

Challenges of Radar Sensor Integration into Modern Vehicles

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RADAR in Automobiles













Radar Sensors in Automobiles are usually integrated or hidden in the outer shell of the vehicle.

For good operation, good plastics are required !





The Way Towards Automated Driving...

- 1. Knowing what is around you
- 2. Knowing my own position
- 3. Knowing where to go
- 4. Handling unpredicable situations





Knowing What is Around....



For highly automated driving and fully autonomous vehicles, the number of sensors increases dramatically. So does the number of Radar Sensors in the vehicle.

Actual concepts plan for 8-10 radars

Mutual Interference inside same vehicle and inter-vehicle disturbances on same frequency band requires intelligent positioning and absorbing materials to avoid leakage radiation.



Method of Searching for Sensor Positions







360° Surround View Safety Cocoon No Redundancy wanted ! Least number of sensors Different Sensors required Max. Redundancy wanted ! Sensor Fusion Concepts 360° x 180° Surround View Optimization Parameter: Number of Sensors, Type of Sensor Position (x,y,z), Orientation (α,β,δ)

Optimization Problem: Full Vision vs. Least Numbers of Sensors vs. Maximum on Reduncancy



Knowing Where I am...



Radar principle requires good reflection of object to detect them. Opposite in Military: Detection Avoidance -> Stealth Bomber

In vehicular traffic, good reflection of objects increases detection Good detection (and visibility) of objects increases road safety.

Boundaries of Road and ego-Position on the road must be know precisely.



Not only sensors for the horizon required, also for vertical area.

- Curbstones as road markers and boundaries
- Bridges, Tunnels, Underways
- Walls and Fences along the path





Where to Place the Sensors ?





The Housing of the Radar Sensor requires low-loss plastics. Low-Loss for Electromagnetic Waves at 77 GHz Radar Band

In addition:

- mechanically durable
- assembly by Laser melting preferred
- robust against chemical loads

The shell in front of the Radar Sensor requires low-loss plastics. Amorphous materials perform much better than crystaline structures.

In addition:

- mechanically durable and flexible
- Painting preferred
- robust against chemical loads
- cost efficient



Knowing where to go...



Positioning and Routing Traffic Flow Analysis Way Guidance Platooning and Collaboration



Car-to-Car or V2X Communication require antennas and placement on outer shell of car body



Navigation and Traffic Flow require wireless backbone network for data aggregation and distribution on outer shell of car body



Tackling Unforseen Situations...



You never walk alone !

Vulnerable Road Users

Traffic Congestion / Jam

Breakdown and Failures

Weather Conditions....







Handling Surprises...





The internal heat dissipation of a radar sensor is about 25-30 Watts for cooling over the chassis.

In icy weather conditions, about 20-25 Watts electrical heating is provided to melt snow on sensor or cover.

Installed Performance





- The Antenna Performance without housing or Radome is often close to perfect
- Installation into a housing, the characteristics detorate
- Integration into vehicular chassis and body work change characteristics dramatically
- Awareness and Carefulnes of side-lobe degradation and main-lobe deformation needed





Deep Dive Radoms: Material Properties



- Insertion Loss must be low
- 0,5dB ... 1,0 dB achievable
- Material selection from amorphous group
- Examples: ASA, ABS, PC, PMMA
- Avoid cristalline Structures (PA, PP, PE)





Deep Dive : Plastics in front of Radars





The Radar Transparency Window



- Material Parameters (Permittivity), thickness and surface roughness influence wave penetration, absorption and reflection properties.
- Full Radar-Band Coverage (76-81 GHz) is very hard to achieve.
- Complex Curvages distort wave propagation
- Painting and structural stiffening elements influence further

Color and Paints: eat-up reserves

Gletscherweiß

Eissilber





unlackiert

Brilliantschwarz

Dakotagra

Einfachlackierung 3,1

Ibisweil

Lavagrau

Zweifachlackierung 3,1

Monsungrau

---- Dreifachlackierung 3,1

- Pigments in the paint liquid are irregularly oriented
- Dry paint layers can form solid layers of pigments
- If electrical conductive, the paint becomes reflective
- Additional layers of paint can cause increased attenuation
- The Paint on the Radome will absorb reserves of the system

Summary:

Modern Automobiles are fully loaded with Radars !

The Radar-Sensor requires some special properties:

- $\checkmark\,$ Good Positioning in the Vehicle
- $\checkmark\,$ Good transmission for radio waves
- ✓ Highly reflective for radio waves
- ✓ Highly attenuative for radio waves
- ✓ Good thermal conductivity
- ✓ Good mechanical durability
- ✓ Good chemical resistance
- ✓ Good pricing





Means: Superior in all Aspects !