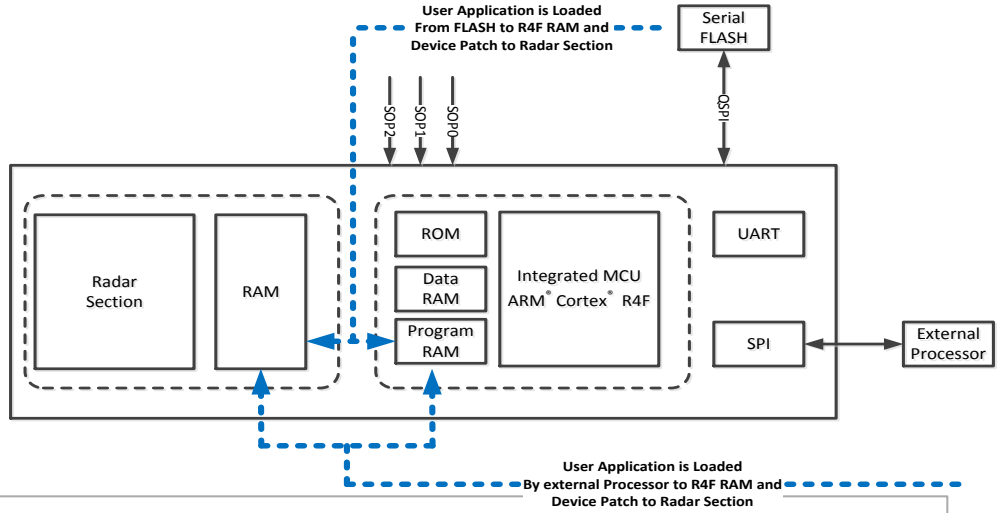


Flashing Mode:

- Bootloader enables the UART driver
- Expects a data stream comprising of User Application (Binary Image)
- Loads data to appropriate sections of the serial FLASH

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



Software Platform

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mmWave Software
Simplified evaluation and development

mmWave SDK

Includes:

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

mmWave Examples

- TI Designs:
  - Power-Optimized Field Transmitter
  - Traffic monitoring
- Examples:
  - mmWaveDemo (OOB)
- Labs:
  - Water Vs Ground Lab
  - Vital Sign Lab

mmWave Studio

Includes:

- 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

Simplified mmWave sensor configuration

- Generate mmWave sensor chirp configurations through system-level parameters to control [Range, Velocity, Angle] output
- mmWave OOB GUI for visualization of the output

Customer Inputs	
Maximum Range	Minimum Object Size
Minimum Range / Resolution	Frame Rate
Maximum Velocity	Sensitivity
Minimum Velocity / Resolution	Field of View
Device (IWR14x vs IWR16x)	Frequency Band

mmWave Studio →

Internal RF Chirp Configuration
Range FFT Size
Doppler FFT Size
Chirp Duration & Ramp Slope
Chirp Bandwidth
Chirp Ramp Slope
… +40 other parameters

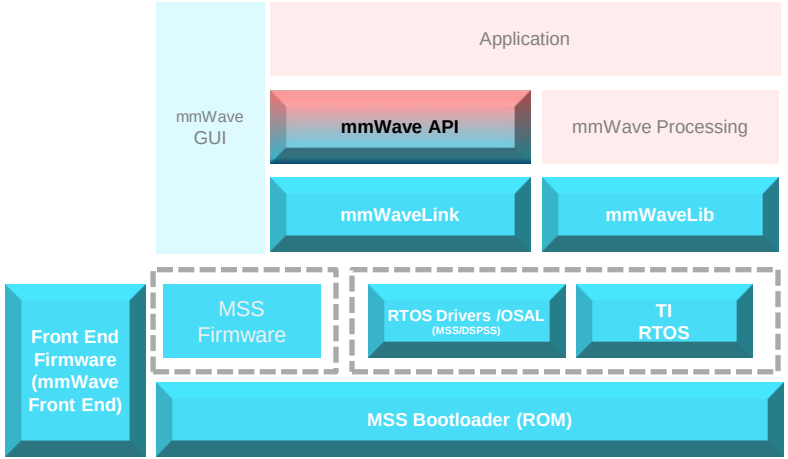
mmWave SDK – The TI components

TI code

Customer code

mmWave SDK

- Modular design
- Well defined APIs
- Documentation – doxygen, release notes, user guide
- MISRA-C compatibility for all foundational components
- Applicable for IWR1443/IWR1642



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
- Accelerate customer code development and reduce SW effort to achieve a working radar processing chain

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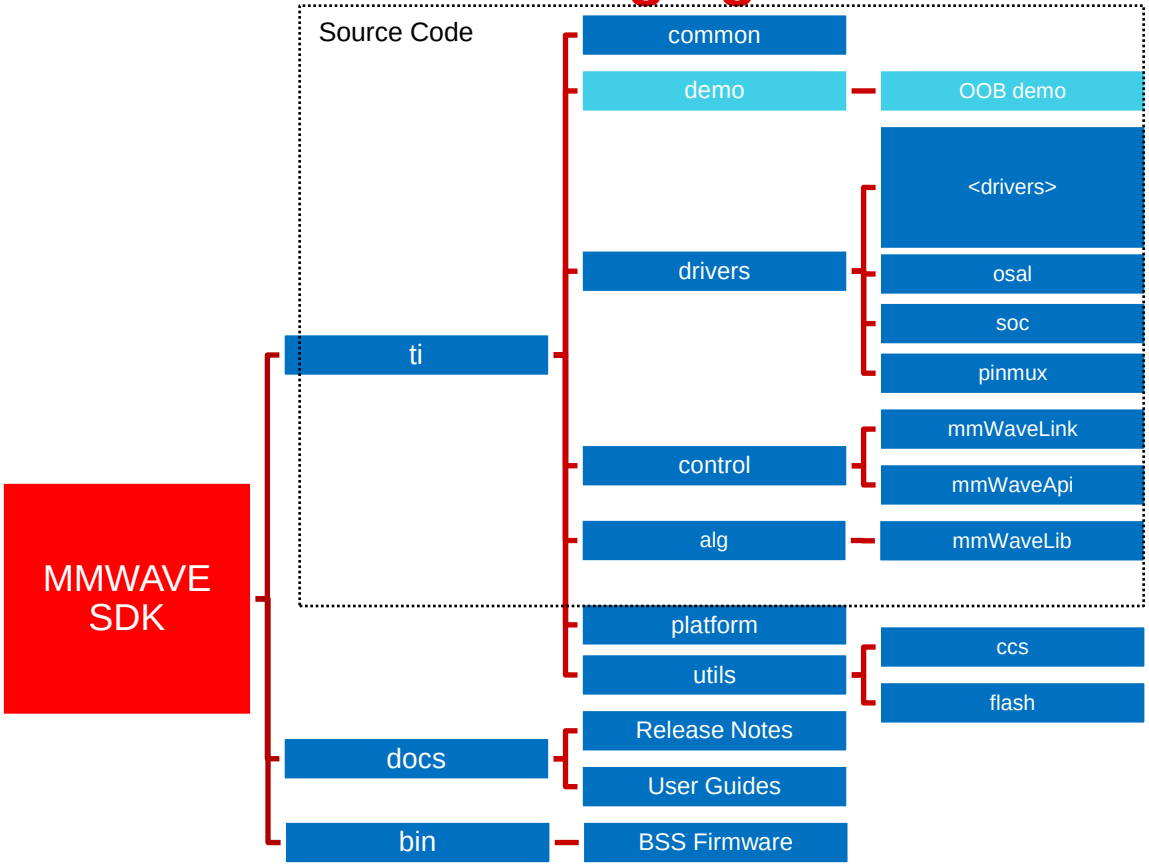
mmWave SDK - Packaging



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

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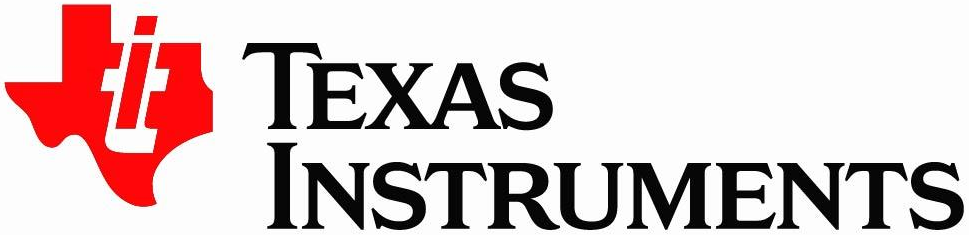
Learn more about Industrial mmWave Sensors

- Learn more about IWR1x devices, please visit the product pages
  - IWR1443: http://www.ti.com/product/IWR1443
  - IWR1642: http://www.ti.com/product/IWR1642
- Get started evaluating the platform with IWR1x EVMs, purchase EVM at
  - IWR1443 EVM: http://www.ti.com/tool/IWR1443BOOST
  - IWR1642 EVM: http://www.ti.com/tool/IWR1642BOOST
- Download mmWave SDK @ http://www.ti.com/tool/MMWAVE-SDK
- Ask question on TI's E2E forum @ http://e2e.ti.com



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