An introduction to commercial radar sensors

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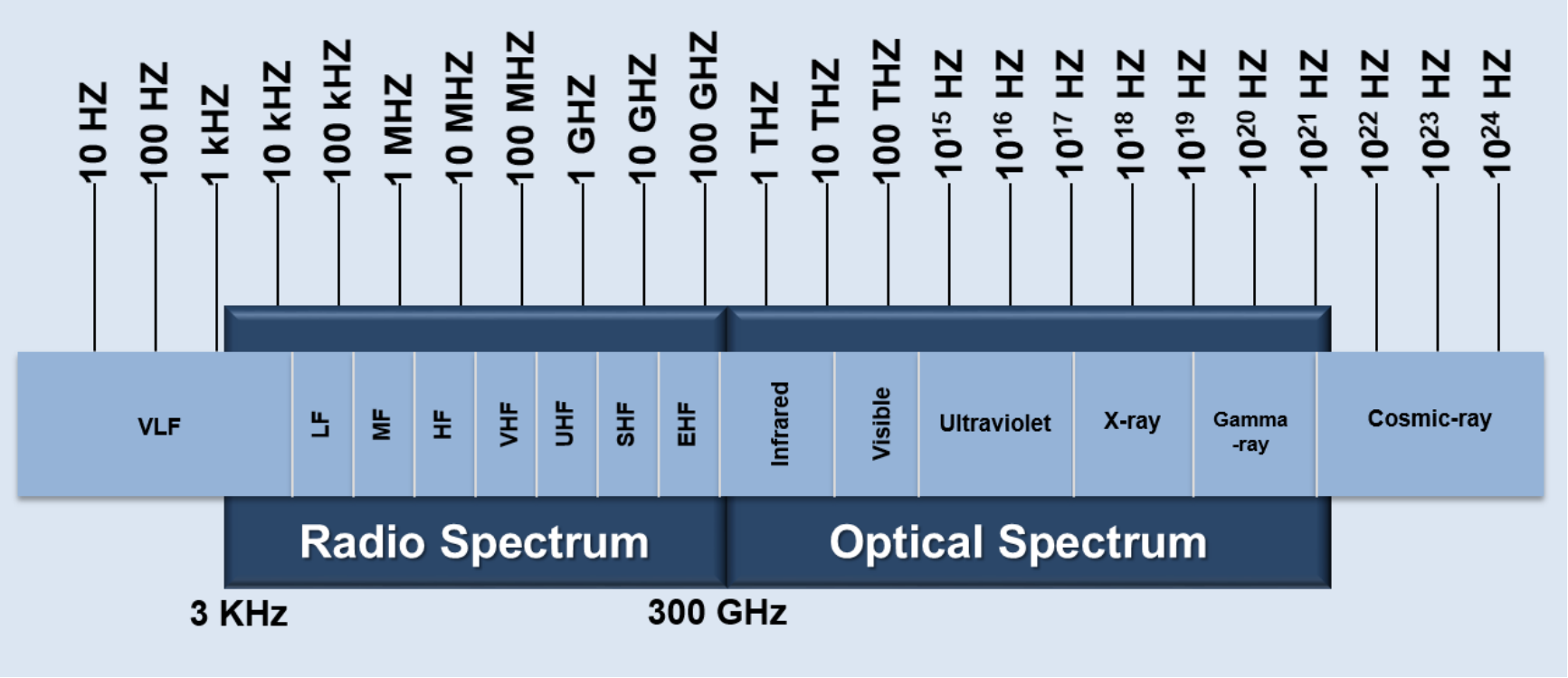
Introduction: what is radar

- Radar is a measurement principle based on monitoring echos in the EM spectrum. The typical range of frequencies: 1 to 122GHz



Introduction: what can we measure

With radar we can measure

- Speed
- Range
- Direction
- Target pattern

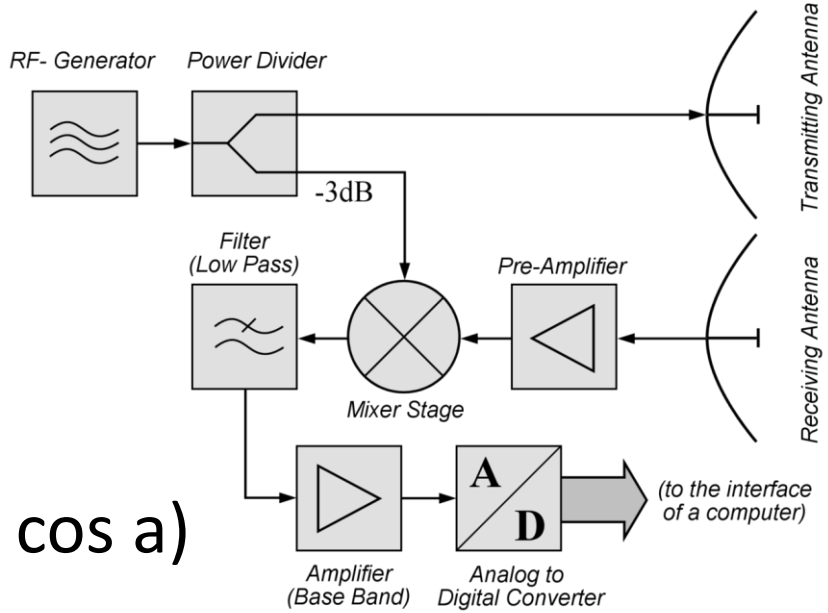
The above can be measured by using various modulation techniques, the most popular ones will be discussed.

CW modulation

Continious **W**ave radar (CW radar):

- Most basic radar
- No modulation
- Only radial (!) velocity info
- fD = 2 f0 v/c0 cos a (~fD = 44 Hz / (km/h) cos a)

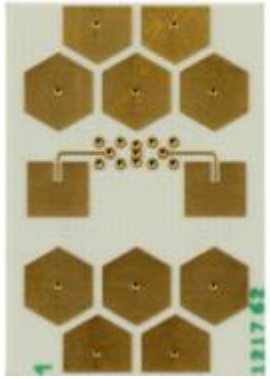
(for fo =24GHz)

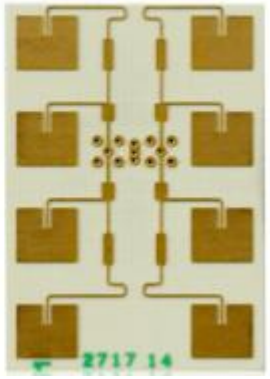


- Variety: using two (I and Q) mixer. These mixers are 90 degrees shifted in phase. Allowing to sense if a target moves towards or away from the sensor

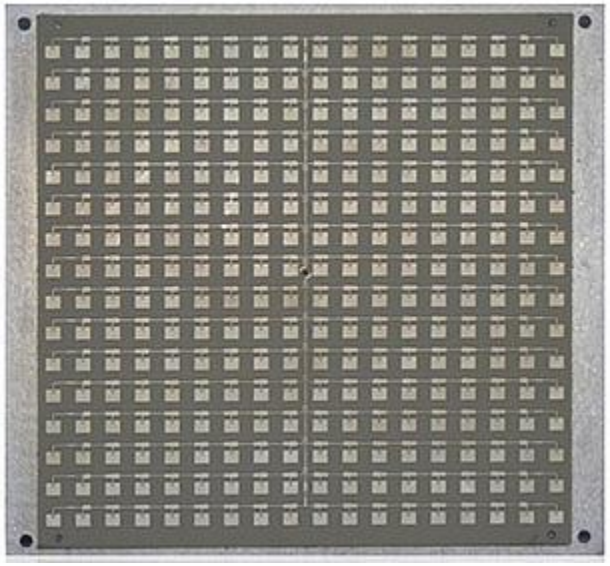
CW modulation: applications

- Speed radar (fixed angle, counting “zero crossings”)
- Intrusion alarm
- Door openers
- Presence detection





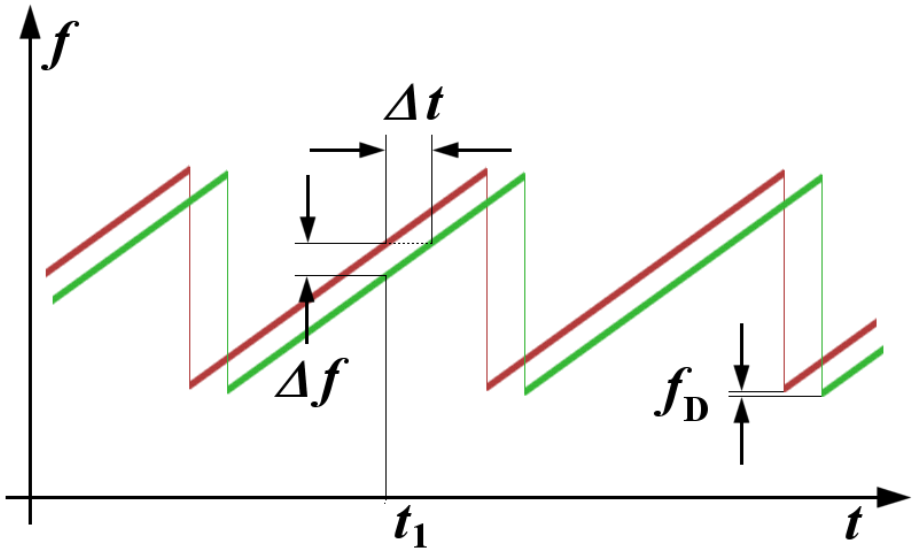
Full integrated radar front end, 24GHz.
Pricing << 5 Euro in large qts



High end, small aperture CW
parabolic dish replacement

FMCW Modulation

- **F**requency **M**odulated **C**ontinious **W**ave radar (FMCW radar):
- Measures speed and range (again both radial!!).
- fbeat = 2*R*BW/c/Tsweep ± fD
- he oscillator sweeps in frequency. The time difference/delay is a measure of the range and actually obtained in the electronics from a measurement of delta F

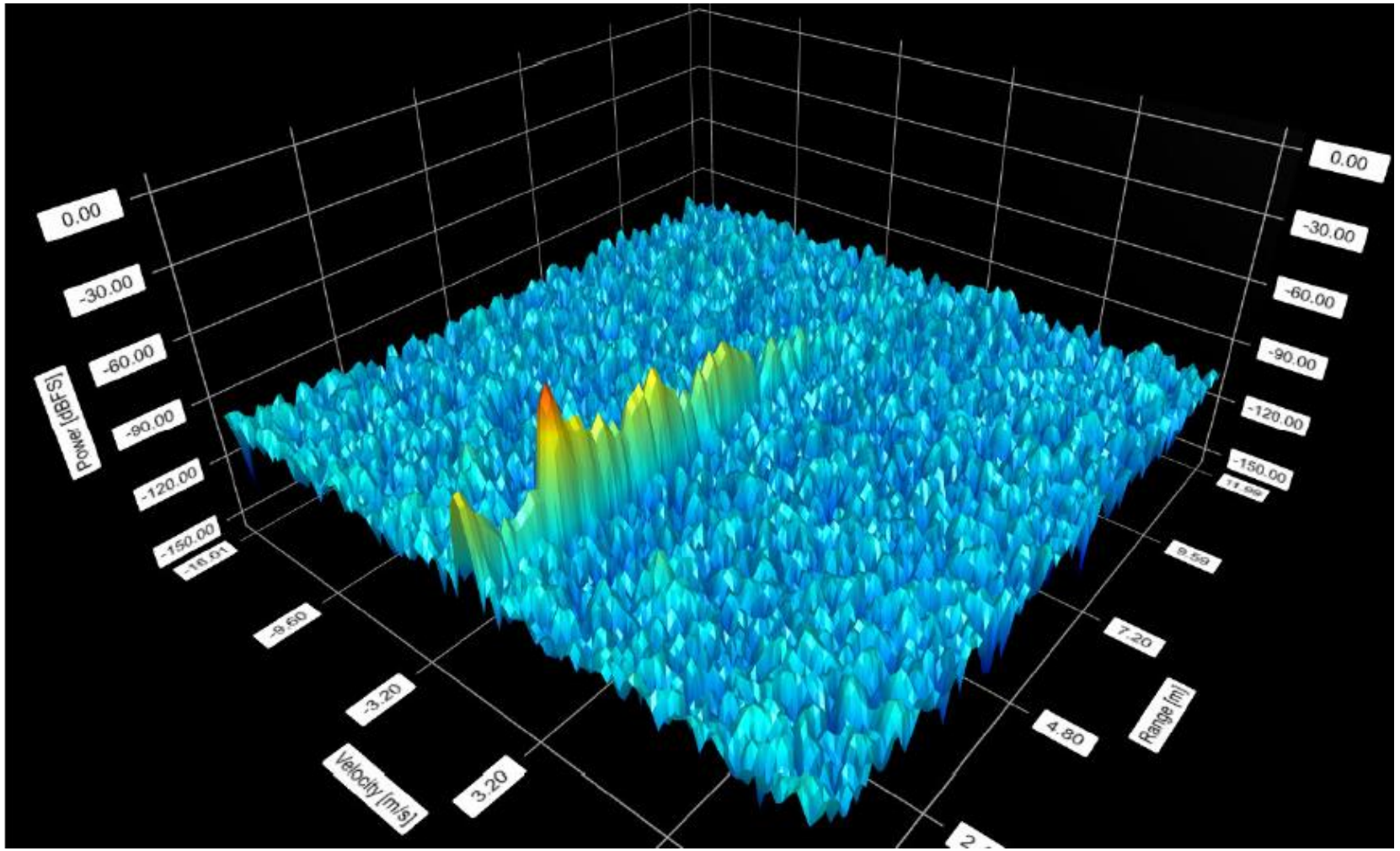


FMCW Modulation

Typical aspects:

- Resolution: inversely proportional to bandwidth (be aware…something different than accurary).
- Bandwidth is limited by ETSI.
- Doppler dilemma: Since the maximum unambiguous range is inversely related to the PRF while the maximum unambiguous Doppler velocity is directly related to the PRF, there is no single PRF that can maximize both at the same time. Therefore always a trade of between max range and max speed
- For processing the IF is digitized and converted to the frequency domain (Fast fourier transformation), see next slide.

FMCW Modulation

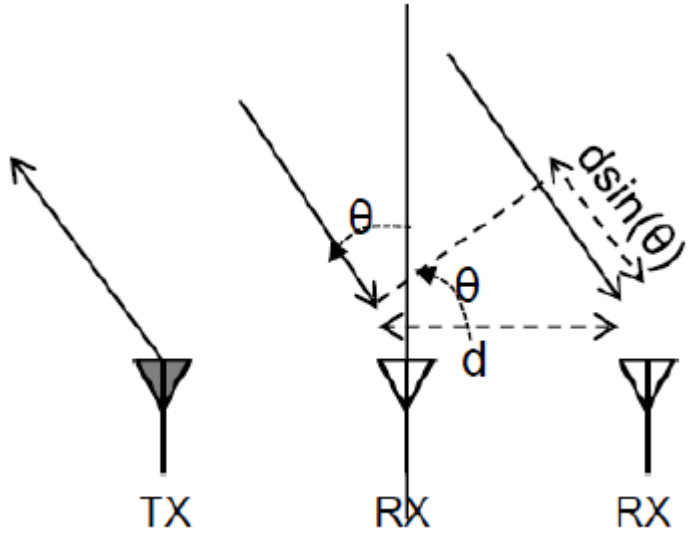


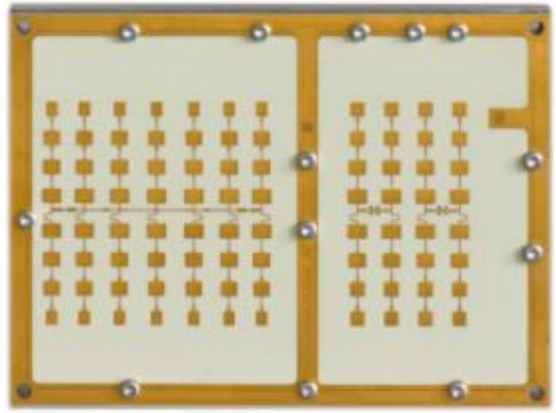
FMCW applications

- Level measurement
- Speed enforcement with lane indication
- Anti-Collision

Mono pulse radar

- Based on FMCW principle….but measures besides speed and distance also **angle** of the target relative to the radar.
- It has one Tx channel and two Rx channels to retreive the angle in one plane:





Mono pulse radar

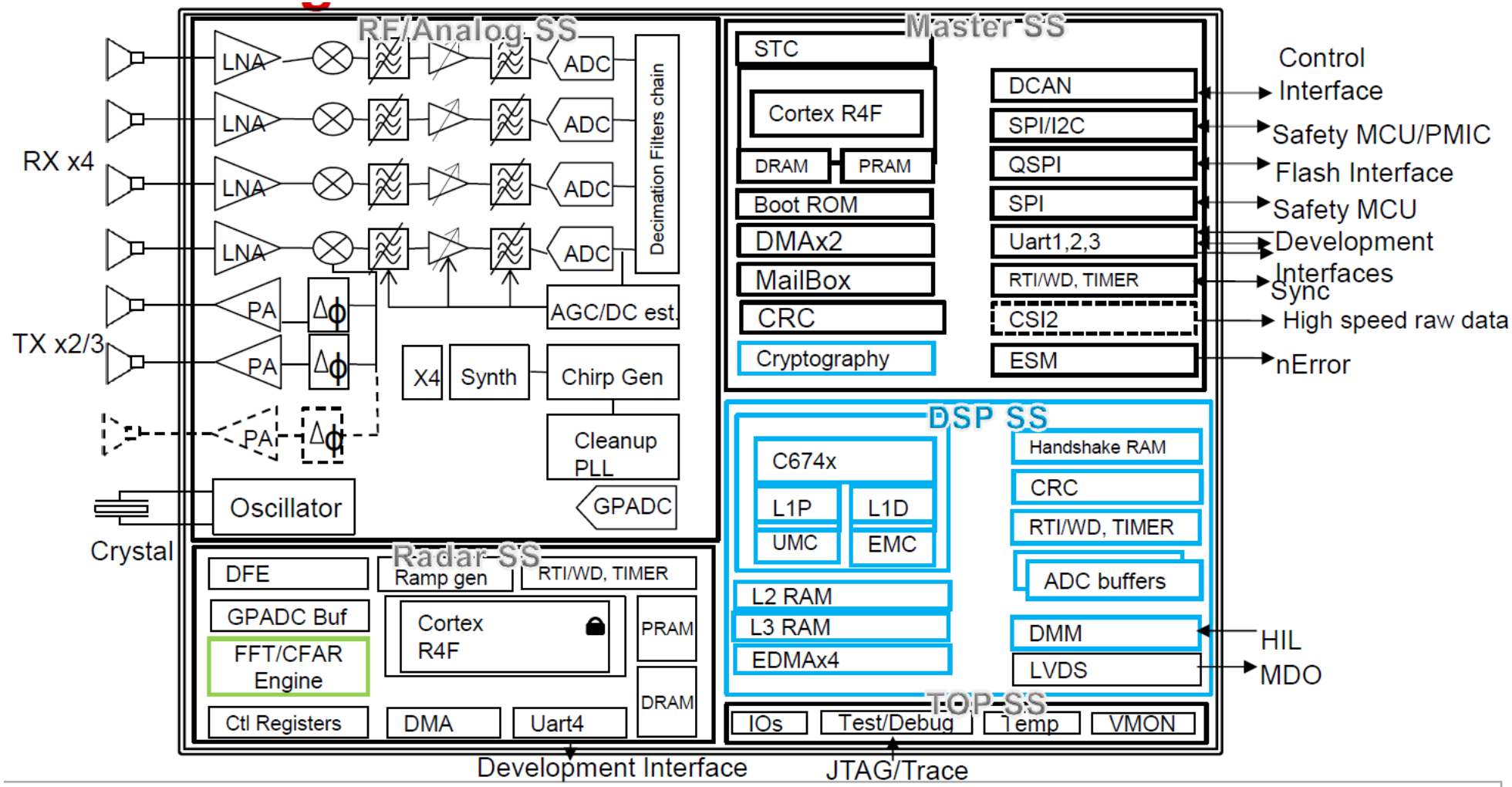
- Allows to see multiple targets at the same time, but again a compromise…..we first need to separate the targets. This can be done by range and velocity.
- Now we can start tracking the targets! This is done by tracking algorithms.

Red light enforcement system uses tracking radar

Latest commercial technology: MIMO

- Multiple Tx antennas and multiple Rx antennas.
- Less antennas versus classical phased antenna array.
- Measures **angle** of the target in parallel with range and speed.
- More Tx and Rx antennas, higher resolution.
  - Downside: measurement time and processing!!
- CW or FMCW modulation by multiplexing the Tx/Rx channels in time domain.
- Also alternative modulation types (i.e. bi-phase, pseudo-random)

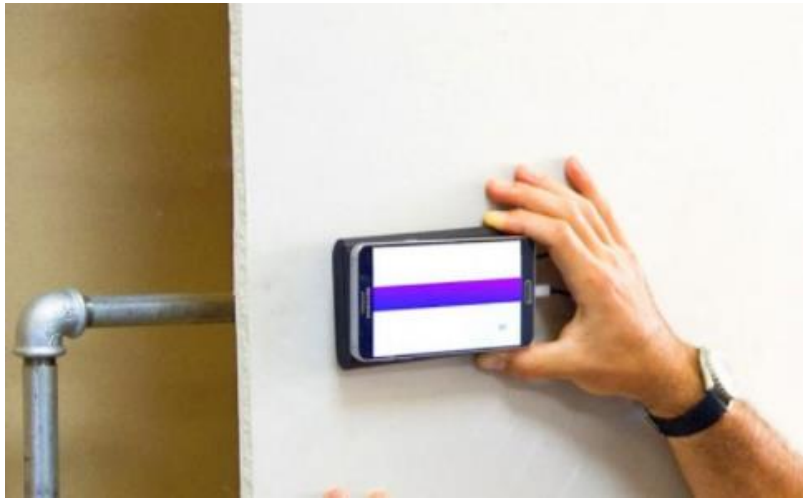
Latest commercial technology: MIMO



Critical selection parameter: TX-frequency

UWB: 3 to 10 GHz:

- Good for (ground) penetration radar
- Low cost commercial solutions
- Range limited
- Typically for “slow” detections for focussed radar images
- Examples: Novelda, Vayyar



Critical selection parameter: TX-frequency

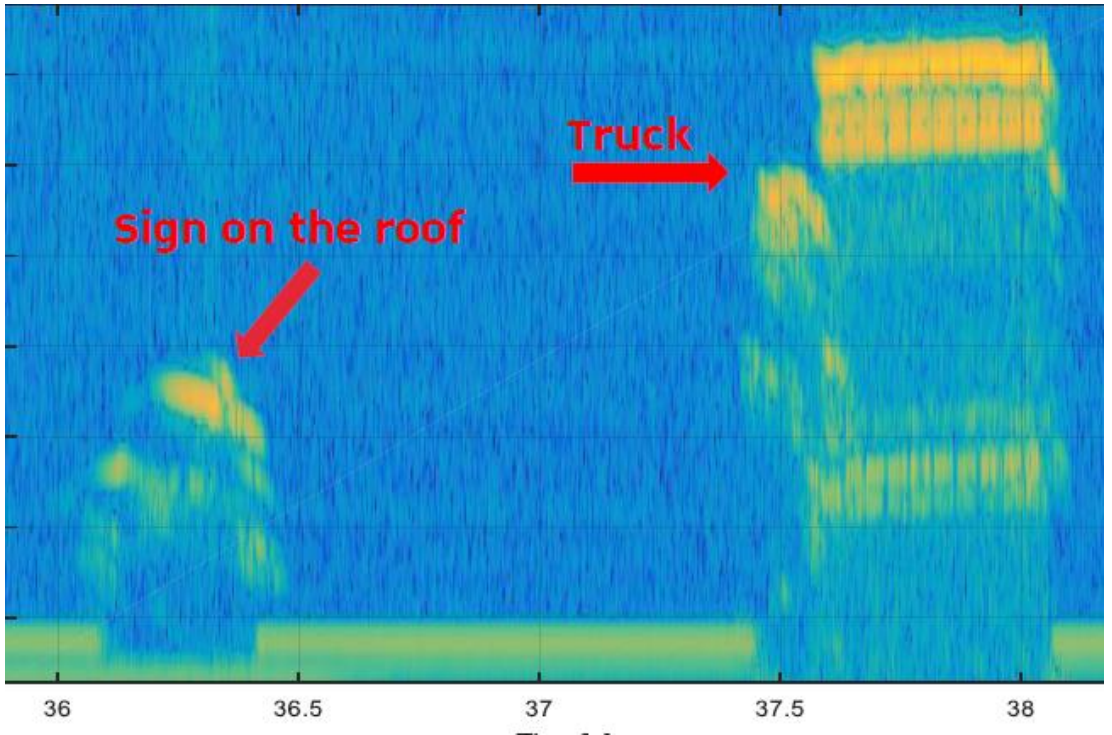
24GHz ISM band (250 MHz bw)

- Very popular band. Majority of applications in this band
- Good trade-off between range, accuracy, measurement speed and resolution
- Calculation/processing requirements easily feasible in micro-controllers
- Wide variaty of of-the-shelf modules available

Critical selection parameter: TX-frequency

mmWave (61GHz)

- 61GHz (57 to 64 GHz) very interesting for high resolution requirements. No interference with ADAS systems
- Processing hungry



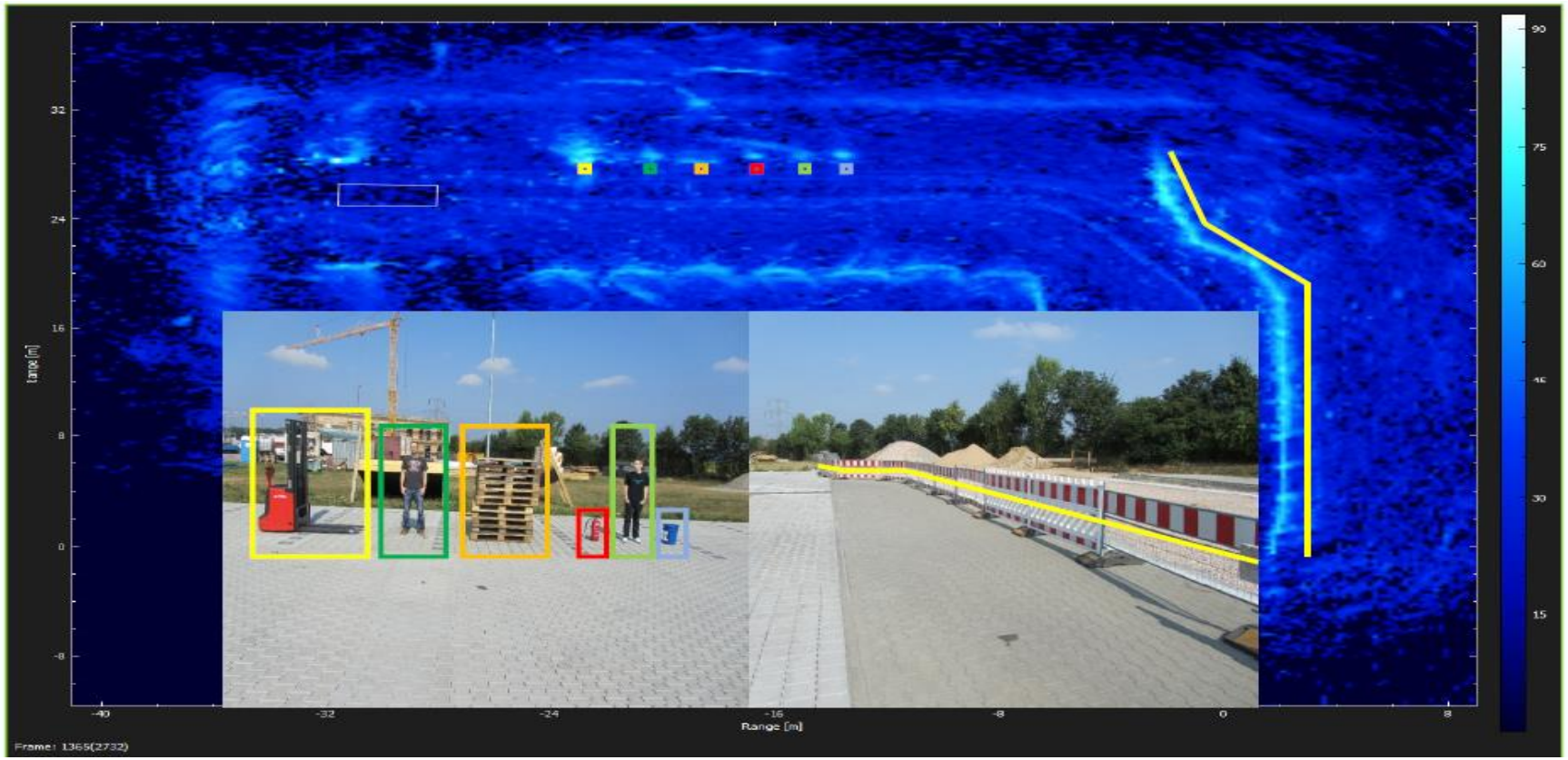
Critical selection parameter: TX-frequency

mmWave (79GHz)

- 79 GHz (77 to 81GHz) very interesting for high resolution requirements.
- Typically for automotive/AGV applications
- Automotive pushes the volume of integrated solutions. Low cost
- Highly complex processing, as majority is MIMO

Critical selection parameter: TX-frequency

mmWave (79GHz) example of a short range



Other parameters/points of attention

- Antenna patterns (beamwidth): What you don’t receive, you do not have to filter or process
- Modulation: what do you want to measure. Keep it as simple as possible
- Optimise your processing always to the task (remember the doppler dilemma)
- A radar module will never be a drop in component. One always needs to do some post processing/optimisation

Any questions or radar challanges:

- Contact:

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