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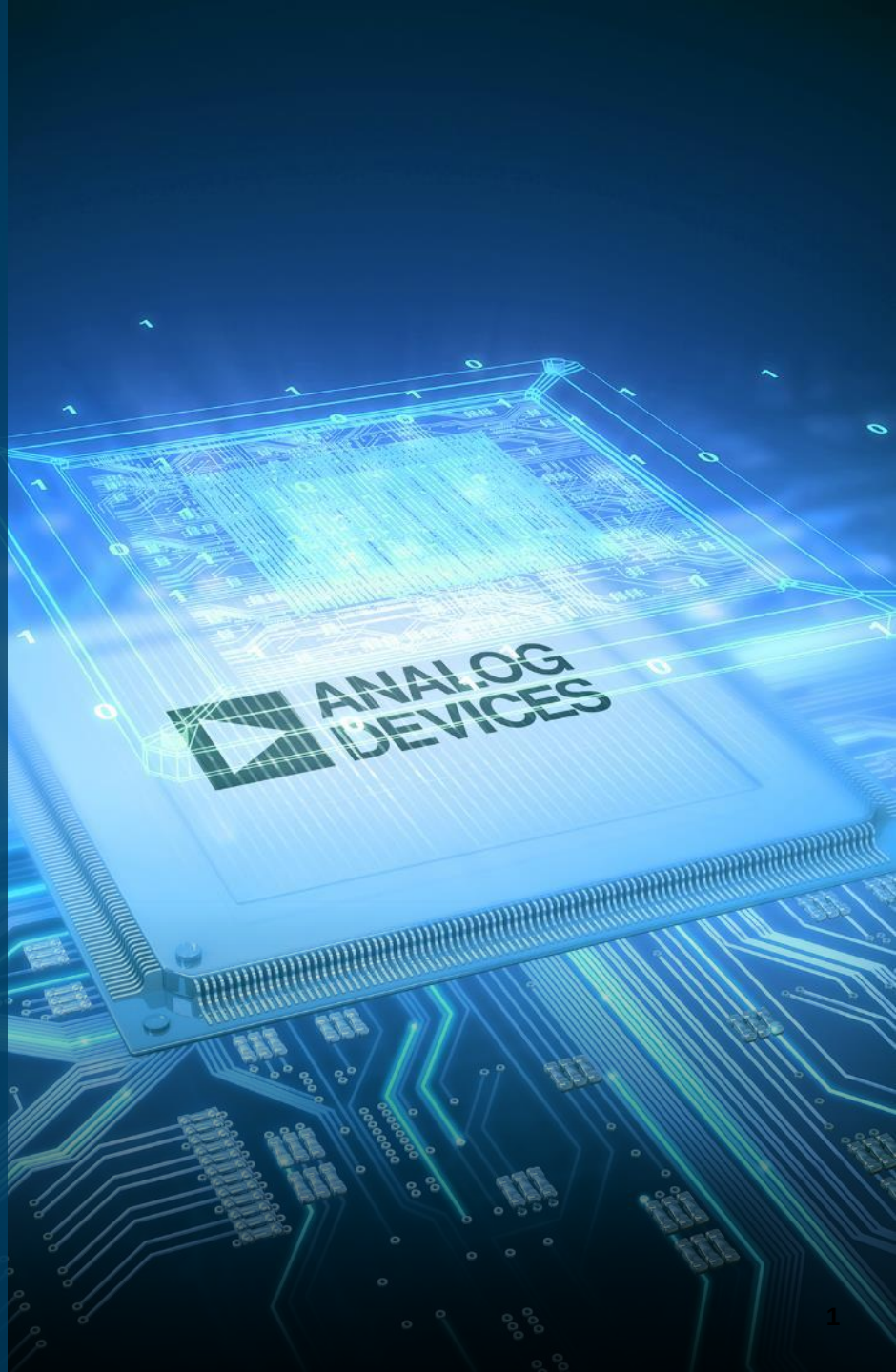
DemoRad Platform

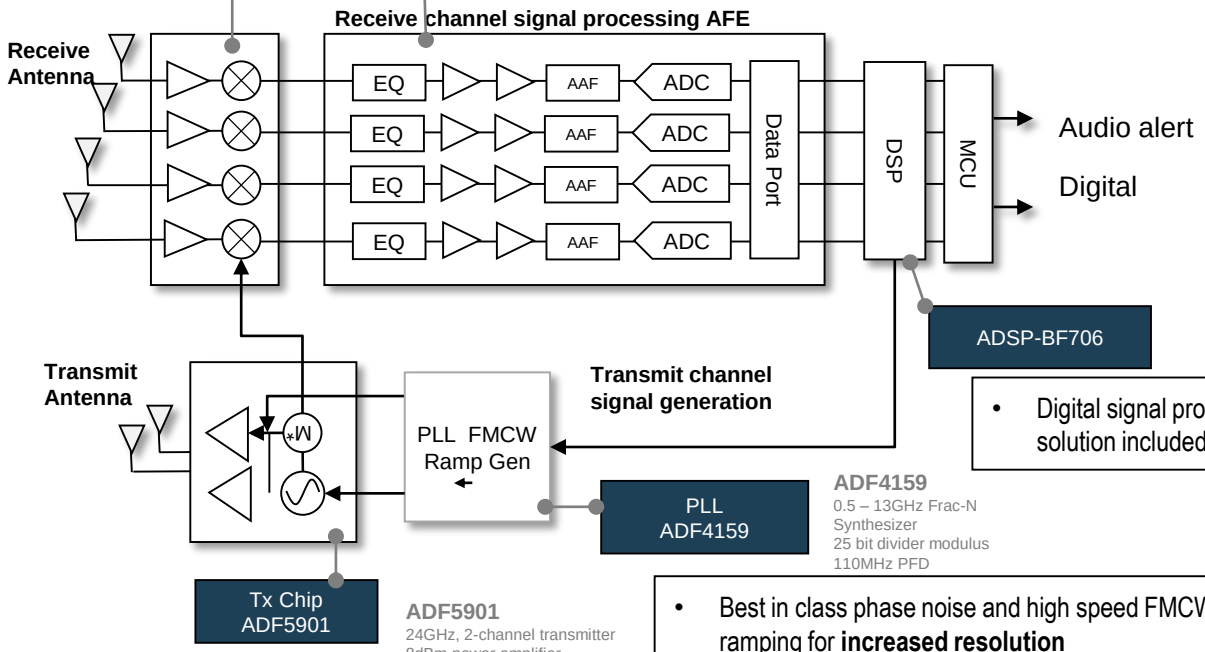


24GHz ISM Multi-channel Radar Signal Chain Solution

Complete RADAR Solution

ADF5904
24GHz, 4-channel Rx Downconverter
SPI programmable
Integrated temperature sensor
LO power detector

ADAR7251
Analog baseband (AFE)
Low speed ramps
1.2MHz input BW
16-bit, 2.4MSPS (per channel)



ADF4159
0.5 – 13GHz Frac-N Synthesizer
25 bit divider modulus
110MHz PFD

ADF5901
24GHz, 2-channel transmitter
8dBm power amplifier
-85dBc/Hz @ 100kHz VCO
-105dBc/Hz @ 1MHz VCO

Architecture Benefits

- Multi channel architecture allows: beam forming for better field of view and angle resolution
- Provides spatial flexibility
- Simplifies design architecture with integration
- ISM band allows worldwide application without restrictions

ADI Value

- Full signal chain solution
  - Analog front end
  - Mixed signal solution
  - Digital baseband
- Higher integration simplifies design and reduces time to market
- Wider field of view with multiple channels
- Separate Tx and Rx modules to provide flexibility in spatial design
- Better noise and linearity resulting in **greater effective range** and **accuracy**

- Digital signal processing solution included

- Best in class phase noise and high speed FMCW ramping for **increased resolution**

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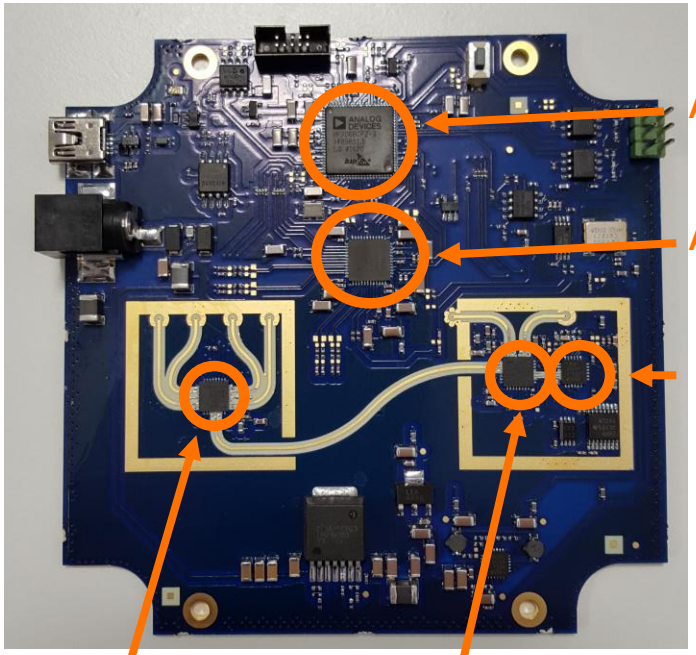
DemoRad
(4Rx, 2Tx, USB Interface)

- 4RX2TX(MIMO) Radar + ADI-DSP digital baseband

Single Board



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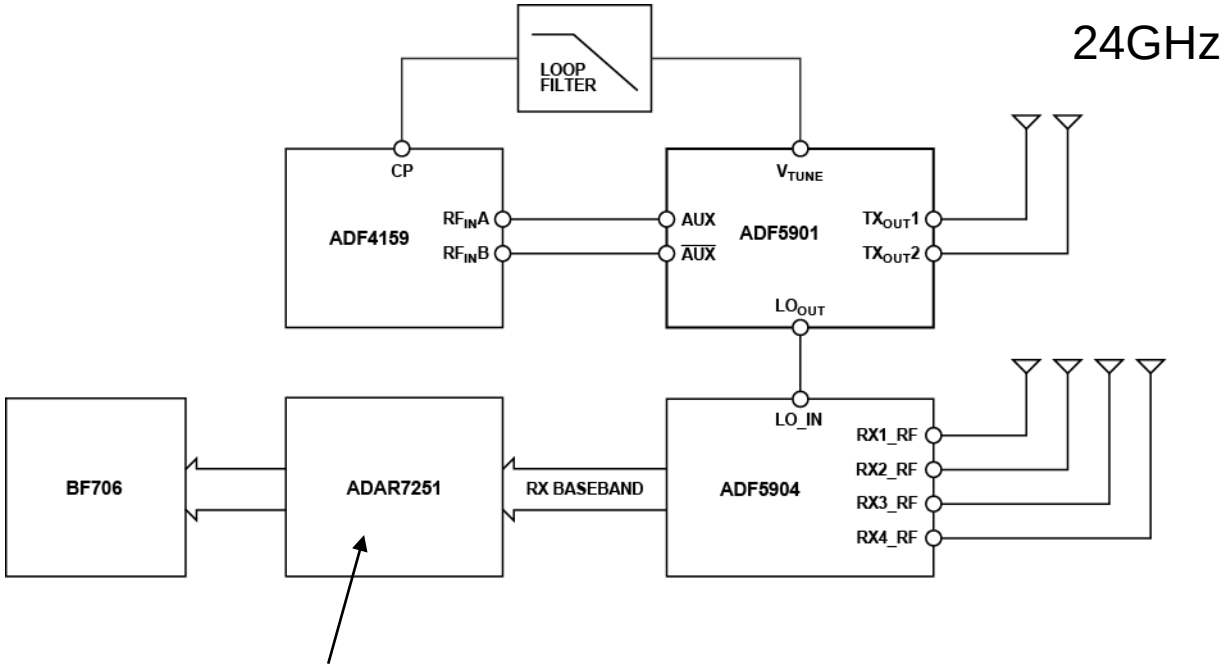
DemoRad Simplified Block Diagram

2Tx : 4 Rx radar configuration with BF DSP baseband processing –

Medium or Low Speed Ramp FMCW capability



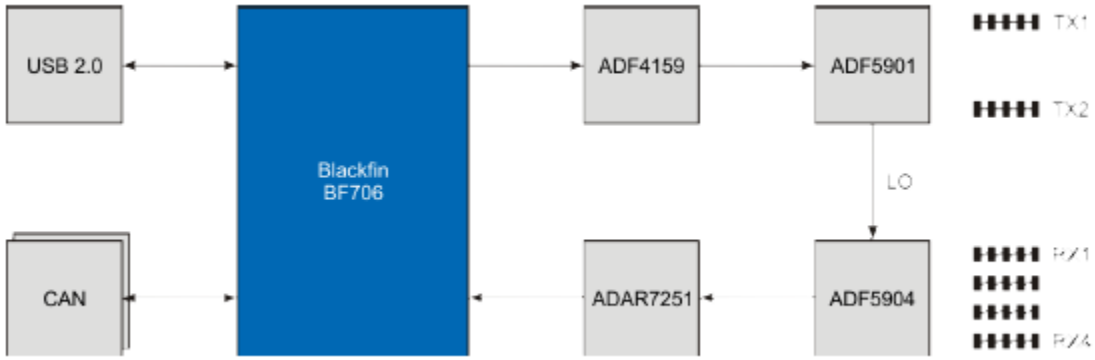
Multi-channel 16bit 1.8MSPS ADC radar converter

DemoRad

DemoRad is a standalone radar system with a 24GHz MIMO FMCW frontend featuring two transmit (TX), four receive (RX) channels, ADC, and a Blackfin DSP from Analog Devices. The system is mainly designed for range-Doppler and MIMO radar applications and the DSP enables real-time signal processing capabilities. The antenna arrangement is chosen to support a uniform virtual array with a spacing of half the wavelength. When using both TX antennas 7 virtual elements can be generated with two virtual element overlapping in order to implement motion compensation algorithms. The main features of the 24GHz radar system include

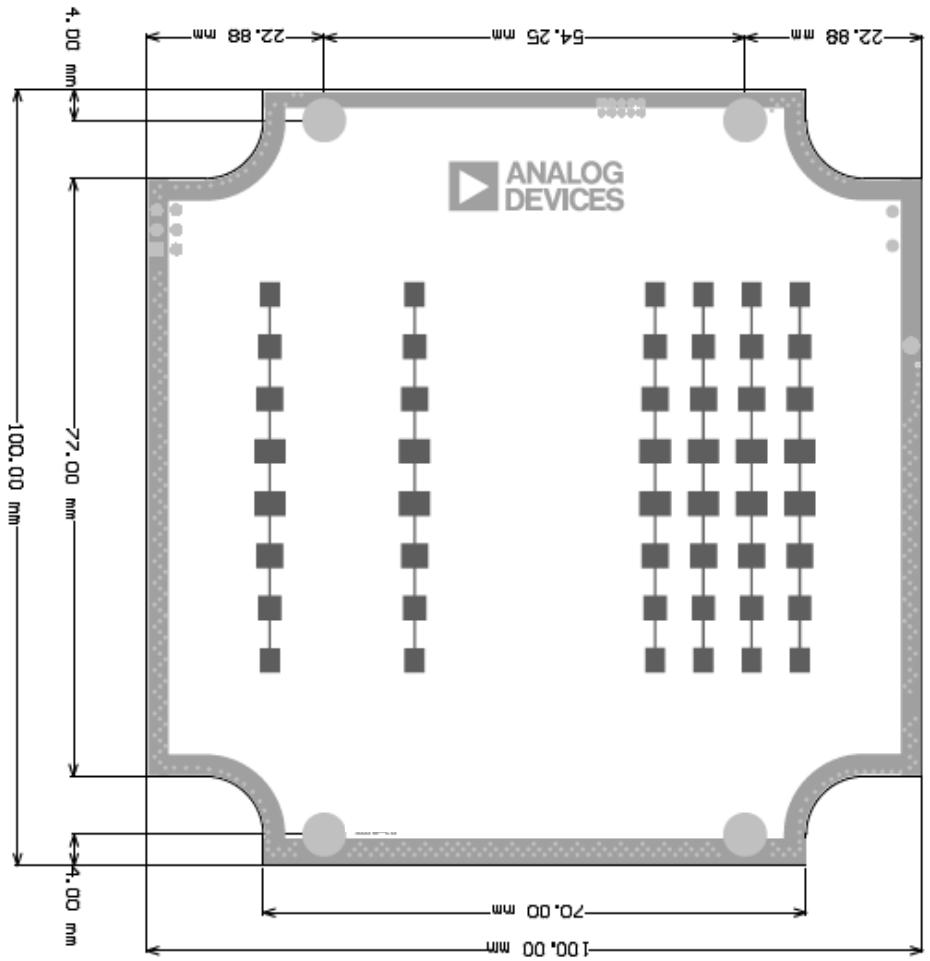
- 24GHz ISM band operation
- Sampling rate up to 1.2 MSPS per IF channel
- Ramp Synchronous sampling
- Freely programmable FMCW timing
- MIMO processing with arbitrary antenna activation
- Real-time signal processing on the Blackfin DSP
- USB 2.0 interface for communication.

Block Diagram



A Blackfin BF706 DSP is used to control the RF frontend and to process the measured radar signals of the receive channels. An ADF5901 dual-channel transmitter in conjunction with the frequency-synthesizer ADF4159 is used to generate the FMCW transmit signal. The two TX antennas (TX1, TX2) are fed from the ADF5901 transmitter whereas the receive path of the frontend is realized with a ADF5904 quad-channel receiver. An ADAR7251 analog frontend is used to amplify and sample the measured IF signals of the receiver. Thereafter, the signals are processed in the DSP and the results can be accessed with a USB 2.0 interface. The entire board including the power supply is designed on a single PCB with a total size of 100 mm x 100 mm.

Mechanical Data



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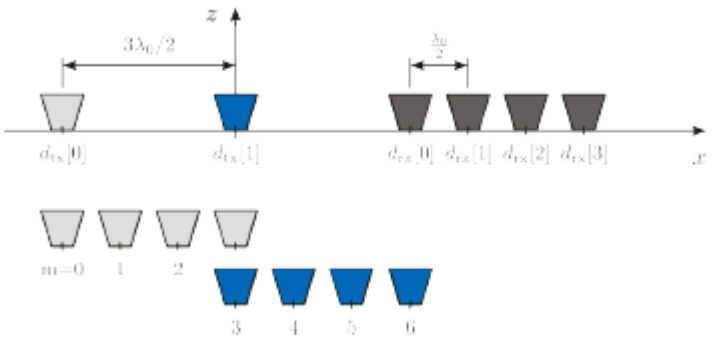
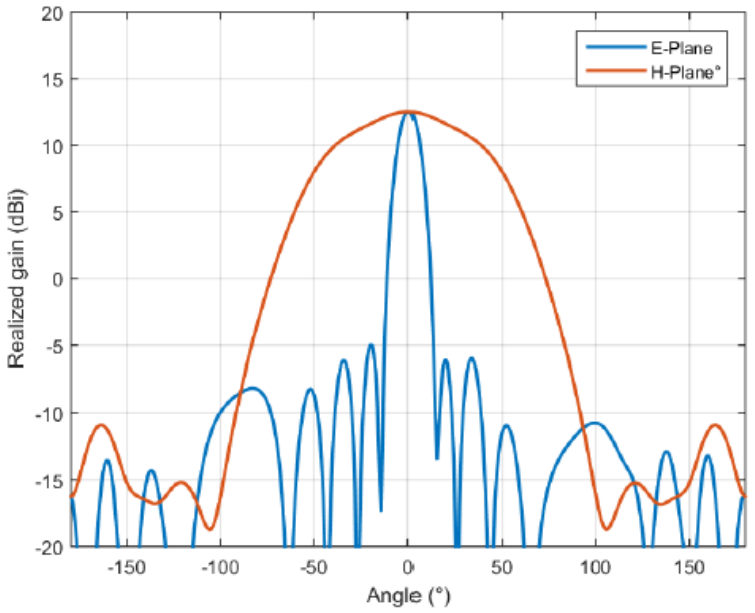
Antenna

The serial fed patch antennas feature eight elements with an amplitude taper and are fed from the backside of the PCB. The antennas are fabricated on a Rogers 4350 substrate.

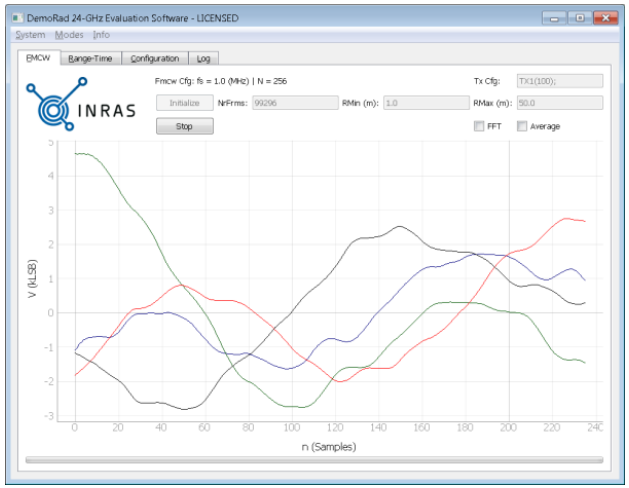


Antenna arrangement with virtual antenna positions.

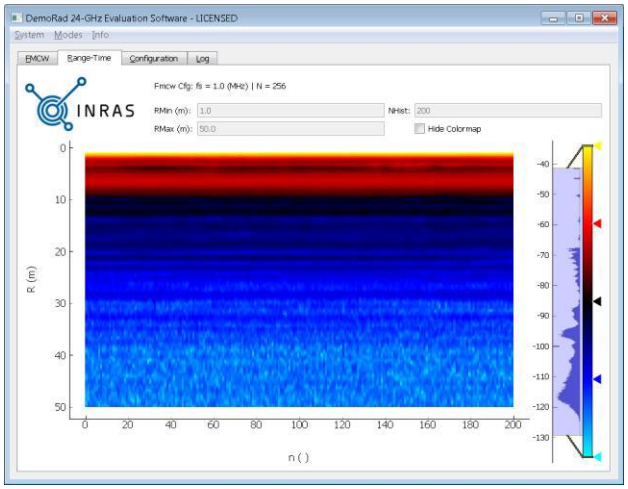


Parameter		Value
G	Realized Gain	13.2 dBi
ΔS	Sidelobe suppression	-18 dB
Θ_H	Horizontal 3 dB beamwidth	76.5°
Θ_V	Vertical 3 dB beamwidth	12.8°

DemoRad GUI FMCW Mode



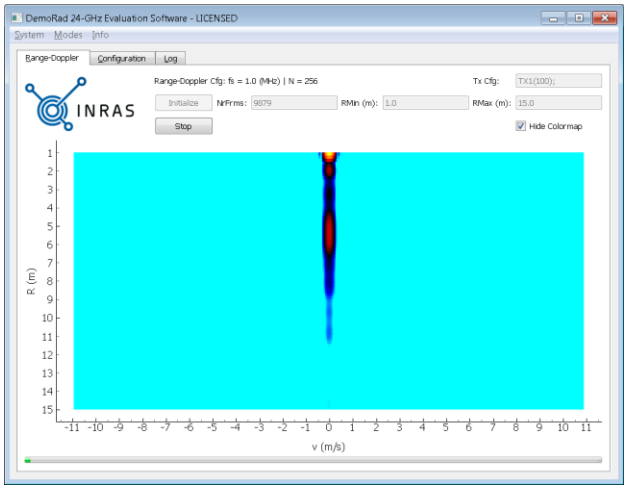
Raw Data



Range Data over time

In FMCW mode the distance to stationary targets can be measured. The frequency of the down converted Rx signal for a target is proportional to the distance to the target. In the GUI FFT processing can be done to determine the frequency. Using the Range-Time display option makes it possible to view moving targets, the display stores a number of FMCW sweeps.

DemoRad GUI Range Doppler Mode

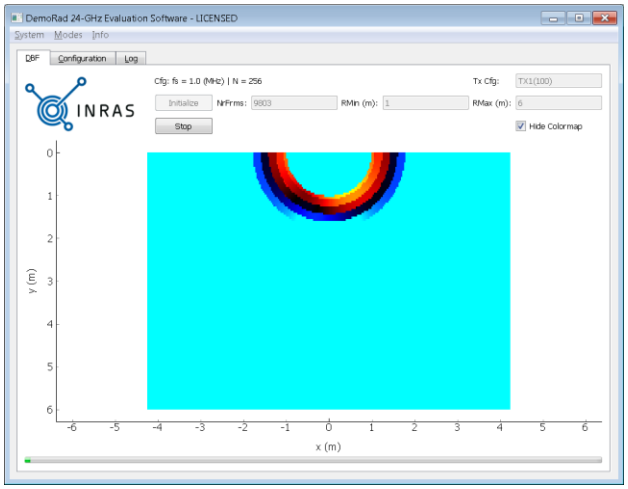


Range and velocity of target

In Range-Doppler mode the range to the targets as well as the speed can be analyzed. Range-Doppler mode is one of the most powerful modes of operation. Range-Doppler processes multiple up chirps simultaneously by evaluating a two-dimensional Fourier transform. The Range-Doppler processed data is displayed in the Range-Doppler map.

Range Doppler is powerful in that it allows to separation of targets with different velocities even if they are located at the same distance. This is useful to resolve complicated traffic scenarios with cars moving in opposite directions or during overtaking manoeuvres.

DemoRad GUI Digital Beam Forming Mode



Distance and angle of target

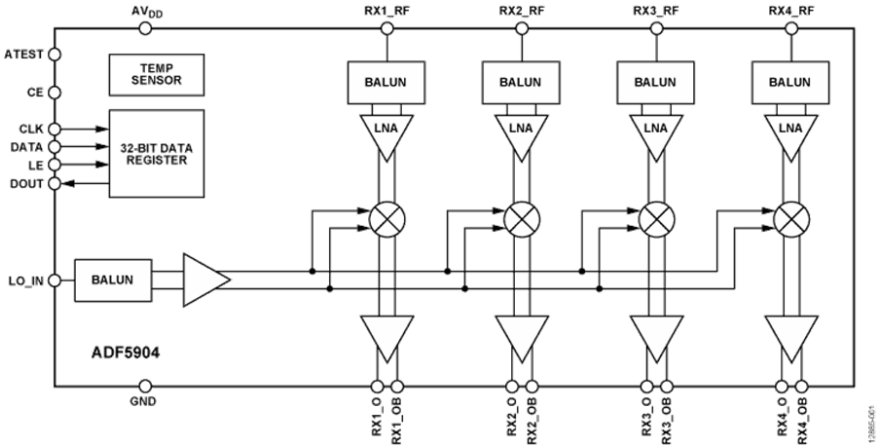
In DBF mode the distance and the angle to the target are displayed. For this reason the receive signals from the four Rx receive antennas are used to estimate the angle of the target. The display shows spatial distribution of targets in the xy-plane. In DBF mode the system is configured the same as FMCW mode with the difference in the processing of the IF signals. After calculating the range the angle of target is calculated by evaluating the phase differences between the receive channels. In DBF mode a calibration radar frontend is required to eliminate unwanted deterministic phase variations between the receive channels. Each Demorad comes with calibration data that is loads when the GUI is run and the sampled IF signals are corrected before evaluating the data.

ADF5904: 4 Channel Receiver

Rx MMIC for 24GHz FMCW Radar Applications

Key Specifications

- Rx channel gain: 22 dB
- Integrated baluns for single-ended receiver (Rx) inputs and local oscillator (LO) input
- Noise figure of 10 dB
- P1dB: −10 dBm
- LO input range: −8 dBm to +5 dBm
- Rx to IF isolation: 30 dB
- RF signal bandwidth: 250 MHz
- Rx output impedance: 900 Ω differential
- LO input buffer: 24 GHz
- RF and LO S11 at 50 Ω: −5 dB
- Temperature sensor with analog output: ±5°
- Electrostatic discharge (ESD) performance
  - Human body model (HBM): 2000 V
  - Charged device model (CDM): 500 V
- Qualified for automotive applications



Key Benefits

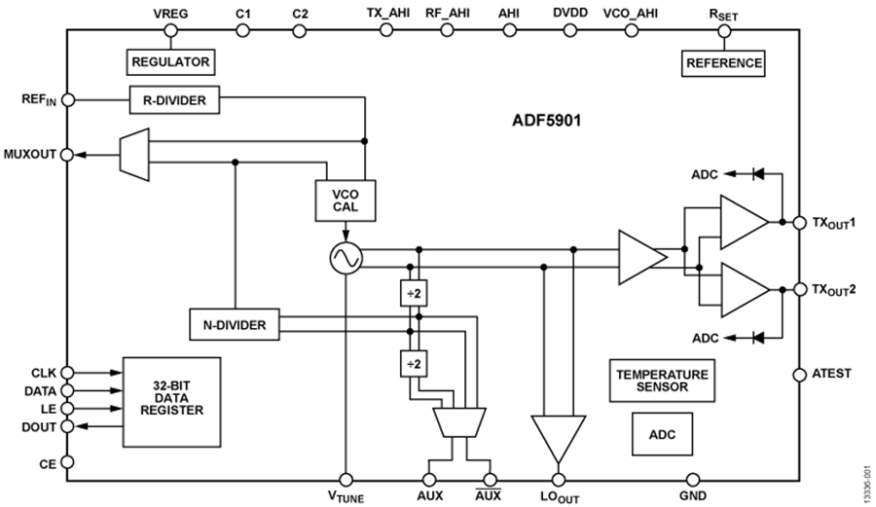
- Highest performance and integration level for 24GHz multichannel receiver in the industry
- Lower total cost of ownership for Rx:
  - Highly integrated design eliminates the need for discrete
  - Small size sensors using 4 channels in single chip
  - Lower power consumption
  - Ease of adoption and use
- Increased reliability using built in test capability

ADF5901: 2 Channel Transmitter and VCO

Tx MMIC for 24GHz FMCW Radar applications

Key Specifications

- 24GHz VCO with 2 channel power amplifier output
  - 24 GHz to 24.25 GHz voltage controlled oscillator (VCO)
  - 2-channel 24 GHz power amplifier with 8 dBm output
  - Single-ended outputs
  - 2-channel muxed outputs with mute function
  - Programmable output power of -5dB to +8dB in 1dB steps
  - N divider output (frequency discriminator)
  - 24 GHz local oscillator (LO) output buffer
  - 250 MHz signal bandwidth
  - VCO Phase noise:
    - -85dBc/Hz @ 100kHz offset
    - -105dBc/Hz @ 1MHz offset
- Power control detector
- Auxiliary 8-bit ADC
- ±5°C integrated temperature sensor
- Programmable SPI interface
- Single supply operation at -3.3V
- 170mA current @ 3.3V: 560mW @ 100% duty cycle
- Operating temperature range of -40C to +105c
- 32 lead, 5mm x 5mm LFCSP



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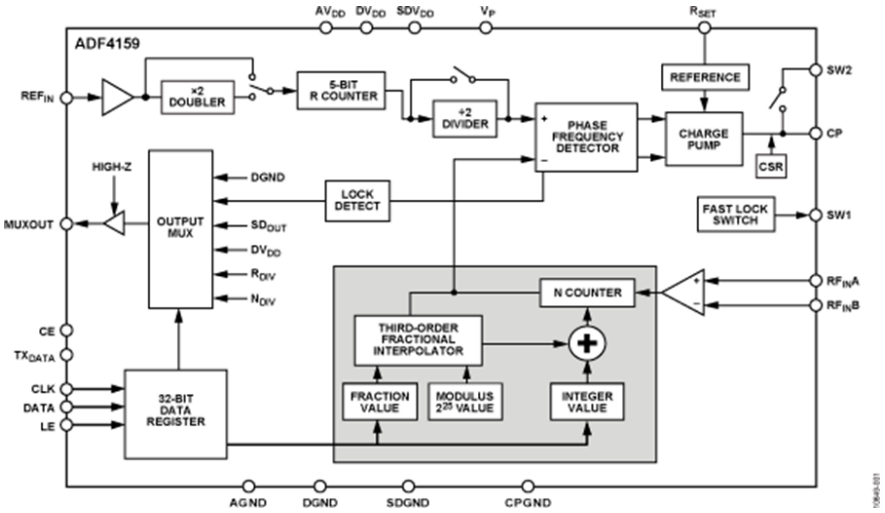
ADF4159: Direct Modulation/ Waveform Generating 13GHz Fractional-N Frequency Synthesizer

PLL with ramp function for 24GHz FMCW Radar applications

Key Specifications

- 500MHz – 13GHz range
- 25 bit divider modulus
  - Sub-1Hz frequency resolution
- 110MHz PFD maximum frequency
- Normalized phase noise floor of -224dBc/Hz
- Programmable phase control
- 2.7V to 3.45V analog power supply
- 1.8V digital power supply
- Programmable charge pump currents
- 3-wire programmable serial interface
- Digital lock detect
- FSK and PSK modulation capabilities
- Supports fast ramps
- Ramp delay, frequency reed back and interrupt functions
- Generates highly linear saw tooth and triangular waveforms
- Cycle slip reduction for fast lock times
- ESD performance: 3000V HBM, 1000V CDM
- Qualified for automotive applications
- 24-LFCSP (4mm x 4mm) package



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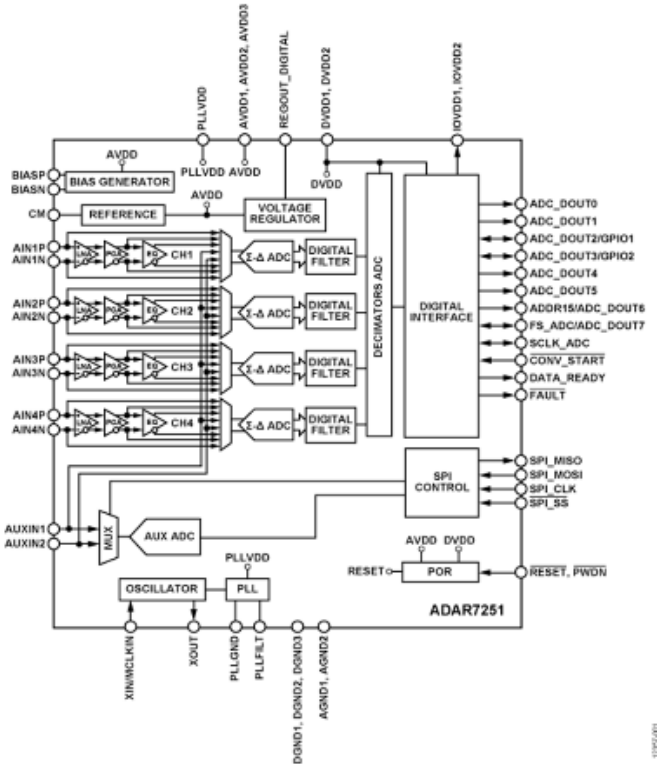
ADAR7251 – 4ch Low Speed Ramp AFE Continuous Time Sigma Delta

Key Specifications

- Low noise: 2.4 nV/√Hz input referred voltage noise at maximum gain setting
- Wide input signal bandwidth: 500 kHz at 1.2 MSPS sample rate, 16-bit resolution
- Additional sample rates supported: 300 kSPS, 450 kSPS, 600 kSPS, 900 kSPS, and 1.8 MSPS
- 4 differential simultaneous sampling channels
- No active antialiasing filter required
- LNA and PGA with 45 dB gain range in 6 dB steps
- Selectable equalizer
- Flexible data port supports serial or parallel mode
- Supports FSK mode for FMCW radar systems
- On-chip 1.5 V reference
- Internal oscillator/PLL input: 16 MHz to 54 MHz High speed serial data interface



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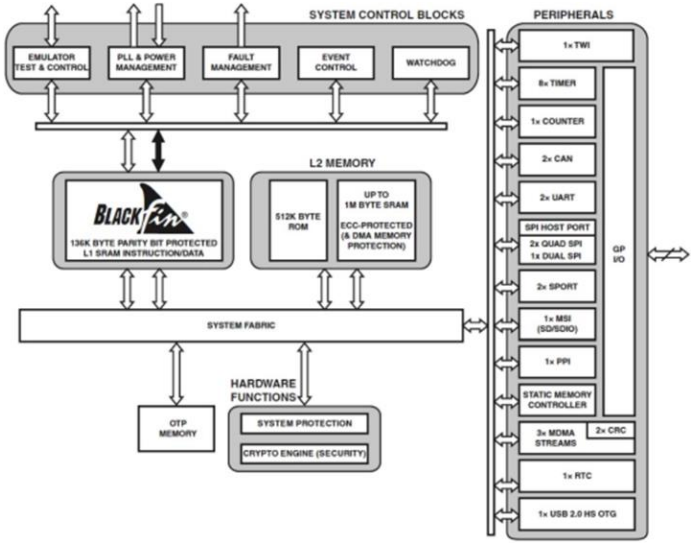
ADSP-BF706 Blackfin DSP

Low Power 400MHz Blackfin+ Embedded Processor with 1MByte L2 SRAM

Key Specifications

- Blackfin+ core with up to 400 MHz performance
  - Dual 16-bit or single 32-bit MAC support per cycle
  - 16-bit complex MAC and many other instruction set enhancements
  - Instruction set compatible with previous Blackfin products
- On-Chip Memory
  - 136KB L1 SRAM with multi-parity-bit protection (64KB instruction, 64KB data, 8KB scratchpad)
  - 1MByte on-chip L2 SRAM with ECC protection
  - 512KByte On-chip L2 ROM
- Key Peripherals include
  - USB2.0 HS OTG
  - 2x CAN2.0B
  - ePPI Video I/O
  - 2x SPORTs (w/I2S)
  - 2xQuad-SPI / 1xDual-SPI (w/ Host mode option)
  - I2C
  - 2xUART
  - SD/SDIO/MMC (4-bit)
- Security and one-time-programmable memory
  - Crypto hardware accelerators for fast secure boot/IP protection memDMA encryption/decryption for fast run-time security
- Low-cost packaging
  - 88-Lead LFCSP (QFN) package (12 mm × 12mm), RoHS compliant
- Low system power with < 100 mW at 400 MHz (< 0.25 mW/MHz) at 25°C $T_{JUNCTION}$



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