Low-cost single-chip radar design and applications at 60 GHz

Paul van Zeijl
CTO
Omniradar
paul.van.zeijl@omniradar.com
Our Mission

to be a major supplier
of innovative integrated radar IC's

for consumer, industrial and
automotive markets,

leveraging the knowledge on
radar in The Netherlands.
Contents

- Problems presence sensor technology.
- Problems current radar technology.
- The Omnipolar value proposition.
- Doppler and FMCW radar.
- Opportunities.
- Why 60 GHz?
- IC architecture.
- Measurement results.
- The potential of integrated radar.
- The team.
- Conclusions
Problems
Presence Sensor Technology

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation in dust or hall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation in fog or snow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low sun and dazzling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day and night operation capability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor blockage risk (e.g. dirt on sensor)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounting constraints on vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface/Cover transparency constraints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MOSARIM FP7 project

Most sensors cannot handle harsh environments.
Problems
Current Radar Technology

Discrete solutions = costs
24 GHz bandwidth = no resolution
Higher frequency = complex
Expert design work = costs
Value Proposition

We take the microwave hassle out of engineering

We bring radar technology to industrial and consumer markets

with our solution:

- Fully Integrated 60 GHz
- high bandwidth frontend
- RADAR with antenna’s
Doppler radar

\[ \Delta f \approx \frac{2 \cdot v_{\text{object}}}{c} f_{RF} \]

Using \( f_{RF} = 60 \text{ GHz} \), \( v=10-100 \text{ km/hr}=2.8-28 \text{ m/s} \) \( \Rightarrow \Delta f = 1-11 \text{ kHz} \).
FMCW radar

- Triangular frequency modulation (many other patterns possible).
- Measures both distance \(d=(\Delta f_1+\Delta f_2)T_{ch}/f_{swp}\) and speed \(v=(\Delta f_1-\Delta f_2)c/(2f_{RF})\).
Opportunities

Better performance, smaller outline and lower pricepoint will open up many applications for ranging, velocity, imaging.
More opportunities.

- UAV applications.
- Car applications.
- Automatic Guided vehicles.
- Speedometer.
- Intruder alarms.
- Proximity switches in sanitary equipment.
- Robot sensors for proximity and speed.
- Ultrasound transducer replacement.
- Standard “radar” component for all engineers.
Why the 60 GHz ISM band?

Small applications possible (wavelength=5 mm).

Source: agentschap Telecom
IC architecture 1(2)

- Generic solution for FMCW, FSK, doppler radar applications.

- 7 GHz bandwidth $\Rightarrow$ 4 cm resolution

- 2 * RX: direction of arrival
- RX I/Q: direction of object-movement.

- PLL
- Low-cost XTAL (10-50 MHz)
- Analog or digital IF output
IC architecture 2(2)

• Single supply (2.6-2.9 V) via on-chip low-dropout regulators.
• “SW programmable radar” to program various functionality (150 bits) via SPI.
• Antenna on-silicon or in the package.
• For our customers: NO hassle in RF board or antenna design
• Just connect power supply, signal processing unit and have a working radar!
Measurements

Signal profile

PSD, [dBm/Hz]

range, [m]
Distance Measurement

Measured distance

Measurement error
Angle of arrival
UNLOCKING POTENTIAL OF INTEGRATED RADAR

DRIVERS:
COST
SIZE
PERFORMANCE

PRICE CURVE
CONVENTIONAL

TRUCKS

LEVEL GAUGING

DOORS

LIGHTING B2B

PRESENCE B2B

LIGHTING CONS.

PARKING SENSORS

LEVEL GAUGING AUTOMOTIVE

PRESENCE CONSUMER

PRICE CURVE OMNIRADAR

PRICE

€15

€10

€5

€1

0 1 2 3 4 5 6 YEARS
The Team

Ir. Hans Brouwer
CEO
Over 30 years experience in semi and new product development

Ir. Tim Savelyev
System Architect
Over 15 years of hands-on and Architect radar experience. Eurad best paper award 2012

Ir. Jacques Rompen
Designer
60GHz Design Expert

Dr. Ir. Paul van Zeijl
CTO
World’s first single chip Bluetooth. 30 Patents. Several 60GHz designs. Over 40 publications.

Ir. Peter-Paul Vervoort
Sr. IC Designer
Experienced chip designer Bluetooth, DECT integration

Jan-Willem Wakker
Electronic & SW Designer
Conclusions

• Summarized problems in state-of-the-art presence sensor technology and radar technology.
• There are lots of opportunities for radar.
• Our value proposition is a one-chip-radar at 60 GHz: NO hassle in RF board or antenna design for our customers. Connect power, signal processing unit and start measuring.
• Shown the IC architecture and two designs:
  – Antenna on-silicon
  – Antenna in-package
• We have demonstrated radar measurement results (distance, angle-of-arrival).
“The successful realization of such items as phased-array antennas, for example, using a multiplicity of integrated microwave power sources, could revolutionize radar”

Gordon Moore, April 19, 1965