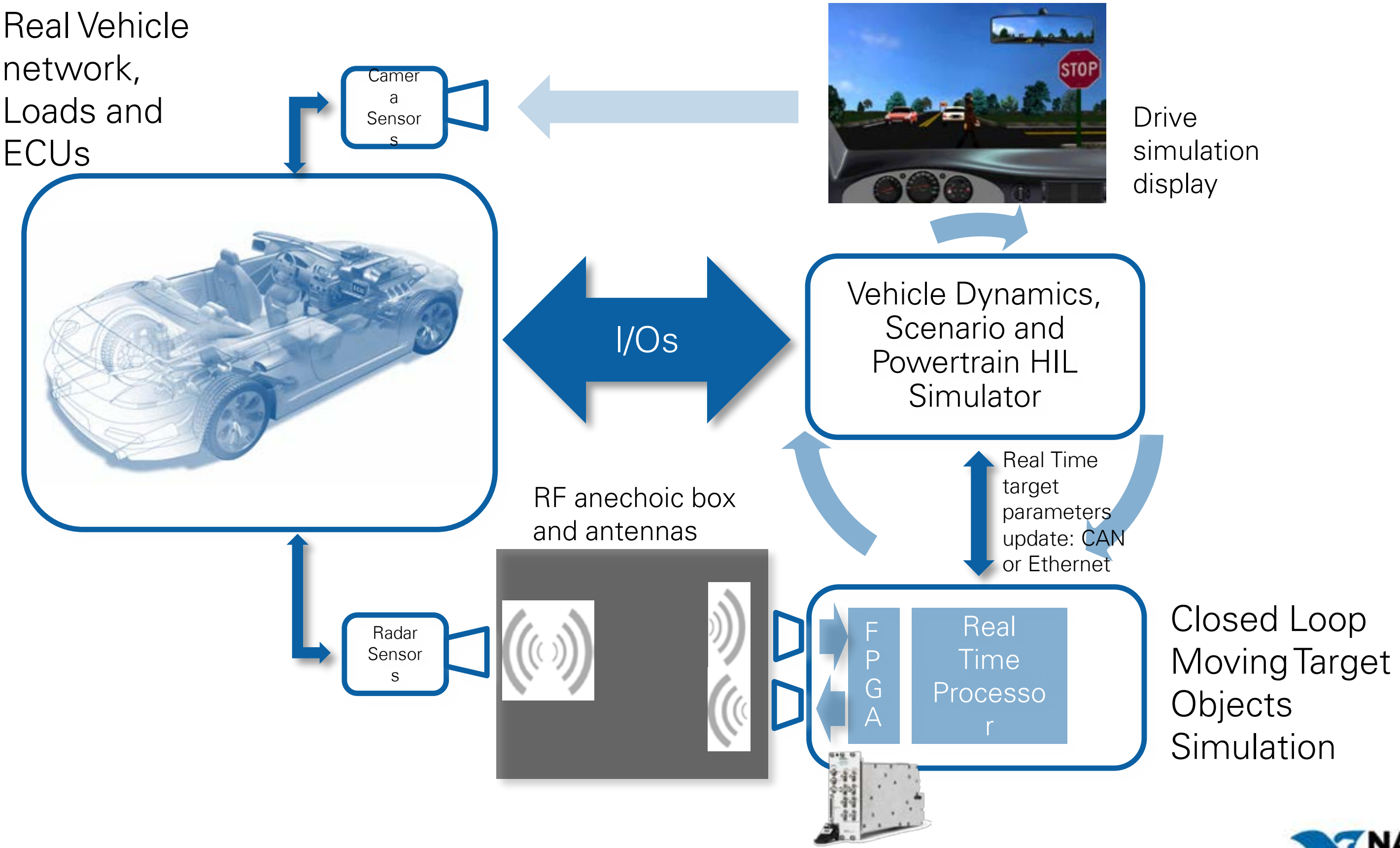
Audi 사례로 알아보는, 자율주행 자동차 ADAS 테스트

정호민 부장 - Automotive Business Development Manager(NI)
Abhay Samant – Group Manager of RF Instruments(NI)
Joachim Glaess – Account Manager(Konrad Technologies)

Auto pilot accident : Tesla S -> really safe?

NATIONAL INSTRUMENTS™

Hardware in the Loop ADAS Validation



CarMaker/HIL on National Instruments Hardware

Fusion of leading technologies

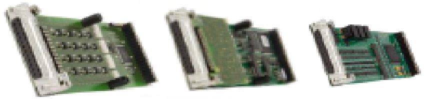
CarMaker Platform

PXI Platform

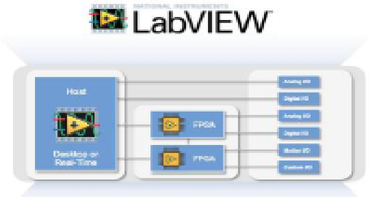
- NI PXI or NI PXIe realtime system, running Phar Lap ETS (NI ETS) operating system
- LabVIEW Real-Time Module
- LabWindows/CVI Run-Time Engine for RT
- NI-CAN for direct CAN Access
- NI-XNET
- NI-VISA for IPG HW and USB access

IPG HW for NI

- FPGA-based IPG M-Module
- Full PXI compatible
- Customized FPGA for Automotive
- Sensor Simulation
- Camera Simulation

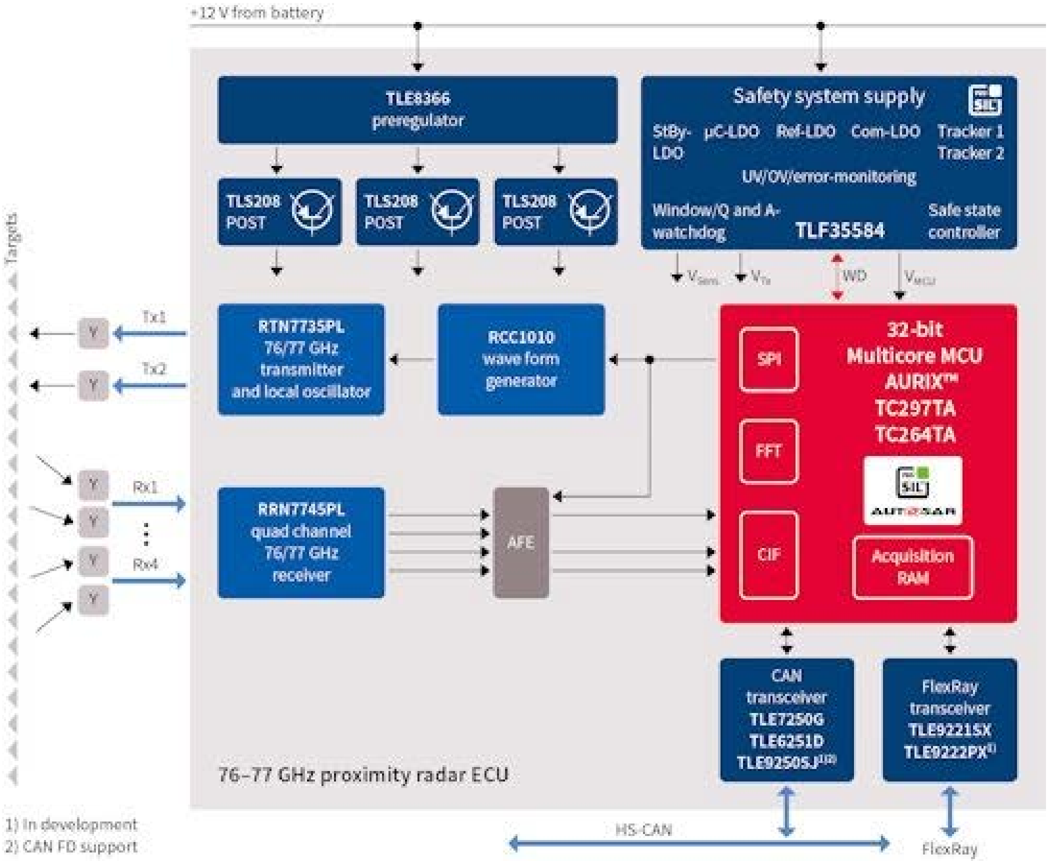


Supported NI SW



- LabVIEW 2014

- VeriStand 2014
- NI VeriStand Engine



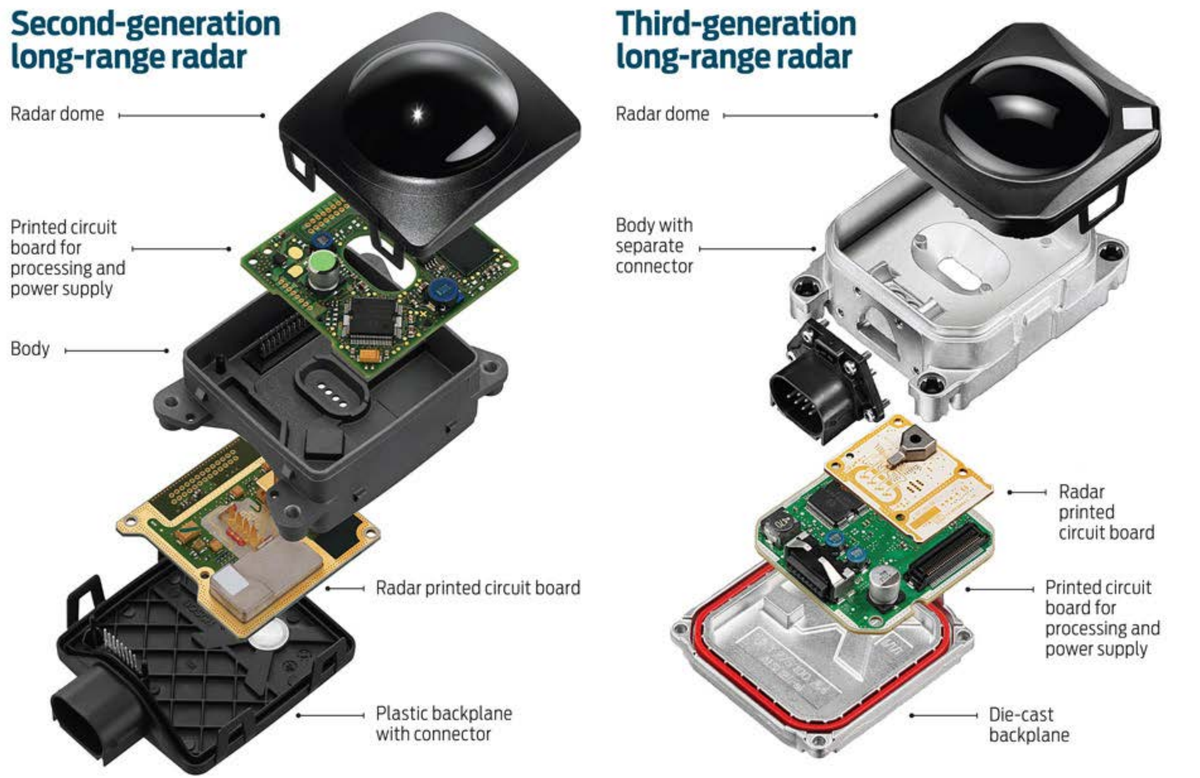
Ref : http://www.infineon.com/

NATIONAL INSTRUMENTS

New development Automotive Radar

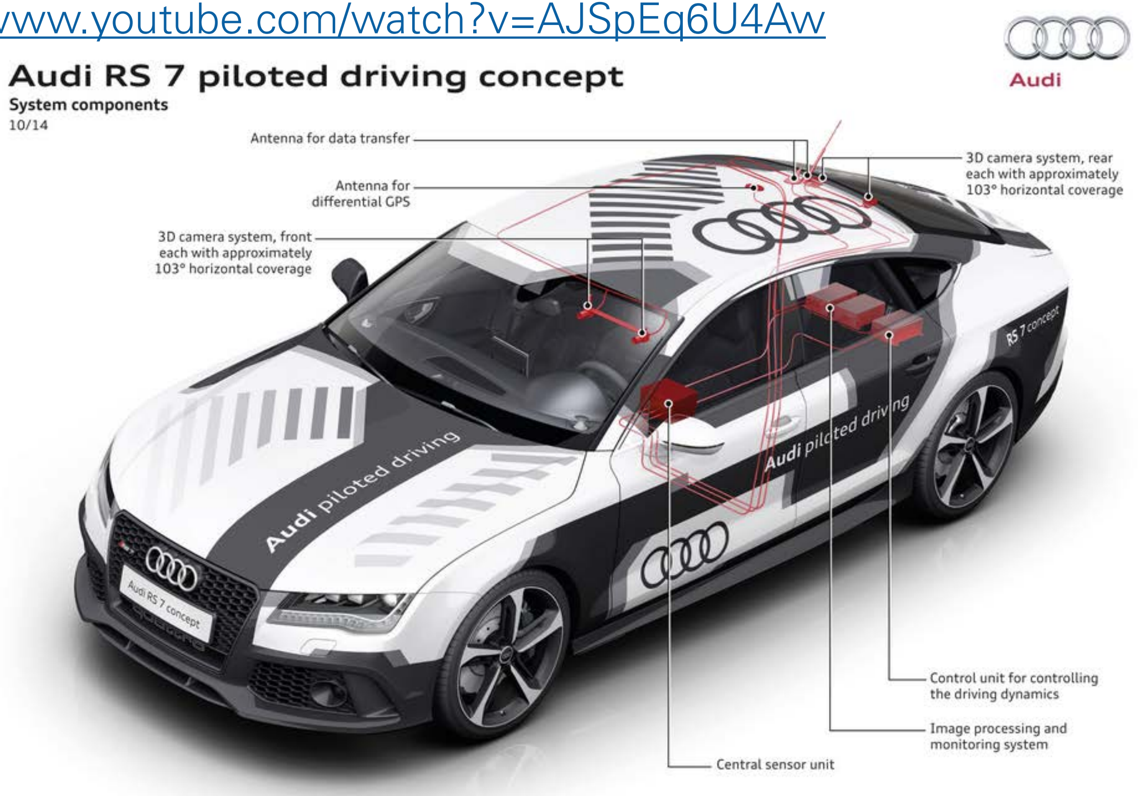
HOW to test rightly?

EVOLUTION OF A RADAR Bosch's latest long-range system greatly simplifies the radar's printed circuit board. Instead of a handful of gallium arsenide chips to generate, amplify, and detect the 77-gigahertz microwaves, the system uses just one or two (as shown) of Infineon's silicon germanium chips.



Audi & Konrad

- Audi Radar case - https://www.youtube.com/watch?v=AJSpEq6U4Aw



Radar basic concept & test (30 min)
- NI . RF product marketing , Abhay Samant

Konard Radar simulator(20min)
- German test expert company , Joachim Glaess

Radar concept & test

Abhay Samant – Group Manager of RF Instruments(NI)

Automotive Applications

ADAS	Communications	Infotainment	PowerTrain	Chassis and Body
Short Distance Radar	802.11p	GPS, GLONASS	Engine	Doors
Long Distance Radar	DSRC	AM,FM,RDS DVB, DAB	Transmission	Light
Camera	E-Call	Bluetooth	HEV/EV	Steering
LIDAR	WiFi	NFC	…	…
Ultrasonic sensors	Future 5G Technologies	WPC		

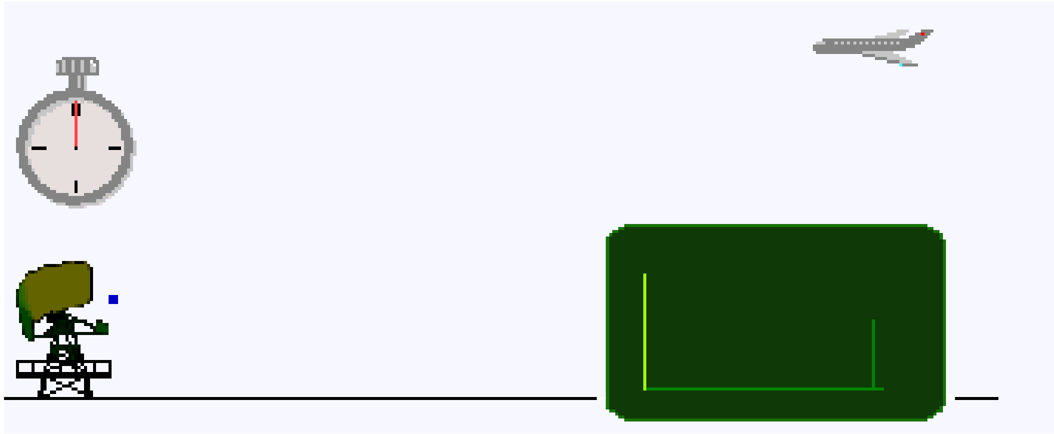
Embedded Software

Principles of Radar

- RAdio Detection And Ranging
- Uses radio waves (~3kHz/100km– 300GHz/1mm)
- Can determine range, angle, velocity
- Active (emits energy) or passive (uses available energy)
- Applications:
  - Air traffic control
  - Missile defense
  - Astronomy
  - Weather monitoring
  - Automotive

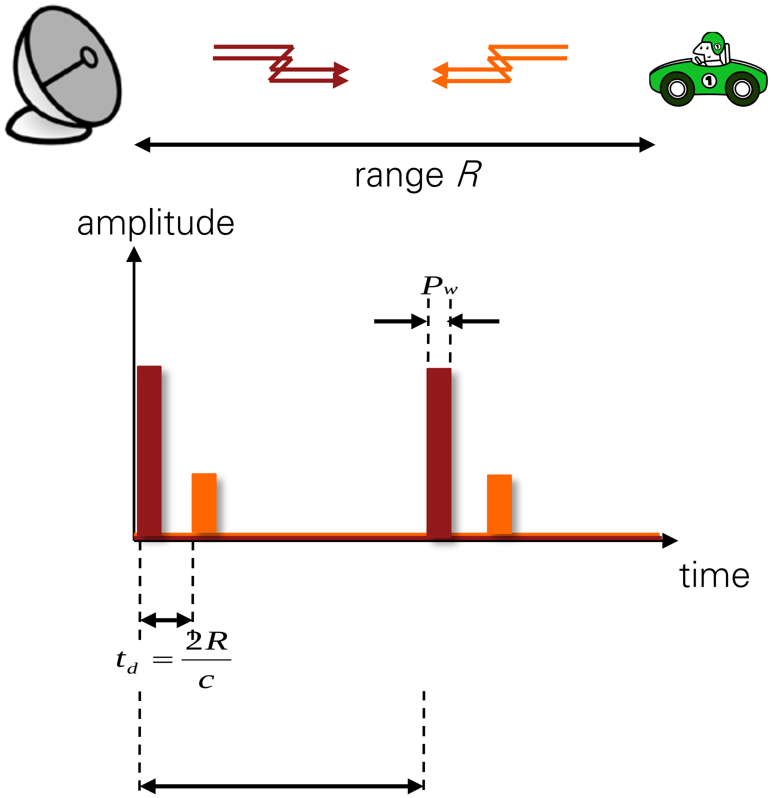
Principles of pulsed radar

- Emit a pulse, wait for a return reflection



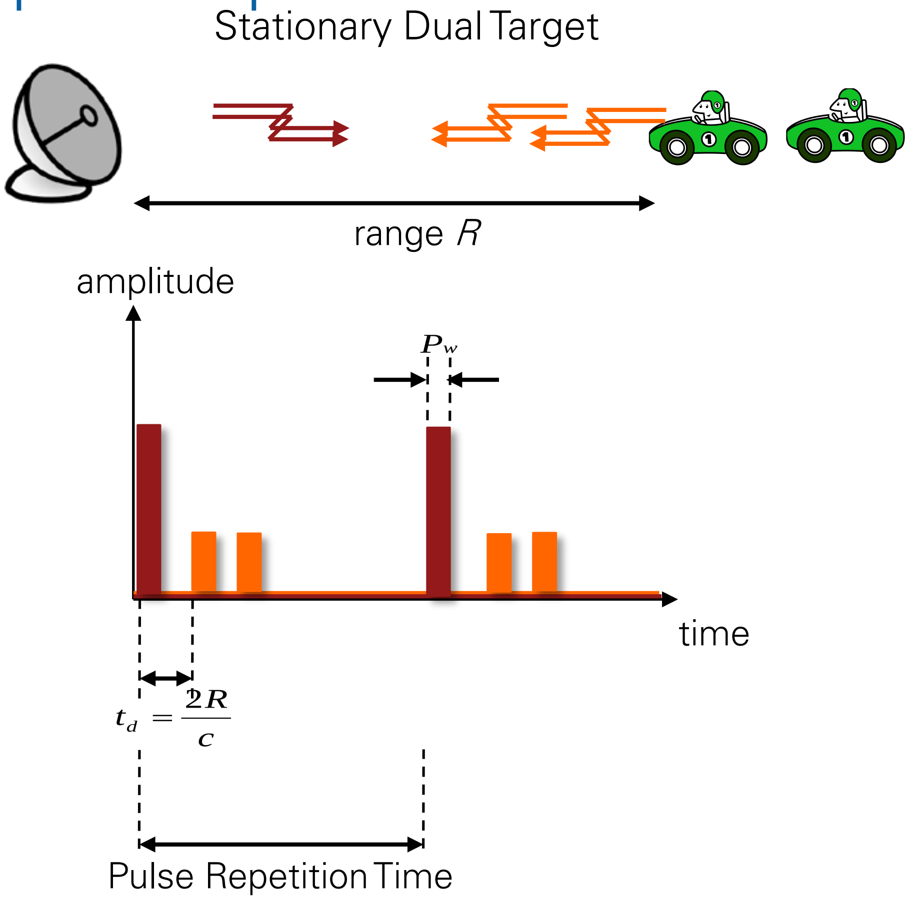
Principles of pulsed radar

Stationary Single Target

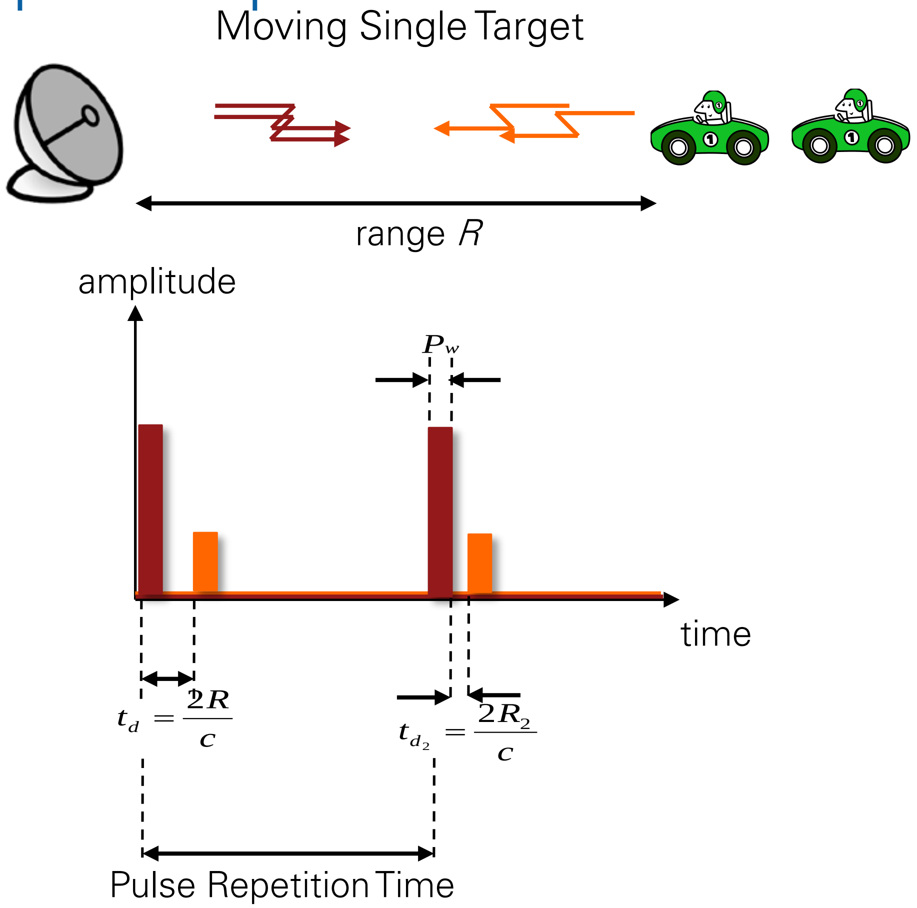


NATIONAL INSTRUMENTS

Principles of pulsed radar



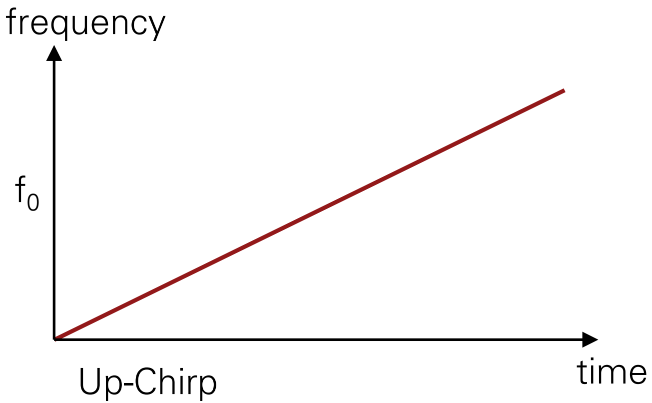
Principles of pulsed radar



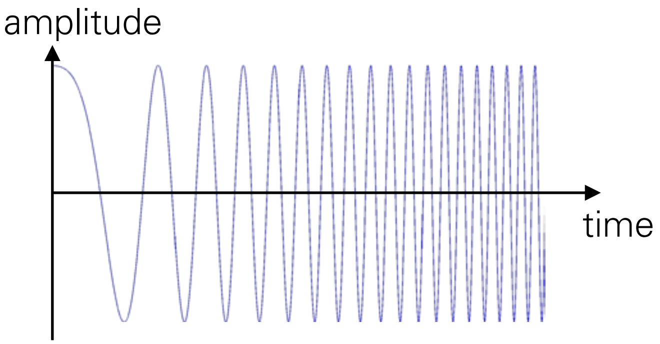
Principles of FMCW radar

frequency-modulated continuous-wave

(IEEE Std. 686-2008):
A radar transmitting a continuous carrier
modulated by a periodic function such as a sinusoid or sawtooth wave

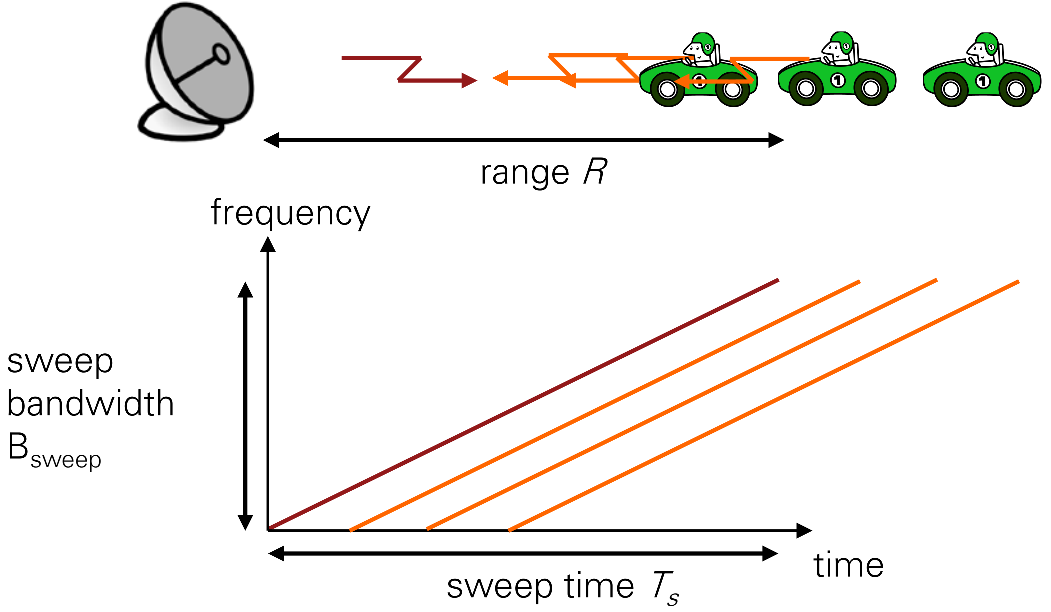


Up-Chirp
(modulated with a triangle wave)



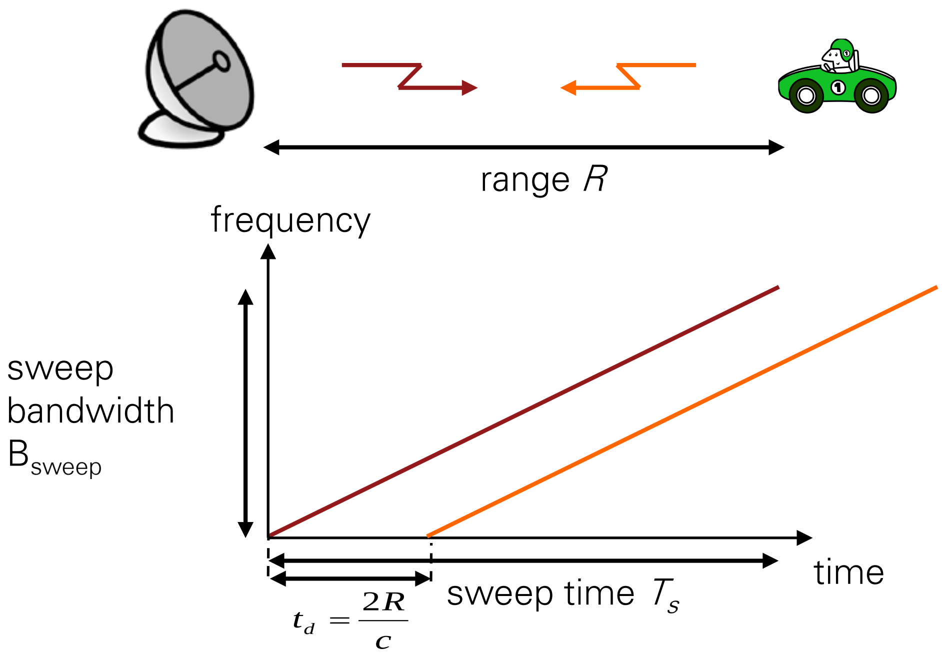
Principles of FMCW radar

Stationary Single Target



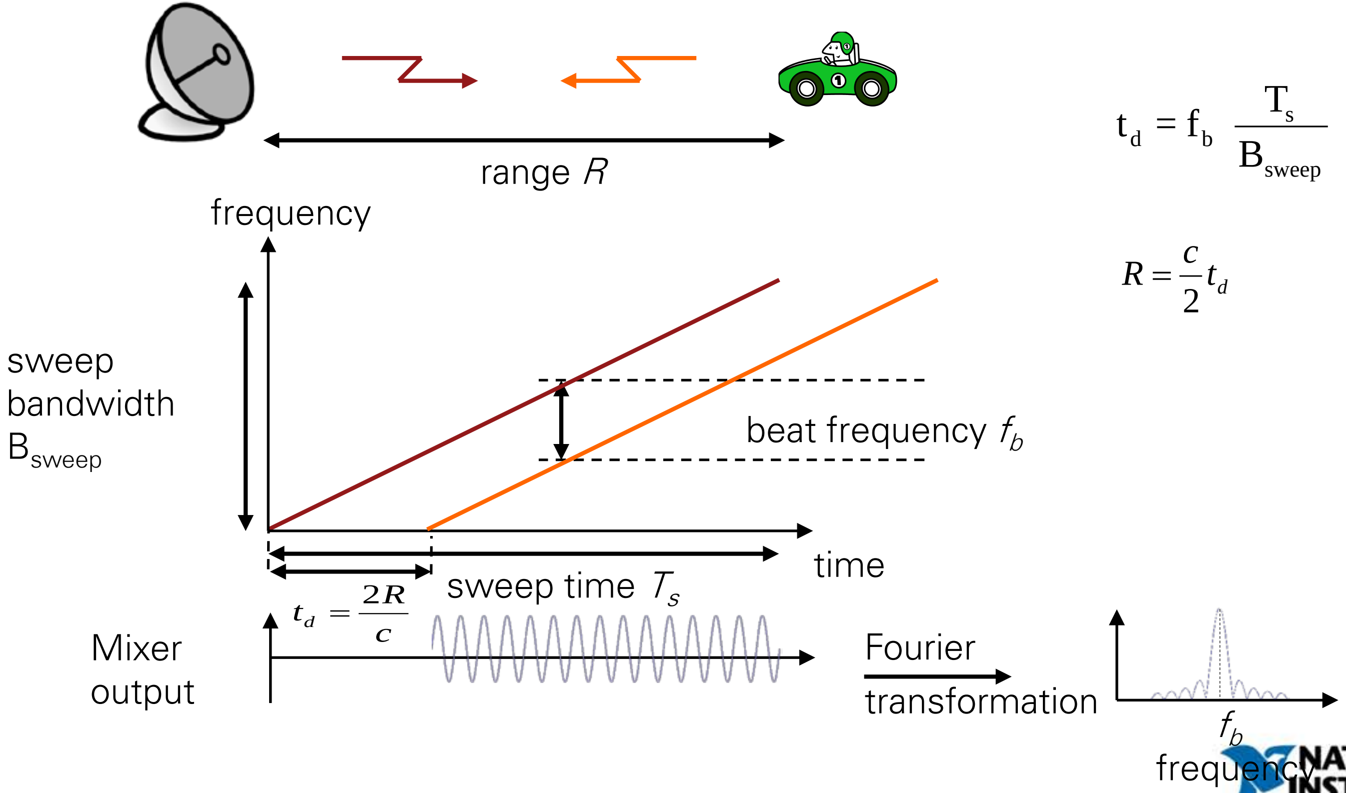
Principles of FMCW radar

Stationary Single Target



Principles of FMCW radar

Stationary Single Target

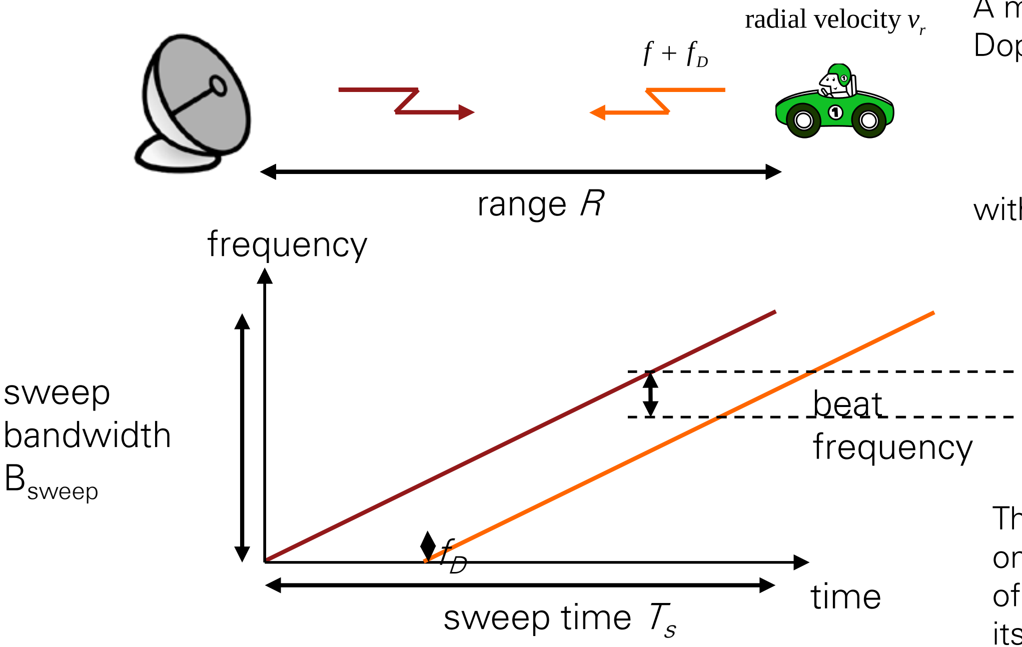


$$t_d = f_b \frac{T_s}{B_{sweep}}$$

$$R = \frac{c}{2} t_d$$

Principles of FMCW radar

Moving Single Target



A moving target induces a Doppler frequency shift

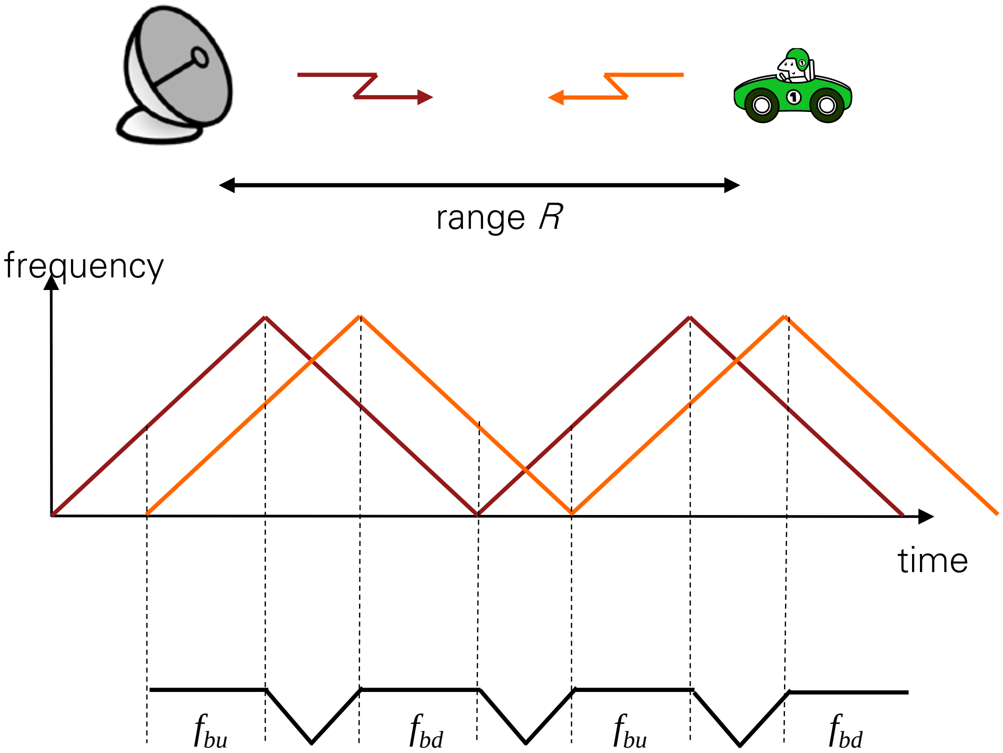
$$f_D = \frac{2v_r}{\lambda}$$

with the radar wavelength λ.

The beat frequency is not only related to the range of the target, but also to its relative radial velocity with respect to the radar.

Principles of FMCW radar

Stationary Single Target



Beat frequency components due to range and Doppler frequency shift:

$$f_r = \frac{2R}{c}\frac{B_{sweep}}{T_{sweep}}$$

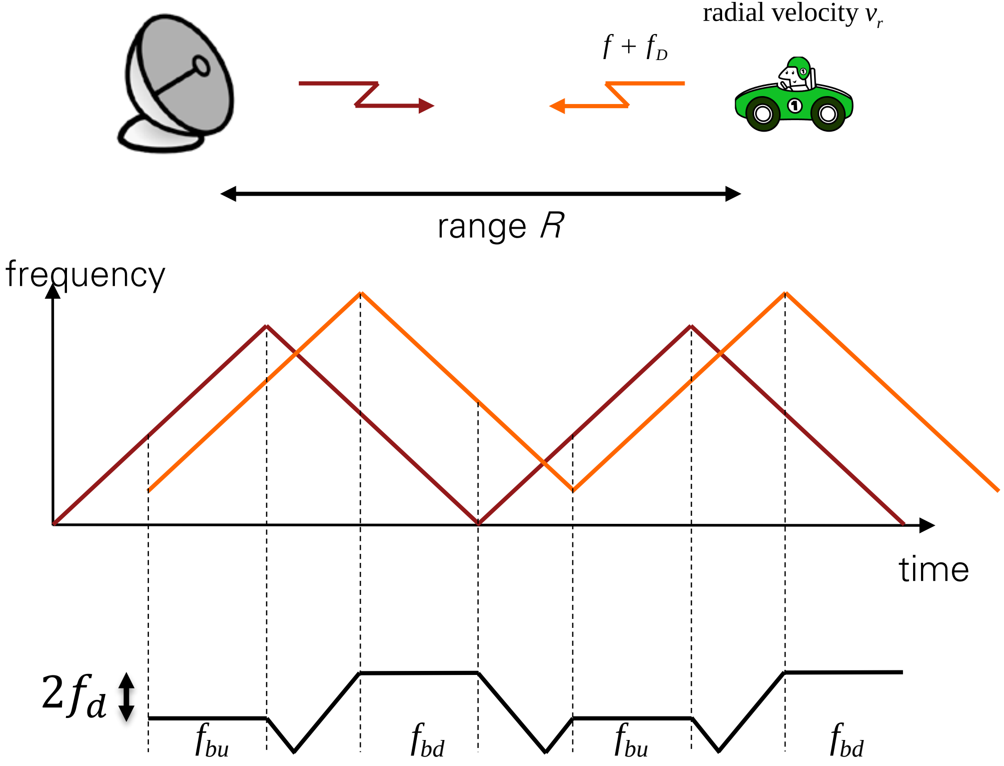
$$f_r = f_{bu} = f_{bd}$$

so range and radial velocity can be obtained as

$$R = \frac{cT_{sweep}}{2B_{sweep}}\frac{f_{bd} + f_{bu}}{2}$$

Principles of FMCW radar

Moving Single Target



Beat frequency components due to range and Doppler frequency shift:

$$f_r = \frac{2R}{c} \frac{B_{sweep}}{T_{sweep}}$$

$$f_d = \frac{2v_r}{\lambda}$$

that are superimposed as

$$f_{bu} = f_r - f_d$$

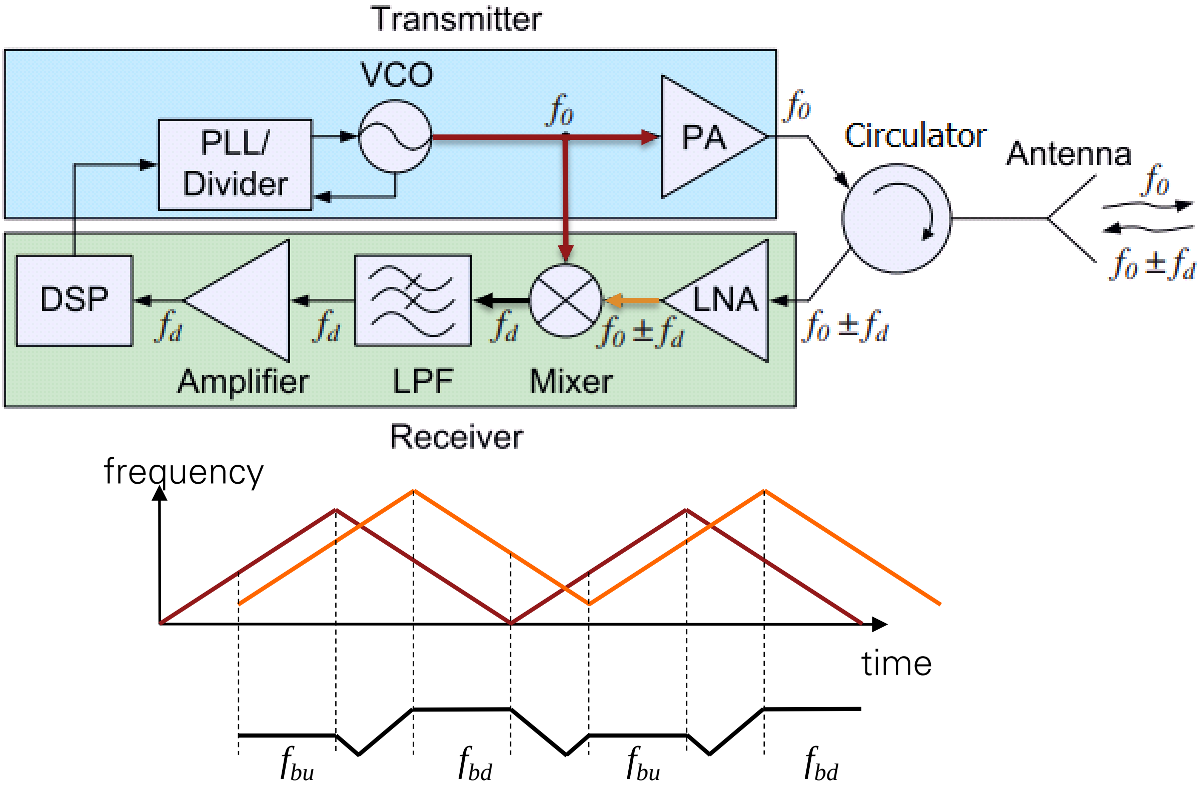
$$f_{bd} = f_r + f_d$$

so range and radial velocity can be obtained as

$$R = \frac{cT_{sweep}}{2B_{sweep}} \frac{f_{bd} + f_{bu}}{2}$$

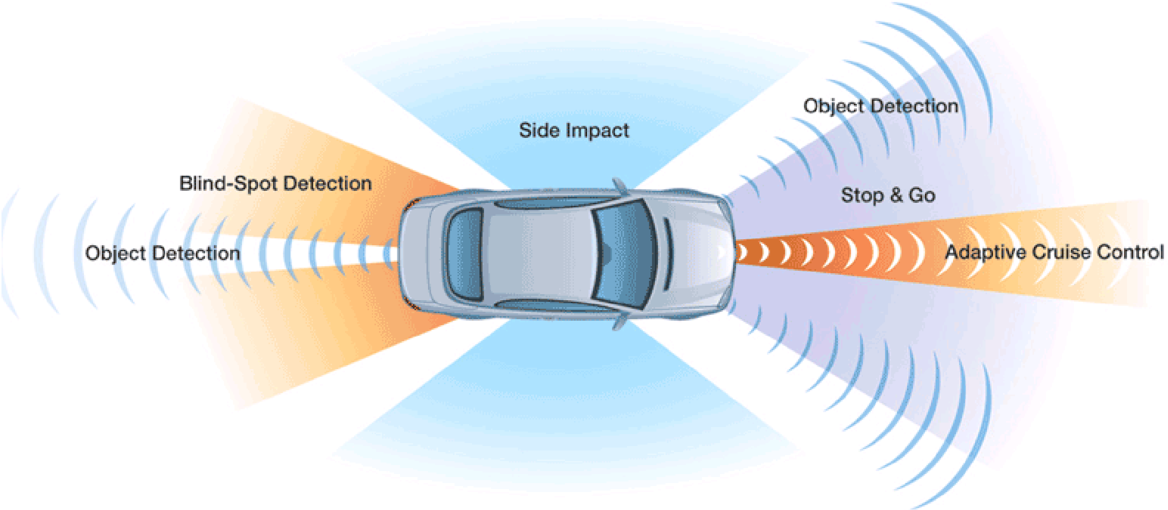
$$v_r = \frac{\lambda}{2} \frac{f_{bd} - f_{bu}}{2}$$

FMCW Transceiver Architecture



Target Simulation

Test radar sensors and higher level algorithms in a controlled environment



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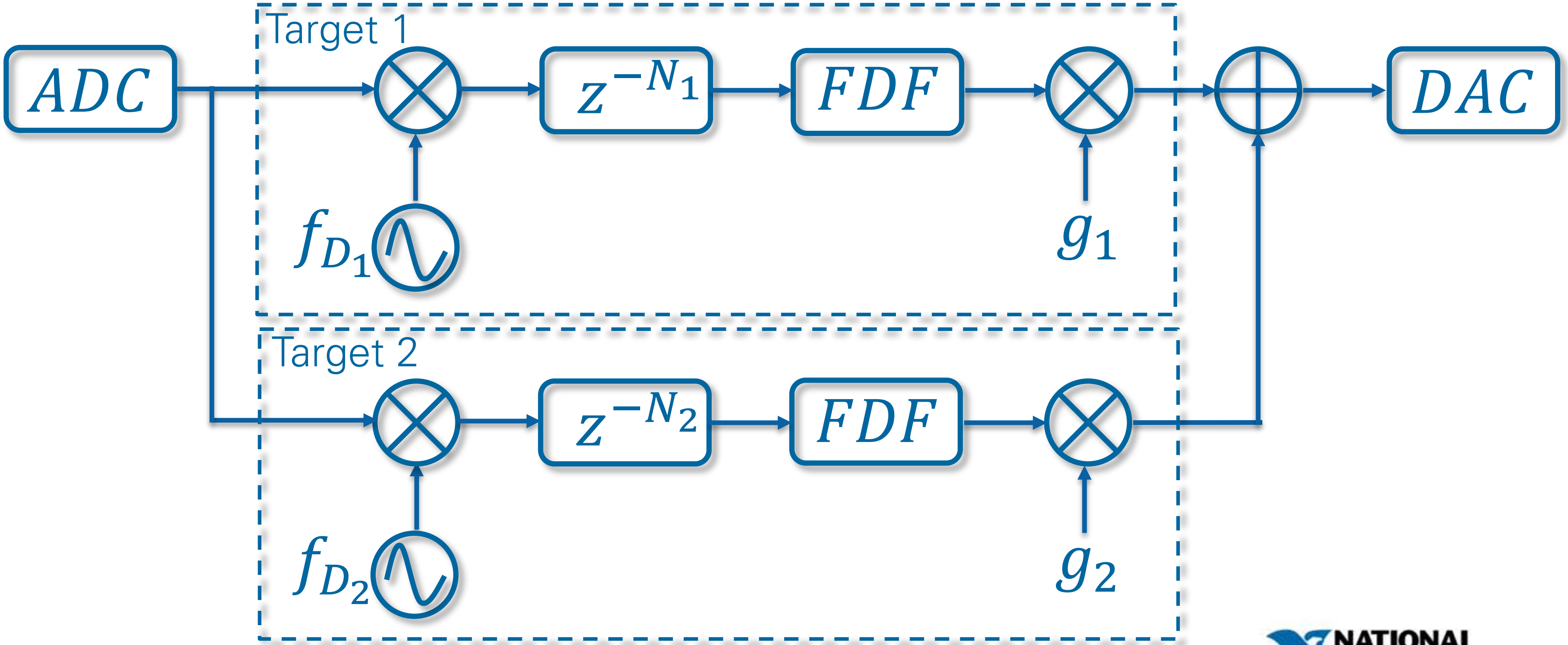
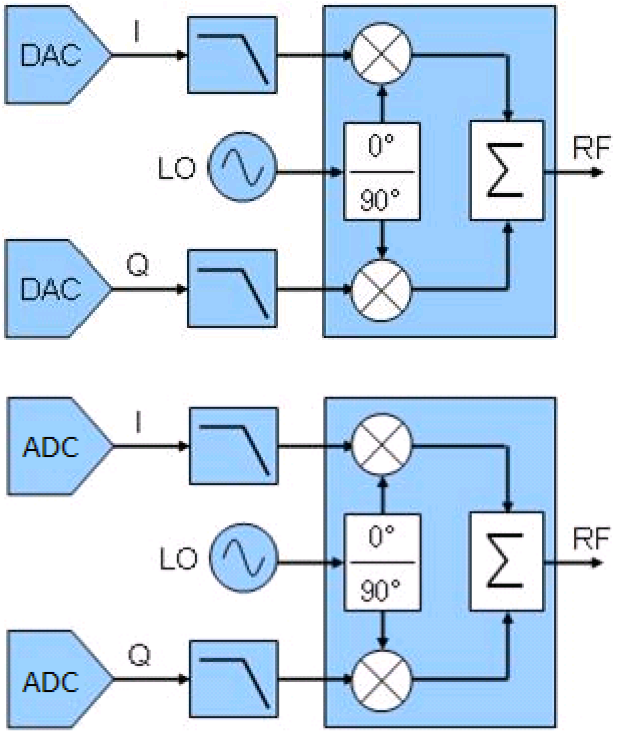
Target Simulation



NI PXIe-5840 Vector Signal Transceiver



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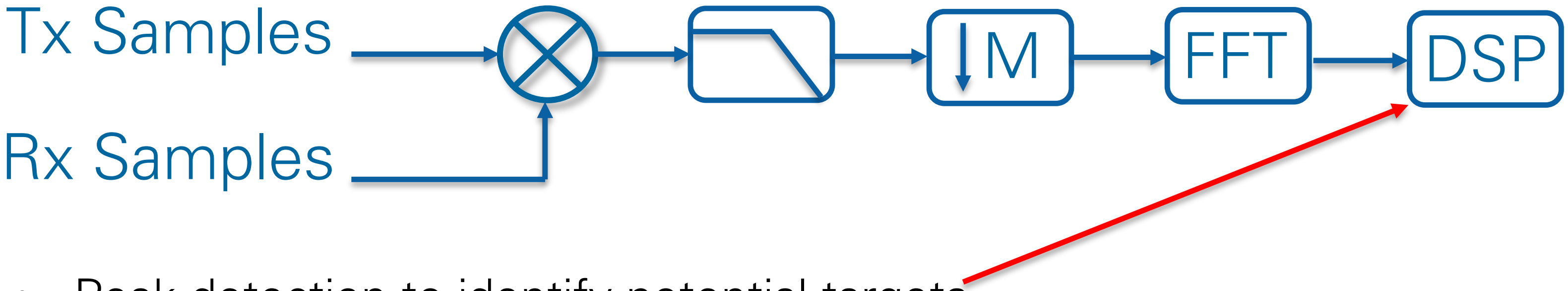
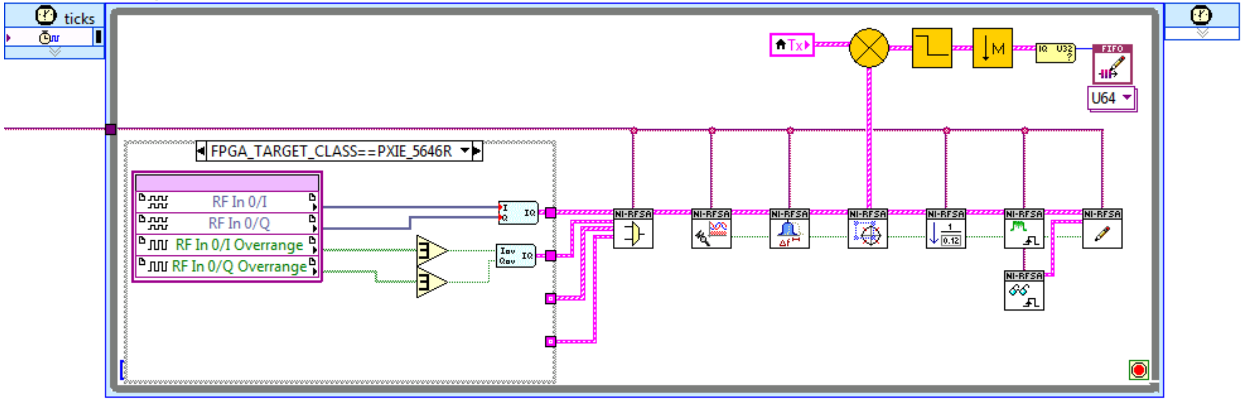
FMCW Radar Emulator with VST



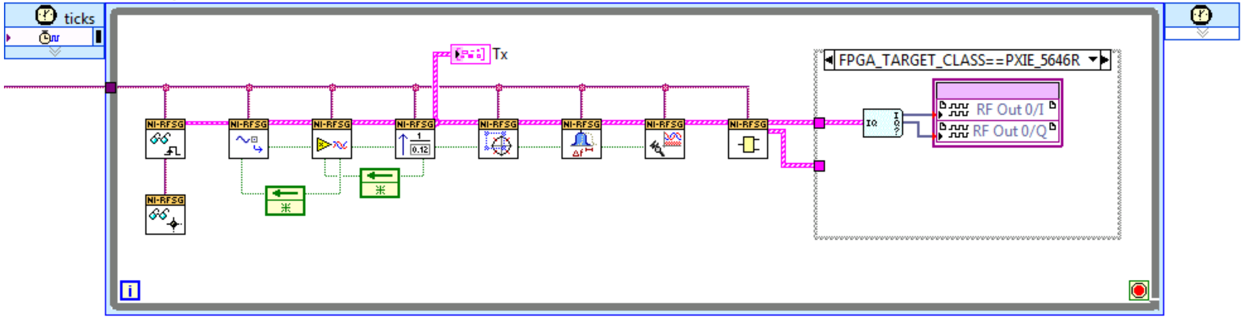
- Peak detection to identify potential targets
- Filtering targets based on the application
- Tracking targets over time

Leverage FPGA

RF Input

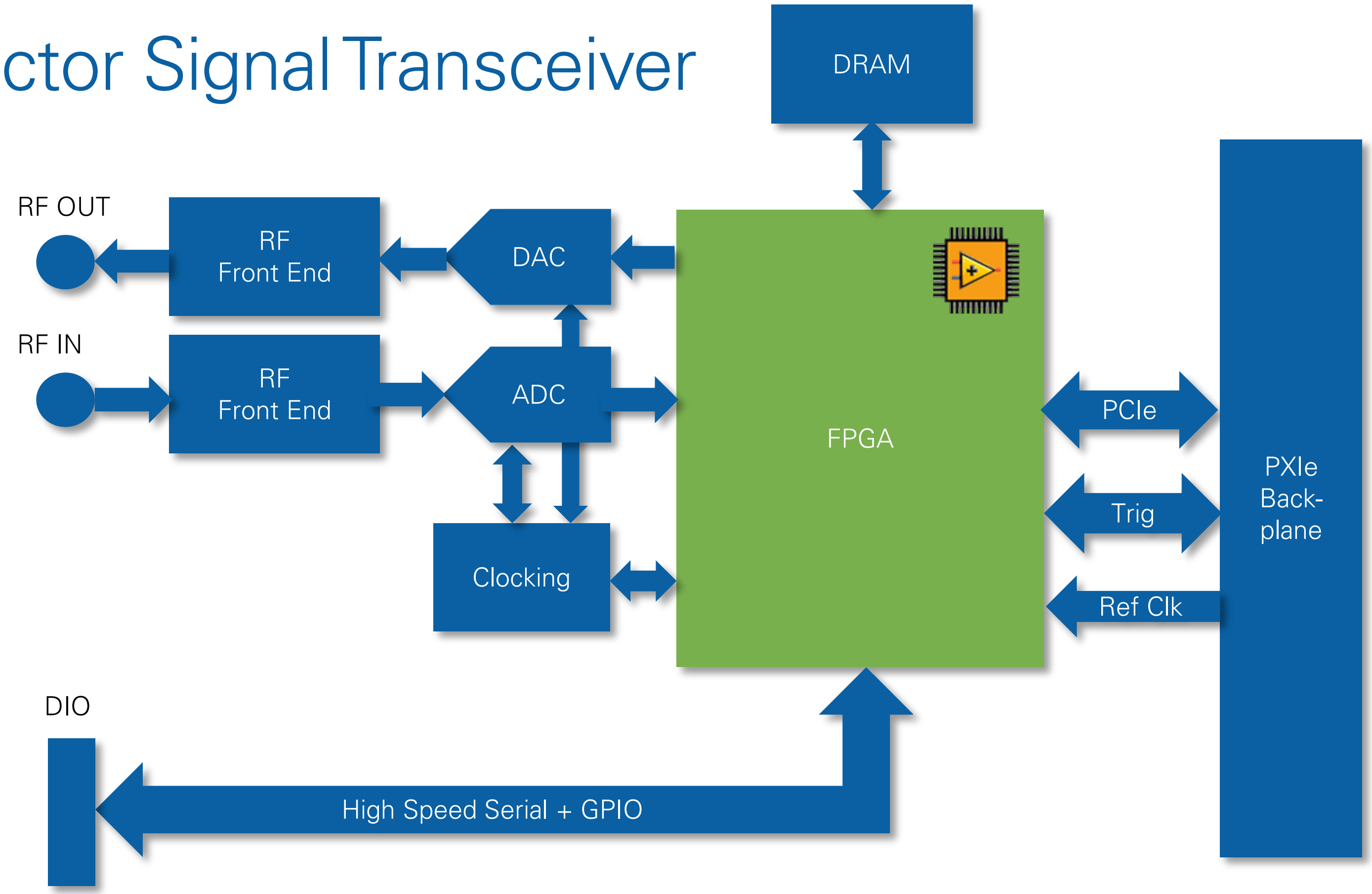


RF Output



- After decimation, sample rate is 125kS/s
- Requires 61x2048-pt FFTs per second

NI Vector Signal Transceiver



2^{nd} Generation VST: NI PXIe-5840

Only 2 PXI Slots!!

6.5 GHz VSG with
1 GHz Instantaneous BW

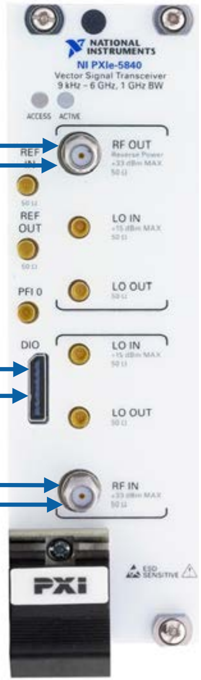
+8 dB Higher Output Power

50 MHz, 8 port high-speed parallel digital interface

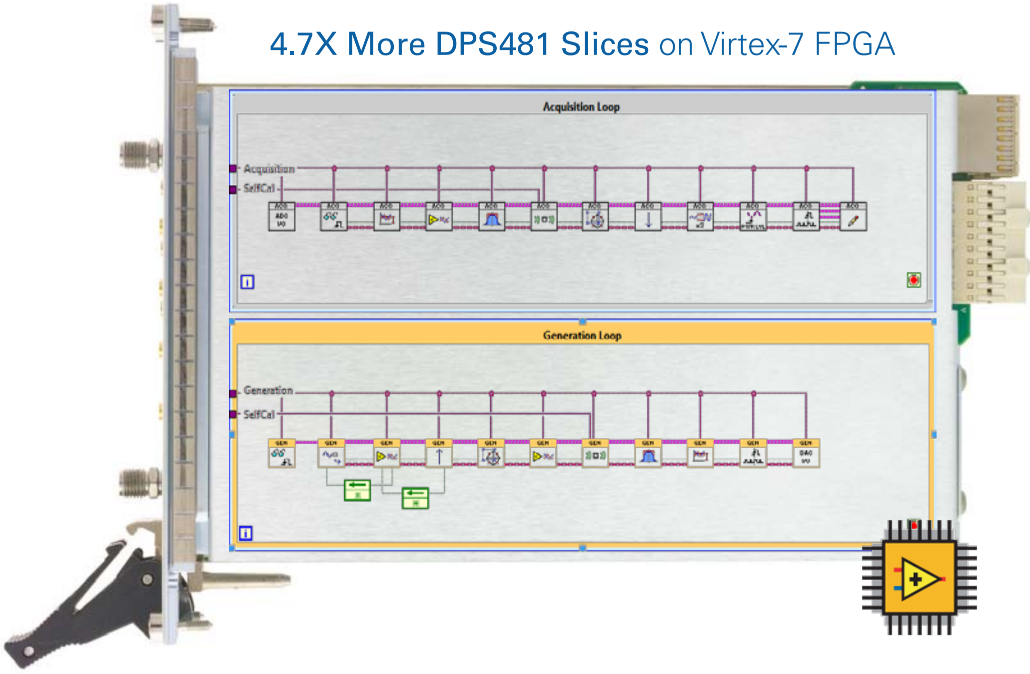
NEW high speed serial interface *(12.5 Gbps, 4 Tx & 4 Rx Lanes)*

6.5 GHz VSA with
1 GHz Instantaneous BW

Better EVM Performance



4.7X More DPS481 Slices on Virtex-7 FPGA



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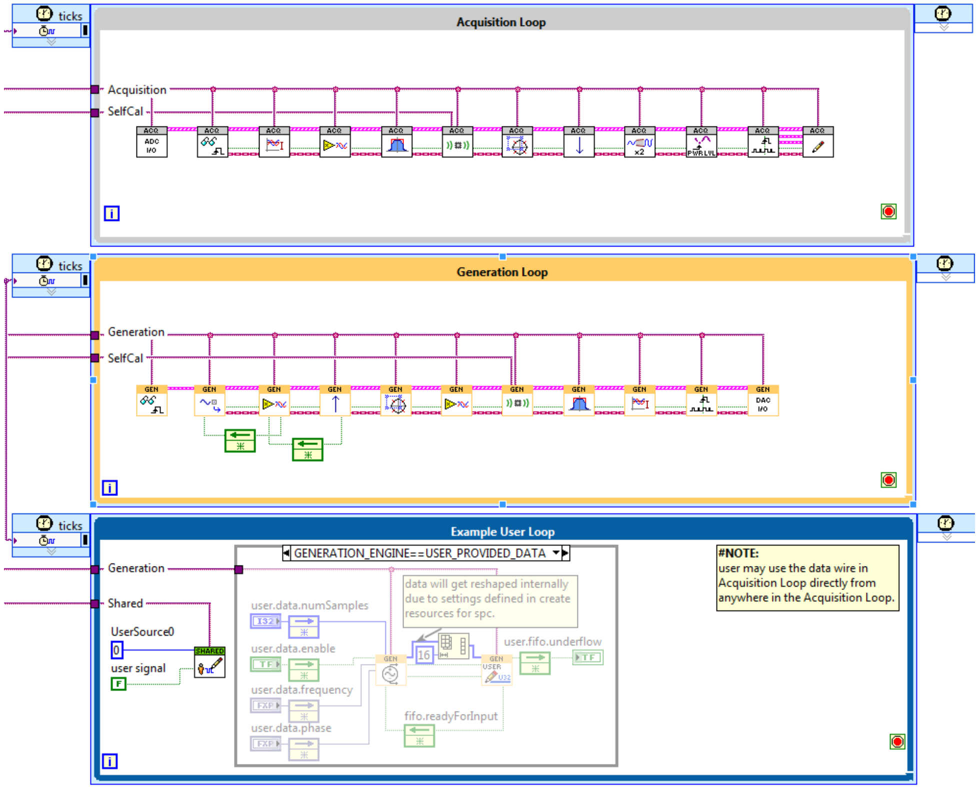
Customize VST with a User-Programmable FPGA



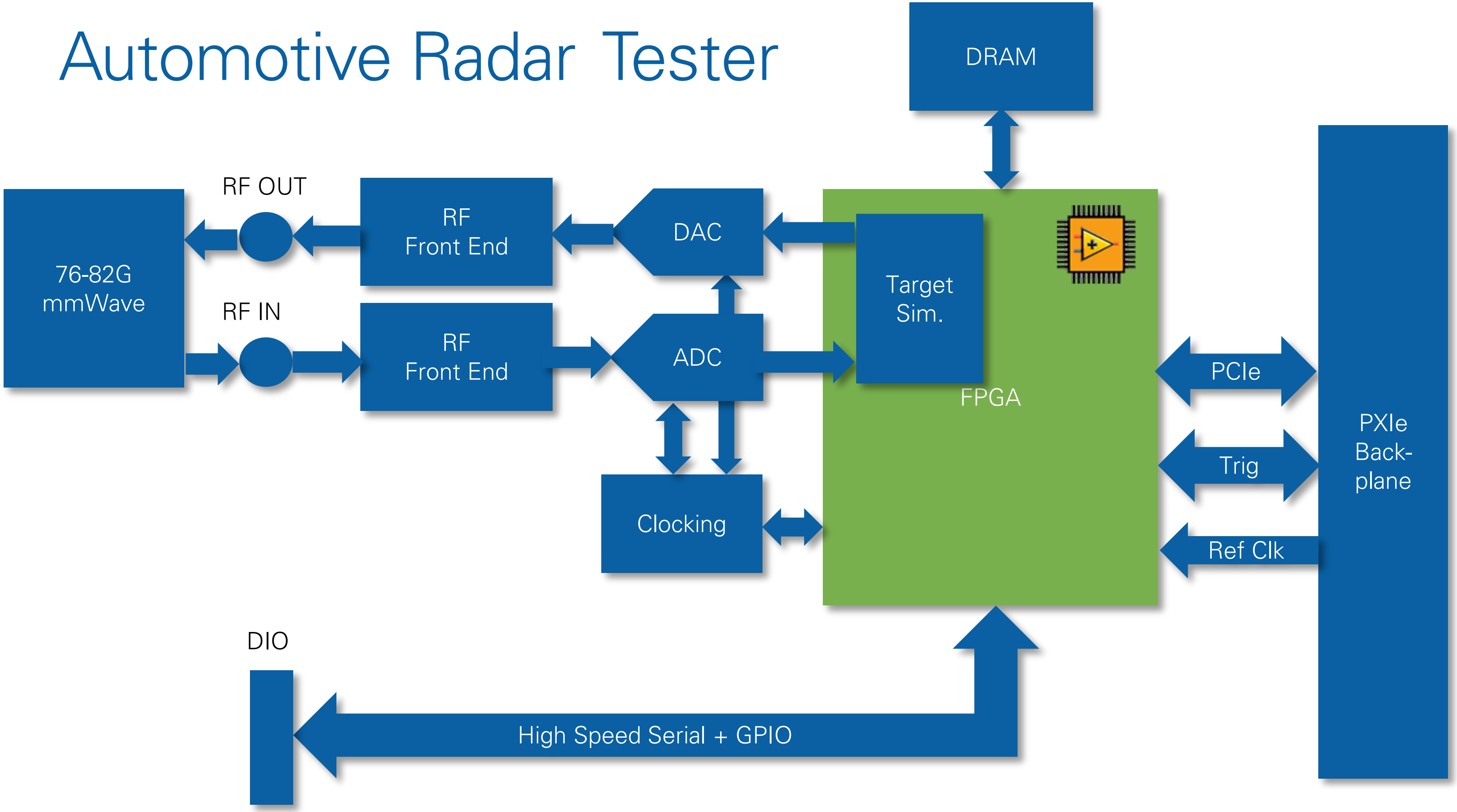
APPLICATION IP

Channelizer	Digital Pre-Distortion	RADAR Target Emulator
Power Servoing	LTE Carrier Aggregation	Custom IP

Use LabVIEW FPGA Extensions IP for evolving test requirements

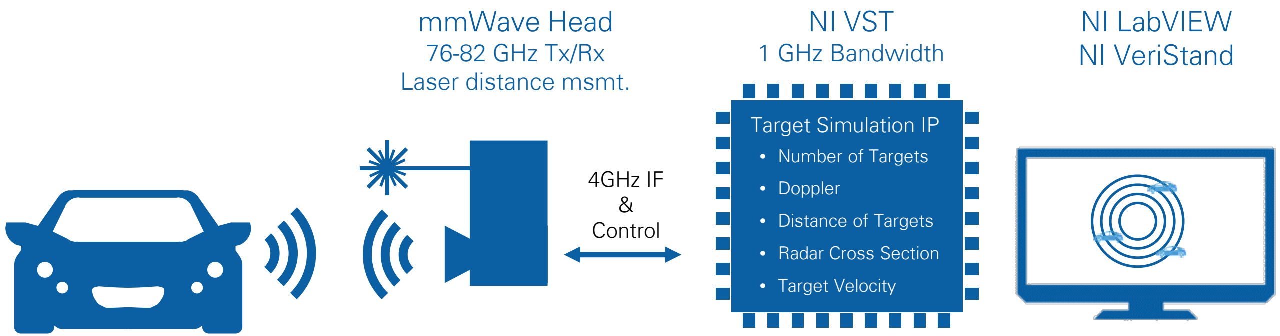
- Connecting new data and handshake signals
- Modifying the timing information accordingly
- Resampling, interpolation, pipeline delay, and group delay values
- Correct marker and trigger alignment and TClk
- Adding new target scenarios

Automotive Radar Tester



VRTS demo video of Shanghai

Automotive Radar Testing at 77 GHz



"The combination of the industry's widest bandwidth and low latency software-designed instrument allowed us to discover our automotive radar sensors as never before, and even allowed us to identify problems very early in the design phase that were previously impossible to catch. With the VST and FPGA programmable by LabVIEW, we were able to rapidly emulate a wide range of diverse scenarios, thus influencing safety and reliability aspects in autonomous driving."

-- Neils Koch, Component Owner Radar Systems, Audi AG. "

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NI Software Advantage

MEASUREMENTS

Radiation Pattern
EIRP
Phase Noise
Spectrum Occupancy
Beam Width
Chirp Analysis
Custom

RFmx API
Out of box examples

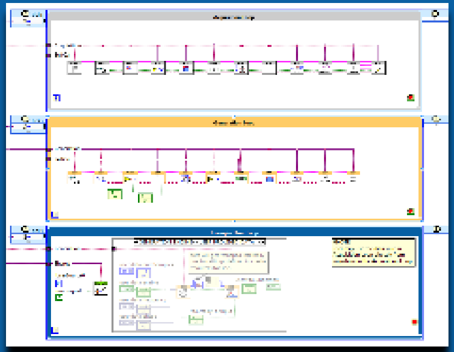
TARGET SIMULATION

NI Target Simulation Reference Architecture

- Targets (2 Per VST)
- Stationary (1m to 250m, 0.1 m resolution)
- Multiple object scenarios
  - Velocity
  - Radar Cross Section
  - Angle of arrival

Host to LV-FPGA function calls

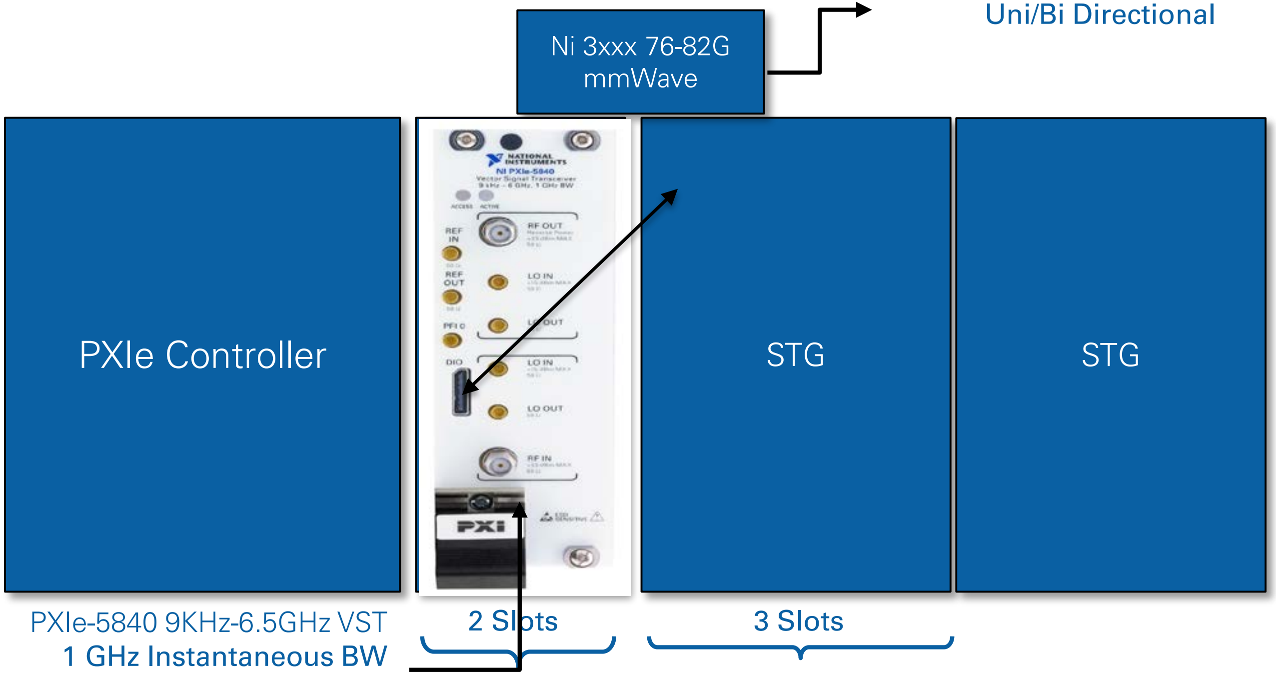
CUSTOMIZE



Flexibility to add custom scenarios

2-Target System Architecture

77G-82G
10 dBm Output Power
Integrated LO
Uni/Bi Directional



PXIe-5840 9KHz-6.5GHz VST
1 GHz Instantaneous BW
High Speed Serial

STG: Short Target Generator (Distances: 1 to 90m, with 0.1m resolution

Using the NI Active Target Simulator and a LabVIEW Based Scene Editor to Test Radar Sensors

Joachim Glaess - Key Account Manager at Konrad Technologies

konrad
technologies

NATIONAL INSTRUMENTS Platinum Alliance Partner

NATIONAL INSTRUMENTS

Radar and its Uses

- EM waves discovered by Heinrich Hertz in late 19th century
- *"I do not think that the wireless waves I have discovered will have any practical application."*
- Radar is a broad topic and has massive applications
  - Speeding Tickets
  - Weather Forecasts
  - Automotive!

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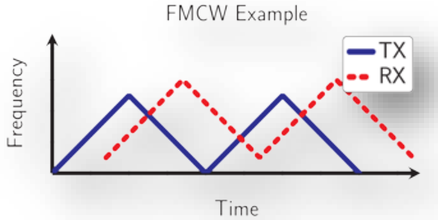
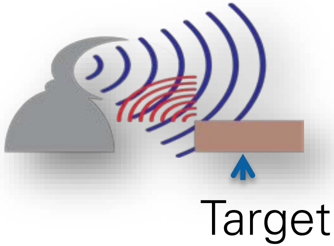
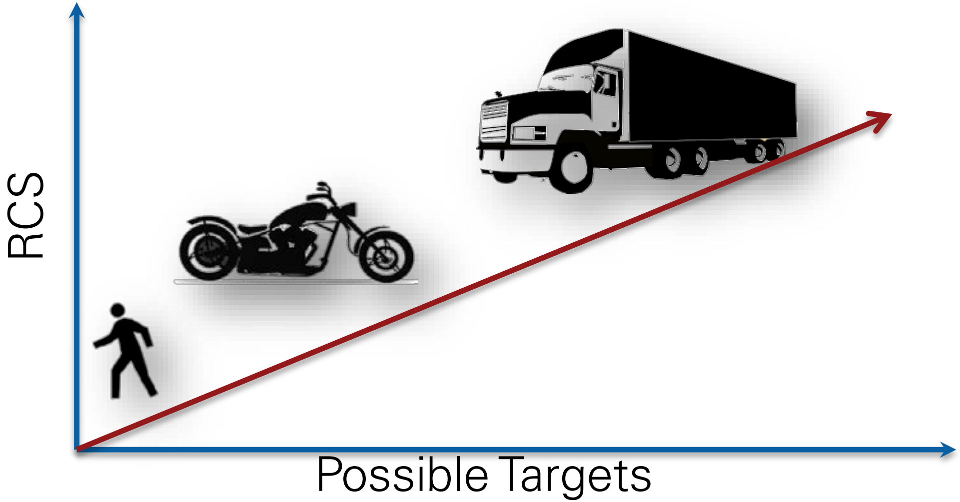
Main Deducible Parameters

- Distance to the transceiver => delay of the signal
- Speed of the object => doppler shift
- Angle of reflection => multi-antenna decomposition
- Size of the object (RCS) => reflected power





Radar Cross Section



The larger the area, the larger the RCS.

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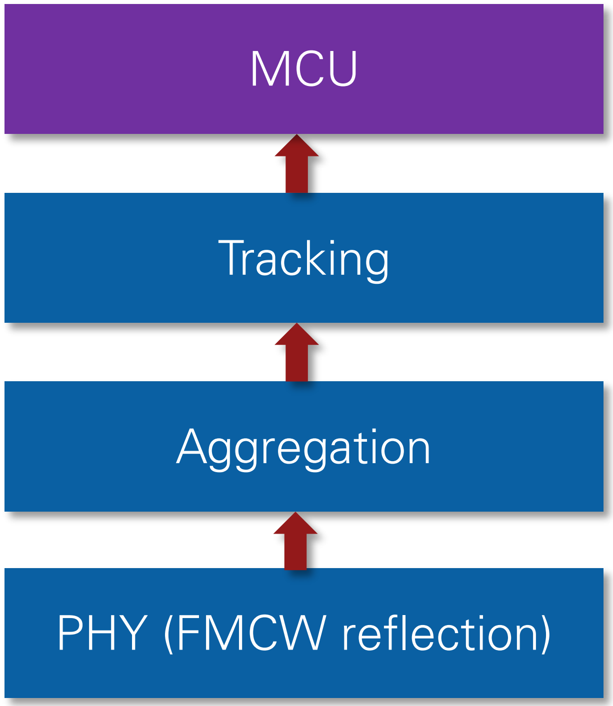
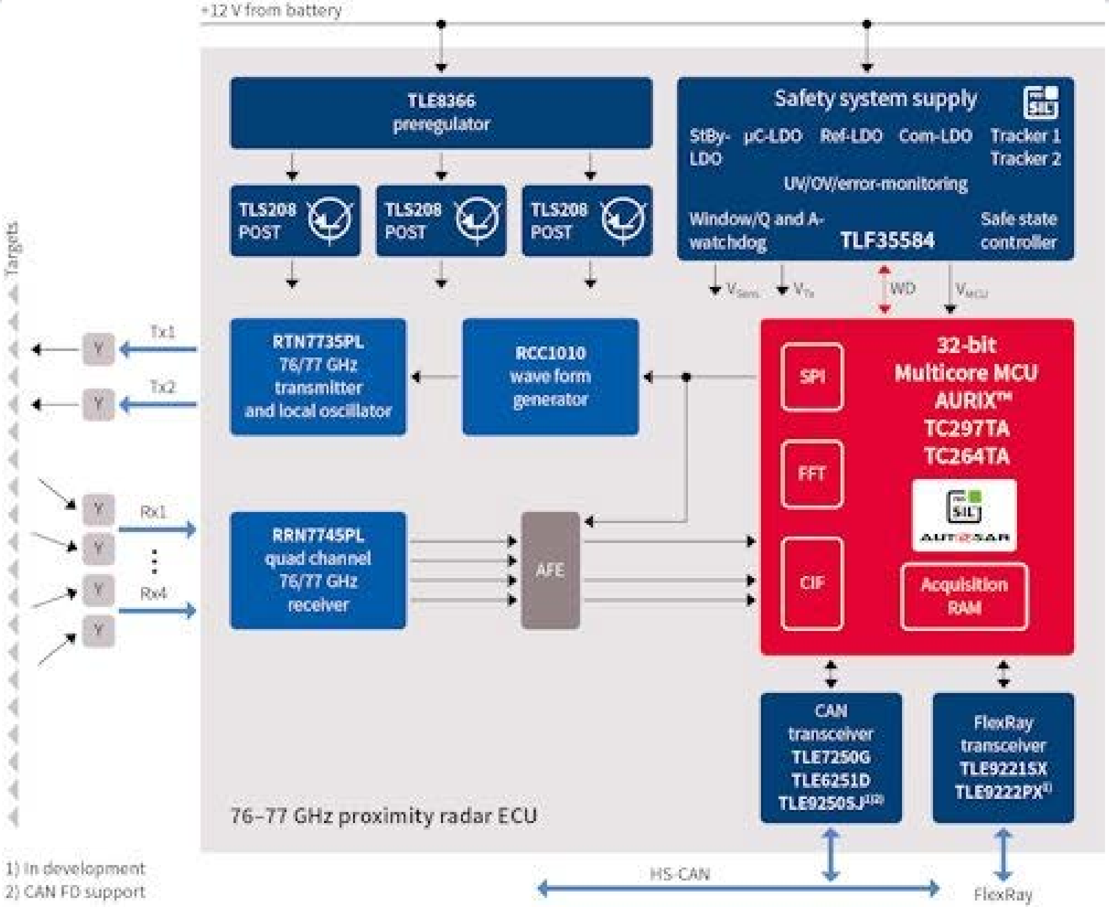
Determining Targets

- Sensor accumulates reflection information
- Looks for a logical pattern
  - Distance changes correctly with respect to speed
  - Reflected power changes according to distance
- Assigns a target or a track





Ref : http://www.infineon.com/

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Some Stages of Sensor Testing

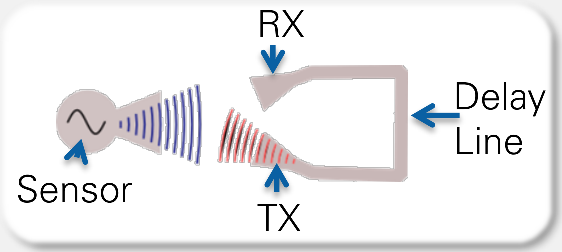
- When making a vendor decision
- Bumper installation
- Bumper material
- Fully integrated test

- Goal is to catch problems as EARLY as possible

Passive vs Active Radar Simulation

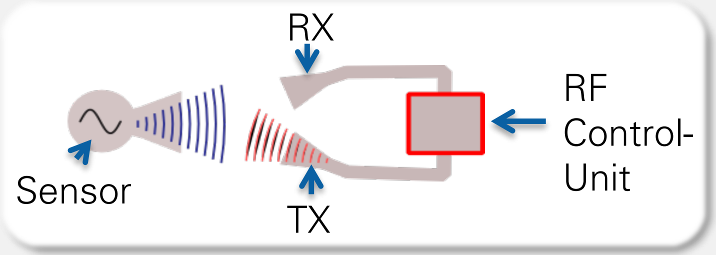
Testing Methods

Passive Target Simulation:



- 👍 Simple set-up.
- 👎 No moving targets
- 👎 Limited distance
- 👎 Simple targets, no scenarios

Active Target Simulation



- 👍 Variable target control
- 👍 Complex scenarios possible
- 👎 Complexity

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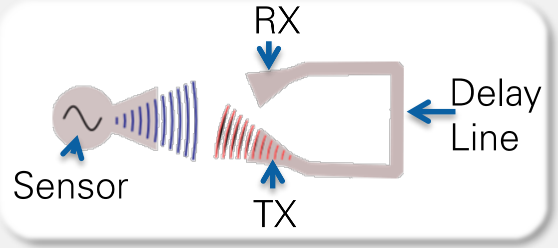
Passive vs Active Radar Simulation

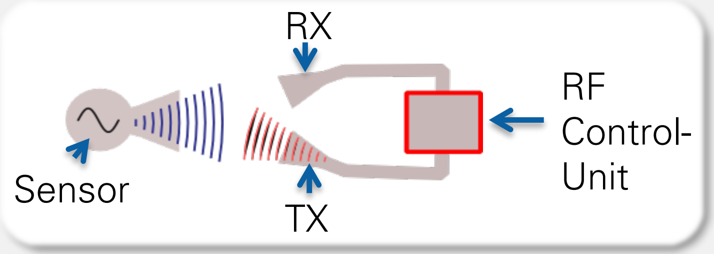
Testing Methods

Passive Target Simulation:



- 👍 Simple set-up.
- 👎 No moving targets
- 👎 Limited distance
- 👎 Only simple scenarios

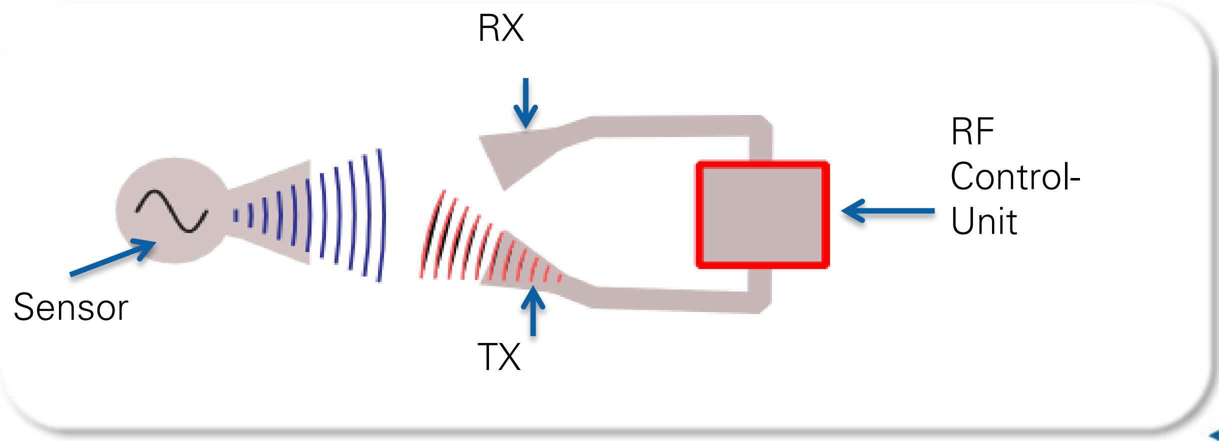
Active Target Simulation



- 👍 Variable target control
- 👍 Complex scenarios possible
- 👎 Complexity

Angular Movement

- Requires moving the physical location of the reflection
- Or…
- Put the sensor on a motor!



Konrad Technologies -
Next Generation Sensor Manipulator

- 6-Axis Robot
- High process stability
- Precise operation
- Very good price performance

Simulating a Target with Hardware

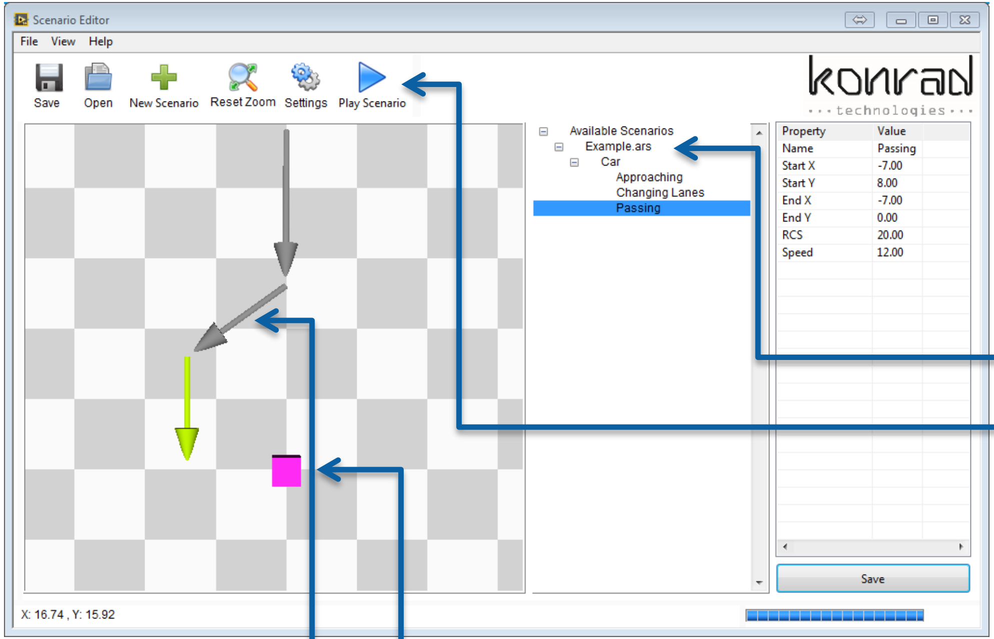
In order to simulate dynamic targets, several parameter have to be manipulated:

- RCS
- Doppler shift
- Delay
- Angle

The simulation system has to fullfill some requirements:

- Bandwidth
- Dynamic range
- Update rate

Radar Scenario Editor



The shown user interface makes it easy to set-up complex scenarios.

You can combine tracks, record them and simulate a scenario.

Select available scenario

Play scenario

Track

Radar Sensor

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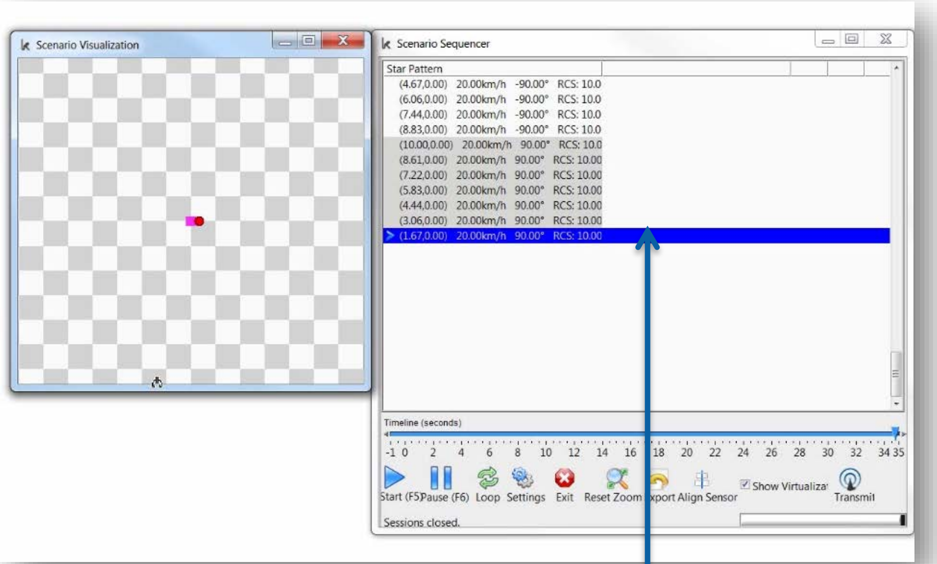
Simulation Capabilities



● Target ■ Sensor Current simulation point

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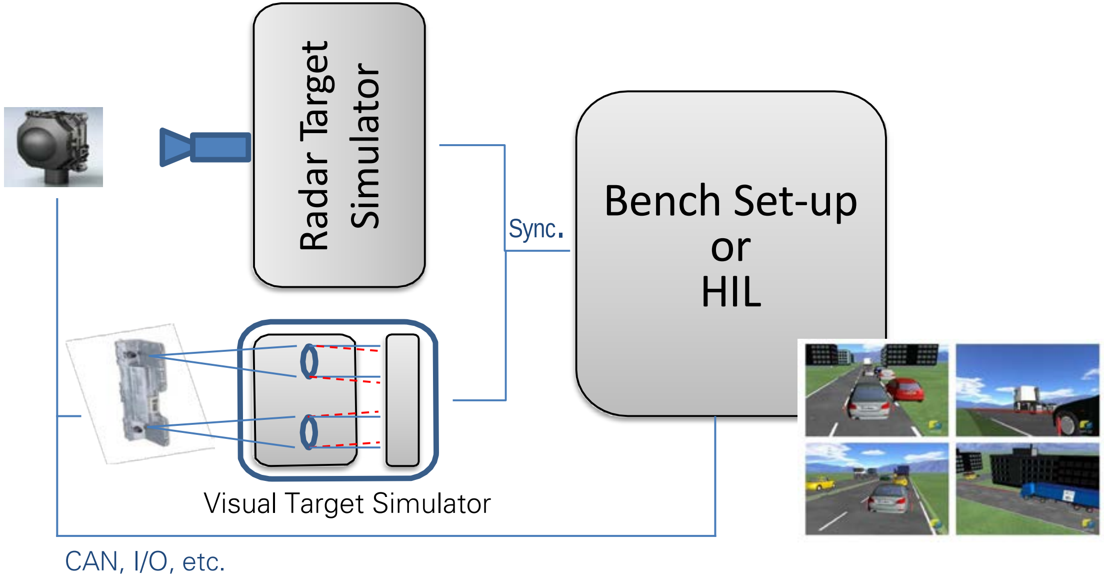
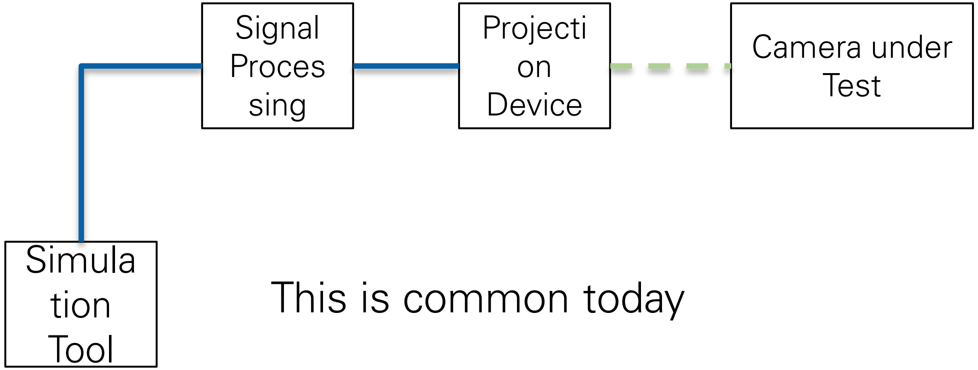
ADAS Target Simulator - Synchronized Camera Test

- Synchronized Target Generation
- Synchronized CAN
- Synchronized additional I/Os

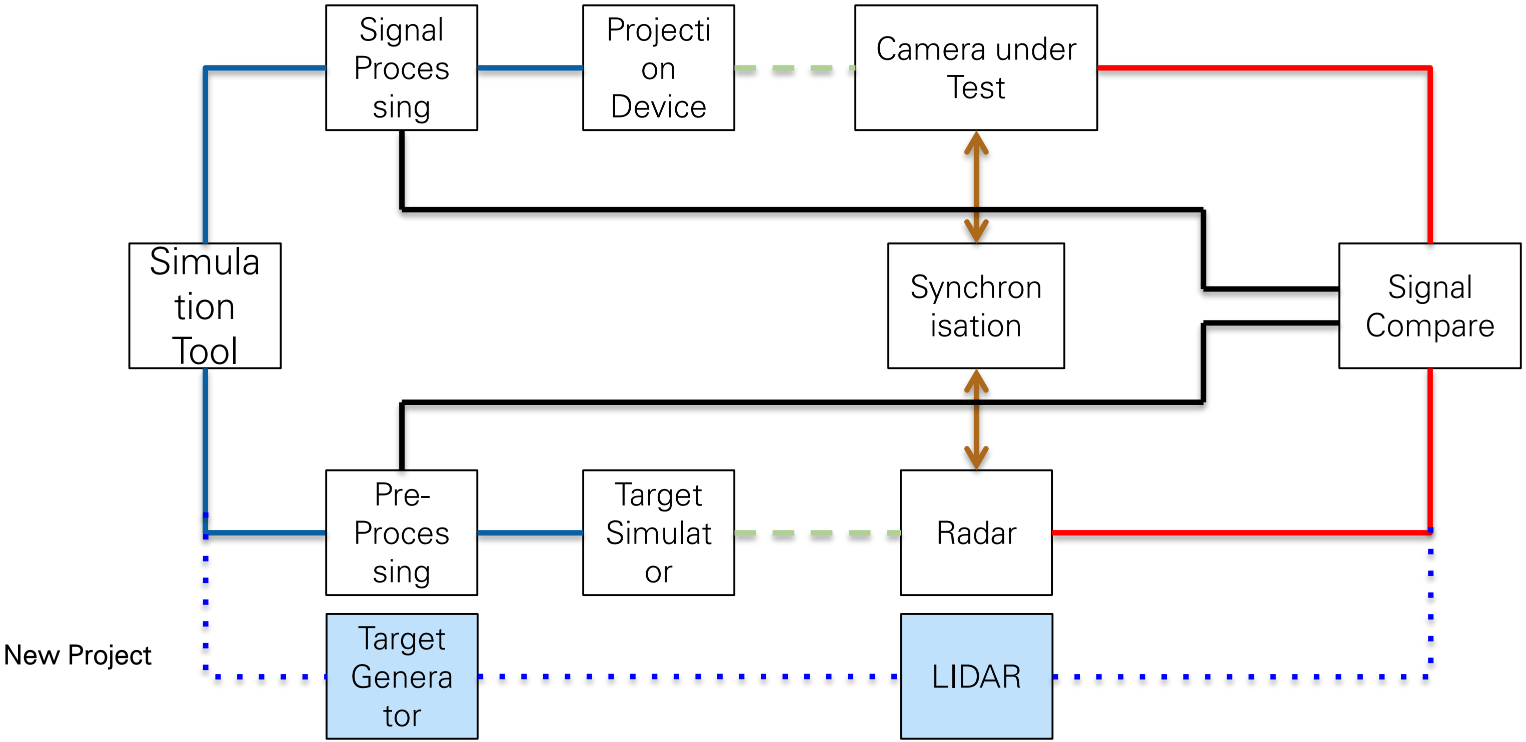


ADAS Target Simulator



This is common today

ADAS Target Simulator



Automotive Radar - Target Simulator 77GHz in Production Environment

National Instruments VRTS 77 GHz Radar Target Simulator built into Konrad ABex as Production System

19" 6HE Rack, all electronics and RF components integrated in one box.

Antenna blind mate connectors for remote antenna connection.

NATIONAL INSTRUMENTS

Thank You!

Joachim Glaess
Key Account Manager

Konrad Technologies
Fritz-Reichle-Ring 12
D-78315 Radolfzell
Germany

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Mobile: +49 (0) 172 14 99 892

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