FMCW Surveillance Radar

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Sections

1. Surveillance FMCW radar
2. SiRad Easy
3. Rotary Platform
4. Desktop Application
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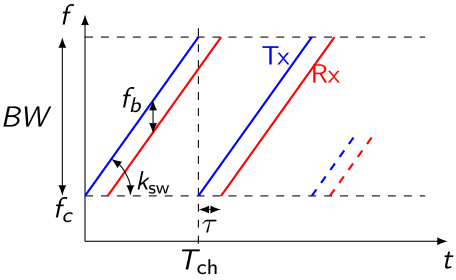
Surveillance Radar

- Detection of target in plane or 3D space
- 2 basic approaches
  - Electronic beamsteering: MIMO systems, complex processing, preferred for demanding applications
  - Mechanically steered beam: simpler, easier processing, cheaper, less reliable
- Generally based on pulsed radars

FMCW Radar

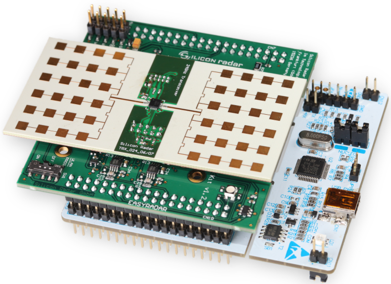
- Broadcasts frequency modulated signal
- Low power consumption with great ranger resolution
- Range of target: proportional to beat frequency
- Speed of target: causes phase shift across many chirps



FMCW TX and RX Signal

SiRad Easy

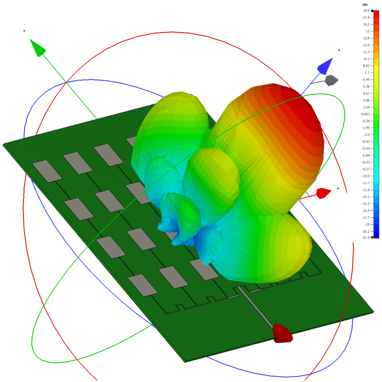
- Evaluation kit from Indie Semiconductors
- 24 GHz and 122 GHz transceivers modules
- Provides raw data from ADC converters over serial
- Slow update rate (at best around 20 ms)
  - Max target speed bellow 1 ms/s
  - Rotation speed limited to low RPM



SiRad Easy 24 GHz Configuration

SiRad Easy: 24 GHz module

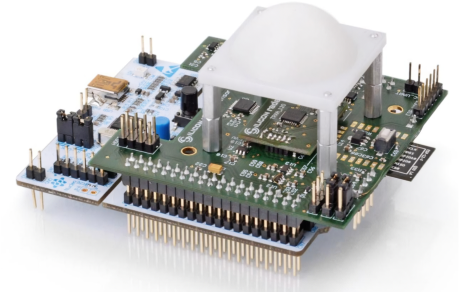
- Radiation characteristics simulated in CST studio
- 16 degrees in azimuth, 30 degrees in elevation
- Long range applications (300 m)



Radiation Pattern of 24 GHz Header

SiRad Easy: 122 GHz module

- Tight radar beam $\pm 4°$ in both directions
- Measured maximal range of 30 m
- Ideal for close range, high resolution (5 cm) applications



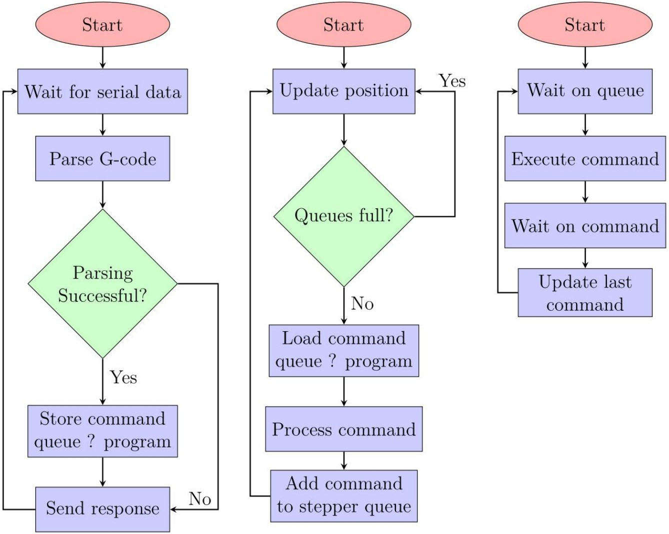
SiRad Easy 122 GHz Configuration

Rotary Platform

- Two axis of movement, at low RPM
- Continuos rotation in azimuth
- ESP32C6 microcontroller
- G-Code-like API over serial
- Supports: automatic homing, relative/absolute positioning, spindle, preprogramming movement sequences

Platform with 122 GHz Module

Platform Firmware Flow

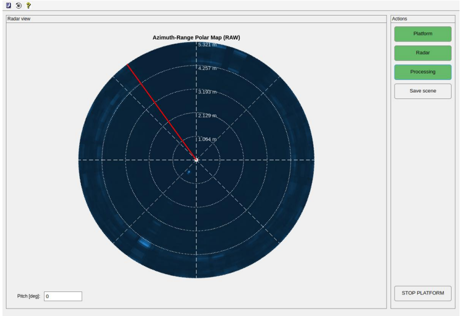


Platform Program Example

Command	Mode	Purpose
`P90 rotTilt`	Header	Initialize program rotTilt
`G91`	Header	Set relative positioning
`G21`	Header	Set units to steps
`G28`	Header	Start auto home routine
`G0 P-50 S6`	Header	Move pitch 50 steps
`W3 T5000`	Header	Wait five second
`P92`	Header	Set current position as home
`P29`	Header	Enable infinite looping
`M03 SY6 Y+`	Header	Start Yaw spindle (6 RPM)
`P92`	Header	Finalize header declaration
`G0 S5 P40`	Body	Pitch movement
`G0 S5 P-40`	Body	Return pitch
`P92`	Body	Finalize program

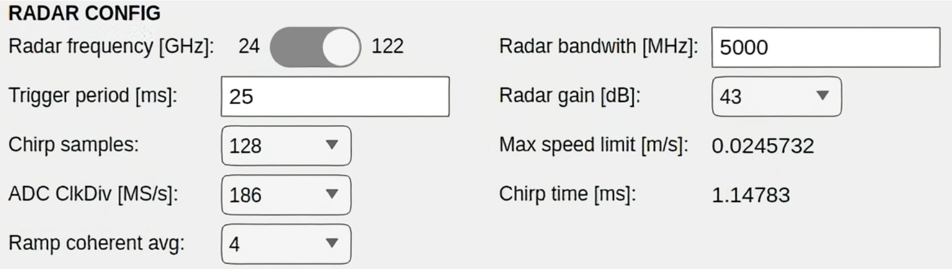
Desktop Application

- Control app written in MATLAB
- Integrates radar and platform data
- Offers wide degree of customization

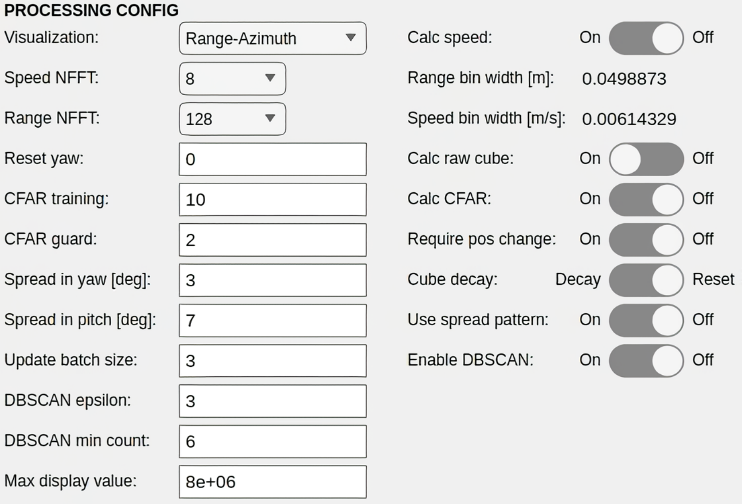


Main App Window

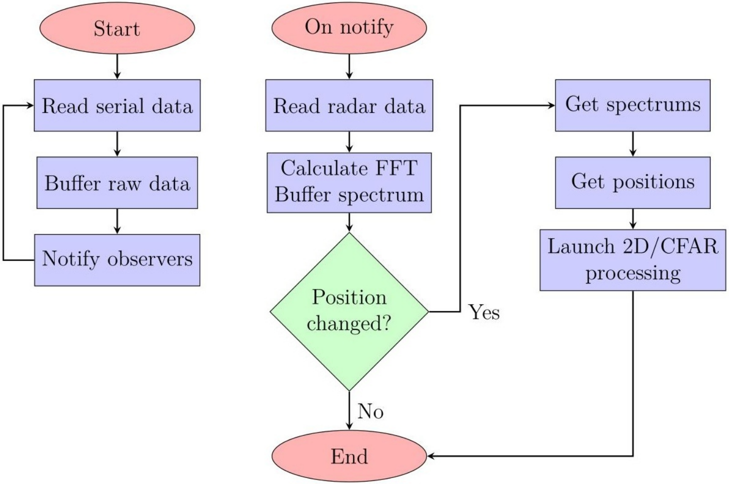
Preferences: Radar



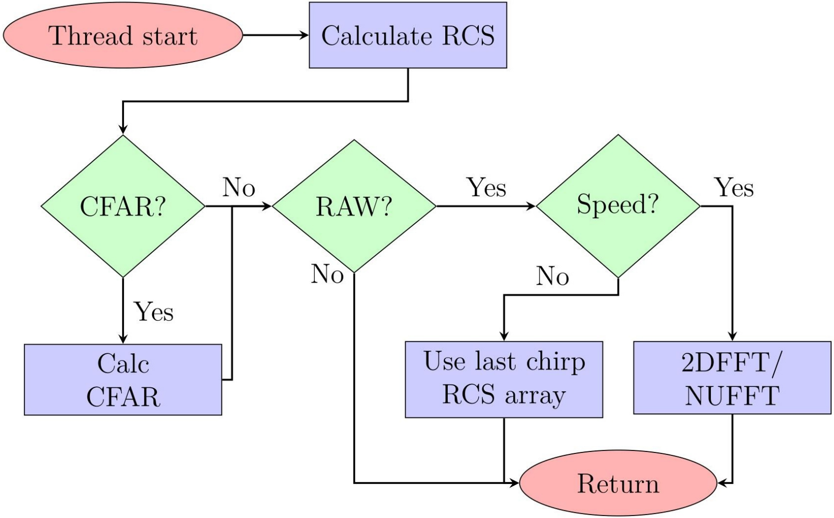
Preferences: Processing



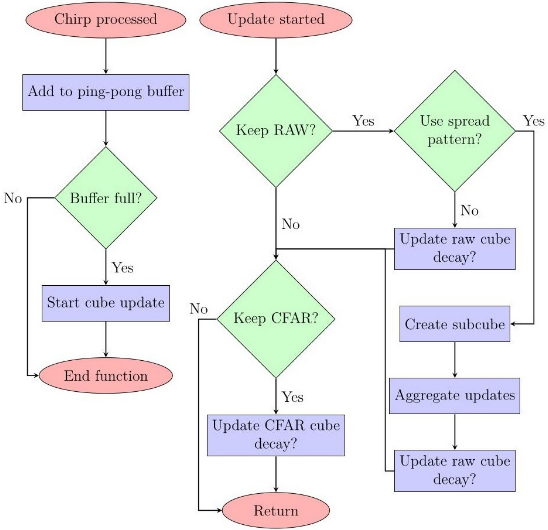
Data Aquisition



Data Processing



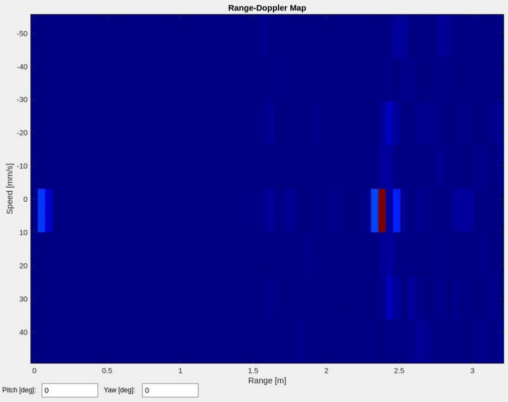
Data Storing



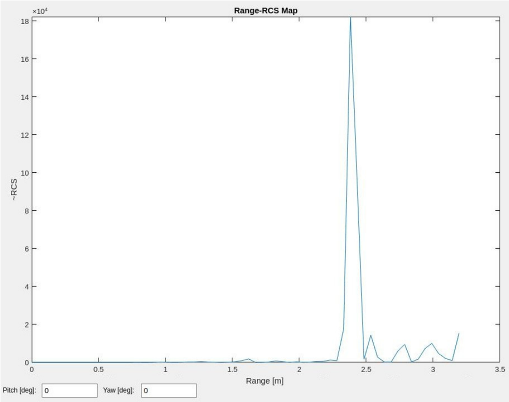
Visualization

- Data are only provided in a graphic way to the user
- Three visualization styles
  - Range-RCS or Range-Doppler (fixed azimuth and elevation)
  - Range-Azimuth (fixed elevation)
  - 3D

Visualization: Range-RCS/Doppler

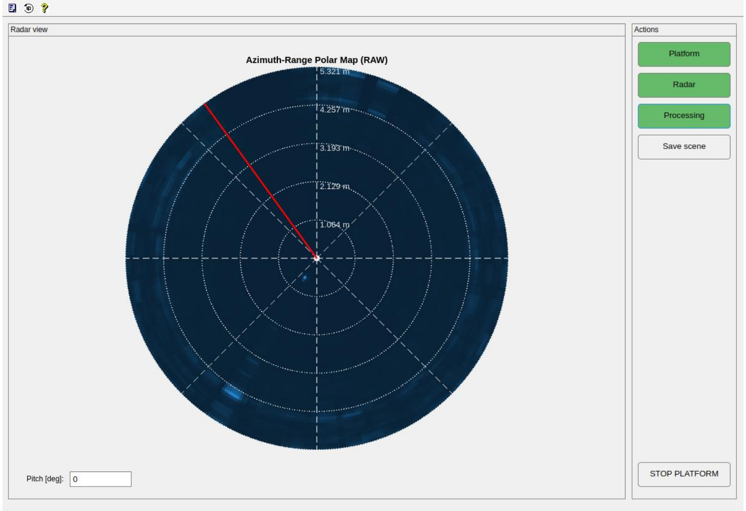


Range-Doppler

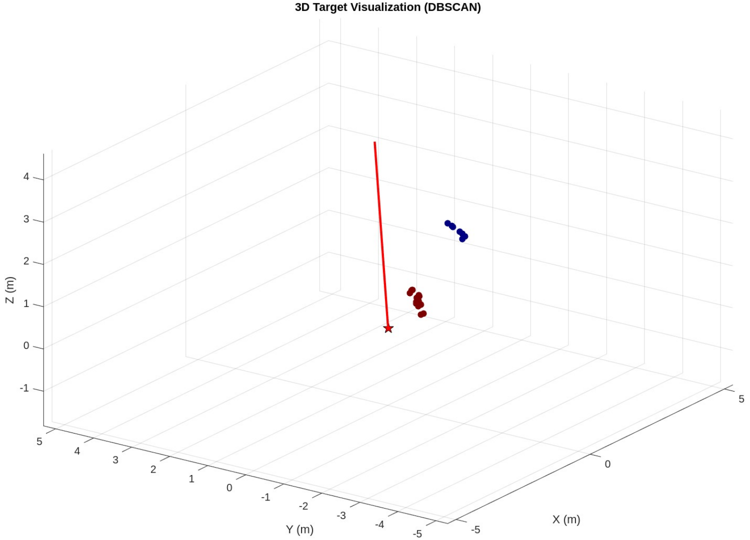


Ranger-RCS

Visualization: Range-Azimuth



Visualization: 3D



Conclusion

- SiRad Easy
  - Sufficient for monitoring static scenes
  - Speed estimation is limited – tracking application isn't a possibility
- Rotary platform
  - Matches design requirements
  - Underpowered azimuth motor and low belt tension
- Desktop application
  - Great degree of configuration
  - Pipeline performant, except for final visualization under Linux

Q1: Exprimental Data

- Large number of parameters: header, bandwidth, gain, target, CFAR setting – requires fine tuning
- Rotary movement + inconsistent radar timing complicate reproducibility
- Author couldn't establish correct, reproducible, validation methodology to give measured data any validity
- No testing in controlled environment was done
- When static the radar capabilities generally match advertised
  - 122 GHz header – Tight beam $\Rightarrow$ very sensitive to target orientation